Geology of the Thomas Range fluorite district, Juab County, Utah

By Mortimer H. Staatz and Frank W. Osterwald

Trace Elements Investigations Report 252

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UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

GEOLOGY OF THE THOMAS RANGE FLUORITE DISTRICT, JUAB COUNTY, UTAH*

By

Mortimer H. Staatz and Frank W. Osterwald

February 1955

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*This report concerns work done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

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By Mortimer H. Staatz and Frank W. Osterwald

ABSTRACT

The Thomas Range fluorite district includes an area of about 34 square miles surrounding Spors Mountain in central Juab County, 46 miles northwest of Delta, Utah. Between the time of its discovery in 1943 and the end of 1952, this district produced a total of 75,312 short tons of fluorite ore from 12 properties. Almost all the fluorite deposits have an abnormally high uranium content. All but one of the seven sampled fluorite veins and pipes that contained over 0.050 percent uranium are on the southern end of Spors Mountain.

The rocks exposed in the district range in age from Lower Ordovician to Pleistocene. The greater part of Spors Mountain is made up of a thick series of apparently conformable Paleozoic rocks, which are chiefly carbonates. The Ordovician Garden City formation, which is chiefly limestone, is the oldest rock exposed in the district. Two other Ordovician formations, the Swan Peak formation consisting of a lower shale member and an upper quartzite member and the Fish Haven dolomite overlie the Garden City formation. Five newly named Middle Silurian formations: the Floride dolomite, the Bell Hill dolomite, the Harrisite dolomite, the Lost Sheep dolomite, and the Thursday dolomite overlie the Fish Haven. The Devonian Sevy dolomite and the Simonson and Guillmette formations, undivided (dolomites and limestones), overlie the Silurian dolomites and are the youngest Paleozoic rocks in the district. Volcanic rocks, which include latite, quartz latite, rhyolite, agglomerate, lapilli tuff, quartz latitic tuff, and rhyolitic tuff, of probable Tertiary age, surround the Paleozoic sediments. Dikes and plugs of intrusive breccia, rhyolite, and quartz latite intrude the Paleozoic rocks, commonly along faults.

All the Paleozoic sediments and the volcanic rocks strike northeast and dip northwest. These consistently dipping rocks are cut by about 980 faults belonging to at least five sets of faulting: 1) northeast-trending thrusts, 2) northeast-trending normal and reverse faults, 3) northwest-trending faults,

4) east-trending faults, and 5) north-trending faults. The first three sets were formed prior to the emplacement of the volcanic rocks, but the latter two sets cut both groups of rocks and movement along the north-trending set raised Spors Mountain to its present elevation.

During Pleistocene time Lake Bonneville surrounded the Thomas Range, and gravels, conglomerate, and marl were deposited at that time on its flanks and in the surrounding area which is now a desert.

Fluorite deposits are of three types: 1) oval to irregular pipes, 2) veins, and 3) disseminated deposits. The pipes, which show considerable variation in shape and size with depth, have produced more than 99 percent of the ore. Fluorite deposits are found chiefly in the Silurian dolomites and the underlying Ordovician Fish Haven dolomite, and show two chief types of structural control: 1) in or adjacent to faults, and 2) adjacent to intrusive breccia bodies. The ore consists of 65 to 95 percent fluorite with montmorillonite, dolomite, quartz, chert, calcite, and opal as impurities. The fluorite closely resembles a brown, white, or purple clay and forms either soft pulverulent masses or boxworks. With depth the grade of the ore commonly decreases, and masses of montmorillonite, chert, or quartz and dolomite have been found in increasing abundance in some deposits.

The ore is believed to have been formed from fluorine-rich fluids which brought in minor amounts of uranium, and which were derived from the magma that formed the topaz-rich rhyolites of the Thomas Range during the last stages of vulcanism. These fluids rose along faults and replaced shattered zones in the dolomite. Introduced elements other than fluorine and uranium were probably obtained from rocks underlying the deposits.

Uranium analyses on 155 fluorite samples ranged from 0.003 to 0.33 percent uranium. The highest uranium samples came from the Bell Hill, Harrisite, Eagle Rock, Lucky Louie, and two small prospects. Deposits at all of these properties except the Bell Hill are small. The grade of the uranium in the fluorite ore varies considerably even on individual levels of a single mine. Uranium was secondarily enriched, however, near the surface of most deposits. This is believed to have been caused by slow leaching of the upper part of the ore body in an arid climate, in part from material being actively eroded. The uranium was redeposited a few inches to 30 feet below the position from which it was leached because the dry underlying ore absorbed the ground water. The uranium content of the fluorite ore from the upper workings may be as much as twice that found in depth.

INTRODUCTION

Scope of report

The fluorite district in the western part of the Thomas Range, Juab County, Utah, is one of the newest mining districts in western United States; since 1950 it has been the largest producer of fluorite west of the Mississippi River. The present report covers the geology of the entire fluorite producing area, and supplements an earlier report by Staatz, Wilmarth, and Bauer (1954) on the individual mining properties. Additional material is given on all old operating properties, as well as on those properites developed between September 1950 and February 1953.

Location and surface features

The Thomas Range is on the eastern edge of the Basin and Range province in central Juab County, Utah (fig. 1). The range is about 17 miles long and has a maximum width of 9 miles. It trends northwest and is composed of three distinct topographic units. The eastern unit is a block approximately 12 miles long and 3 to 6 miles wide, composed of Tertiary (?) rhyolite and tuff. About 2 miles to the west is a second unit approximately 6 miles long and 1 1/2 to 2 miles wide composed chiefly of complexly faulted early to middle Paleozoic sediments. The third unit, three and one half miles farther northwest, is a circular group of mountains about 4 miles in diameter composed of middle Paleozoic sediments.

All the known fluorite deposits are in the second unit called Spors Mountain by Fitch, Quigley, and Barker (1949, p. 63-66). Mining has been limited to an area approximately 5 miles long by 1 mile wide along the eastern side of Spors Mountain. The present report covers an area of approximately 34 square miles. It includes all of Spors Mountain and extends about 2.4 miles south of its southernmost end. See figure 1 and plate III.

The mapped area is in Tps. 12 and 13 S., R. 12 W., Salt Lake principal meridian. The nearest town is Delta in Millard County, approximately 46 miles southeast from the southern part of the district.

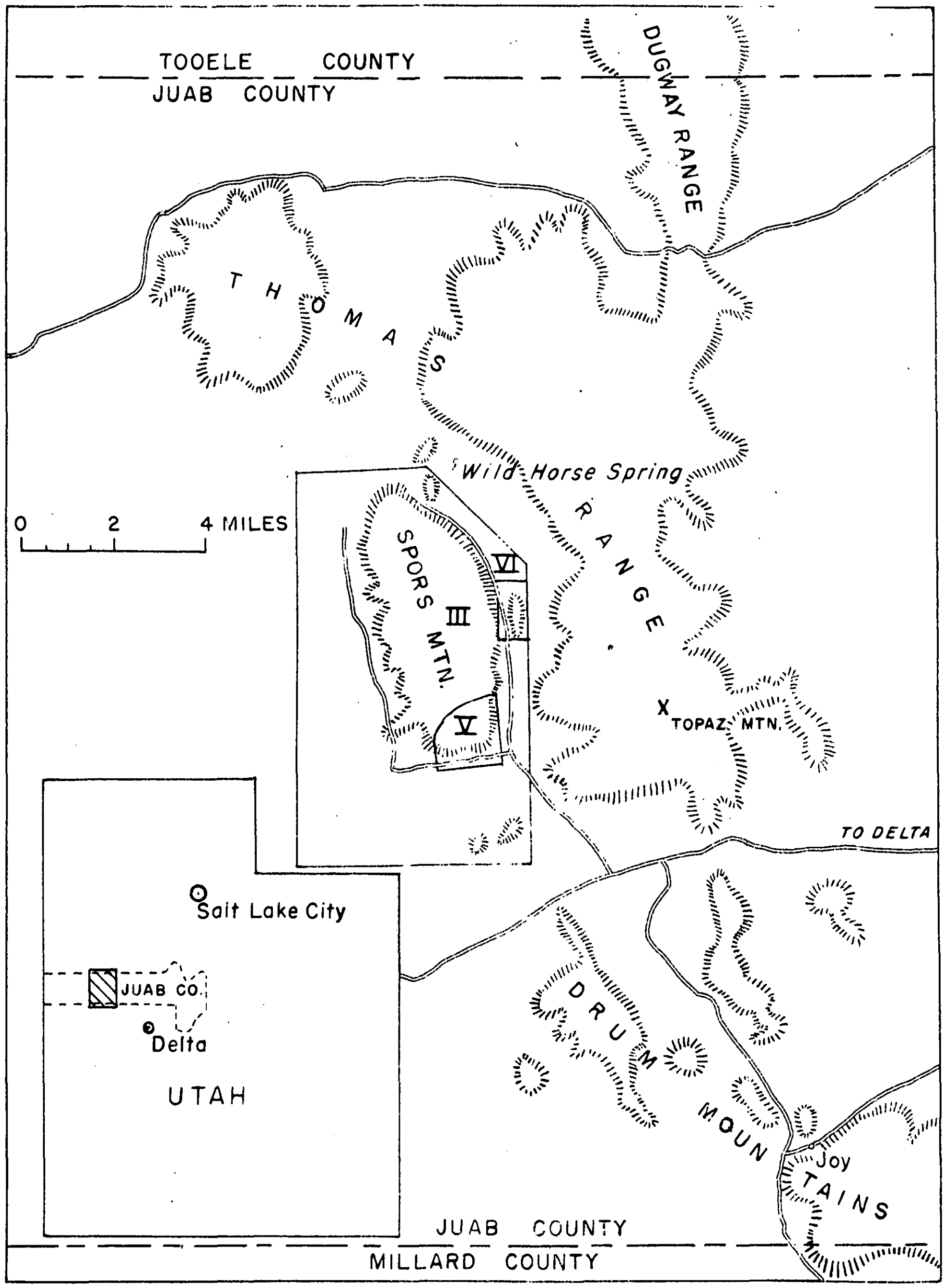

FIGURE I. INDEX MAP OF THE THOMAS RANGE FLUORITE DISTRICT, JUAB COUNTY, SHOWING AREAS OF PLATES III, V, AND VI

The area is reached from Delta, the nearest railhead on the Union Pacific Railroad, by 15.4 miles of paved and 30.9 miles of improved dirt road. In the spring of 1952, the Bureau of Public Roads improved and straightened the road along the east side of Spors Mountain. From this road a second road leads around the south end of Spors Mountain and north along its western side (fig. 1). The north part of this second road is passable only by jeep. Several haulage roads lead to the various mines from the main east side road. During the summer months cloudbursts sometimes wash out the roads.

Spors Mountain rises steeply out of Lake Bonneville sediments, which surround it, and forms a small rugged range (fig. 2). The base of the mountain is at an elevation of approximately 5,000 feet, and the highest peak reaches an elevation of 6,584 feet (pl. 1). Along the western and southern sides of this small range, low hills, as much as several hundred feet high, protrude through a cover of Lake Bonneville gravels. Bars of Lake Bonneville gravel as much as 50 feet high are also found across the mouths of valleys, and wave cut benches formed by old Lake Bonneville are prominent in the southernmost part of the district (pl. 2). Along the east side of the district, especially the central and northern parts, the topography is steep and the valleys are V-shaped.

No permanent streams are found in the area, and surface water flows in the water courses only during and shortly after occasional summer cloud bursts. Rainfall is scant; during the winter as much as 2 feet of snow falls hampering mining operations from late December to early April. The nearest permanent water supply is east from the northeast corner of the district. There is also a well for watering sheep near the Delta-Callao road approximately 2-1/2 miles south of the district. As the nearest water is either saline or in remote locations, the miners bring their drinking water from Delta.

The area is covered by bushes six inches to a foot high which is thickest in the flat area surrounding Spors Mountain. The only trees are twisted junipers, averaging about 7 feet in height, which are most abundant in the north and central parts of the mountain. These trees are not used as mine timber because they are too small.

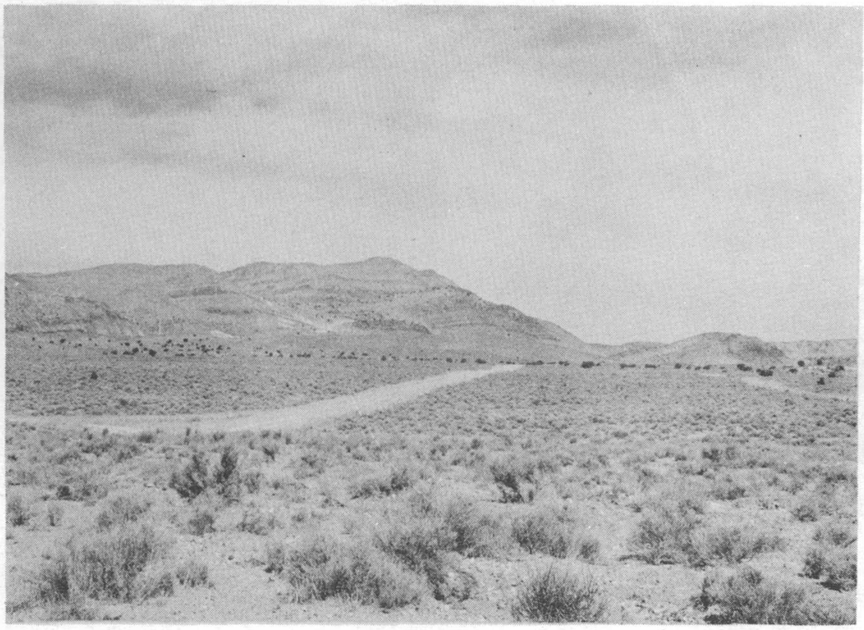

Plate 1.--Panorama of the southern end of Spors Mountain looking north along the east side. Eagle Rock Ridge is on right side of picture.

Plate 2.--Benches cut in a quartzite hill at the south end of the district by waves of old Lake Bonneville.

History and production

All of the mines in this district produce fluorite. The fluorite ore contains uranium minerals, but up to January 1953, no uranium was recovered from any of the ores. No copper, lead, zinc, silver, gold, or manganese minerals are known from the district.

The first fluorite was mined from the Floride claim of George Spor and sons in 1943, and was sold the following year. From 1944 to 1947 there was little other activity in the district, and the Floride continued to be the only shipper. Late in 1947 the Dell No. 1 and No. 2 deposits were located, and this was followed in rapid succession by the discovery in 1948 of the Blowout, Dell No. 5, Eagle Rock, Fluorine Queen, Hilltop, Lost Sheep, Lucky Louie, Nonella, Oversight, and Thursday; and in 1949 by the location of the Bell Hill and Harrisite. By the end of 1949, almost all of Spors Mountain was covered by claims.

In 1948, production from the Floride claim was augmented by that from the Dell Nos. 1 and 2, the Fluorine Queen, and the Lost Sheep; in 1952 eight properties were in production. Altogether, by December 31, 1952, twenty deposits on 12 different properties had produced a total of 75,312 short tons containing 65 to 94 percent fluorite (table 1). All of this was mine run ore and was sold for metallurgical use.

From 1944 to 1949 ore was shipped to Geneva Steel Company at Geneva, Utah. Since 1950 the ore has been sold to Continental Ore Buyers of Chicago, Ill., brokers, who ship it to various parts of the country.

Ore sold for approximately $23.50 a ton in 1952 delivered in Delta, Utah, based upon a 60 percent effective grade CaF_2._/

_/ The effective CaF_2 is determined from an analysis of the ore by subtracting 2 1/2 percent CaF_2 for each 1 percent of SiO_2 in the ore. Thus, an ore containing 75 percent CaF_2 and 4 percent SiO_2 would be rated at 65 percent effective.

Table 1.--Fluorite production of the Thomas Range district from 1944 through 1952.

Mine	Number of deposits producing fluorite	Production (short tons)									
		1944	1945	1946	1947	1948	1949	1950	1951	1952	Total production
Bell Hill	3	0	0	0	0	0	0	← 7,480 →		4,466	11,946
Blowout	1	0	0	0	0	0	1,100	2,355	1,313	1,128	5,896
Dell	3	0	0	0	0	800	3,000	1,300	0	0	5,100
Dell No. 5	1	0	0	0	0	0	205	0	0	0	205
Floride	1			← 8,748 →			0	463	0	0	9,211
Fluorine Queen	2	0	0	0	0		← 9,071 →		4,321	3,727	17,119
Harrisite	2	0	0	0	0	0	0	0	55	0	55
Hilltop No. 1	2	0	0	0	0	0	0	0	0	100 1/	100
Lost Sheep	2	0	0	0	0		← 11,625 2/ →		5,729	6,241	23,595
Lucky Louie	1	0	0	0	0	0	0	0	0	1,432	1,432
Oversight	2	0	0	0	0	0	0	0	0	598	598
Thursday	1	0	0	0	0	0	55 2/	0	0	0	55
TOTAL											75,312

1/ Tonnage estimate from size of workings.

2/ From Bauer, H. L., Jr., 1952, Fluorspar deposits north end of Spors Mountain, Thomas Range, Juab County, Utah: Univ. Utah, unpublished thesis.

Mining in the district is generally begun by open pit methods. The open pit method is continued as long as walls remain intact, but several mines have had to use underground methods, when their open pit became too deep. The small ore pipe on the Lost Sheep and the east ore pipe on the Fluorine Queen deposits have been mined by driving a short adit to the ore body and raising to the surface. The ore in the open pit is then drawn by slusher to the raise and trammed out underground. The Lucky Louie and Oversight deposits were shaft-mined by sinking on the ore body and hauling the ore out in a bucket. The Bell Hill operators drove an adit 86 feet below the surface and then mined the ore body from a number of stopes both above and below the adit. The large ore pipe on the Dell Nos. 1 and 2 was mined by an adaptation of the block caving technique. The ore was drawn off at the chutes and trammed to the ore bins. The wall rocks are sufficiently solid in all mines so that little timber is necessary.

Previous work

Early work on the Thomas Range was confined to the eastern part, where rhyolite yields the beautiful wine-colored topaz crystals, which have long been a collector's item. The area is the type locality of the mineral bixbyite, which was first collected by Maynard Bixby (Penfield and Foote, 1897, p. 105-108).

The topaz area was first reported by Henry Engelmann, geologist for Captain J. H. Simpson's expedition across the Great Basin of Utah, in 1859 (Simpson, 1876, p. 325). Since that time, numerous articles on topaz and its associated minerals have appeared in print (Kunz, 1885, p. 738; Cross, 1886, p. 436-438; Alling, 1887, p. 146-147; Kunz, 1893, p. 764; Jones, 1895, p. 175-177; Penfield and Foote, 1897, p. 105-108; Hillebrand, 1905, p. 330-331; Patton, 1908, p. 177-192; Palache, 1934, p. 14-15; and Montgomery, 1934, p. 82-87).

The western part of the Thomas Range (Spors Mountain) attracted little geologic attention before 1948. No published geologic maps of the Thomas Range are known, though some mapping was done by W. P. Fuller for International Smelting and Refining Company, J. J. Beeson for Geneva Steel Company, and James Quigley for Chief Consolidated Mining Company. The fluorite district is briefly described by Fitch, Quigley, and Barker (1949, p. 63-66). The district was visited during August and September of 1950 by M. H. Staatz, V. R. Wilmarth, and H. L. Bauer, Jr. of the U. S. Geological Survey, who were investigating uranium resources in western Utah. Most of the mining properties were sampled and were mapped by plane table and telescopic alidade on scales of 1 inch to 40 feet and 1 inch to 50 feet in 1950. The results of this work are combined in a paper on fluorspar deposits of Utah (Thurston, and others, 1954).

Herman L. Bauer, Jr. mapped and described the mines and the areal geology of part of the northern end of Spors Mountain during the fall of 1951 (Bauer, 1952).

During 1952, the district was visited by geologists from the Union Pacific Railroad Company under Arden Blair.

Field work and acknowledgments

This mining district had never been thoroughly studied, and the ore controls were unknown. Therefore the present study of the fluorite mining district is regional and includes detailed mapping of the whole of Spors Mountain, as well as economic evaluation of the potential sources of fluorite and uranium. This investigation was made on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

Field work in the area was started in July 1951 by Staatz, who was assisted by H. L. Bauer, Jr. and E. W. Tooker until September 1951. R. A. Christman assisted between September and December 1951, and the field work was recessed in February 1952. Staatz and Osterwald started field work again in July 1952, assisted by L. F. Emmett and P. B. Barton, and finished in September 1952.

Mapping of the whole area was done on aerial photographs at the approximate scale of 1:12,000. The final geologic map was compiled by multiplex from the aerial photographs on the original topographic map manuscript (fig. 2, pl. 3), by the Topographic Division of the U. S. Geological Survey. The southern end of Spors Mountain, an area of about 1.6 square miles (pl. 5), and the east side of the district containing the Eagle Rock claim (pl. 6), an area of about 0.9 of a square mile, were mapped by plane table and telescopic alidade on the scale of 1:6,000. These two areas included all deposits from which analyses showed more than 0.05 percent uranium. In addition, plane table maps on the scale of 1 inch to 40 feet and mine maps were made of deposits not previously described (Thurston, and others, 1954).

Two core holes were drilled on the Bell Hill property by the U. S. Bureau of Mines under direction of A. A. McKinney, and the results were made available to the writers. The writers were visited in the field and received advice from L. R. Page, R. J. Roberts, Helen Duncan, Jean Berdan, and R. J. Ross, Jr. of the U. S. Geological Survey and C. C. Towle, T. P. Anderson, and E. E. Thurlow of the U. S. Atomic Energy Commission. Robert Winkle of the Atomic Energy Commission aided in some of the sampling.

The miners and owners of all the mines have freely given of their time and knowledge of the district. Those who have been particularly helpful are Chad Spor, Ray Spor, Faye Spor, Fred Staats, Les Price, Earl Dalton, Scott Chesley, T. A. Claridge, L. N. Rasmussen, Al Willden, Earl Willden, W. W. Watson, and C. D. Searle.

GEOLOGY

General features

The rocks in the Thomas Range fluorite district range in age from Lower Ordovician to Pleistocene. Spors Mountain, which occupies the greater part of the district, is made of Paleozoic sedimentary rocks intruded by small dikes and pipes of latites and acid igneous rocks; volcanic explosion pipes filled with breccia are common along its east side. The Paleozoic rocks range in age from Lower Ordovician to Middle Devonian and appear to be a conformable sequence consisting of: The Ordovician Garden City formation (mostly limestone), Swan Peak formation (lower part shale, upper part quartzite), and Fish Haven dolomite; the Silurian Floride dolomite, Bell Hill dolomite, Harrisite dolomite, Lost Sheep dolomite, and Thursday dolomite; and the Devonian Sevy dolomite and the Simonson and Guillmette formations, undivided (lower part mostly dolomite, upper part mostly limestone). The Floride, Bell Hill, Harrisite, Lost Sheep, and Thursday dolomites are new Middle Silurian formations. Outcrops of Devonian rocks are more abundant north and west of Spors Mountain, and Ordovician rocks are found only to the south and east.

Volcanic flows and tuffs of probable Tertiary age overlie and surround the Paleozoic sediments.

Pleistocene Lake Bonneville sediments cover the surrounding desert and the lower elevations of Spors Mountain. Gravel bars, as much as 60 feet high, are found in the mouths of several canyons.

The Paleozoic sediments and the Teritary (?) volcanic rocks strike consistently northeast and dip northwest. Though the beds have been tilted, no fold axes cross the district.

The district is cut by innumerable faults which can be divided on the basis of strike and dip into five groups. Three of these, a few small thrusts, a prominent northeast-trending set of faults, and an apparently later northwest-trending set, cut the Paleozoic rocks but must have preceded the volcanic rocks because they served as conduits for plugs and dikes. Two later sets, trending east-northeast to east, and north, cut both the Paleozoic sediments and the volcanics. The north-trending set shows the largest offset, and along this set Spors Mountain and the neighboring ridges were raised to their present elevation.

Ordovician sedimentary rocks

Garden City formation

Name and distribution.--The Garden City formation of Ordovician age was first described by Richardson (1913, p. 408-409) from Garden City Canyon in northeastern Utah. The most comprehensive work at present is that of Ross (1951) who has studied the stratigraphy and paleontology in detail. At its type locality the Garden City is 1,225 feet thick (Ross, 1951, p. 3).

The Garden City formation crops out in only two places in the fluorite district: (1) in hills along the extreme southern margin of the district (pl. 3), and (2) in a small area about 2,800 feet southeast of the Fluorine Queen mine along the east flank of Spors Mountain. At neither place is the entire formation exposed, for in the southern area the base is covered by Quaternary sediments, and in the eastern area it is cut out by faulting. At both localities the Garden City is overlain conformably by the shale member of the Swan Peak formation.

Lithology.--Most of the Garden City formation is gray to greenish-gray limestone. The bedding is very irregular with numerous pinches and swells, and individual beds are most commonly less than 1 inch thick. The rock has a characteristic lumpy appearance, though the lower part of the measured section (table 2) contains massive limestone in beds up to 3 feet thick (pl. 7, A and B). Thin laminae of fissile green shale separate many beds of limestone. Some beds contain irregular chert nodules, particularly in the interval between 76.7 feet and 302.3 feet above the base of the measured section (table 2). Edgewise conglomerates within the Garden City formation crop out in fault blocks, along the south margin of the district. These conglomerates are common in the type section (Ross, 1951, p. 7-24), in the lower part of the formation.

Chemical analyses on both massive and lumpy limestone (table 3) indicate that the massive sample contained 4 percent dolomite in the carbonate fraction and the lumpy sample 5 percent.

Thickness and correlation.--The Garden City formation was measured at the southern edge of the district (pl. 3) in SE 1/4 sec. 23, T. 13 S., R. 12 W. (fig. 2). The exact place of measurement is a prominent ledge about 80 feet high along the north side of a large dry wash (pl. 7). The exposed thickness is 730 feet; the base of the section is covered by Quaternary and Recent deposits, and the top of the formation apparently conforms to the Swan Peak.

The formation contains many fossils; one 2-inch slab of limestone about 14 inches long by 8 inches wide yielded parts of over 3,000 trilobites (R. J. Ross, Jr., oral communication). Brachiopods are very common, and some beds are almost entirely composed of their remains. Locally planospiral gastropods are common, and the thin shale beds contain a few graptolites. The following fossils were identified by Reuben J. Ross, Jr.

pliomerid free cheek, probably Pseudomera barrandi
Anomalorthis sp.
Orthis cf. O. subalata, Ulrich and Cooper
Hesperonomiella cf. H. minor (Walcott)
Cybelopsis aff. C. speciosa, Poulsen
Lachnostoma latucelsum, Ross
Pseudocybele nasuta, Ross
Kirkella cf. K. declevita, Ross
Hesperonomia sp.
Tetragraptus cf. T. taraxacum, Ruedemann
Tetragraptus cf. T. dissipiens
Macronotella sp.

Table 2.--Stratigraphic section of the Garden City formation measured at the south end of the Thomas Range fluorite district.

Description	Bed thickness	Cumulative thickness
Swan Peak formation		
Quartzite member		
Shaly member		
Dolomite, medium-grained, orange to red, limy, interbedded with layers of fissile green shale, Orthambonites michaelis	90.6	193
Covered	102.1	102
Top of Garden City formation on basis of fossil float.		
Covered	162.8	730
Limestone, light gray, medium-grained, with a few small shale partings	33.6	567
Covered	83.6	534
Limestone, thin-bedded, light gray, fine-grained, 70 percent brown chert	22.0	450
Covered	83.5	428
Limestone, coarse-grained, dark gray; no chert, Hesperonomiella sp.	9.7	345
Covered	32.7	335
Limestone, fine-to medium-grained, medium gray, 25 to 75 percent brown, irregular chert	52.7	302
Covered	21.3	250
Limestone, dark to medium-gray, about 25 percent brown chert	1.5	227
Covered	135.1	226
Limestone, medium-grained, medium-gray, about 45 percent irregular chert	14.0	91

Table 2.--Stratigraphic section of the Garden City formation measured at the south end of the Thomas Range fluorite district--Continued.

Description	Bed thickness	Cumulative thickness
Coquina, dark gray	1.3	77
Limestone, massive, medium-grained, medium-gray, numerous irregular "blebs" of shale	1.5	75
Shale, light green, limy; a few gray limestone lenses	2.3	74
Limestone, massive, medium-gray; numerous irregular "blebs" of shale	10.4	72
Limestone, light gray, fine-grained, interbedded with light greenish-gray shale	1.0	61
Limestone, medium-grained, dark gray, in part coquina, Tetragraptus sp.	1.3	60
Limestone, fine-grained, light gray, interbedded with about 40 percent light greenish-gray shale, Tetragraptus dissipiens	2.8	59
Limestone, coarse-grained, gray, stained reddish-brown on outside	1.5	56
Limestone, light gray, interbedded with 40 percent light gray shale, Cybelopsis aff. C. speciosa, Lachnostoma latucelsum, Pseudocybele nasuta, Kirkella cf. K. declevita, Hesperonomia sp., Tetragraptus cf. T. taraxacum, Tetragraptus cf. T. dissipiens	4.9	55
Limestone, massive, medium-grained, light gray	6.7	50
Limestone, light gray, fine-grained, interbedded with light, greenish-gray, non-limy shale	5.9	43
Limestone-coquina, dark gray, Cybelopsis aff. C. speciosa, Lachnostoma latucelsum, Pseudocybele nasuta, Kirkella cf. K. declevita, Hesperonomia sp., Tetragraptus cf. T. taraxacum, Tetragraptus cf. T. dissipiens	2.1	37
Limestone, light gray, about 20 percent, greenish-gray shale as fine partings. Contains a few coarse-grained purplish gray coquina lens	5.6	35
Coquina, purplish gray, coarse-grained, lenticular Cybelopsis aff. C. speciosa, Lachnostoma latucelsum, Pseudocybele nasuta, Kirkella cf. K. declevita, Hesperonomia sp., Tetragraptus cf. T. taraxacum, Tetragraptus cf. T. dissipiens	0.7	29

Table 2. --Stratigraphic section of the Garden City formation measured at the south end of the Thomas Range fluorite district--Continued.

Description	Bed thickness	Cumulative thickness
Shale, light green and gray, limy	0.3	29
Coquina, dark purplish gray	0.2	28
Shale, light greenish gray, limy; a few coquina lenses	0.6	28
Coquina, dark purplish gray	0.1	28
Limestone, light gray, fine-grained, about 25 percent shale as partings; Cybelopsis aff. C. speciosa, Lachnostoma latucelsum, Pseudocybele nasuta, Kirkella cf. K. declevita, Hesperonomia sp., Tetragraptus cf. T. taraxacum, Tetragraptus cf. T. dissipiens	10.9	28
Limestone, light gray, medium-grained small layers of greenish yellow and pinkish shale, Cybelopsis aff. C. speciosa, Lachnostoma latucelsum, Pseudocybele nasuta, Kirkella cf. K. declevita, Hesperonomia sp., Tetragraptus cf. T. taraxacum, Tetragraptus cf. T. dissipiens	4.2	17
Limestone, irregularly bedded, light gray, fine-grained, containing green shale partings	2.4	12
Limestone, light gray, medium-grained	10.0	10
Lake Bonneville gravels		

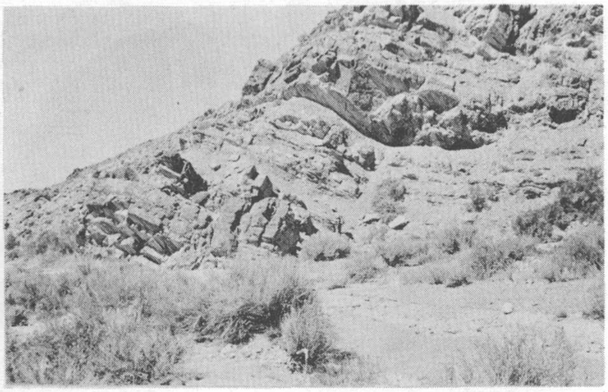

Plate 7A.--Garden City formation at south end of district. Stratigraphic section in table 2 was measured at this point.

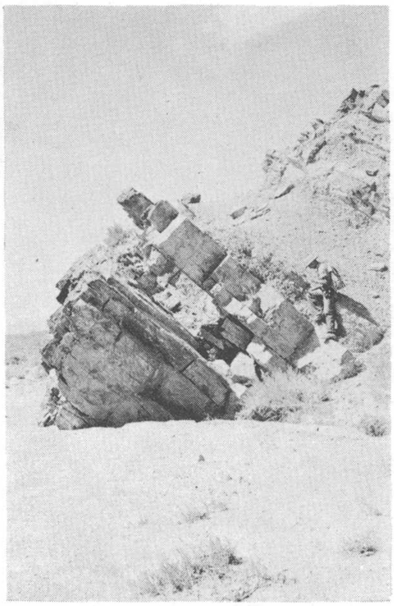

Plate 7B.--Garden City formation at south end of district showing the difference in resistance to weathering between the massive and the lumpy limestone beds. Base of measured stratigraphic section is at bottom of massive outcrop.

Table 3.--Lime and magnesia content of limestones and dolomites from Spors Mountain

Formation	Location	CaO 1/ content (percent)	MgO 1/ contents (percent)	Percent dolomite in carbonate fraction	Rock name 2/	Remarks
Garden City	Southern edge of district	38.13	0.63	4	Limestone	Massive beds
Do.	do.	42.41	0.88	5.2	Magnesian limestone	Lumpy beds
Fish Haven	Near Floride mine	29.81	19.69	95	Dolomite	Lower part of formation
Floride	Mine road northeast of Fluorine Queen mine	30.59	21.11	98	do.	Black-mottled member
Do.	Mine road northeast of the Dell No. 5 mine	33.64	17.01	81	Calcitic dolomite	Slopemaker member
Bell Hill	Near Lost Sheep mine	30.59	21.52	98	Dolomite	
Harrisite	do.	30.69	21.27	98	do.	
Lost Sheep	Near Blowout mine	29.25	19.43	95	do.	Mottled gray part of the gray member
Do.	do.	14.11	9.59	96	do.	Cherty member
Thursday	800 feet northeast of Lost Sheep mine	29.74	20.80	98	do.	
Sevy	Northwest of Spors Mountain	30.29	20.41	96	do.	
Simonson	do.	35.90	16.20	75	Calcitic dolomite	
Guillmette	do.	55.08	0.31	1.4	Limestone	

1/ All CaO and MgO analyses were done by Lucille M. Keho in the Denver Laboratory of the U. S. Geological Survey.

2/ Rock classification is after Pettijohn (1949, p. 313).

Ross states that "the fauna in these collections includes almost the complete faunal assemblage of the "J" zone of the Garden City formation of northeast Utah." This same fauna is listed by L. F. Hintze (1951, p. 17) in the lower part of the Wahwah limestone, one of his subdivisions of the Pogonip formation. He prefers to use the name "Pogonip" because the name antedates "Garden City," and because his measured sections are closer to the type Pogonip locality (Hansen and Bell, 1941, p. 47). The Ordovician limestones in the Spors Mountain district resemble in lithology the Garden City formation of northeastern Utah as described by Ross (1951) more closely than they do the "Pogonip," and because of close faunal similarity, the authors prefer to use the name Garden City formation.

Swan Peak formation

The Swan Peak formation was named by Richardson (1913, p. 409) in the Randolph quadrangle of northeastern Utah and western Wyoming. As shown by Ross (1951, p. 10-23) in the Randolph quadrangle, and Williams (1948, p. 1136) in the Logan quadrangle, the formation consists of three parts: 1) a lower shale interbedded with silty quartzite and limestone beds, 2) a middle reddish-brown quartzite interbedded with shale, and 3) an upper quartzite.

In the Thomas Range the Swan Peak quartzite consists of two prominent parts: 1) the lower of shale interbedded at the top with hematitic quartzite beds which grade downward into a shale interbedded with hematitic sandy dolomite beds, and 2) the upper of massive white quartzite (pl. 8). The upper massive quartzite forms prominent cliffs, and the lower shaly forms gentle slopes. These two members have been mapped separately (pls. 3, 5, and 6).

Shale member

Distribution.--The shale member of the Swan Peak formation conformably overlies the Garden City formation. The shaly part is easily weathered and in most places is covered by slope wash, the best exposures occurring in little steep-sided gullys (pl. 9). The shale member crops out most extensively in several hills at the extreme southern end of the district, but it is also found along the east side of Spors Mountain, chiefly north of the Floride mine and south of the road to the Dell No. 5 mine. The shale member is not as prevalent as the overlying quartzite member because of faulting.

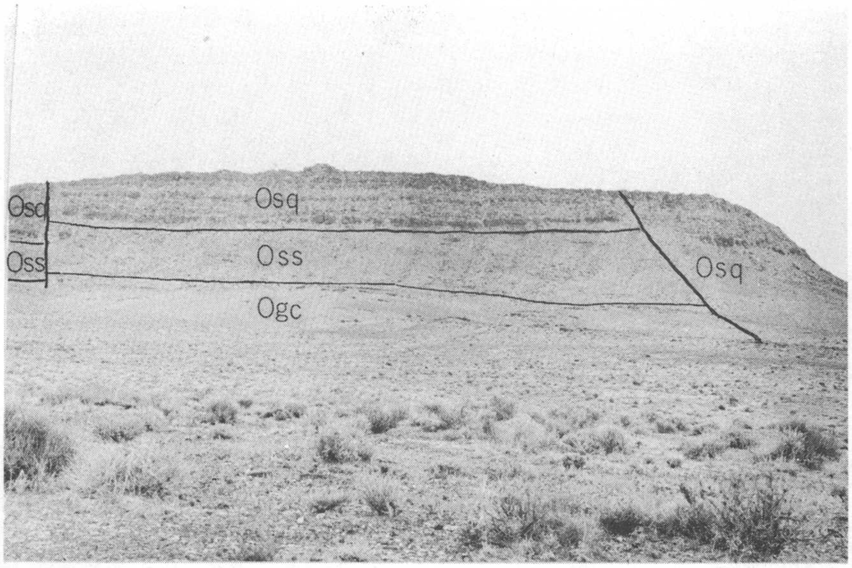

Plate 8.--Swan Peak formation consisting of the shale member (Oss) and a part of the quartzite member (Osq) overlying the Garden City formation (Ogc) at the south end of the district.

Plate 9.--The shale member of the Swan Peak formation in a small gully.

Lithology.--The shale member has not been entirely exposed in any section. The upper 100 feet are best known and a detailed section made a quarter of a mile northeast of the Floride mine is given in table 4. The rock is composed chiefly of dull green shale stained reddish-brown along numerous fractures. The shale contains much fine-grained chert. Most of the shale is calcareous and is interbedded with more resistant beds of quartzite and dolomite, 0.1 to 10 feet thick with the quartzite near the top of the section grading downward through quartzitic dolomite into dolomite. The undersides of some of the quartzite beds show fucoids. The quartzite and dolomite of the shale member are readily distinguished from rocks of similar composition in that they are hematitic red in color.

Thickness and correlation.--The shale member was measured completely in two places: two-thirds of a mile southeast of the Fluorine Queen mine in sec. 35, T. 12 S., R. 12 W. (fig. 2), and in the extreme southern end of the district in sec. 23, T. 13 S., R. 12 W. (fig. 2). At the first locality the shale member is 251 feet thick and at the second locality, approximately 4 miles to the south, it is 388 feet thick. Individual beds also vary in thickness, and the quartzite and dolomite beds cannot be correlated in sections a mile apart.

Two varieties of brachiopods were the only fossils noted; these were scattered throughout both the shale and dolomite from 50 feet below the top of the unit to the bottom. In some small dolomite and shale layers these fossils make up almost the entire layer (pl. 10). Most common is Orthambonites michaelis Clark (previously called Orthis michaelis Clark). The second brachiopod belongs to the genus Anomalorthis; the species is not certain. These fossils were identified by R. J. Ross, Jr., of the Geological Survey.

The shale member is correlated with the lower Swan Peak formation at the type locality both stratigraphically and paleontologically. The Swan Peak in northeastern Utah consists of an upper massive quartzite and a shaly fossiliferous lower part (Ross, 1951, p. 10; Williams, 1948, p. 1136-1137), which is similar to the beds in the Thomas Range. R. J. Ross, Jr. (written communication) in describing the brachiopods from the Thomas Range, states that "these two species are also common in the shaly and silty limestones beneath the quartzitic member of the Swan Peak formation in the Logan quadrangle, Utah."

Table 4.--Stratigraphic section of upper part of shale member of the Swan Peak formation. Locality is approximately one-quarter of a mile northeast of the Floride mine in the SW 1/4 NW 1/4 sec. 2, T. 13 S., R. 12 W.

Description	Bed thickness (feet)	Cumulative thickness (feet)
Quartzite member		
Shaly member		
Shale, fissile, green, stained red along fractures in lower part and interbedded with brick red, hematitic quartzite, in part mottled. Twelve quartzite beds range in thickness from 0.3 to 2.8 feet. Fucoids are found along undersides of quartzite beds at 95 and 107 feet. Some areas are covered.	50.7	117
Shale, fissile, dull green, stained red in part along fractures and interbedded with brick red, hematitic dolomite, which is quartzitic in the upper half. Four dolomite beds range in thickness from 0.1 to 1.6 feet. About three-quarters of the section is covered.	29.2	66
Shale, fissile, dull green, stained red along conchoidal fractures and interbedded with brick red, hematitic, limy, arenaceous dolomite and limestone layers and lenses. Nine dolomite and limestone beds range in thickness from 0.1 to 2.7 feet. Numerous brachiopods with Orthambonites michaelis being found in shale at 35 feet, in dolomite at 10.8, 17.1, 17.6, 31.0, and 37.0 feet, and in limestone at 21.1 and 24.4 feet; Anomalorthis sp. being found in shale at 35 feet, in dolomite at 16.8 and 31.0 feet, and in limestone at 24.4 feet.	36.7	37
Slope wash		

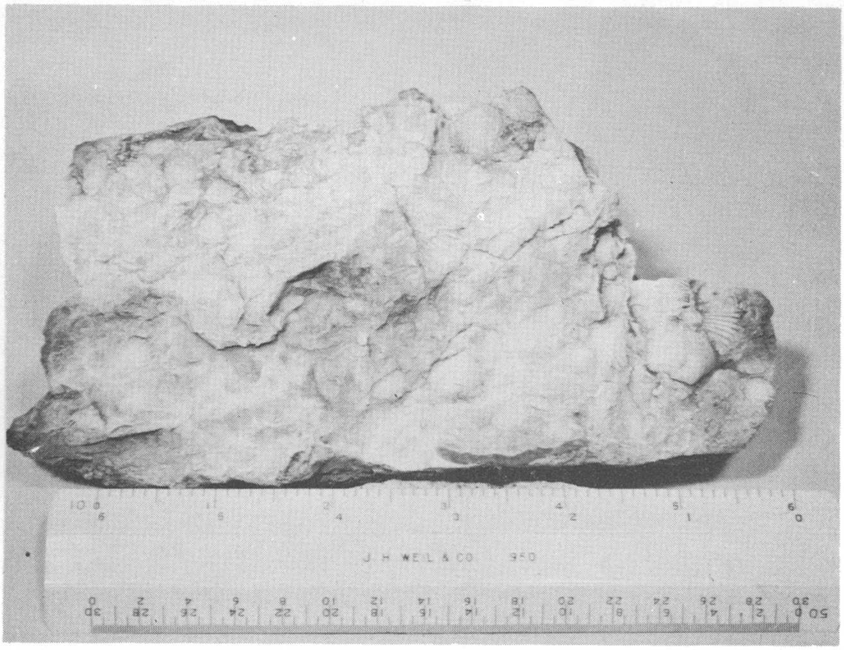

Plate 10.--Fossiliferous dolomite from the shale member of the Swan Peak formation. The brachiopod is <u>Orthambonites michaelis</u>.

He further states that "the lithology of the specimen submitted to me is identical to that of part of the Swan Peak in that area." According to Ulrich and Cooper (1938, p. 101) Orthambonites michaelis Clark (listed as Orthis michaelis Clark) has also been found in the Swan Peak formation in Utah at the following localities: a mile west of Ibex in the Confusion Range, on the west shore of Bear Lake on Swan Creek, and in Wasatch Canyon, 4-1/2 miles north of Brigham.

Orthambonites michaelis Clark and Anomalorthis sp. have been described from the Pogonip group by Hintze (1951, p. 18-19, 57, 62, 64, 68-73, 75-78, 80-81, 83, 85). According to Hintze the faunal zones of the Pogonip group for the most part correspond with those in the Garden City and Swan Peak formations of northeastern Utah. Hintze subdivided the Pogonip into six formations and the two brachiopod species are found only in his Kanosh shale, which is probably equivalent in age to the shale member of the Swan Peak formation.

Quartzite member

Distribution.--The quartzite member of the Swan Peak formation is the most resistant rock to weathering of any formation in the district, and forms prominent reddish-brown cliffs along the eastern side of Spors Mountain. It is also found in fault blocks near the center part of the range, and crops out extensively in several hills at the extreme southern end of the district.

Lithology.--The quartzite member is a remarkably uniform rock that is generally white, though in some places pinkish where fresh, and reddish-brown to black where weathered. Black coloring is most common along fractures and appears to be a manganese oxide staining. The greater part of the quartzite is fine-grained and consists chiefly of clear interlocking sub-rounded quartz grains. Amethyst, orthoclase, and rounded biotite books are present in minor amounts. The chief heavy minerals are well-rounded and pitted olive green tourmaline and well-rounded clear zircons. Most of the beds are well-cemented, but locally some beds are friable. Cross-bedding was noted throughout the section. Individual beds in this formation range from 1 to 10 feet thick but generally ranged between 2 to 4 feet thick.

Thickness and correlation.--The quartzite member is apparently conformable with the overlying Fish Haven dolomite. It is, however, bounded by faults either on its upper or lower side throughout most of the district. The only area in which both contacts are exposed is along the eastern side of Spors Mountain between the Floride and Fluorine Queen mines. A section measured approximately 800 feet northeast of the Floride mine showed the quartzite to be 592 feet thick at this point.

No fossils were found in the quartzite. The same quartzite overlain by the identical sequence of dolomites occurs in the northern part of the Fish Springs Range, 12 miles to the west. In the Gold Hill mining district (Nolan, 1935, p. 16), 28 miles northwest of the Fish Springs Range, an unconformity separates the Lower Ordovician from the Upper Ordovician Fish Haven dolomite. No Middle Ordovician is found in the Tintic area (Lovering, T. S., oral communication). The quartzite in the Thomas Range is correlated with the upper part of the Swan Peak formation, on the basis of its stratigraphy and its position between the lower fossiliferous part of the Swan Peak formation and the Fish Haven dolomite.

Fish Haven dolomite

Name and distribution.--The Fish Haven dolomite was named by Richardson (1913, p. 409-410) for its occurrence in the Randolph quandrangle in northern Utah and western Wyoming, where it was described as a fine-grained medium-bedded dark gray to blue-black cherty dolomite containing a Richmond fauna, and immediately overlying the Swan Peak formation. Rocks of similar lithology and age are described as Fish Haven dolomite in the Gold Hill mining district by Nolan (1935, p. 16-17). In the western part of the Thomas Range here described, rocks of similar lithology, lying on top of the Swan Peak formation and containing Upper Ordovician fossils, are correlated with the Fish Haven.

The Fish Haven dolomite crops out chiefly along the east side of the southern half of Spors Mountain. Other good sections are found on the northwest side of the canyon that trends southwest from the Fluorine Queen property (pl. 11, A), and along the northwest side of the canyon that trends southwest from the Dell No. 5 property. In general this formation weathers easily and commonly forms smooth debris-covered slopes.

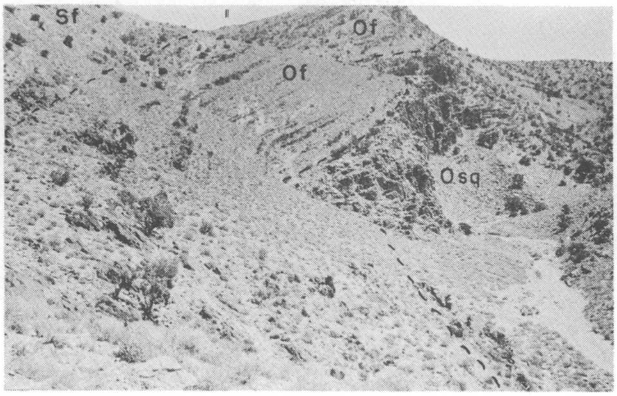

Plate 11A.--Fish Haven dolomite (Of) between the Floride dolomite (Sf) and the quartzite member of the Swan Peak formation (Osq). View looking up northwest side of canyon, which trends southwest from the Fluorine Queen mine.

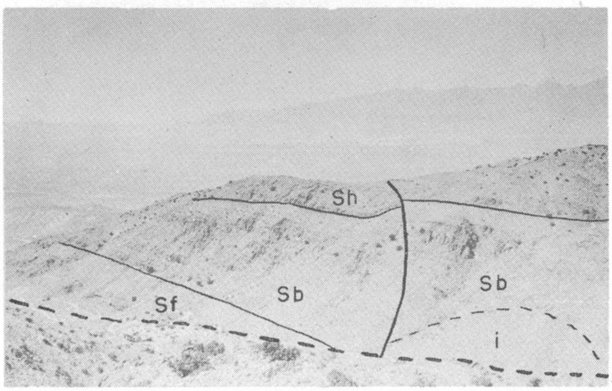

Plate 11B.--Bell Hill dolomite (Sb) cropping out between the overlying Harrisite dolomite (Sh) and the underlying Floride dolomite (Sf). Intrusive breccia (i) pipe in right foreground.

Lithology.--The Fish Haven dolomite is in general a light-gray to black fine-grained dolomite with chert in some parts (fig. 3). The lower 30 to 50 feet is banded, contains small amounts of quartz sand in some layers, and as much as 10 percent chert, chiefly along fractures. Commonly a thin (2 foot) quartzite bed is found about 20 feet from the base of the section. Above this lower part the dolomite lacks visible quartz sand and contains little chert. About two-fifths of the way up in the formation, a light-gray fine-grained calcitic dolomite containing numerous small holes as much as 1 mm in diameter that are commonly filled with white calcite, forms a distinctive marker bed approximately 30 feet thick. A light-to dark-gray banded smooth-weathering calcitic dolomite overlies this unit in the middle and northern parts of the district. In the southern part, however, the rock is chiefly limestone. (See section 2, figure 3.)

The Fish Haven formation is distinctive because it is the only carbonate rock containing visible quartz sand and is the only formation above the Ordovician Garden City and below the Middle Devonian Simonson-Guillmette formations that contains any limestone.

Although the upper part of this unit consists of calcitic dolomites and limestones, the lower part is dolomite. A sample collected from the lower part in the vicinity of the Floride mine was analyzed (table 3) and was found to contain 29.81 CaO. The MgO content of this sample compares favorably with the 21.35 percent MgO found in a sample from near the type section on Fish Haven Creek (Richardson, 1913, p. 410).

Thickness and correlation.--The Fish Haven dolomite was measured in two places: half a mile north of the Floride mine in the NE 1/4 NE 1/4 sec. 3, T. 13 S., R. 12 W., and 1,700 feet northeast of the Dell No. 5 mine in sec. 27, T. 12 S., R. 12 W. The thickness in the two sections (fig. 3) is 212 feet and 180 feet respectively.

The only fossils found came from the limestone in the upper part of the formation in the southern part of Spors Mountain. The following fossils, found only in Upper Ordovician rocks, were identified by Helen Duncan and Jean Berdan of the Geological Survey:

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REPORT 252

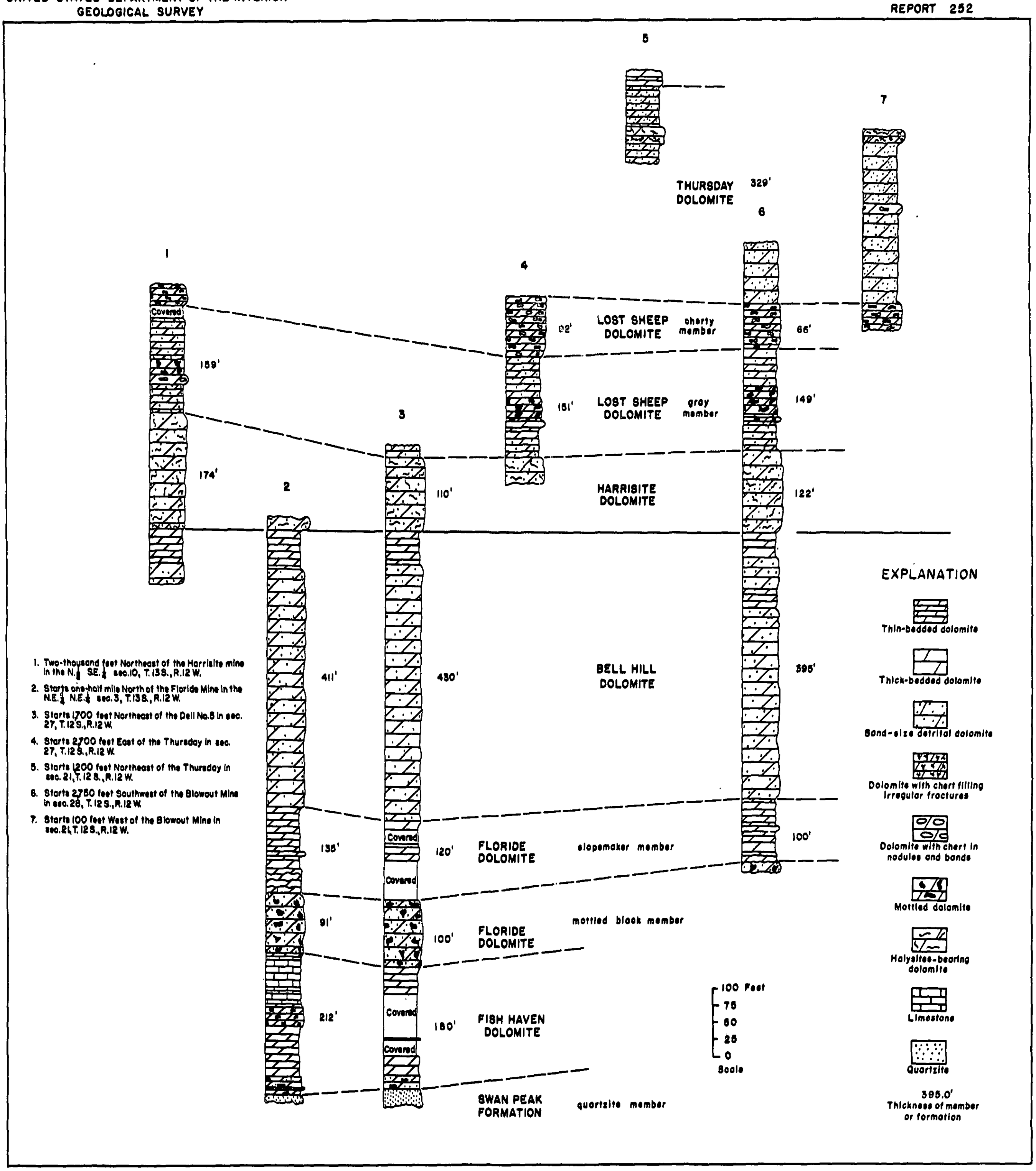

FIGURE 3. GENERALIZED DIAGRAMMATIC STRATIGRAPHIC SECTIONS OF THE FISH HAVEN, FLORIDE, BELL HILL, HARRISITE, LOST SHEEP, AND THURSDAY DOLOMITES.

Catazyga ? sp.

Hesperorthis sp.

Fardenia sp.

Favosites sp.

Horn coral, undetermined

Bryozoans, undetermined

High-spired gastropod, undetermined

Stromatoporoids

The lithology of the Upper Ordovician dolomite exposed in the Thomas Range was examined by R. J. Ross, Jr., who states (oral communication) that it is almost identical with the lithology of the type Fish Haven dolomite. This dolomite, on the basis of its Late Ordovician age, its stratigraphic position above the Swan Peak formation, and the similarity between the two lithologies, is correlated with the Fish Haven dolomite.

Silurian sedimentary rocks

Dolomites of Middle Silurian age crop out over most of the western part of the Thomas Range. In order to show the structure in the range the Middle Silurian rocks were divided into five new formations. These are the Floride dolomite, the Bell Hill dolomite, the Harrisite dolomite, the Lost Sheep dolomite, and the Thursday dolomite (fig. 3), in order of decreasing age. The new formations were also recognized by the authors in the northern part of the Fish Springs Range, 15 miles northwest of the northern end of Spors Mountain. The lithologic change between these formations is as striking as the contrast between the Fish Haven formation of Ordovician age and the Middle Silurian formation which overlies it.

Fossil collections from these formations were examined by Helen Duncan and Jean Berdan, who state that all appear to be Middle Silurian in age. Indications, however, point to two intergrading faunas. The lower formations (Floride and Bell Hill) contain a reef with Circophyllum, two kinds of Halysites with small corallites, Heliolites, many horn corals, and pentameroid brachiopods. The uppermost formation (Thursday) contains a reef in which stromatoporoids appear to be much more abundant than in the lower formations. This fauna also contains the coral Zelophyllum in fair abundance and a form of Halysites characterized by larger corallites than the two species common in the lower reef. In addition, many of the species found in the earlier reef also appear to persist into the later reef.

Fossils collected from the five Silurian dolomites such as *Favosites* sp., *Halysites* sp., *Heliolites* sp., *Virgiana* sp., are similar to those found in the Laketown dolomite in the Logan quadrangle of northeastern Utah (Williams, 1948, p. 1138), the Randolph quadrangle of northern Utah and western Wyoming (Richardson, 1913, p. 410), and the Gold Hill mining district in western Utah (Nolan, 1935, p. 18). Some of the fauna, however, contains elements not observed in the type Laketown. The Silurian rocks of the Thomas Range are probably correlative, at least in part, with the Laketown dolomite of northeastern Utah; however, too little is known about the exact age of the type Laketown to correlate the Silurian formations in the Thomas Range with all of it.

Floride dolomite

Name and distribution.--The Floride dolomite, named for its occurrence at the Floride mine, crops out chiefly along the east side of Spors Mountain in the southern half of the range. In addition prominent outcrops occur along the lower northwest sides of three canyons which trend southwest from the Fluorine Queen, Dell No. 5, and Blowout mines, respectively. Although the section is complete at the Floride mine, the type section (section 2, fig. 3) was measured on a steep hillside, starting half a mile north of the Floride, because of better exposures. Other good sections are located on the northwest side of a steep canyon 1,400 feet southwest of the west pipe of the Fluorine Queen, and on a mountain 1,700 feet northeast of the Dell No. 5.

Lithology.--The Floride dolomite is made up of two units which can be easily recognized in the field and which are shown separately on the detailed regional maps (pls. 5 and 6). The lower two-fifths is called the black mottled member and the upper three-fifths, the slopemaker member.

The black mottled member is a resistant unit, which forms a prominent black band along the mountain sides. This rock is a dark gray to black medium-grained locally cross-bedded detrital dolomite with sand-size grains. The most distinctive feature is a dark mottling, which is most pronounced in the lower half. Small cavities are common and near the base of this member are commonly lined with white dolomite. A sample of this rock (table 3) was analyzed and found to contain 98 percent dolomite in its carbonate fraction.

The slopemaker member separates two resistant dolomites and is covered by slope wash in most places. Several distinct units are found but all are fine-grained, light to medium gray, and smooth weathering. The lower 39 feet consists of thin undulating beds, which weather with an irregular bumpy surface. This dolomite is pinkish in a few places and is commonly stained red by iron oxide along bedding-plane surfaces and fractures. The next 20 feet is light gray limy dolomite, followed by 8 feet of medium gray dolomite containing numerous small cavities as much as 1 mm in diameter. The uppermost unit is a light to medium gray banded dolomite showing a faint mottling in a few places. In general chert is rare in this member, though locally 1 to 2-inch bands of chert parallel the bedding in the upper part. A sample of the limy dolomite (table 3) with numerous small cavities was analyzed and found to contain 81 percent dolomite in its carbonate fraction. According to Pettijohn (1949, p. 313) this rock would be classified as a calcitic dolomite.

Thickness and correlation.--The thickness of the entire Floride formation was measured in two places: at the type section half a mile north of the Floride Mine in the NE 1/4 NE 1/4 sec. 3, T. 13 S., R. 12 W., and 1,700 feet northeast of the Dell No. 5 mine in sec. 27, T. 12 S., R. 12 W. In addition, the slopemaker member was also measured 2,750 feet southwest of the Blowout mine in sec. 28, T. 12 S., R. 12 W. The thickness of the black mottled member ranges from 91 to 100 feet, and the slopemaker member from 100 to 135 feet (fig. 3).

The black mottled member contains numerous crinoid stems and a few horn corals including *Circophyllum* ? sp. identified by Helen Duncan and Jean Berdan. The slopemaker member yielded only a few unidentified horn corals from the upper part. Although the Floride formation is not very fossiliferous, the few specimens found are similar to those of the overlying Bell Hill formation, and it is, therefore, regarded as of probable Middle Silurian age.

Bell Hill dolomite

Name and distribution.--The Bell Hill dolomite, named from the Bell Hill mine on the southern end of Spors Mountain, is the thickest Silurian formation in the district. Although named after the Bell Hill mine, numerous faults and poor exposures make this one of the poorer places to study the formation, therefore, section 2 (fig. 3), on a steep mountain side half a mile north of the Floride mine is designated the type section. Other good sections are found on the north side of the canyon southwest of the Fluorine Queen property and on the north side of the canyon southwest of the Blowout property (sec. 6, fig. 3). Fault blocks containing the Bell Hill dolomite are scattered throughout Spors Mountain with the exception of its northern tip.

The Bell Hill dolomite is a resistant formation and forms steep hills with prominent outcrops (pl. 11, B), especially in the central and southern parts of the range.

Lithology.--The Bell Hill dolomite is made up of two members: the lower eight-ninths is a dark-gray coarse-grained clastic dolomite, and the upper one-ninth is a light-gray fine-grained dolomite. The cliff-forming lower part is most commonly dark gray but in some places varies to light gray along strike, with color variations possibly being related to the intensity of dolomitization. This massive rock is characterized by detrital sand-size grains of dolomite, local cross-bedding, common banding, and few distinctive layers. However, in the northern part of Spors Mountain, a 28-foot thick dolomite bed with a highly distinctive contorted, convoluted appearance (thinly laminated "curly" beds [pl. 12, A]) occurs approximately 40 feet from the top of the unit. The upper part is commonly covered but, where exposed, is a thin-bedded light-gray banded dolomite. Unlike the sandy lower part, this fine-grained upper part is a smooth weathering rock, that in places is somewhat limy. This rock is the marker bed between the lower dark-gray sandy part of the Bell Hill dolomite and the overlying dark-gray sandy Harrisite dolomite.

A sample from the lower part of the Bell Hill dolomite (table 3) was analyzed and found to contain 98 percent dolomite in the carbonate fraction.

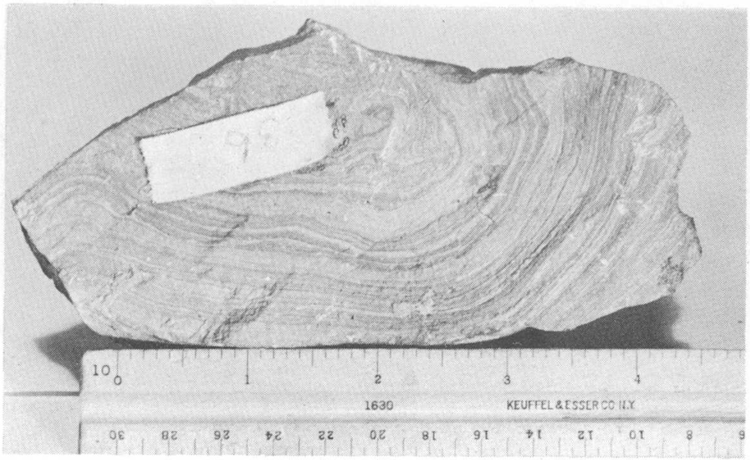

Plate 12A.--Thinly laminated "curly" beds from upper part of the Bell Hill dolomite.

Plate 12B.--Horn corals from prominent fossil-bearing bed, 4 to 10 feet above the base of the Bell Hill dolomite.

Thickness and correlation.--The Bell Hill dolomite was measured in three places: half a mile north of the Floride mine in the NE 1/4 sec. 3, T. 13 S., R. 12 W., 1,000 feet northeast of the Dell No. 5 mine, in sec. 27, T. 12 S., R. 12 W., and 2,000 feet southwest of the Thursday mine in sec. 28, T. 12 S., R. 12 W. The measured thickness of the entire formation ranged from 395 to 430 feet (fig. 3), with the upper member making up from 34 to 53 feet of this formation.

Fossils are common in the lower 200 feet of the lower member but are scarce in the upper part; none were noted in the upper member. The most prominent fossil-bearing bed is a detrital dolomite with thin shale lenses, 4 to 10 feet above the base of the formation (pl. 12, B).

Horn corals make up better than 85 percent of the fossiliferous material in this bed. The following fossils were identified from this bed by Helen Duncan and Jean Berdan:

Circophyllum sp.	Heliolites sp.
Entelophyllum ? sp.	Cephalopod, undetermined
Favosites sp. (small corallites)	Stromatoporoids
Halysites (Catenipora ?) sp.	Crinoid columnals
Halysites (Cystihalysites) sp.	Branching favositid corals
Pycnactis ? sp. and other horn corals	Fragments of pentameroid brachiopods

Two of the best fossil localities in this horizon were found on the Bell Hill property. The first locality is a prominent ledge 190 feet S. 30° W. of the southwest end of the largest ore body, and the second locality is on the top of a hill, 450 feet S. 66° W. of the largest ore body.

Above this bed the fossils scattered through the rock consist chiefly of Favosites sp., horn corals, and crinoid columnals. The following fossils were identified:

Favosites sp. A (small corallites)	Virgiana cf. V. decussata
Favosites sp. B (large corallites)	Platyceratid gastropod

Crinoid columnals

One good fossil locality was found on the Bell Hill property on the top of a small knoll between the two largest ore bodies; several others were found on the Fluorine Queen property: 1) a few feet southwest of the west pipe, 2) 40 feet northwest of the same pipe, and 3) 50 feet east of the east pipe.

The age of the Bell Hill dolomite is Middle Silurian. Some of the fossils are similar to those described in the Laketown dolomite in the Randolph quadrangle (Richardson, 1941, p. 18), the Logan quadrangle (Williams 1948, p. 1138), and the Gold Hill mining district (Nolan, 1935, p. 18) and to the Hidden Valley dolomite in the Quartz Spring area, California (McAllister, 1952, p. 15-18).

Harrisite dolomite

Name and distribution.--The Harrisite dolomite is named for exposures that cap the hill just east of the Harrisite mine. The section here is not complete however, and the type section is designated as the steep west side of a canyon 2,000 feet northeast of the Harrisite mine (section 1, fig. 3, and pl. 13). Other good sections are found on the northwest side of a canyon 3,000 feet southwest of the Blowout mine and on the northwest side of a canyon 4,000 feet south-southwest of the Oversight mine. Fault blocks containing the Harrisite dolomite are scattered throughout Spors Mountain. The Harrisite dolomite is a relatively resistant formation and, with the Bell Hill dolomite, forms many steep mountain sides and caps numerous ridges (pl. 13).

A sample from the Harrisite dolomite (table 3) taken near the Lost Sheep mine was analyzed and found to contain 98 percent dolomite in its carbonate fraction.

Lithology.--The Harrisite dolomite is a massive dark gray to black locally banded dolomite, containing as much as 20 percent black chert, chiefly as blebs and discontinuous layers along the bedding. The lower 10 feet of this formation has a mottled appearance and is commonly limy. The Harrisite closely resembles the Bell Hill dolomite in lithology but does not show any variance in color along the strike. The most distinguishing characteristic of the Harrisite dolomite is faint white squiggly lines (pl. 14, A), most commonly preserved in white calcite, which are the remains of *Halysites* (chain corals).

Thickness and correlation.--The Harrisite dolomite shows considerable variation in thickness. It was measured in three places: 1) at the type section in sec. 10, T. 13 S., R. 12 W., 2,000 feet northeast of the Harrisite mine; 2) 1,000 feet northeast of the Dell No. 5 mine in sec. 27, T. 12 S., R. 12 W.; and 3) 2,750 feet southwest of the Blowout mine in sec. 28, T. 12 S., R. 12 W. The thickness of the Harrisite dolomite ranged from 110 to 174 feet (fig. 3).

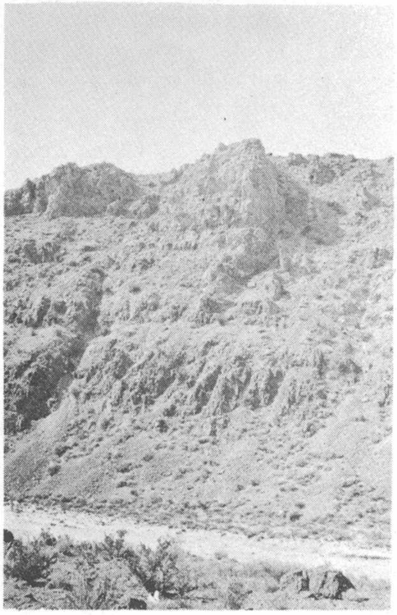

Plate 13.--Harrisite dolomite cropping out along a canyon in the southern part of Spors Mountain. This is the type section.

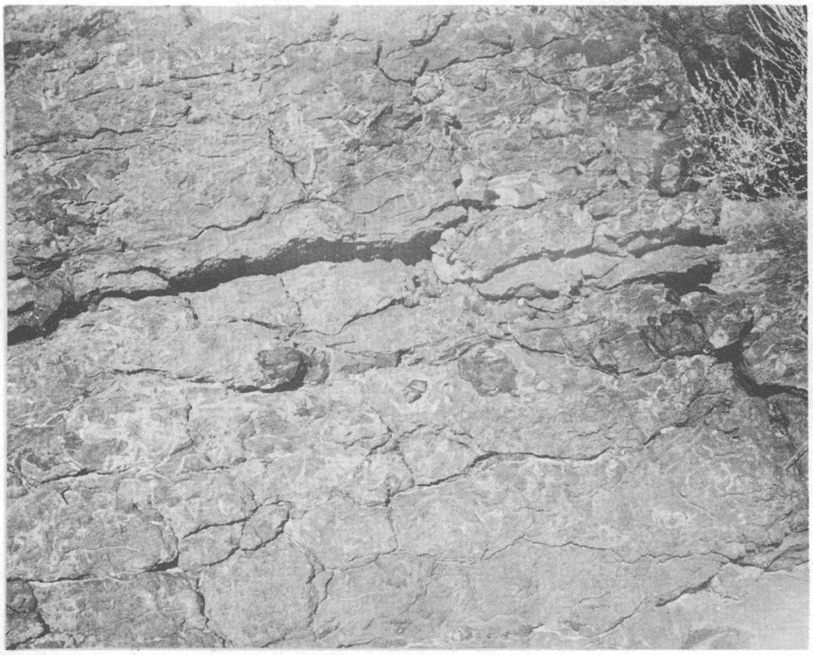

Plate 14A.--Harrisite dolomite containing numerous partly dolomitized *Halysites*.

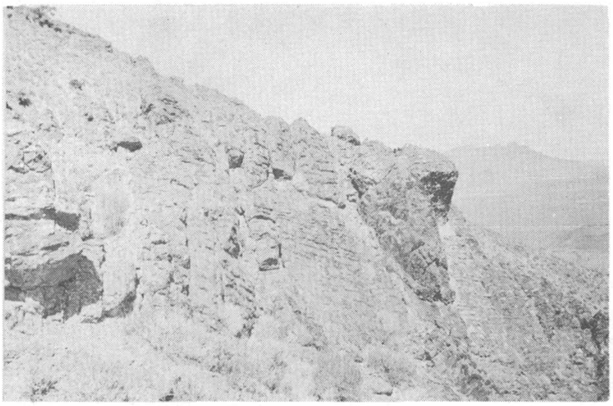

Plate 14B.--Cherty member of the Lost Sheep dolomite. Note parallel bands of chert.

Halysites and crinoid stems are common throughout the formation but are generally too poorly preserved to identify. Dolomitization has destroyed the distinguishing characteristics of most of the fossils. The best preserved ones are commonly silicified. One of the best exposures of the Halysites-bearing Harrisite dolomite is seen on the hill just east of the workings of the Harrisite mine (pl. 5). The following fossils collected from this hill were identified by P. E. Cloud, Jr., of the Geological Survey.

Halysites sp.	Gastropod, undetermined
Pentamerid brachiopod	Crinoid stem

According to Mr. Cloud the pentamerid brachiopod along with the Halysites sp. indicates that this rock is of Silurian age, even without knowledge of its stratigraphic position between the Bell Hill and Lost Sheep dolomites.

Lost Sheep dolomite

Name and distribution.--The Lost Sheep dolomite, named for its occurrence at the Lost Sheep mine, is widely distributed on the western side of Spors Mountain. The type section is in the same outcrop strip as that surrounding the Lost Sheep mine but was measured on the northwest side of a steep canyon 2,000 feet southwest of the neighboring Blowout mine (section 6, fig. 3). Other good sections are found 1,550 feet and 4,000 feet southwest of the Oversight mine. In addition to the main Lost Sheep ore body, the Blowout, Oversight, and Lucky Louie ore bodies are found in this formation.

Lithology.--The Lost Sheep dolomite is made up of two members, mapped separately on the detailed regional maps (pls. 5 and 6). The lower two-thirds is called the gray member and the upper third, the cherty member. The gray member is made up of three light-to medium-gray units and one thin black bed. The lower unit, which averaged 43 feet thick, consists of light-gray coarse detrital dolomite, whose upper part is somewhat darker and more limy near the center of Spors Mountain. Chert is found only in a few places as thin fracture fillings. On top of this unit is a thin 6- to 13- foot bed of fine-grained black to dark gray banded dolomite, containing 20 to 50 percent gray to black chert in discontinuous 1- to 5-inch bands, which parallels the bedding. This unit forms a prominent marker bed, being somewhat more resistant than the surrounding dolomite. The next unit, which averaged 32 feet thick, is medium gray mottled dolomite, whose subtle gray mottling is one of the best guides in recognizing this member. Chert is common only in insoluble residues, where it occurs as white dolocasts with little clear quartz. A sample of this rock (table 3) taken near the Blowout mine was analyzed and was found to contain 95 percent dolomite in the carbonate fraction.

The uppermost unit of the gray member, which averaged 67 feet thick, is a light-gray medium- to coarse-grained detrital dolomite. It closely resembles the lowest unit of the gray member; the chief difference is that the grain size is a little smaller in the upper unit in some places.

The cherty member of the Lost Sheep dolomite is a medium-grained locally faintly mottled gray dolomite, which is considerably darker than the underlying light gray unit of the gray member and which crops out as prominent ledges, forming an excellent marker bed. The most distinctive feature is pink to gray chert in bands 1 to 6 inches wide parallel to the bedding (pl. 14, B). The chert content is variable, commonly making up 15 to 60 percent of the rock, though in the southern part of Spors Mountain the central 10 to 20 feet of this member contains no chert, and in a few places in the northwestern part of the range small sections are made up of as much as 95 percent chert. These small high-chert areas appear to be related to fractures, suggesting that some of the chert may be of later origin. In the northern part of the mountain the chert is white to pink, and this unit was called the "pink chert unit" by Bauer (1952, p. 12), though in other parts the chert is light gray. A sample of dolomite from near the Blowout mine was analyzed and found to contain 96 percent dolomite in the carbonate fraction.

Thickness and correlation.--The thickness of the entire Lost Sheep dolomite was measured in two places: at the type section 2,000 feet southwest of the Blowout mine in sec. 28, T. 12 S., R. 12 W., and 2,700 feet east of the Thursday mine in sec. 27, T. 12 S., R. 12 W. In addition the lower gray member was also measured 2,000 feet northeast of the Harrisite mine in N 1/2 SE 1/4 sec. 10, T. 12 S., R. 12 W. The gray member ranges from 149 to 159 feet thick, and the cherty member from 66 to 92 feet (fig. 3), averaging about 70 feet.

The thin black cherty dolomite unit is the chief fossil-bearer in the gray member, though a few fossils have been found in the gray mottled unit. The gray member contained crinoid columnals, unidentified horn corals, Halysites sp., fragments of a smooth pentamerid brachiopod, fragments of a ribbed brachiopod, and an undetermined gastropod. Though fossil debris is abundant, it is difficult to collect identifiable material.

Fossils are exceedingly rare in the cherty member, but Halysites (Cystihalysites) sp. was identified by Helen Duncan and Jean Berdan. This coral, in conjunction with the pentamerid brachiopods, identifies this formation as of Silurian age, a conclusion which is verified by its position in the section between the more complete Silurian fossil collections in the lower Bell Hill and the upper Thursday dolomites.

Thursday dolomite

Name and distribution.--The Thursday dolomite, named for outcrops at the Thursday mine, is best exposed in the northern half of Spors Mountain, where it caps a series of long northeast-trending ridges. Smaller areas are found in fault blocks scattered throughout the rest of the range, though they are commonest in the western half. Complete sections of the Thursday dolomite are rare; the formation is either cut off by faults, or covered by Lake Bonneville sediments in most of this district. The only known complete section crops out on the west side of Spors Mountain, 4,200 feet west-southwest of the Thursday mine.

Lithology.--The Thursday dolomite is a light-gray medium-grained friable rock, which is in general a slopemaker. A medium-grained gray dolomite bed approximately 15 feet thick with 1- to 4-inch bands of pink chert parallel to the bedding occurs about 135 feet from the base of the formation in the northern part of Spors Mountain. The lithology of this band is identical with the underlying cherty member of the Lost Sheep dolomite. In the northern part of the district a net work of thin brown chert is found in several beds of dolomite approximately 340 feet above the bottom of the formation. This silicified part of the Thursday is quite resistant and was mapped as a separate unit by Bauer (1952, p. 12). More recent mapping has shown, however, that the chert is secondary and the chert-bearing beds are not regional in scope.

Insoluble residues of the dolomite show that it contains minor amounts of clear quartz grains as well as small amounts of white chert.

A sample of the light-gray medium-grained dolomite (table 3) from the lower part of this formation was analyzed; the carbonate fraction contained 98 percent dolomite.

Thickness and correlation.--The lower part of this formation, from the base to the thin network chert bed was measured 100 feet west of the Blowout mine in sec. 21, T. 12 S., R. 12 W. (section 7, fig. 3), and the thickness from the bottom of this bed to the overlying Sevy dolomite was measured 1,400 feet southeast of the lower part of the section (section 5, fig. 3). The composite thickness thus obtained is 329 feet. The lower light-gray dolomite is unfossiliferous; the only fossils found were preserved in chert in the upper part of the formation. A collection made on the east side of the extreme northern end of Spors Mountain was identified by Helen Duncan and Jean Berdan, and contained the following fossils:

Zelophyllum aff. Z. intermedium	Favosites ? sp. (small corallites)
Halysites sp. (large corallites)	Alveolites sp.

Stromatoporoids

These fossils suggest a middle Silurian age for the formation.

Devonian Sedimentary rocks

Sevy dolomite

Name and distribution.--The Sevy dolomite was named by Nolan (1935, p. 18) from outcrops in Sevy Canyon in the Deep Creek Range, Utah. Donovan (1951, p. 50) and Campbell (1951, p. 21-22) have applied the name to Devonian rocks in the Confusion Range in western Utah.

The Sevy dolomite crops out extensively west and northwest of the main ridge of Spors Mountain. It also forms many isolated ridges and hills whose angular ledges project above the flat surface of the Lake Bonneville sediments (pl. 15, A). A few smaller blocks of Sevy dolomite are found within the main mass of Spors Mountain, particularly east of the Blowout mine, and on the southern end of Eagle Rock ridge.

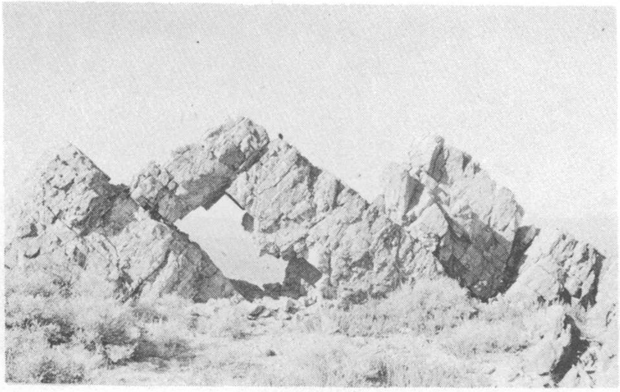

Plate 15A.--Sevy dolomite forming small natural arch on west side of Spors Mountain.

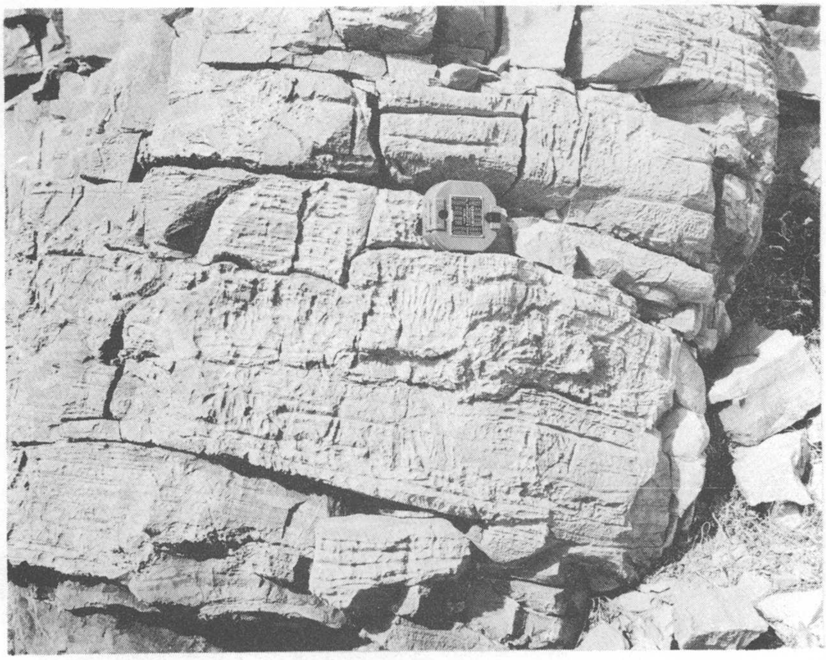

Plate 15B.--Sevy dolomite showing characteristic grooving along and across laminations.

Lithology.--The Sevy dolomite is a fine-grained massive mouse-gray dolomite of uniform and distinctive character. The color is even for the most part, though a few beds in the lower part are a little darker or lighter gray and a few show vague mottling. Toward the top of the formation some of the dolomite layers are blue-gray. The composition is not uniform, as weathered surfaces are rough with numerous sharp projections and trenches. Exposed surfaces are characteristically grooved with numerous curving and crisscrossing channels one-thirty second of an inch to three-sixteenths of an inch deep, probably formed by differential solution (pl. 15, B). The formation is thin- to medium-bedded. Some of the beds contain a few scattered orange, white, or colorless euhedra and subhedra of dolomite, most of which are less than three-sixteenths of an inch in size. Toward the base of the formation a little dark-colored irregular chert fills joints and fracture planes.

In some places the Sevy dolomite has a gradational contact with the underlying Thursday dolomite, but in others the contact is sharp. Near the contact in the northern part of Spors Mountain, beds of typical mouse-gray dolomite are interlayered with beds of white detrital dolomite in which thin chert bands fill a network of fractures. In measuring the stratigraphic section (table 4), the base of the Sevy dolomite was arbitrarily placed at the top of the uppermost white sandy dolomite layer. Near the south end of Spors Mountain the contact is abrupt, and no interlayering is evident. The upper contact with the undivided Simonson-Guilmette formation, is similarly gradational; the top of the Sevy dolomite was placed at the base of a 10-foot bed of white massive dolomite, which underlies a 3-foot bed of black massive dolomite. These two thin beds are quite persistent and constitute a prominent sedimentary marker, even though some beds of Sevy-type lithology are present above them. Nolan (1935, p. 19) found a similar break above the Sevy dolomite in the Gold Hill district.

A sample of the Sevy dolomite (table 3) collected northwest of Spors Mountain was analyzed; dolomite made up 96 percent of the carbonate fraction.

In thin section the rock is very fine-grained and the epiclastic fraction is well-sorted; most of the slide consists of a mixture of clay and clay-sized dolomite grains. Scattered through the fine-grained matrix are numerous irregular-shaped aggregates of clear dolomite anhedra less than 1 mm long. The matrix also contains scattered clots of fine-grained clay and carbonate, all of which contain limonite. The limonite either forms a well-defined ring inside the clot but parallel to its outline, or it is spread throughout the clot with the highest concentration at the center.

Thirty grams of powdered Sevy dolomite yielded 0.4 grams of acid insoluble material, neglecting the clay fraction which was not saved. Of the residue 50 percent was sugary white chert occurring as dolocasts and 50 percent was clear quartz; a trace of pyrite also was noted.

Thickness and correlation.--The thickness of the Sevy dolomite was measured across the formation beginning at a point 5,540 feet N. 78° W. from the Oversight mine. Total thickness at this point is 1,122 feet (table 5). At the type locality (Nolan, 1935, p. 18) the Sevy consists of 450 feet of homogeneous, mouse-gray, well-bedded dolomite. Campbell's composite section (1951, p. 21) shows 2,560 feet of Sevy (?) dolomite in the Confusion Range.

The formation is unfossiliferous in the Spors Mountain district. It has been assigned to the Devonian because it underlies the Middle Devonian Simonson-Guillmette sequence, and because of its lithologic similarity to the type Sevy dolomite at Gold Hill, Utah.

Simonson and Guillmette formations, undivided

Name and distribution.--Two Middle Devonian formations overlying the Sevy dolomite, in the Gold Hill mining district, have been described by Nolan (1935, p. 18-21). The older is the Simonson formation, a dark crystalline laminated dolomite with interlayers of light-gray dolomite resembling the Sevy dolomite; the younger is the Guillmette formation, which includes both dark- to medium-gray dolomites and brownish- to bluish-gray limestones. In Gold Hill, Nolan placed the base of the Guillmette at the bottom of a persistent limestone conglomerate. In Spors Mountain, however, no such marker bed could be found, and for this reason, though rocks resembling both the Simonson and Guillmette formations are present, the authors have not attempted to separate the two.

Table 5.--Stratigraphic section of the Sevy dolomite, measuring started at a point 5,540 feet N. 78° W. of the Oversight mine.

Description	Bed thickness (feet)	Cumulative thickness (feet)
Dolomite, black, fine-grained	2.8	13
Dolomite, massive, white, marked by a fine-textured, brecciated chert network at the base	10.3	10
Top of Sevy dolomite		
Covered interval, with small projecting ledges of dolomite, light medium-gray, fine-grained	122.4	1122
Dolomite, light-gray to tan, black chert lenses along bedding	11.3	1000
Covered, with small projecting ledges of dolomite, medium-gray, fine-grained	91.0	989
Dolomite, medium-gray to light-gray to bluish-gray, fine-grained, with large covered intervals	123.4	898
Dolomite, light-gray, fine-grained, with small beds of light bluish-gray in lower one-third, and with large covered intervals	485.3	774
Dolomite, light- to medium-gray, fine-grained, in part covered	69.1	289
Covered interval, with 1.3' bed of dolomite, gray to buff, medium-grained, slabby to blocky at base	219.9	220
Top of Thursday dolomite		
Dolomite, weathers with a characteristic reticulate surface, buff to brown, blocky, thick-bedded, numerous chert veinlets along fractures and bedding planes; chert stains black		

Lithology.--The base of the Simonson-Guillmette is placed at the base of a persistent black dolomite layer 10 to 25 feet thick, in many places directly overlain by a white massive dolomite bed about 10 feet thick (table 5). These beds represent a distinct lithologic break from the monotonous mouse-gray Sevy dolomites.

The lower 188 feet of the sequence is a series of medium gray to black dolomites and calcitic dolomites with thin dolomitic limestones and limestones. A few of the beds are medium-brown to dark-brown on weathered surfaces. Near the base of the formation several dolomite beds exhibit the jagged surface and weathering channels characteristic of the Sevy dolomite. The color of these beds is not, however, the typical mouse-gray of the Sevy dolomite but is olive-drab. All of the rocks of the Simonson-Guillmette consist of sand-size clastic grains of calcite and dolomite.

Specimens of both the Simonson and Guillmette lithologies (table 3) were collected northwest of Spors Mountain and analyzed. The dolomite (Simonson-type lithology) contained 75 percent dolomite in the carbonate fraction, and the limestone (Guillmette-type lithology) contained 1.4 percent dolomite in the carbonate fraction.

Samples of the Simonson and Guillmette rock types were dissolved in acid, and clay fractions were decanted. The Simonson dolomite insoluble residue was made up of a small amount of clear quartz. The Guillmette limestone yielded no insoluble residue.

Thickness and correlation.--The Simonson-Guillmette formation was measured starting from a point 11,970 feet S. 77° W. of the Lost Sheep main pit in sec. 30, T. 12 N., R. 12 W. The measurement started at the top of the Sevy dolomite and ended where covered by Lake Bonneville sediments. The thickness at this locality is 348 feet (table 6).

Fossil fragments found 56.7 feet above the base were identified by Jean Berdan of the U. S. Geological Survey as Amphipora sp. This fossil places the Simonson-Guillmette in the Middle Devonian, probably equivalent in age to the Jefferson dolomite of northeastern Utah, (Williams, 1948, p. 1140-1141) Idaho, Montana, and Wyoming.

Table 6.--Stratigraphic section of the Simonson and Guillmette formations, undivided, measuring started at a point 11,970 feet S. 77° W. from the Lost Sheep main pit.

Description	Bed thickness (feet)	Cumulative thickness (feet)
Lake Bonneville sediments		
Simonson and Guillmette formations		
Limestone, black to gray, fine- to medium-grained, sandy	10.8	348
Covered, limestone float	39.0	337
Limestone breccia, black to gray, sandy; probable small fault	6.5	298
Covered, limestone float	2.6	291
Limestone, black, fine- to medium-grained, sandy	2.9	289
Covered, limestone float	17.0	286
Limestone, black, medium-grained, sandy	6.0	269
Limestone, medium-brown, fine- to medium-grained, sandy, dolomitic	3.0	263
Covered, limestone float	44.7	260
Limestone, thick-bedded medium to dark gray, medium-grained, sandy	11.4	215
Covered, black, gray, and brown limestone float	12.9	204
Limestone, black, medium-grained, sandy	2.7	191
Limestone, thinly-laminated to thick-bedded, light brown, medium-grained, sandy, dolomitic	6.5	188
Covered	21.9	182
Limestone, medium-brown, medium-grained, massive, sandy, dolomitic	1.4	160

Table 6.--Stratigraphic section of the Simonson and Guillmette formations, undivided, measuring started at a point 11,970 feet S. 77° W. from the Lost Sheep main pit--Continued.

Description	Bed thickness (feet)	Cumulative thickness (feet)
Covered	13.5	158
Covered, limy dolomite float	16.0	145
Dolomite, light gray, fine-grained	5.0	129
Covered, dolomite float	7.0	124
Dolomite, light brown, coarse-grained, massive	7.0	117
Dolomite, dark gray to brown, coarse-grained, sandy, limy	4.0	110
Covered	29.0	106
Dolomite, medium gray, fine-grained	14.9	77
Dolomite, thick-bedded, medium to dark gray, medium-grained, sandy, limy	5.1	62
Dolomite, black to dark gray, fine-grained, sandy, *Amphipora* sp.	2.0	57
Covered, brown to gray limestone float	29.6	55
Dolomite, thin- to thick-bedded, blocky to platy, black, fine- to medium-grained, sandy	25.1	25
Top of Sevy dolomite		
Covered	5.8	7
Dolomite, light gray, medium-grained, sandy	1.5	2

Lake Bonneville sediments

Spors Mountain is entirely surrounded by valley fill of Lake Bonneville sediments. The greater part of these are gravels, which are most conspicuous along the west side of the range, are plastered against the sides of outlying hills of Devonian sediments. They also form bars across some of the canyon mouths; on the northwestern end of Spors Mountain there is a large semicircular bar, approximately 50 feet high and half a mile across (pl. 16, A).

Gravels consist of subangular fragments of dolomite, limestone, quartzite, and volcanic rocks. Generally the dominant rock types are those derived from nearby outcrops.

Most of the gravels are unconsolidated, but along the south side of Spors Mountain near the Harrisite and Bell Hill properties and on the east side, north of the Oversight property, a well-consolidated conglomerate with calcareous cement is found along the sides of small canyons (pl. 16, B). These beds are flat-lying and dip from 3 to 10 degrees downstream. Eroded gravel remnants cover canyon walls along many water courses in the northwest part of Spors Mountain, at elevations as much as 100 feet above the nearby desert.

Marl underlies the gravels but is exposed only at a few spots in the deeper washes at the northern and southern ends of the district. This rock is cream colored, friable, and extremely susceptible to weathering.

Volcanic rocks

Introduction

The volcanic rocks of the Thomas Range consist of flows, tuffs, and intrusive plugs which range in composition from augite-enstatite latite to rhyolite. Light-colored rhyolitic rocks present a striking escarpment 1,000 feet high on the west side of the main mass of the Thomas Range, 2 miles east of Spors Mountain (fig. 1). Smaller outcrops of volcanic rocks are scattered around Spors Mountain, and numerous plugs and intrusive breccia bodies cut the Paleozoic rocks. The volcanic rocks, which surround Spors

Plate 16A.--Semicircular bar of Lake Bonneville gravels on the northwestern end of Spors Mountain.

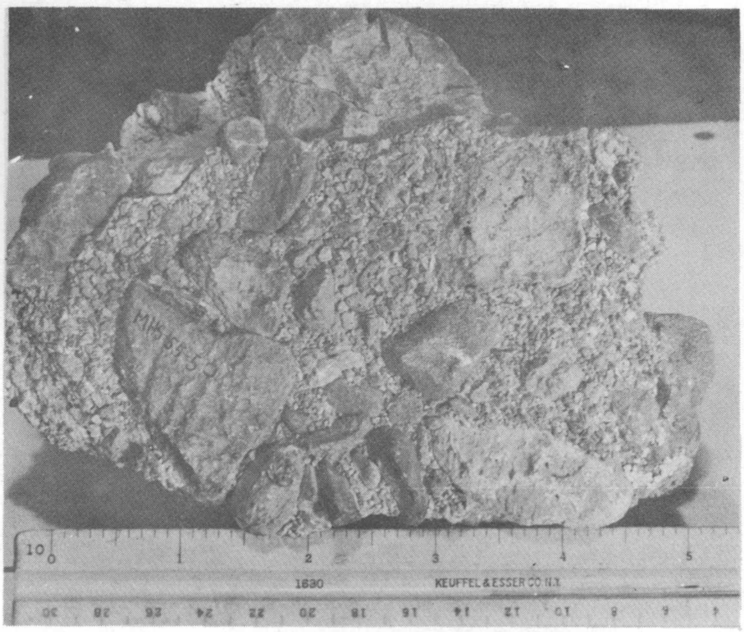

Plate 16B.--Well-consolidated Lake Bonneville conglomerate.

Mountain, strike northeast and dip northwest, generally parallel to the sedimentary rocks. Volcanic rocks in the main part of the Thomas Range are nearly horizontal. Many masses of intrusive breccia and igneous plugs are distributed along faults, but others are cut by faults; they are partly synchronous with deformation and partly later. Though most relationships are obscure, the latites seem to be older than the quartz latites and rhyolites. The pyroclastic rocks are probably of intermediate age. In general, latites are more abundant in the southern part of the district; quartz latite and rhyolite predominate to the north (pl. 3). A layer of light-colored vitreous rhyolitic rock, with abundant spherulites and lithophysae (pl. 3), makes a convenient map unit along the east side of the mountain. It is probable that some welded tuffs are included in the rocks mapped as rhyolite, spherolitic rhyolitic glass, and tuff, but because of the varying degrees of welding, these rocks can not be separated until more detailed work is done in the main Thomas Range.

Classification

The intrusive and extrusive rocks were classified according to Grout (1932, p. 50) because his system is sufficiently definite to allow accurate subdivision of intermediate rock types, yet not too complex and cumbersome to permit use of simple rock names. This classification is also quite similar to that used by Hatch, Wells, and Wells (1949, p. 181-356). The chief difference is that Grout bases his terminology of the acid and intermediate rocks mainly on the quartz and feldspar content, while in addition Hatch, Wells, and Wells use the color index and the presence of various other minerals. In some rocks these added determinants lead to confusion, as one set of indicators point toward one rock name and second set toward another.

In describing the various rock types, it was found that the anorthite content of many of the plagioclases was higher than normal. For that reason, thin section measurements were made only on grains with clearly identifiable orientation. These included grains showing well-defined combined Carlsbad-albite twins, combined albite-pericline twins, and those showing sharp albite twins with sharp transverse cleavage. Extinction angles were measured, and anorthite content determined by using the curve of Crump and Kettner

(Emmons, and others, 1953, fig. 6) for combined albite-pericline twins and the curve of F. E. Wright (Rogers and Kerr, 1933, p. 212) for combined Carlsbad-albite twins. Because of the carefully identified grain orientations, the determinations are probably as accurate as ones made by the usual universal-stage thin-section techniques. However, as shown by the chart of Crump and Kettner, the results can be statistically accurate only to about ± 10 percent. The curve given by Wahlstrom (1947, p. 73) was used to determine anorthite content of plagioclase microlites.

Petrography

Enstatite-augite latite

Enstatite-augite latites are restricted to a few scattered areas in the southern part of the Spors Mountain district (pl. 3 and 5). Most contacts of the latites with other rocks are obscured, but they are probably small intrusive masses. The rocks are dark gray or brown to black, and contain anhedral phenocrysts of green pyroxene up to a maximum of 30 percent. The phenocrysts are about one sixteenth inch to an eighth of an inch across.

In thin section the latites contain between 15 and 30 percent subhedral to euhedral enstatite and augite in approximately equal amounts. Many of the augite crystals are twinned and some show distinct zoning. Quartz phenocrysts less than 1 mm in diameter make up a maximum of 3 percent of the rock; most are deeply corroded and show marked reaction rims. Scattered ragged and zoned crystals of plagioclase (An 53 percent), biotite laths largely altered to hematite, and a very few orthoclase crystals make up the remainder of the phenocrysts. Occasional ragged grains of magnetite are scattered through the slides.

The groundmass consists of numerous felted plagioclase microlites (An 72 percent) and minute crystals of pyroxene, probably pigeonite, with considerable black opaque iron oxide "dust". Much of the groundmass has an index that is lower than balsam, which suggests the presence of considerable occult potassium feldspar. To verify the presence of potassium, several rock slabs and thin sections were stained with a sodium cobalt nitrite solution according to the method of Gabriel and Cox (1929, p. 290-292). The results indicated that the groundmass is high in potassium, and, therefore, contained considerable amounts of potassium feldspar. Similar rocks, containing no visible potassium feldspar, which when analyzed showed a high K_2O content, were described by Nolan (1935, p. 50-51) in the Gold Hill district.

Hypersthene latite

Hypersthene latite is most abundant in the south-central part of the Spors Mountain district and near the south end of Eagle Rock Ridge (pls. 3 and 6). The rocks are dark-gray to black in hand specimen but are full of subhedral plagioclase phenocrysts as much as a quarter of an inch long, which make up about 30 to 60 percent of the rock. The matrix is fine-grained and locally glassy. In a few places the latite has good flow structure, marked by platy plagioclase phenocrysts. Clear contact relations between hypersthene latite and other rocks are rare. A mass of latite with a fine-grained to glassy matrix, which intruded Lost Sheep dolomite, is exposed along a wash 2,000 feet west of the Bell Hill mine. Rhyolite that invaded and incorporated pieces of latite may be seen along a large wash, a few hundred feet north of the area shown on plate 3.

Thin sections of hypersthene latite show abundant subhedral to euhedral plagioclase phenocrysts (An 50 to 93) with good albite and Carlsbad twins and oscillatory zones, set in a matrix of plagioclase microlites and hypersthene rods. Associated with the plagioclase phenocrysts are scattered, pleochroic, subhedral to anhedral crystals of hypersthene as much as 0.1 mm in medial dimension. Accessories include magnetite and apatite. Some thin sections have abundant brown glass (hyalopilitic texture), which has an index less than balsam. Stain tests (Gabriel and Cox, 1929, p. 290-292) reveal that the groundmass contains considerable potassium. Hence, the rock is designated a latite.

A few of the latites contain abundant calcite, which is probably secondary.

Acid igneous rocks

Though the rhyolites and quartz latites are geographically restricted and sufficiently distinct to be mapped individually, they have many common and interrelated features. To avoid repetition they will be described together.

The acid igneous rocks are light-colored; some are almost white; others have a pale reddish or purplish cast. Though there are exceptions, the rhyolites tend to be white or reddish, the quartz latites, purplish. Euhedral and subhedral crystals of smoky quartz as much as 4 mm long are common; most are doubly terminated pyramids, with very subdued prism faces. Phenocrysts of glassy sanidine and plagioclase are also common. Many of the rocks contain colorless or opaque euhedral topaz crystals as much a 1 inch long. Flow structure is pronounced in some of the extrusive acidic rocks, particularly the glassy ones. Locally the acidic rocks contain lithophysae as much as 4 inches in diameter (pl. 17, A). The large lithophysae are most numerous along the ridge northeast of the U. S. Bureau of Public Roads haulage road in the northeastern part of the district.

In thin section, most of the acid igneous rocks show a mosaic of quartz and feldspar anhedra less than 0.1 mm in diameter. Phenocrysts of quartz, sanidine, and plagioclase (An 28 to 52 percent) are scattered through the matrix and make up a maximum of 40 percent of the rock; some are partially resorbed. The borders of some sanidine crystals enclose grains of matrix minerals, suggesting a late stage growth of the larger crystals. Ragged green pleochroic biotite plates are the chief accessory. The glassy rocks show irregular areas of granular "matrix," and scattered individual crystals, suggesting devitrification. Spherulitic intergrowths of quartz and potash feldspar as much as 0.2 mm in diameter are common in glassy rocks and in a few dellenites which contain no glass. Elongate aggregates of quartz anhedra are distributed along flow planes. Topaz subhedra, less than 0.1 mm long are common in thin sections of all acid rocks except the glasses, though they are more commonly found in quartz latite. Many of the topaz crystals are arranged in rosettes. Rocks which contain topaz crystals sometimes have a little microscopic fluorite and garnet. Topaz rods appear in feldspar crystals, but not in quartz, suggesting selective replacement. This observation is in general agreement with the results of Patton (1908, p. 187-188) on the Topaz Mountain rocks.

Intrusive breccia

Masses of intrusive breccia are common in Spors Mountain. They range from small dikes an inch or two thick, to large masses 200 to 300 feet wide (pl. 3). The largest masses of intrusive breccia are

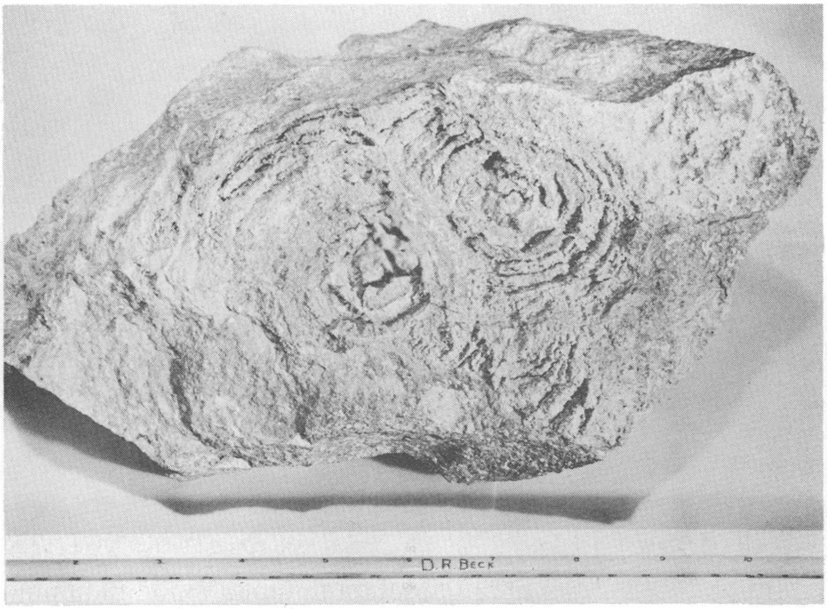

Plate 17A.--Large lithophysae in spherulitic rhyolitic glass, from ridge 4,500 feet east of Lost Sheep pit.

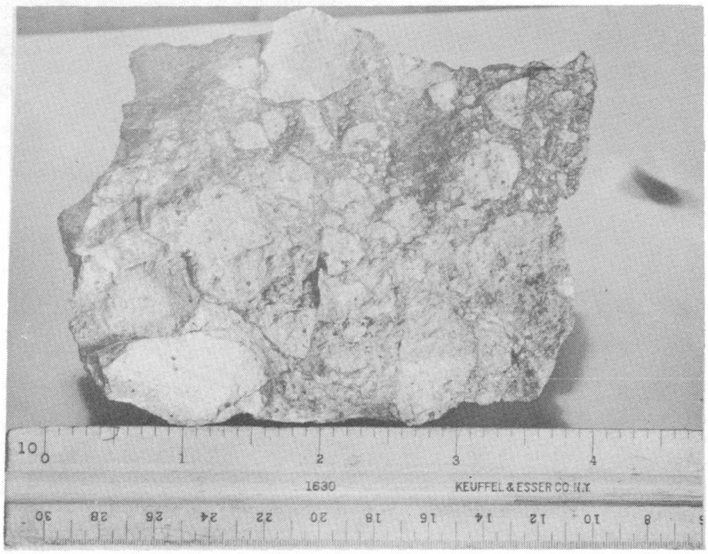

Plate 17B.--Intrusive breccia from Hilltop no. 1 property. Dark specks in matrix and fragments are smoky quartz crystals. Light-colored angular rhyolite fragments are set in fine-grained reddish matrix.

distributed along the east side of Spors Mountain where they are easily recognized by a distinctive pale brick-red soil, by smooth slopes with poor outcrops, and by randomly oriented blocks up to the size of houses made up from all formations. Because of the smooth rounded appearance of slopes underlain by intrusive breccia bodies, they are easily confused for slope wash overlying other types of rock. In such places, the red soil is the best criterion.

Many masses of intrusive breccia consist of dolomite blocks in a red matrix of secondary dolomite. Elsewhere, blocks of igneous rock are associated with the dolomite, and some of the bodies are composed entirely of igneous blocks, in a red dolomitic matrix. Though most intrusive breccia bodies with igneous blocks contain pieces of rhyolite or quartz latite (pl. 17, B), a few contain enstatite-augite latite. The most notable example is about 3,000 feet south-southeast of the Bell Hill mine, along both sides of a wash. At this locality, a mass of enstatite-augite latite contains blocks of dolomite up to 15 feet in diameter from formations stratigraphically higher than the Paleozoic sediments which surround the latite mass. Intrusive breccia composed of rhyolite fragments may be observed best in the Blowout adit (fig. 9).

In a few places some material has been introduced into the intrusive breccia after its emplacement. This is shown by fluorite which replaced the intrusive breccia in the Blowout tunnel and on the Dell property. As shown in plate 17-B, crystals of smoky quartz are scattered through both the rhyolite fragments and the matrix, which suggests late introduction of silica.

The intrusive breccia masses are similar to the British ones described by Geikie (1897, p. 276-297), although the material in the breccia masses shows no evidence of stratification as do some of those described. The inclusion of fragments of Paleozoic sediments in a matrix of dolomitic material is suggestive of the diatremes in Missouri (Rust, 1937, p. 48-75). The Spors Mountain intrusive breccias are believed to have formed by gaseous "blow-out," similar to the processes outlined by Geikie, Rust, and particularly by Walker (1928). In the classification proposed by Walker (1928, p. 942), the intrusive breccia masses would be divided into three types of explosion pipes: those occupied only by explosion breccia, those partly filled by lava, and those completely filled by lava. All three types are found in the Thomas Range.

Pyroclastic rocks

In subdividing the pyroclastic rocks into map units, the classification recommended by the Committee on Sedimentation of the National Research Council (Wentworth and Williams, 1932) was followed. An igneous rock name (as rhyolitic) was added to the pyroclastic rock name as a general description of the composition.

Large areas east and northeast of Spors Mountain are underlain by tuffs and lapilli tuffs, containing crystal, vitric, and lithic fragments. Most of these rocks are of a rhyolitic composition though few are quartz latitic and latitic. The tuffs range from white and yellow through pink and orange to reddish colors; most of the rhyolitic tuffs are white or yellow; the quartz latitic ones are darker in color. The body of dacitic crystal tuff shown at the south edge of plate 3 is unique and does not resemble any other rock in the district. This dacitic tuff is white to light gray with numerous biotite crystals as much as three-sixteenths of an inch in size, which distinguish it from other white tuffs. Welded rhyolitic tuff is found in a few small outcrops north of Spors Mountain, and probably elsewhere.

Agglomerate.--The oldest pyroclastic rock in the district is a dark reddish agglomerate, which contains boulder- and cobble-sized pieces of hypersthene latite and Paleozoic dolomites. Many of the volcanic fragments are epidotized. The rock has a well-defined stratification, which parallels the regional structure.

Quartz latitic tuff.--Quartz latitic tuff is pink to reddish, sometimes with an orange, green, or purplish cast. It is most abundant west of Eagle Rock Ridge. Crystal fragments are most common in quartz latitic tuff, but some fragments are vitric and lithic. Latitic and acidic rock fragments, with a few sedimentary blocks, are scattered through the tuff.

Thin sections of quartz latitic tuff show anhedral and subhedral broken crystals of quartz and feldspars as much as 2 mm across set in a matrix of fine-grained crystal and vitric fragments. Small pleochroic biotite laths are not uncommon. Rock fragments are rare.

Rhyolitic tuff.--Rhyolitic tuff is distributed around the northeast, east, south, and west sides of Spors Mountain (pl. 3). The white or light-colored rocks generally are fine-grained and uniform. In most places they form smooth rounded slopes with a pronounced yellow or white soil. In a few places the rhyolitic tuffs are weakly fluoritized.

Microscopically the rocks show numerous angular pieces of quartz, sanidine, and plagioclase less than 1 mm in diameter, set in a matrix of small glass fragments together with a few fragments of chert, dolomite, and Swan Peak quartzite. Fragments of vesicular glass are not uncommon. The glassy portions show numerous very minute crystallites, probably of quartz and feldspars. Laths of dark brown biotite are associated with the other crystal fragments.

Lapilli tuff.--Lapilli tuff is a light-gray to purplish rock, commonly rhyolitic in composition. Lithic fragments in the rock are sub-angular to rounded, and as much as 4 inches in length; the average is less than half an inch. The matrix is fine-grained and under the microscope shows minute crystals of quartz and feldspar, associated with fragments of glass. Though the rock has been partly devitrified, some of the glass shows the curved and concave surfaces of fracture vesicular material (vitroclastic texture) and includes fragments of glass with good internal flow structure. Lapilli tuff commonly underlies a spherulitic rhyolite glass.

Petrology

Chemical composition of rhyolites.-- Because some of the uraniferous fluorite pipes are adjacent to intrusive rhyolite plugs, chemical analyses were made of intrusive and extrusive rhyolite, in the hope that some light might be shed on the chemistry of ore deposition. The analyses, together with two taken from the literature, are given in table 7. The molecular norms, also given in table 7, were calculated according to the rules summarized by Barth (1952, p. 76-82). The molecular norm was used rather than the usual weight norm (CIPW) because it more nearly represents the amounts of the various cations in the analysis. The molecular norm was devised by Niggli (1936).

The norms of the four rocks differ mainly in the amounts of the minor minerals. The Topaz Mountain flow, which contains numerous topaz crystals, has a norm comprising feldspars and quartz with a little diopside; this suggests that the topaz was, at least in part, made from material already in the rock, only fluorine being added. The small amount of corundum in two of the norms may represent topaz in part and may suggest the addition of a little alumina. Part of the alumina necessary to make topaz may have been derived from the feldspars.

Table 7.--Chemical composition in weight percent and molecular norms of Thomas Range rocks

	I	II	III	IV
SiO_2	76.54	73.30	74.49	74.50
Al_2O_3	12.16	14.27	14.51	13.28
Fe_2O_3	.92	.34	.57	1.50
FeO	.37	1.89	.32	-
MgO	.14	.13	Trace	Trace
CaO	.78	.34	1.03	1.46
Na_2O	3.50	3.86	3.79	5.23
K_2O	4.97	4.76	4.64	3.54
H_2O -	.05	.11	-	-
H_2O +	.11	.39	.64	-
TiO_2	.09	.03	-	-
CO_2	.16	.06	-	-
P_2O_5	.02	.03	-	-
MnO	.05	.07	Trace	-
LiO_2	-	-	Trace	-
	99.86	99.58	99.99	99.51
Less O equiv. for F	99.73	99.42		
Loss on ignition	.37	.22		
Percent F	.32	.39		
Percent eU	.003	.004		
Percent U	.001	.001		

Table 7. --Chemical composition in weight percent and molecular norms of Thomas Range rocks--Continued

NORMATIVE MINERALS IN MOLECULAR PERCENT

	I	II	III	IV
Orthoclase	27.5	28.5	28.0	21.0
Albite	20.4	33.5	34.5	38.0
Anorthite	-	-	3.0	2.5
Quartz	30.2	32.7	29.3	35.5
Corundum	1.5	1.7	1.5	-
Diopside	-	-	-	-
Hypersthene	-	-	-	-
Wollastonite	-	-	-	2.0
Magnetite	.3	.75	.6	-
Hematite	-	-	-	1.1
Fluorite	.9	1.4	-	-
Ferrosilite	2.8	.3	-	-
Topaz	2.8	-	-	-

I Rhyolite, Topaz Mountain, Utah, - L. M. Kehl, analyst, U. S. Geological Survey

II Rhyolite plug, Eagle Rock Ridge, Thomas Range, Utah, - L. M. Kehl, analyst, U. S. Geological Survey

III Rhyolite, Thomas Range, Utah, - L. G. Eakins, analyst (Cross, 1887, p. 69)

IV Rhyolite tuff, Thomas Range, Utah, - J. W. Whitehurst, analyst (Patton, 1908, p. 187)

Because of their relatively high potassium content, it is suggested that the rocks of the Thomas Range did not follow the "normal" crystallization series of rocks derived from primary basaltic magma. The abnormal composition is evidenced by sanidine phenocrysts in latites as well as in rhyolites, and by the high K_2O to (Na_2O + CaO) ratio found in the analyzed rhyolites (table 6). To test this hypothesis, a ternary diagram (Barth, 1952, p. 101) was used. This diagram (fig. 4) is based on normative feldspar and shows the boundary curve between the crystallization fields of primary orthoclase and primary plagioclase. Figure 4 shows the six available analyses of Thomas Range rhyolites plotted in the Or-An-Ab triangle. Two of the available analyses of Thomas Range rocks fall inside the curve and two outside, but all are near the Ab-Or line. The location of the points suggests that the magma was strongly alkalic and possibly mildly potassic.

Petrogenesis. --The assemblage of igneous rocks in the Spors Mountain district correleated remarkably well with the series proposed by Turner and Verhoogen (1951, p. 201, 212-224) for the end stages of an orogenic region. They give examples from the literature, particularly the San Juan province in Colorado and the Cascade Province in northwestern United States. The characteristic features of the association which are found in the Spors Mountain rocks are given below:

1) Variation in An percent of plagioclase in phenocrysts.

2) Corroded phenocrysts of quartz and sanidine scattered in latities.

3) Composition of plagioclase phenocrysts shows little relation to the rocks in which they occur.

4) Chemical composition of Spors Mountain rocks closely resembles analyses of rhyolitic rocks from the Cascade province.

The latites of the Spors Mountain district, although not typical of orogenic regions, probably reflect the mildly alkalic character of the volcanic rocks of the Basin and Range Province. Nolan (1935, p. 49-52) has described mildly alkalic rocks from the Gold Hill quadrangle in western Utah, and it is probable that many others have been overlooked.

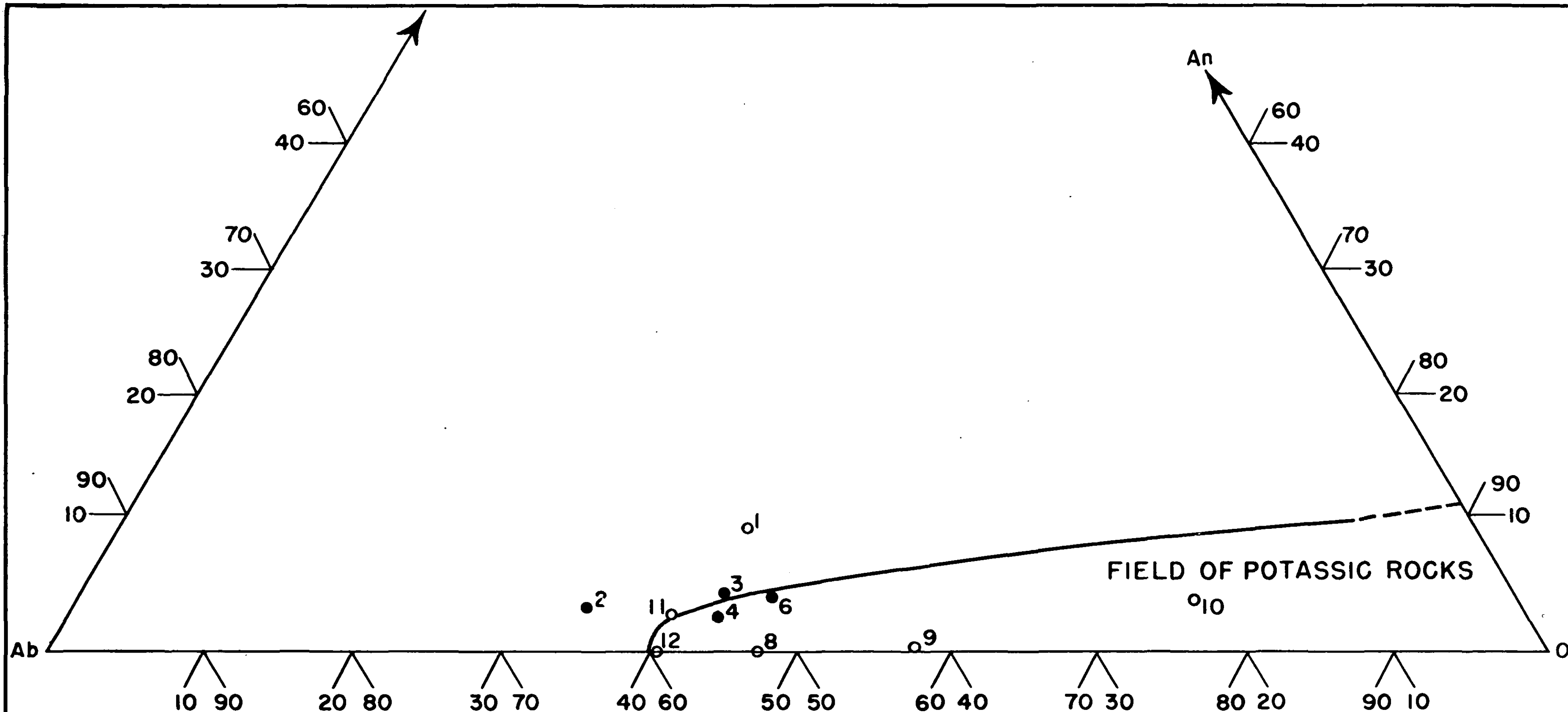

FIGURE 4 —. NORMATIVE FELDSPAR RATIOS OF RHYOLITES

EXPLANATION

1 Average rhyolite (Daly, 1914, p. 19)
2 Rhyolite tuff (Patton, H.B., 1908, p. 187)
3 Rhyolite, Thomas Range, (Cross, 1887, p. 169)
4 Rhyolite plug, Eagle Rock Ridge, Thomas Range, Utah, analyst L. M. Kehl
6 Rhyolite, Topaz Mountain, Thomas Range, Utah, analyst L. M. Kehl
8 Rhyolite obsidian, Medicine Lake, California (Anderson, C. A., 1941, p. 387)
9 "Pitchstone," Arran (Hatch, Wells and Wells, 1949, p. 221)
10 Potash rhyolite, Snowden (Hatch, Wells and Wells, 1949, p. 221)
11 Rhyolite, Chalk Mountain, Colorado (Cross, 1886, p. 438)
12 Rhyolite, Nathrop, Colorado (Cross, 1886, p. 438)
● Analyses of rocks from Thomas Range, Utah
○ Analyses of rocks from other localities

Because of poor outcrops, the age relationships of the various rocks are by no means clear, but on the basis of stratigraphic position and general field association, it is believed that the latites preceded the more acidic rocks. Because of the anomalous character of the rocks (intermediate plagioclase in rhyolitic and quartz latitic rocks, and general alkalic composition) it is unlikely that the series arose from pure crystallization differentiation. Differentiation and contamination of paligenic magma, formed as a result of depression of the Cordilleran geosyncline is more likely. High-lime plagioclase in most rock types and hypersthene phenocrysts in latite make assimilation of Ca and Mg from dolomite a possibility.

Though many of the Spors Mountain volcanic and pyroclastic rocks conform to the regional strike and dip and are thus earlier than some of the faults, at least some of the intrusives rose along faults (pls. 3, 4, and 6). Volcanism, thus, was relatively late in the geologic history of the region.

The exact age of the volcanics has not been determined. Nolan (1935, p. 49) tentatively assigned the volcanic rocks in the Gold Hill quadrangle, Utah, to the late Pliocene. Westgate and Knopf (1932, p. 26) concluded the lavas of Pioche, Nev., were Tertiary (?). Gilluly (1932, p. 65-66) found that a late Eocene or Oligocene age for the volcanic rocks in the Stockton and Fairfield quadrangles, Utah, was most reasonable. Muessig (1951, p. 97-99) reports that the pyroclastics of Long Ridge, Utah, near Nephi, are middle Eocene, on the basis of a flora in the interbedded Sage Valley limestone member. By analogy with these surrounding areas, it seems likely that the Spors Mountain volcanic rocks are early Tertiary in age.

STRUCTURE

Introduction

The Spors Mountain district is structurally complex. Although the strata have a consistent northeast strike and northwest dip, the area is broken by many faults which give the Paleozoic rocks a mosaic-like outcrop pattern (pl. 18, A and B, pl. 3). Several long steeply-dipping north-south faults, brought the Tertiary(?) volcanic rocks down against the Paleozoic sediments, as Spors Mountain was uplifted above the surrounding desert.

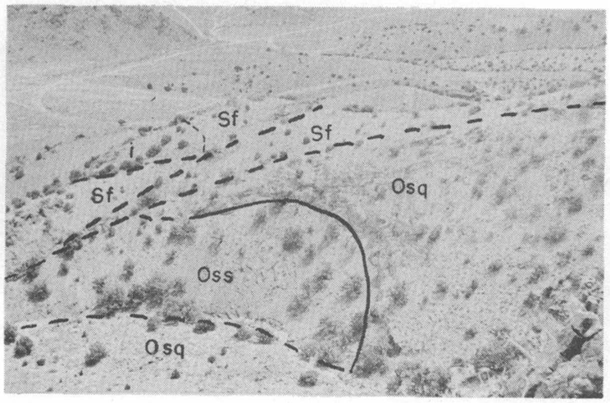

Plate 18A.--Fault pattern just north of Dell property. (Oss-shale member and Osq-quartzite member, Swan Peak formation; Sf-Floride dolomite; i-intrusive breccia.)

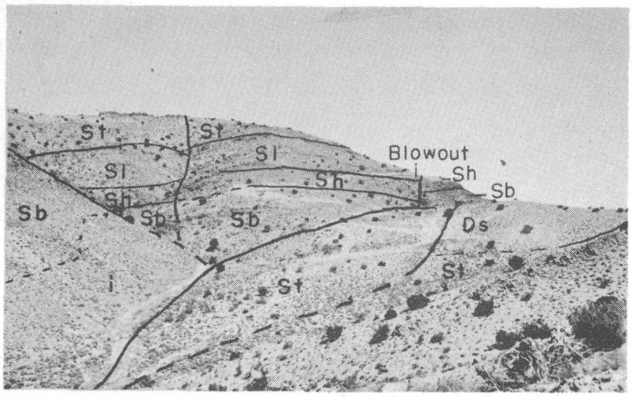

Plate 18B.--Fault traces southwest of Blowout mine. (Ds-Sevy dolomite, St-Thursday dolomite, Sl-Lost Sheep dolomite, Sh-Harrisite dolomite, Sb-Bell Hill dolomite, i-intrusive breccia.)

Folding

The strike of the Paleozoic beds varies from east-northeast to almost north; dip ranges between 20 and 60 degrees northwest. This variation in strike and dip is the only evidence of folding in the district. In general, the strike is nearer north in the northern and eastern parts of the district, and nearer east in the southern and western parts.

The strike and dip of bedding in tuffs and of layering in flows surrounding Spors Mountain are generally parallel to the bedding in the Paleozoic rocks. Volcanic rocks east of Eagle Rock Ridge and on the main eastern mass of the Thomas Range are more nearly horizontal, and locally, as on the ridge half a mile east of the Lost Sheep mine (pl. 3), the volcanics strike northeast and dip southeast. This suggests a sharp structural separation between the highly faulted rocks of Spors Mountain on the west and the main mass of the Thomas Range on the east. The intrusive rhyolite plugs and the ore pipes are steeply plunging and show no evidence of folding or rotation; some were emplaced after faulting and occur along faults (pl. 3).

The sedimentary and volcanic rocks were tilted at least after part of the volcanic rocks were formed, probably during late Tertiary time. Whether the rocks were folded before the last stages of faulting is not known.

Faulting

Spors Mountain is cut by hundreds of faults; nearly a thousand have been mapped (pl. 3), and many more are present but are not shown because of small displacement, lack of key beds, or a cover of alluvium. Because the relations appear so complex, it is particularly useful to group the faults according to probable relative age, and on this basis 5 sets of faults have been distinguished. Beginning with the oldest, these are: (1) small northeast-trending thrust faults, (2) northeast-trending normal and reverse faults with moderate dip, (3) northwest-trending faults mostly high-angle, (4) north-trending faults, and (5) east-trending faults. The first three sets of faults are intruded by igneous rock and are, therefore, clearly pre-volcanic; the latter two sets cut and displace the volcanic rocks and are, therefore, post-volcanic. Within these groups, however, the relative ages are based on fault offsets and thus are subject to some error, but no better means of dating them is available.

Thrusts

The oldest and least common faults in the district are thrusts, which parallel the northeast-trending normal and reverse faults and dip west or northwest at angles less than 45 degrees. Thrusts cut Silurian rocks along the west side of Eagle Rock Ridge (pl. 6) and 700 feet southeast of the Harrisite workings (pl. 5, pl. 19). The thrusts on Eagle Rock Ridge are associated with a low angle normal fault, which has an outcrop pattern similar to that of the thrusts. A prominent westward dipping breccia zone up to 20 feet thick northwest of Spors Mountain apparently marks a thrust near the top of the Sevy dolomite. Whether this fault is contemporaneous with those on Eagle Rock Ridge and near the Harrisite property is not known. The amount of movement on these faults is difficult to measure, as the trend of the faults parallels the strike of the beds and with depth cuts across them at a small angle; the dip-slip, however, is approximately 400 to 1,000 feet. Faults of all other systems cut the thrusts. The thrusts are probably pre-volcanic in age, as shown by plate 3.

Northeast-trending normal and reverse faults

Many northeast-trending normal and reverse faults cut across the trend of Spors Mountain and repeat the stratigraphic section numerous times (pl. 20, A). Most of these faults dip between 35° and 65° SE. Many of the canyons cut into the flanks of the mountain approximately follow major northeast fault traces. Brecciated rock and zones of varicolored coarsely crystalline travertine as much as 10 feet wide are common along the faults which are also the locus of many small intrusions of rhyolite porphyry and intrusive breccia. These small intrusions are closely grouped along several faults on the west side of Spors Mountain and in plan view resemble a string of link sausages. Most of the large ridges in Spors Mountain are separated by these faults. Dip-slip movement ranges from a few inches up to about 1,100 feet.

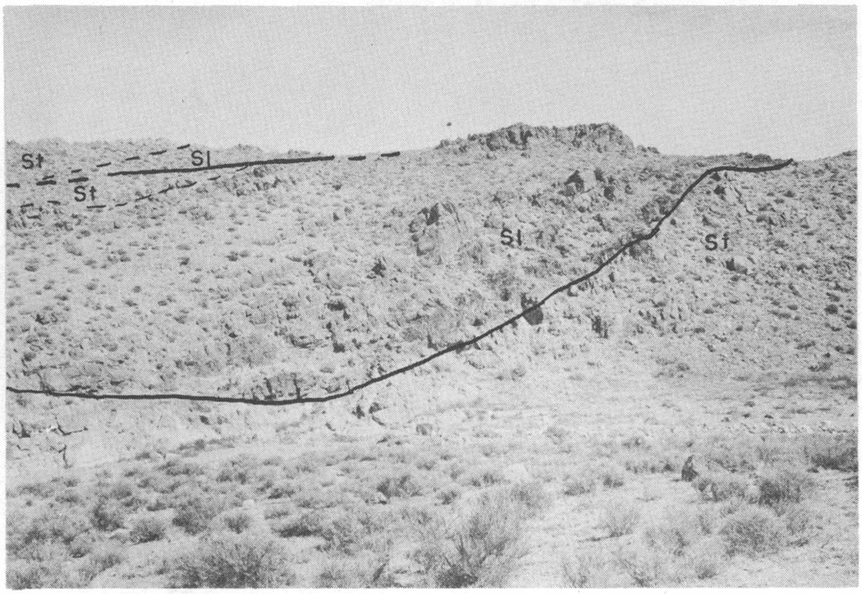

Plate 19.--Thrust fault near the Harrisite mine with Lost Sheep dolomite (Sl) overlying Thursday dolomite (St). Fault in background is a normal fault.

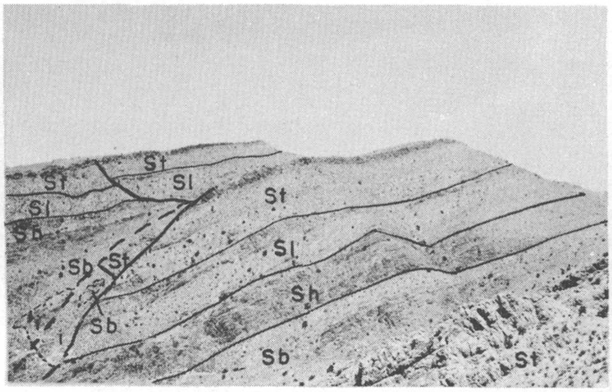

Plate 20A.--Repetition of section by northeast-trending faults in the northern part of Spors Mountain. (St-Thursday dolomite, Sl-Lost Sheep dolomite, Sh-Harrisite dolomite, Sb-Bell Hill dolomite, and i-intrusive breccia.)

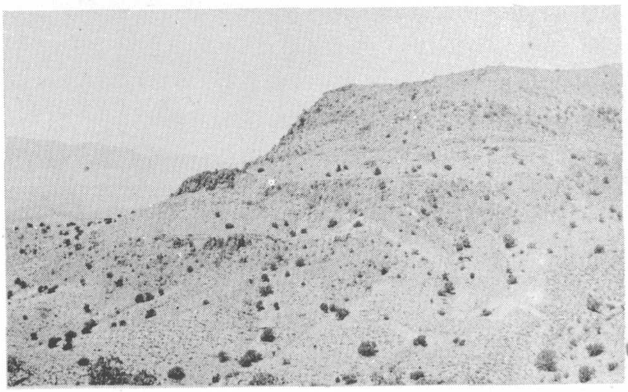

Plate 20B.--Offset of beds on east-trending fault partially filled by travertine vein.

North-west-trending faults

A series of nearly vertical faults, which trend northwest, intersects and commonly offsets the northeast set of faults. Though faults of this series may be observed throughout the length of Spors Mountain, they are most numerous in the northeastern part (pl. 3). All of the Paleozoic beds are cut by faults in this series. Many faults belonging to this series have a displacement too small to show on plate 3. Dip-slip displacement on individual faults of the northwest set ranges from a few feet to several hundred feet.

North-trending faults

A few large, steeply-dipping, north-trending faults have brought Tertiary volcanic rocks against Paleozoic sediments along the east side of Spors Mountain (pl. 3). This set resembles a typical "Basin Range" fault system and has produced striking physiographic and structural effects; Spors Mountain is the result of displacements along this set. Along the east side of Spors Mountain these faults are covered by Lake Bonneville sediments in most places but can be traced by abrupt changes in topography and by the different rock types on opposite sides of covered areas. Plunge of striations on the fault surfaces indicate that most of the movement is dip slip, and displacements are as large as 1,700 feet as shown by relative offset of beds in structure sections (pl. 4). Faults of the north-trending set commonly offset northwest- and northeast-trending faults.

East-trending faults

A few faults of moderate displacement strike east across Spors Mountain (pl. 20, B). Apparent dip-slip displacement on individual faults ranges from 300 to 500 feet. These faults most commonly intersect and offset the north-trending faults, but at the south end of Eagle Rock Ridge (pl. 6), a north-trending fault offsets an east-trending fault. Most east-west faults dip steeply south, and most of the striae on the fault planes plunge 50° to 55° southeast. The hanging wall side of the fault commonly moved down, though on some faults it has moved up (pls. 3 and 4).

Age of faulting

The exact geologic time at which the rocks were faulted is not known. Middle Devonian beds are faulted and Pleistocene sediments show no visible offset. The volcanic rocks have been faulted but cannot be accurately dated by geologic means; they are questionably assigned a Tertiary age. (See page 74.)

In the Deep Creek Range, Nolan (1935, p. 64) concluded that the faulting began in Cretaceous or early Eocene time and that the latest stage of faulting began before Upper Pliocene time. Gilluly (1932, p. 85-86) in the Stockton and Fairfield quadrangle, Utah, found an early stage of faulting dating from the early Tertiary, and a later stage (the "Basin Range faulting") which began in Miocene or early Pliocene time. Large-scale high-angle faults trending north through central Utah, are believed to be Pliocene by Eardley (Hansen and Bell, 1949, p. 22-23). It is possible that the north-south set of faults in the Thomas Range can be correlated with Gilluly's Miocene or early Pliocene faults and the Pliocene fault system of Eardley. In the structurally similar Fish Springs Range (Butler, and others, 1920, p. 467-468), 15 miles west of Spors Mountain, Gilbert (1928, p. 71) found evidence of post-Lake Bonneville movement on the north-south fault bounding the east side of the range.

Mechanics of faulting

The complex pattern of faulting cannot have been produced by any simple mechanism. Each set of faults of different orientation probably was produced by diverse forces. Only with the northeast-trending faults is a reliable interpretation possible. Inasmuch as most of the larger northeast faults dip toward the structurally higher part of the area, they are probably similar to the antithetic fractures of Hans Cloos (1928). Numerous small northeast-trending fractures that dip northwest probably represent Cloos' sympathetic fractures. This pattern is probably the result of relative uplift to the southeast and relative depression to the northwest, combined with rotation and tilting of individual fault blocks. Alternatively, the pattern could be formed by effective northwest directed compression, with resultant block rotation in a vertical plane. The large, north-south, Basin-Range faults probably are the result of effective tension, caused by either regional uplift and stretching, or to a relaxation of compression. The graben-like valley between Spors Mountain and the main Thomas Range to the east suggests that these faults are similar to the graben-border faults of Cloos (1939, p. 416), formed by uplift and stretching.

Ore deposits

Types of deposits

Over 40 fluorite deposits, not including the many small veinlets, are known in the Spors Mountain district. These deposits may be divided into three types: (1) pipe-like bodies, (2) veins, and (3) disseminated deposits.

Pipes.--The pipe-like bodies are the most important deposits in the district, and 19 of the 20 producers with 99.95 percent of the total production are of this type. Pipe-like ore bodies include the deposits at the Lost Sheep, Fluorine Queen, Blowout, Bell Hill, Floride, Lucky Louie, Oversight, Hilltop No. 1, Dell, Dell No. 5, and Harrisite properties.

The pipe-like deposits range in size from less than a foot in diameter to 155 feet long by 106 feet wide. In plan some are oval, as at the Lucky Louie mine, and others are highly irregular as at the Bell Hill property. In section, a few of the pipes are vertical, but most show a definite plunge at a moderate to high angle (52 to 90 degrees). Most of the pipes plunge east with little variation, but a few show a reversal of plunge. The Bell Hill pipe, for example, plunges 52° northeast above the 87-foot level, and 70° east-southeast below it.

Most of the fluorite pipes show a consistent tendency to narrow with depth. Some bodies, such as the large pipe on the Dell claims, were remarkably uniform, but most ore bodies diminish in size. Some pipes pinch quite rapidly, such as that at the Lucky Louie, which has an oval cross section with a length of 35 feet and a maximum width of 14 feet at the surface, and a length of 10 feet and a maximum width of 7.5 feet at a depth of 120 feet below the surface. The small oval pipe on the Harrisite property was 6 feet long by 4 feet maximum width at surface and was 4 feet long by 2 feet wide at a depth of 22 feet below the surface. Other pipes that diminish in size with depth are the Floride, the east pipe on the Fluorine Queen property, the Blowout, the two large pipes on the Bell Hill property, and the Oversight.

Some ore bodies also change radically in shape. The large ore body of the Bell Hill has an H-shape on the surface and is lenticular on the 60-foot level. The east ore body of the Fluorine Queen on the adit level has a large irregular dolomite horse, which is not found on the surface. The large pipe on the Oversight property splits into two smaller pipes about 60 feet below the surface (Bauer, 1952, p. 36).

At the surface and in underground workings, the fluorite pipes are found in both members of the Lost Sheep dolomite, the Harrisite dolomite, the Bell Hill dolomite, both members of the Floride dolomite, the Fish Haven dolomite, acid intrusives, and intrusive breccias. Two pipes on the Dell property are reported to have been followed to the massive quartzite member of the Swan Peak formation. The miners reported the ore bodies were cut off at both places. The bottom of the large pipe was inaccessible, but the smaller western pipe was examined. Although this ore body is cut off, fluorite mineralization does not end at the quartzite. Instead anastamosing veins as wide as 6 inches extend into the quartzite for at least several feet. The fluorite veins, however, appear to become smaller as they penetrate farther into the quartzite.

Veins.--Veins are common throughout Spors Mountain but most of them are small. Only one vein, the Thursday, has produced fluorite and its production amounted to only about 55 tons (Bauer, 1952, p. 38). Claims have been located, however, on a number of vein deposits. Besides the Thursday these include the Eagle Rock, Lost Soul, and Blue Queen No. 1 claims. In addition, some of the properties including the Bell Hill, Harrisite, and Dell, which have pipe-like deposits, contain lesser amounts of fluorite in veins.

Fluorite veins range in width from a fraction of an inch to 14 feet and in length from a few inches to at least 220 feet. One of the chief characteristics of the veins is their variation in thickness. In a trench on the Eagle Rock property, for example, a vein 4 feet wide at the depth of 6 to 12 feet is absent at the depth of 2 feet.

The veins strike in all directions and most of them dip steeply. In some places the veins form irregular networks. Examples of these networks may be seen at two places on the Bell Hill property and on the adit level of the Oversight property.

Veins have been found in the Sevy dolomite, Thursday dolomite, Lost Sheep dolomite, Harrisite dolomite, Bell Hill dolomite, Floride dolomite, Fish Haven dolomite, acid intrusives, intrusive breccias, and even in lapilli tuff. No fluorite has been reported from the Simonson and Guillmette formations, the shale member of the Swan Peak formation or the Garden City formation, but outcrops of these formations are not common on the main ridge of Spors Mountain and the lack of mineralization may be due to their scarcity in the highly mineralized parts of the district.

Disseminated deposits.--Fluorite is disseminated in volcanic rocks chiefly along the south and west side of Spors Mountain. The fluorite content of these deposits rarely exceeds 30 percent, and no attempt has been made to market this low-grade material, though numerous claims have been located.

The deposits occur in latite, rhyolite, and tuff, commonly close to the contact with the dolomite where the volcanics have been altered. This alteration zone is several feet thick and starts in fresh volcanic rock and gradually becomes soft and clayey toward the dolomite. The carbonate content of this zone increases in the same direction. Original texture of the volcanic rock can be traced in the altered zone to within approximately 1 foot of the dolomite. At the Harrisite mine and at a prospect 1,650 feet northwest of the Lucky Louie mine (pl. 3), disseminated deposits are adjacent to veins and pipe-like fluorite bodies in the dolomite. At other properties, such as the Rainbow No. 2, the deposits are in tuff adjacent to faults.

The size and shape of the disseminated deposits are not known, as both fluorite and volcanic rocks weather easily and are covered with a blanket of debris. Exposures are limited to pits and trenches, and the low grade of the deposits has encouraged little prospecting.

The distribution of fluorite in the volcanic rocks is irregular; it may constitute 15 percent of the rock in one place and only a fraction of a percent a few feet away. The richest and most extensive deposits occur in tuff, where fine-grained purple fluorite is found completely replacing clay-rich layers around large fragments in the tuff (pl. 21) as well as replacing some of the smaller lithic fragments. Fluorite in flow rocks occurs as thin veinlets and as small crystals lining cavities and fractures.

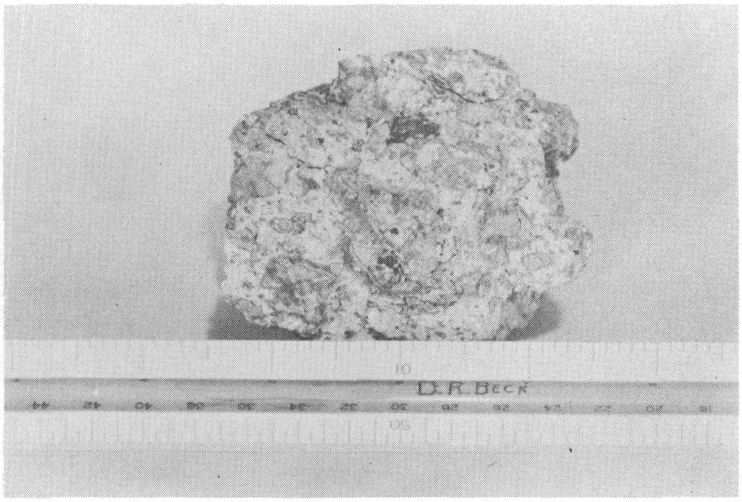

Plate 21.--Fluorite in narrow clay-rich layers around fragments in tuff.

Structural control

The fluorite deposits are formed by replacement along shattered zones in dolomite or volcanic rocks. Most of the mined deposits have been found in the dolomites, controlled by two chief types of structural environment: (1) in or adjacent to faults, and (2) adjacent to intrusive breccia bodies. Fluorite bodies along faults include: the pipe in pit no. 1 on the Bell Hill property, which is in a fracture zone between two faults; the pipe in pit no. 2 on the Bell Hill property, which is on the footwall of a fault; the deposit in trench no. 1 on the same property found along the same fault; the Floride pipe, on the hanging-wall side of a fault; and the small Harrisite pipe. Most other deposits are in fracture zones adjacent to the intrusive breccia pipes. These include the three pipes on the Dell property, the Blowout pipe, and the main pipe on the Lost Sheep property.

Some pipes, though in areas containing both faults and intrusive breccias, are not apparently adjacent to either. The ore body at the Oversight mine, for example, is 65 feet from the closest fault and 150 feet from an intrusive breccia body. The Lucky Louie pipe is also in a highly faulted area but is approximately 90 feet from the nearest fault. Similarly both pipes on the Fluorine Queen property are in a faulted area but neither is adjacent to any of the faults. These ore bodies may, however, overlie an intrusive body, during whose intrusion the overlying sediments were shattered forming channel ways for the later fluorine-rich fluids.

Veins commonly fill faults or small shears. The large Thursday vein is along a small fault and many veins adjacent to faults may be noticed on plate 5.

Replacement of the country rock by fluorite is indicated by relict structures. Deposits disseminated in volcanics with only part of the rocks replaced by fluorite provide the clearest examples (pl. 21), but relict structures still remain in the more completely replaced dolomite. Bauer (1952, p. 20) states that the chert from a black bed in the middle gray unit of the Lost Sheep dolomite, was probably more inert to the mineralizing agents, and can be traced through both the Blowout and the main Lost Sheep pipes. In the underground workings of the Blowout deposit relict bedding which conforms to that of the adjacent wall rocks can be seen in the fluorite ore. Silurian corals completely replaced by fluorite have been found in three mines. Bauer (1952, pl. 2) found a Favosites sp. in the main Lost Sheep pit. The writers discovered another Favosites sp. in the east pipe of the Fluorine Queen property and a horn coral in the large pipe on the Bell Hill property (pl. 22). During the early work in the area the possibility that all the fluorite pipes were replacements of small igneous and intrusive breccia pipes was discussed. The less complete replacement of the volcanic material lends credence to this view, but more careful examination of the larger and higher grade pipes showed that most of the ore bodies were in the dolomite.

Character of ore

The fluorite of the Thomas Range is unique, and though it contains 65 to 95 percent CaF_2, it has so little resemblance to ordinary fluorite as to be almost unrecognizable. Instead of forming coarse purple or green cubes, it is fine grained, almost clay-like and occurs in soft friable masses that may be brown, white, bluish, purple, or any mixture of these colors. The less common resistant pieces are generally boxworks (pls. 23 and 24) consisting of a network of fine fluorite veinlets from which the interstitial material has been removed, leaving open vuggy spaces.

Narrow veinlets of hard crystalline fluorite, consisting of a few colorless or pale purple cubes 1 to 2 mm across, were found in only four places: (1) the Hilltop No. 1 claim, (2) the Dell No. 5 claim, (3) a claim in the northern part of Spors Mountain, and (4) in rhyolite along the eastern edge of the district.

The chief impurity is a white waxy clay mineral called by the miners "mutton tallow," which it closely resembles. This mineral is not readily distinguishable from the fluorite when well intermixed with it. On some properties concentrations of clay as much as 1 foot across were found, as in the underground workings of the Blowout pipe. Three specimens of clay were taken from the main underground workings of the large Blowout pipe and one specimen each from the underground workings on a second small pipe on the same property, from a stope on the 87-foot level of the Bell Hill mine, and from surface workings of the main pipe on Harrisite property. E. W. Tooker of the Geological Survey X-rayed the samples using nickel filtered copper $K\alpha$ radiation. The resulting data indicated that all samples are Ca-Mg montmorillonite.

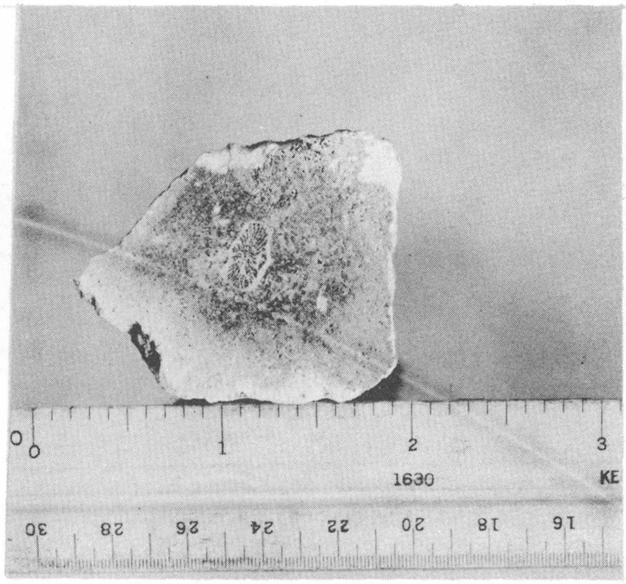

Plate 22.--Horn coral completely replaced by fluorite from center of large ore body, Bell Hill property.

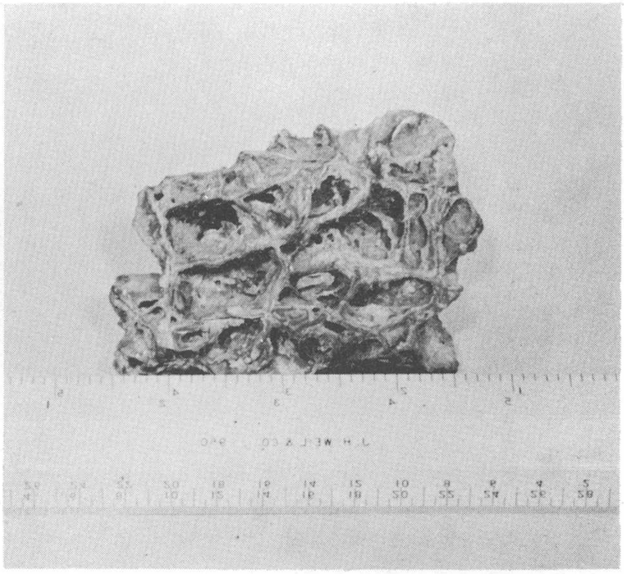

Plate 23.--Brown boxwork fluorite ore from the Oversight mine.

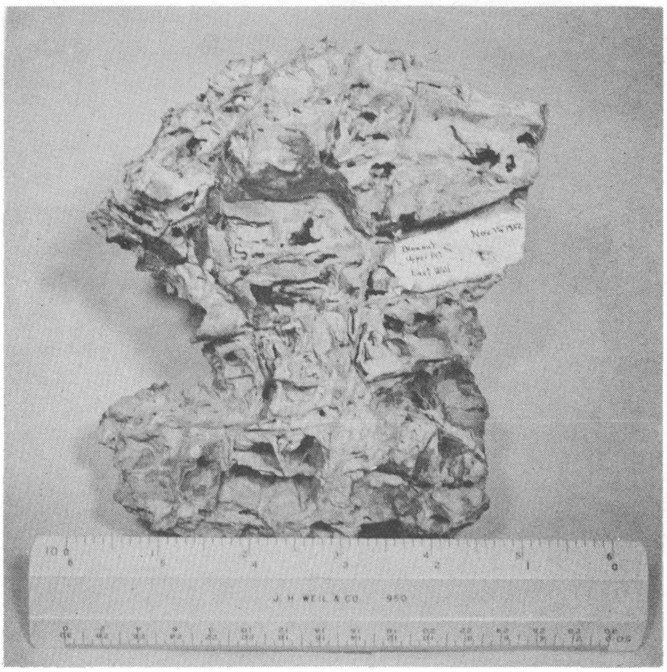

Plate 24.--Boxwork of pale purple fluorite from open cut, Blowout mine.

Quartz, dolomite, chalcedony which resembles chert, calcite, and opal are the other gangue minerals. Small clear quartz crystals form coatings on boxwork type ore as in the Oversight and Blowout mines. White wedge-shaped dolomite crystals accompany the quartz in many places, and in one place in the Oversight mine they fill fractures in the dolomitic country rock (pl. 25). Ore at the Lost Sheep mine, the Lucky Louie mine, the unnamed adit, and the Rainbow No. 2 mine contains chert. Calcite is much less common than dolomite and was observed only from the underground workings of the Blowout mine. Opal has been reported (Thurston, and others, 1954) from the Nonella property.

The fluorite bodies have sharp contacts with the surrounding dolomite. The dolomite shows no visible alteration even adjacent to the largest ore bodies, such as those on the Lost Sheep and Fluorine Queen properties.

The fluorite content of some of the ore has been high. The first carload of fluorite shipped from the Floride mine in 1944 contained 95 percent CaF_2 and 1 percent SiO_2 (Fitch, Quigley, and Barker, 1949, p. 65). A carload of ore shipped from the Lost Sheep mine in 1948 contained 94.9 percent CaF_2, 0.044 percent SiO_2 and 0.012 percent S (Fitch, Quigley, and Barker, 1949, p. 66). Ray Spor (1953, written communication) reported that the Floride mine between 1944 and 1948 averaged 77.5 percent CaF_2 and 0.9 percent SiO_2 and in 1950 averaged 75.2 percent CaF_2 and 1.1 percent SiO_2. The Dell No. 5 mine which also was operated by the Spor family, averaged 71.9 percent CaF_2 and 5.2 percent SiO_2. Fred Staats (1953, written communication) reports that carload lots from the Oversight mine in 1952 contained from 73 to 89.8 percent CaF_2 and from 2.2 to 4.2 percent SiO_2. W. W. Watson (1953, written communication) of Chief Consolidated Mining Company states that though the assay values for every shipment were not returned, a composite assay of those provided showed the Lucky Louie in 1952 averaged 81.6 percent CaF_2 and 5.2 percent SiO_2. The SiO_2 content of the ore in some deposits, such as the Blowout, Lost Sheep, and Fluorine Queen mine, comes mainly from montmorillonite, because quartz and chalcedony are but minor constituents of the ore.

Not only does the size of some deposits change with depth but in some the character of the ore changes also. Many of the deposits have been worked only near the surface and no information is available

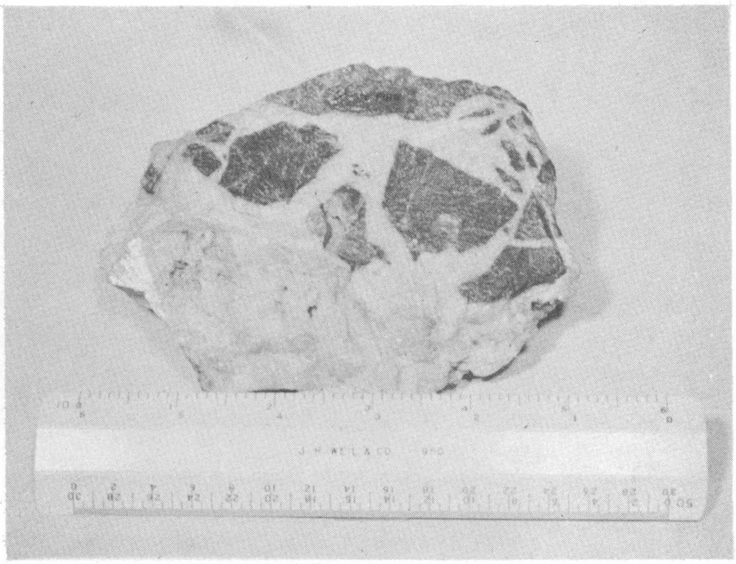

Plate 25.--White dolomite along fractures in gray dolomite country rock.

at depth. The large ore body on the Dell property was mined to a depth of 200 feet below the surface with no reported change in grade. The Blowout mine, in contrast, shows considerable change. In the surface pit the fluorite contains few impurities, but on the adit level 240 feet below, the fluorite contains masses of montmorillonite with minor quartz, dolomite and calcite. At the surface the Lucky Louie was made up almost entirely of fluorite, at 90 feet below the surface black angular pieces of hydrothermal chalcedony resembling chert are found in the ore, and at 120 feet below the surface the entire central part of the much reduced pipe is made up of chalcedony. From the surface to a depth of approximately 80 feet, the large pipe on the Oversight property consisted of a brown boxwork of fluorite; however, an adit driven 150 feet below the surface encountered only fractured dolomite country rock surrounded by a boxwork of brown fluorite veinlets. The large ore body on the Bell Hill can be followed down to the 129-foot level with little apparent change, but on the 150-foot level the east end of the ore body contains a band approximately 8 feet thick of hard vuggy material consisting of quartz and light-colored dolomite. On the lowest level this material is noted both on the east end and along the south side of the deposit. Most ore bodies have shown a change of mineralization with depth, and those that have been mined to depths of greater than 80 feet show that the upper part of the ore body contains chiefly fluorite and that the lower part contains various other minerals in addition to fluorite. The change from rich to lean fluorite ore is commonly fairly abrupt, and with continued depth the tenor of the ore decreases. The lower parts of different deposits vary in composition with the impurities being chiefly montmorillonite, chalcedony, or hydrothermal dolomite and small quartz crystals. This difference may reflect the type of country rock through which the fluorine-rich fluids passed.

Uranium mineralization

Almost all the fluorite deposits show abnormal radioactivity; however, visible uranium minerals are scarce. Powdery yellow uranium minerals were observed only at five deposits: the Eagle Rock vein, the large pipe on the Bell Hill property, a small vein on the contact between basalt and dolomite on the

Harrisite property, the Floride pipe, and the west pipe on the Fluorine Queen property. It was rare at all these localities with the exception of the small Eagle Rock vein. At only two of these properties--the Eagle Rock and Fluorine Queen--did the megascopic uranium mineral actually occur in the ore itself; in the others, it was found on the dolomite or the basalt adjacent to the fluorite body. X-ray examination showed the yellow uranium minerals from the Eagle Rock and Bell Hill properties to be carnotite, but the powder pattern of the yellow uranium mineral from the Harrisite did not match that of any known mineral. Subsequent spectrographic analysis showed that uranium and silicon were the two major constituents.

Fluorite ore from the large Bell Hill pipe, west pipe of the Fluorine Queen mine, main pipe of the Lost Sheep mine, and Blowout pipe was analyzed for vanadium. The Bell Hill contained an excess of uranium; in all others the amount of uranium present was 2.5 to 6.5 times less than the amount needed to form carnotite with the available vanadium. Therefore, another vanadium mineral besides carnotite must be present. If this mineral is one of the other six known uranium-vanadium minerals (Frondel and Fleischer, 1952, p. 3-5, 8-11), it is probably rauvite ($CaO.2UO_3.5V_2O_5.16H_2O$), as this is the only mineral with high enough vanadium to uranium ratio. It, however, might equally well be a vanadium mineral with no uranium.

Autoradiographs were made of several specimens of ore containing better than 0.10 percent uranium in an attempt to localize uranium minerals in the fluorite ore. The autoradiographs showed no concentration of uranium but a more or less uniform haze across the whole autoradiograph. Heavy mineral separates, some of which were centrifuged, contained no recognizable uranium minerals. It is probable that the uranium is either in a uranium mineral with clay size dimensions, scattered through the fluorite or contained in the fluorite lattice. If it is in the lattice, it may substitute for Ca in the lattice or it may fill holes in the structure.

The uranium content of the various veins and pipes ranged from less than 0.003 to 0.33 percent (table 8). Only four properties, however, were found to contain more than 0.10 percent uranium. The largest of these is the pit no. 1 orebody on Bell Hill, from which four surface samples contained over 0.20 percent uranium. The ore bodies on the other three properties are small. These include a vein of

Table 8.--Analyses of samples from the Thomas Range fluorite district, Juab County, Utah.
(All analyses by U. S. Geological Survey, Denver Colorado)

Property	Ore body	Location	Material	Equivalent uranium (percent)	Uranium (percent)	Fluorite[1] (percent)
Bell Hill	Trench no. 1, south body	Surface	Fluorspar	0.028[2]	0.029[3]	---
Do.	do.	do.	do.	0.044[2]	0.059[3]	---
Do.	Trench no. 2	do.	do.	0.012[2]	0.012[3]	---
Do.	Trench no. 3, west body	do.	do.	0.030[2]	0.036[3]	---
Do.	Trench no. 3, east body	do.	do.	0.012[2]	0.010[3]	---
Do.	do.	do.	do.	0.038[2]	0.038[5]	---
Do.	Trench no. 4	do.	do.	0.006[4]	0.006[5]	---
Do.	Pit no. 1	open cut	do.	0.27[2]	0.32[3]	78.5
Do.	do.	do.	do.	0.22[2]	0.26[3]	88.2
Do.	do.	do.	do.	0.085[2]	0.093[3]	90.1
Do.	do.	do.	do.	0.25[2]	0.25[6]	---
Do.	do.	do.	do.	0.33[2]	0.33[6]	---
Do.	do.	do.	do.	0.16[2]	0.17[6]	---
Do.	do.	do.	do.	0.19[2]	0.18[6]	---
Do.	do.	69-foot level	do.	0.19[4]	0.17[7]	}
Do.	do.	do.	do.	0.11[4]	0.094[7]	}
Do.	do.	do.	do.	0.17[4]	0.15[7]	} 80.8
Do.	do.	do.	do.	0.067[4]	0.049[7]	}
Do.	do.	do.	do.	0.19[4]	0.15[7]	}
Do.	do.	do.	do.	0.095[4]	0.069[7]	}
Do.	do.	87-foot level	do.	0.13[4]	0.11[5]	87.8
Do.	do.	do.	do.	0.15[4]	0.15[5]	88.2

Table 8.--Analyses of samples from the Thomas Range fluorite district, Juab County, Utah--Continued.

Property	Ore body	Location	Material	Equivalent uranium (percent)	Uranium (percent)	Fluorite[1] (percent)
Bell Hill	Pit no. 1	87-foot level	Fluorspar	0.15[4]	0.14[8]	---
Do.	do.	do.	do.	0.18[4]	0.14[7]	
Do.	do.	do.	do.	0.069[4]	0.049[7]	63.0
Do.	do.	do.	do.	0.058[4]	0.051[7]	
Do.	do.	do.	do.	0.088[4]	0.059[7]	
Do.	do.	108-foot level	do.	0.10[4]	0.076[7]	
Do.	do.	do.	do.	0.18[4]	0.12[7]	
Do.	do.	do.	do.	0.043[4]	0.029[7]	67.6
Do.	do.	do.	do.	0.074[4]	0.056[7]	
Do.	do.	do.	do.	0.10[4]	0.090[7]	
Do.	do.	do.	do.	0.10[4]	0.072[7]	
Do.	do.	129-foot level	do.	0.094[4]	0.070[7]	
Do.	do.	do.	do.	0.19[4]	0.16[7]	
Do.	do.	do.	do.	0.072[4]	0.060[7]	89.5
Do.	do.	do.	do.	0.12[4]	0.096[7]	
Do.	do.	do.	do.	0.066[4]	0.050[7]	
Do.	do.	150-foot level	do.	0.14[4]	0.12[7]	
Do.	do.	do.	do.	0.17[4]	0.15[7]	
Do.	do.	do.	do.	0.12[4]	0.092[7]	84.8
Do.	do.	do.	do.	0.17[4]	0.14[7]	
Do.	do.	do.	do.	0.14[4]	0.12[7]	
Do.	do.	do.	do.	0.14[4]	0.13[7]	

Table 8.--Analyses of samples from the Thomas Range Fluorite district, Juab County, Utah--Continued.

Property	Ore body	Location	Material	Equivalent uranium (percent)	Uranium (percent)	Fluorite[1] (percent)
Bell Hill	Pit no. 1	168-foot level	Fluorspar	0.18[4]	0.15[7]	}
Do.	do.	do.	do.	0.093[4]	0.074[7]	} 84.8
Do.	do.	do.	do.	0.14[4]	0.11[7]	}
Do.	do.	do.	do.	0.11[4]	0.080[7]	}
Do.	do.	SW-trending winze	do.	0.11[4]	0.090[7]	94.3
Do.	do.	103-feet down, NE.-trending winze	do.	0.21[4]	0.15[9]	88.0
Do.	Small vein	Drill hole no. 2, 256.3-256.8 feet	Fluorspar and silicified dolomite	0.087[4]	0.060[9]	25.6
Do.	Pit no. 1	Drill hole no. 2, 291.6-296.7 feet	Siliceous fluorspar	0.070[4]	0.051[9]	65.6
Do.	do.	Drill hole no. 2, 296.7-299.7 feet	do.	0.076[4]	0.054[9]	55.1
Do.	do.	Drill hole no. 2, 299.7-304.7 feet	Fluorspar.	0.14[4]	0.11[9]	63.3
Do.	do.	Drill hole no. 2, 305.8-307.8 feet	do.	0.15[4]	0.12[9]	76.4
Do.	do.	Drill hole no. 2, 307.8-311.2 feet	do.	0.13[4]	0.10[9]	63.5
Do.	do.	Drill hole no. 2, 311.2-312.3 feet	do.	0.13[4]	0.10[9]	75.2
Do.	do.	Drill hole no. 2, 312.3-315.8 feet	Dolomite cut by fluorspar	0.11[4]	0.080[9]	46.7
Do.	do.	Drill hole no. 2, 315.8-320.7 feet	do.	0.011[4]	0.008[9]	5.17
Do.	do.	Drill hole no. 2, 320.7-323.7 feet	Fluorspar	0.11[4]	0.090[9]	61.5
Do.	do.	Drill hole no. 2, 323.7-328.1 feet	do.	0.19[4]	0.15[9]	77.0
Do.	do.	Drill hole no. 2, 328.1-330.4 feet	do.	0.10[4]	0.076[9]	75.2

Table 8.--Analyses of samples from the Thomas Range Fluorite district, Juab County, Utah--Continued.

Property	Ore body	Location	Material	Equivalent uranium (percent)	Uranium (percent)	Fluorite[1] (percent)
Bell Hill	Pit no. 1	Drill hole no. 2, 330.4-334.2 feet	Fluorspar with Dolomite	0.12[4]	0.088[9]	58.9
Do.	do.	Drill hole no. 2, 334.2-344.0 feet	Dolomite with fluorspar veinlets	0.014[4]	0.009[9]	7.78
Do.	do.	Ore bin	Fluorspar	0.19[4]	0.21[5]	88.8
Do.	do.	do.	do.	0.19[4]	0.20[10]	88.0
Do.	do.	do.	do.	0.19[4]	0.15[10]	84.5
Do.	do.	do.	do.	0.15[4]	0.18[10]	72.5
Do.	do.	do.	do.	0.14[4]	0.16[10]	81.5
Do.	do.	do.	do.	0.13[4]	0.086[10]	---
Do.	do.	do.	do.	0.042[4]	0.047[10]	---
Do.	Pit no. 2	Open cut	do.	0.070[2]	0.073[6]	---
Do.	do.	do.	do.	0.048[2]	0.052[3]	---
Do.	do.	do.	do.	0.061[2]	0.061[3]	---
Do.	do.	do.	do.	0.067[2]	0.064[3]	---
Blowout	do.	do.	do.	0.010[2]	0.005[5]	92.0
Do.		do.	do.	0.028[2]	0.033[5]	79.6
Do.		do.	do.	0.007[4]	0.008[7]	
Do.		do.	do.	0.014[4]	0.011[7]	86.8
Do.		do.	do.	0.011[4]	0.011[7]	
Do.		do.	Altered rhyolite	0.003[2]	0.004[5]	---
Do.		Adit	Fluorspar	0.013[2]	0.013[10]	72.1
Do.		do.	do.	0.008[4]	0.004[11]	---
Do.		do.	do.	0.012[4]	0.004[11]	---
Do.		do.	do.	0.012[4]	0.005[11]	---

Table 8.--Analyses of samples from the Thomas Range Fluoride district, Juab County--Continued.

Property	Ore body	Location	Material	Equivalent uranium (percent)	Uranium (percent)	Fluorite[1] (percent)
Blue Queen		Adit	Fluorspar	0.006[4]	0.004[8]	---
Dell	North body	do.	do.	0.076[2]	0.083[3]	---
Dell	Vein	North adit	do.	0.015[2]	0.016[3]	---
Dell No. 5	North ore body	Surface	do.	0.024[2]	0.020[10]	---
Do.	South ore body	Adit	do.	0.012[2]	0.012[3]	---
Do.	do.	do.	do.	0.033[2]	0.030[10]	---
Eagle Rock		Pit	do.	0.16[2]	0.17[10]	---
Do.		Ore pile	do.	0.18[2]	0.18[10]	---
Floride		Surface	do.	0.017[4]	0.008[11]	---
Do.		do.	do.	0.029[4]	0.021[11]	---
Do.		do.	do.	0.035[4]	0.025[7]	49.5
Do.		Upper adit-level	do.	0.022[4]	0.015[7]	66.8
Do.		Lower adit-level	do.	0.014[4]	0.010[7]	63.5
Do.		do.	do.	0.007[4]	0.006[7]	
Do.		do.	do.	0.016[2]	0.015[6]	---
Do.		do.	do.	0.006[2]	0.005[5]	55.1
Fluorine Queen	West ore body	Open cut	do.	0.040[2]	0.039[10]	---
Do.	do.	do.	do.	0.033[2]	0.018[10]	---
Do.	East ore body	do.	do.	0.017[2]	0.020[10]	61.0
Do.	do.	do.	do.	0.021[2]	0.019[10]	71.3
Do.	do.	do.	do.	0.016[4]	0.023[10]	---
Do.	do.	Adit	do.	0.012[4]	0.010[8]	68.0
Do.	do.	do.	do.	0.015[4]	0.006[8]	82.5
Do.	do.	do.	do.	0.013[4]	0.008[8]	72.6

Table 8. --Analyses of samples from the Thomas Range fluorite district, Juab County, Utah--Continued.

Property	Ore body	Location	Material	Equivalent uranium (percent)	Uranium (percent	Fluorite[1] (percent)
Fluorine Queen	Western small ore body	Surface	Fluorspar	0.013[4]	0.010[8]	---
Do.	Prospect	do.	do.	0.002[4]	---	---
Fluorine Queen No. 4		do.	Fluorspar with dellenite	0.019[2]	0.022[5]	---
Do.		Cut	do.	0.014[4]	0.015[8]	---
Do.		do.	do.	0.017[4]	0.012[8]	---
Do.		Surface	Fluorspar	0.019[4]	0.015[7]	57.3
Harrisite	Wash zone	Open cut	do.	0.12[2]	0.13[6]	---
Do.	do.	do.	do.	0.13[2]	0.16[3]	---
Do.	do.	do.	do.	0.088[2]	0.095[3]	---
Do.	do.	do.	do.	0.15[2]	0.17[3]	---
Do.	do.	do.	do.	0.11[4]	0.073[5]	---
Do.	Vein	Trench	do.	0.084[2]	0.089[6]	---
Do.	do.	do.	Altered basalt	0.011[2]	0.008[6]	---
Do.	Basalt ore body	Open cut	do.	0.039[4]	0.039[5]	---
Do.	do.	do.	do.	0.094[4]	0.094[5]	---
Do.	Prospect	Open cut 800 NW. of main workings	Fluorspar	0.037[4]	0.039[5]	---
Hilltop No. 1	North ore body	Open cut	do.	0.007[4]	0.010[10]	---
Do.	do.	do.	do.	0.005[4]	0.006[7]	59.5
Do.	South ore body	do.	do.	0.009[4]	0.011[10]	---
Lost Sheep	Main ore body	do.	do.	0.020[2]	0.020[10]	82.7
Do.	do.	do.	do.	0.014[2]	0.009[10]	88.0
Do.	do.	do.	do.	0.018[4]	0.011[10]	---

Table 8.--Analyses of samples from the Thomas Range fluorite district, Juab County, Utah--Continued.

Property	Ore body	Location	Material	Equivalent uranium (percent)	Uranium (percent)	Fluorite[1] (percent)
Lost Sheep	Main ore body	Open cut	Fluorspar	0.024[4]	0.016[7]	88.5
Do.	do.	do.	do.	0.019[4]	0.014[7]	
Do.	do.	do.	do.	0.021[4]	0.029[7]	78.6
Do.	do.	do.	do.	0.021[4]	0.016[7]	
Do.	Vein 25 feet east of main ore body	do.	do.	0.048[4]	0.033[7]	---
Do.	South ore body	Surface	do.	0.016[2]	0.014[10]	66.7
Do.	do.	Adit	do.	0.012[4]	0.009[7]	82.5
Lost Soul No. 1	North vein	do.	do.	0.005[4]	0.003[8]	---
Do.	South vein	do.	Fluorspar and dolomite	0.005[4]	0.004[8]	---
Lucky Louie		Surface	Fluorspar	0.059[2]	0.051[10]	60.4
Do.		6 feet below surface	do.	0.069[4]	0.078[10]	74.0
Do.		59 feet below surface	do.	0.059[4]	0.049[8]	78.6
Nonella		Surface	do.	0.014[2]	0.008[5]	---
Oversight	Main ore body	do.	do.	0.007[4]	0.006[7]	62.1
Do.	do.	Ore pile	do.	0.005[4]	0.007[10]	---
Do.	do.	Adit	do.	0.004[4, 12]	0.003[7, 12]	83.5[1]
Do.	Southeast ore body	21 feet below surface	do.	0.005[4]	0.005[10]	---

Table 8.--Analyses of samples from the Thomas Range fluorite district, Juab County, Utah--Continued

Property	Ore body	Location	Material	Equivalent uranium (percent)	Uranium (percent)	Fluorite[1] (percent)
Thursday	Large vein	Large open cut	Fluorspar	0.012[2]	0.012[5]	---
Do.	Prospect	Small pit	do.	0.002[4]	---	---
Unnamed adit		Adit	Breccia and fluorspar	0.002[4]	---	---
Do.		do.	Dolomite	0.003[4]	---	---
Prospect	Vein	3,550 feet south of the Eagle Rock	Fluorspar	0.001[4]	---	---
Do.	do.	4,300 feet southeast of the Fluorine Queen	do.	0.019[4]	0.011[8]	---
Do.	do.	3,200 feet northeast of the Lucky Louie	do.	0.12[4]	0.15[10]	---
Do.	Disseminated	do.	Fluorspar and clay	0.012[4]	0.019[10]	---
Do.	Vein	1,650 feet northwest of the Lucky Louie	Fluorspar	0.059[4]	0.064[10]	---
Do.	Disseminated	do.	Fluorspar and altered dellenite	0.016[4]	0.021[10]	---
Do.	do.	6,000 feet west of the Bell Hill	Fluorspar in tuff	0.009[4]	0.007[8]	2.9
Do.	do.	9,300 feet southwest of the Thursday	Fluorspar in dacite	0.005[4]	0.004[8]	3.8
Do.		1,600 feet north of the Oversight	Alluvium	0.001[4]	---	---

1. Fluorite content calculated from fluorine analyses by Blanche Ingram
2. Radiologist, J. N. Rosholt, Jr.
3. Analyst, Jesse Meadows
4. Radiologist, S. P. Furman
5. Analyst, James Wahlberg
6. Analysts, G. W. Boyes, Jr., A. C. Horr, and E. C. Mallory, Jr.
7. Analyst, R. F. Dufour
8. Analyst, Wayne Mountjoy
9. Analysts, G. T. Burrow and Wayne Mountjoy
10. Analyst, G. W. Boyes, Jr.
11. Analyst, Jesse Meadows and J. P. Schuch
12. __/ Rock consists of a network of brown friable fluorspar surrounding blocks of dolomite. Sample consists of only the fluorspar part.

dark-purple fluorite several inches thick and 6 feet or so long that analyzed 0.15 percent uranium, in a prospect 3,200 feet northeast of the Lucky Louie mine, a similar vein 4 feet wide and at least 40 feet long on the Eagle Rock claim, and two small pipes and several veins filled with whitish fluorite on the Harrisite claims. The small pipes developed in the hanging wall of a small thrust, along which the ore appears to have moved for a short distance.

The Eagle Rock prospect occurs on the northeast part of Eagle Rock Ridge (fig. 2 and pl. 6). The three other deposits occur on the southern end of Spors Mountain (fig. 2 and pl. 5). This relatively small area appears to be the best place to prospect for fluorite deposits with a relatively high uranium content.

The uranium content (table 8) within the same deposit varies from place to place, even on the same level. A distinct decrease in grade occurs in a number of deposits between the surface and the underground workings. An excellent example of this is furnished by the large ore body on the Bell Hill property. Samples from the open cut contained 0.32, 0.26, 0.093, 0.25, 0.33, 0.17 and 0.18 percent uranium and samples from the 69-foot level contained 0.17, 0.094, 0.15, 0.049, 0.15, and 0.069 percent uranium. Another example is the east pipe of the Fluorine Queen, where samples from the open cut contained 0.020, 0.019, and 0.023 percent uranium and those from the adit contained 0.010, 0.006, and 0.008 percent uranium. A similar trend, but on fewer samples, is seen at the Oversight, where a surface sample contained 0.006 percent uranium and one from the adit about 150 feet below contained 0.003 percent uranium; and at the south ore body of the Lost Sheep property which had 0.014 percent uranium at the surface and 0.009 percent in the adit 45 feet below. The main ore body on the Lost Sheep property showed no statistically significant decrease in percent uranium between the surface and a depth of 71 feet.

At first it was believed that the change in uranium content was due to zoning with a gradual decrease in uranium content with depth. As some of the ore deposits are exposed only at the surface, and others are accessible only at two levels (the surface and at one place below) this theory appeared quite feasible. Table 8 and graphs of individual samples plotted against depth also seemed to substantiate this view. With the deepening of the Bell Hill mine it was possible to obtain numerous samples from a number of elevations. A series of samples were taken on six underground levels and from the drill hole that cut the ore body. The analyses of the samples from all levels below and including the 69-foot level showed no greater deviation than was found between individual samples from the same level.

To test the distribution of uranium in the Bell Hill ore body, the statistical method outlined by Blair (1944, p. 481) for comparing groups of samples was used. This statistical method is used to calculate the probability that the difference of the standard deviation between two sample groups is significant, and to show whether or not the two sample groups are related.

The samples from Bell Hill pit no. 1 were compared with the samples from the 69-foot level. For these two groups of 6 samples each the value of 0.05 to 0.02 for the probability suggests that the chances are at least 20 to 1 that the sample groups are different. According to Blair (1944, p. 481) this is not conclusive proof that the two groups are separate, but it is a strong indication that they are. Groups of samples from the 82-foot (adit) level in the Bell Hill mine and the 110-foot level give a probability of 0.4 to 0.5. The difference between these groups is, therefore, not significant and they are probably related. For groups of samples from the 129-foot level and the 150-foot level the probability is 0.9 to 0.8; so the chances are about 20 to 1 that all samples were drawn from the same group; this is a statistically significant probability and suggests that the two groups of samples are related.

The statistical results suggest, perhaps strongly, that the high uranium percentages near the surface in the Bell Hill ore body are not related to the lower grade ore found at depth, and that the mineralization at the surface is, therefore, not due to primary mineralization but to some later reorganization of the material.

The average uranium content was obtained by weighting the chemical analyses of channel and grab samples, except at the north body in Trench no. 1, where it was estimated from Geiger-Mueller counter readings. Each level was carefully sampled and it was found that there was considerable variance between grade of samples of the same level. Each level was individually averaged, and this average plotted on a graph (fig. 5). Although variation occurs between the averages from the different levels, most of the averages fall within rather narrow boundaries, determined on figure 5 by plotting the standard error of the

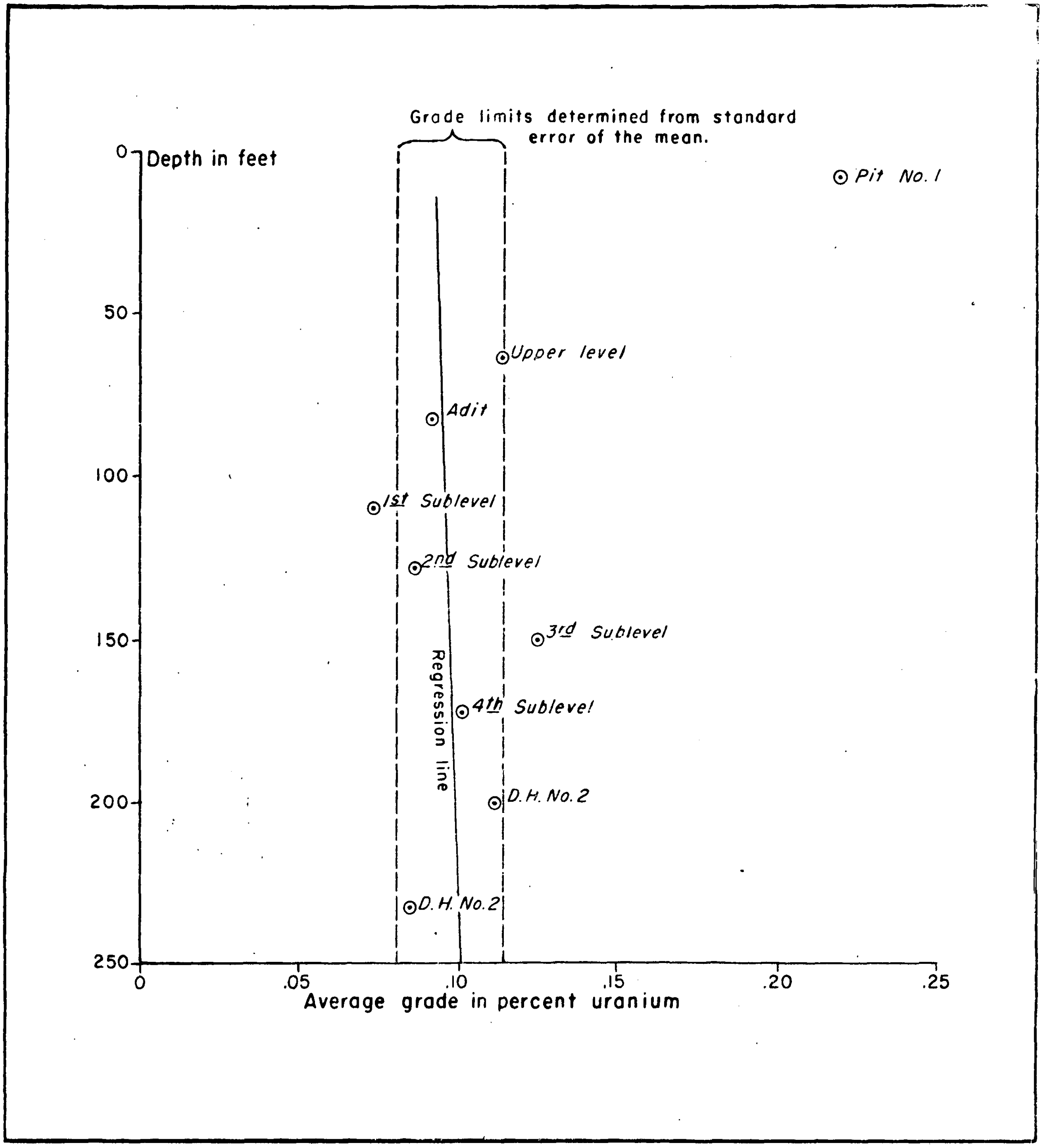

FIGURE 5.-GRAPH SHOWING RELATIONSHIP BETWEEN URANIUM CONTENT AND DEPTH IN LARGE ORE BODY ON BELL HILL PROPERTY

(The average grade for Pit No. 1 was omitted from all statistical calculations) mean for all averages, except that for pit no. 1, above and below the mean value. The exact slope of the line of regression probably has little significance as the 0-foot and 250-foot intercepts differ by only 0.007 percent which is much less than the standard error of 0.016 percent. For this reason the line is considered vertical at 0.097 percent (mean value). The steepness of the regression line and the standard error suggest that 68 percent of all averages in percent uranium from all levels in the pipe will lie within $\pm$ 0.016 percent of 0.097 percent uranium.

The abrupt increase in grade at the east ore body of the Fluorine Queen came at approximately the same distance from the surface. The higher grade uranium samples from the open cut came from between 5 and 20 feet below the surface, and the lower grade ones from the adit 53 feet below the surface. The change can be demonstrated close to the surface at the south ore body on the Lost Sheep property. The higher grade sample came from 42 feet below the surface. Thus, the increase of grade at the top appears to be related to the present topographic surface rather than to a gradual zoning.

A comparison between fluorite and uranium content of individual samples (table 8) shows no apparent relationship. The uranium content of any two samples from the same or different elevations may either increase or decrease with the increase of the fluorite content.

The increase of uranium content near the surface is believed to have been caused by slow leaching of the upper part of the ore body, in part from material being actively eroded. The uranium is carried downward and redeposited, at some level between a few inches and approximately 30 feet below the surface.

Uranium is commonly carried in groundwater and many of its salts are highly soluble. D. M. Sheridan (1953, oral communication) notes that on the Red Desert of Wyoming a uranium deposit containing schroeckingerite ($NaCa_3(UO_2)(CO_3)_3(SO_4)F \cdot 10H_2O$) moves annually with the rising and lowering of the water table. Rankama and Sahama (1950, p. 635-636) state: "Another peculiarity in the manner of occurrence of uranium is its concentration, notably in the company of vanadium, in minerals precipitated from ground waters in arid regions."

Leaching of the Thomas Range fluorite deposits is slow because of the deep water table and the small annual precipitation. The depth of the water table is unknown, but in the long tunnels on the Dell and Blowout properties, which pass 220 and 240 feet below the surface exposures of the ore bodies, the water table has not been reached. The Thomas Range is just south of the Great Salt Lake Desert and is quite arid. No record of the amount of precipitation has been kept in this district, but Ives (1951, p. 783) reports the mean annual rainfall at Dugway, 32 miles northeast of the Thomas Range fluorspar district, as about 5 inches. Most of the precipitation in the Thomas Range falls as snow during the winter months; some comes in the summer as torrential cloudbursts. The slow-melting snow saturates the upper few inches to a few feet of the ore body and leaches the uranium out of the fluorite. The downward migrating ground water is quickly absorbed by the dry underlying ore. The uranium is either precipitated as carnotite or some other secondary mineral. The snow is generally gone before the end of February and the long dry spell that follows quickly dries out the rest of the ore. It should be pointed out that the secondary mineral carnotite has only been found in the upper part of the ore bodies. Carnotite is known to precipitate from ground waters in other districts. E. J. McKay (1953, oral communication) reports carnotite deposited on tunnel walls at the Monogram and Jo Dandy mines in East Paradox Valley, Colo. R. C. Coffin (1921, p. 177) noted woodchuck bones coated with calcium carbonate and carnotite at the Friday claim in Long Park, Colo.

In some places, as at the Lost Sheep mine, no surface enrichment is apparent, probably because of accelerated erosion caused by their topographic position.

Origin

The eastern part of the Thomas Range is made up entirely of volcanic rocks capped by a layer of light-gray rhyolite several hundred feet thick. This rhyolite is noted for the presence of the fluorine-bearing mineral topaz, which occurs as a constituent mineral in the ground mass, as small euhedral crystals in lithophysae, and as larger crystals in vugs. The topaz in the ground mass partly replaces feldspars, but the topaz in the vugs appears to have been formed after the rhyolite solidified. This suggests that the rhyolitic magma contained an excess of fluorine, some of which combined during the crystallization of the rhyolite to form the small topaz crystals in the groundmass and some of which formed the larger topaz crystals in the lithophysae and vugs.

On Spors Mountain light-gray rhyolites and quartz latites occur in small veins and plugs, and as fragments in intrusive breccias. Topaz was identified in thin sections of these rocks collected from various parts of Spors Mountain, as well as in the intrusive rhyolitic tuff found in the underground workings of the Bell Hill mine. Table 6 gives rock analyses from a sample of topaz-rich rhyolite from the large rhyolite flow near Topaz Mountain and from a small plug 400 feet southwest of the Eagle Rock fluorite pit. Although some differences are apparent, the similarity of these two analyses suggests that the two rocks crystallized from the same or at least from similar magmas.

The fluorite deposits were in general formed after most of the volcanics were crystallized. This can be illustrated in a number of places: 1) in the tunnel leading to the Blowout mine, where a small purple fluorite vein cuts the intrusive breccia composed of rhyolite fragments; 2) at the north end of a small tunnel on the Dell property, where a fluorite pipe partially replaces a small rhyolite plug; 3) on the Harrisite property, where a small fluorite vein occurs on a dolomite-latite contact and partially replaces both; and 4) at various localities in tuff, which are described in a succeeding section on "Individual deposits." Bauer (1952, p. 27) also describes fluorite veinlets in agglomerate, and the authors found minute purple fluorite crystals filling fractures and vugs in rhyolite near the north flank of Spors Mountain. Although most of the fluorite mineralization followed the formation of the volcanic rocks, at one place the volcanics appear to be later. An intrusive rhyolite tuff cuts a fluorite body in the underground workings of the Bell Hill mine. Thus, the fluorite deposits formed after the bulk of the volcanic activity, but before the last eruptions.

Fluorine is the only major element (those present is amounts greater than 0.25 percent) in these deposits that could not be derived from the underlying country rocks. That the fluorine is of hydrothermal origin is strongly suggested by the unusual fluorine content of the fluorine-bearing rhyolites of the adjoining Thomas Range. Similarly, uranium, which makes up only minor amounts of the fluorite ore bodies must have been derived from the magmas that formed the rhyolites. The association of these rhyolites with uranium was noted on the eastern side of the eastern part of the Thomas Range, where a yellow secondary uranium mineral is found coating fracture surfaces in tuff and rhyolite (Bauer and Staatz, 1951).

Topaz is found in all the acid igneous rocks in the Thomas Range fluorite district, but it was not noted in the latites and is most common in the thick rhyolite flow that caps the eastern part of the Thomas Range. This suggests that the fluorine was most concentrated in the more acid and hence probably the later part of the volcanic series. Thus, it is probable that the fluorine was progressively concentrated during the differentiation of the volcanic magma, with an excess of fluorine being left in a hydrothermal fluid after the consolidation of at least most of the rhyolite. These fluids are believed to be the source of the fluorine that reacted with the calcium-rich dolomite on Spors Mountain to form fluorite.

This fluorine could have either come directly from the last massive rhyolite flow by separating from it during the last stages of crystallization or from the source magma from which the various volcanic rocks differentiated. Neither source can be eliminated, but the authors feel that the latter explanation most closely fits the data as shown below. The volcanic rocks are younger than the Paleozoic sediments, as can be seen from the numerous volcanic dikes and plugs that cut the sediments. As the massive topaz-rich rhyolite is younger and is a flow, it must have overlain the Paleozoic sediments, if it was present in the area that is now Spors Mountain. The fluorite pipes and veins plunge and dip steeply indicating that the fluorine-rich fluids either went down or came up, but had very little horizontal movement. Thus, the fluorine has either come from a consolidating rhyolite above or from a deep seated magma below. As the relief of pressure is easiest upwards and as the dikes and plugs suggest a source magma below connected by fractures, it seems more likely that the fluorine-rich fluids came from below.

The extremely fine-grained friable ore of the Thomas Range is unique among fluorite deposits, though fine-grained fluorite is also found at the Poncha Springs and Brown's Canyon deposits in Chaffee County, Colo., and the Daisy deposit in Nye County, Nev., (Van Alstine, R. W., oral communication, 1954).

These ores, however, differ in having a grain size clearly visible to the naked eye and in being compact. The Thomas Range ore, though simple in mineralogy consists entirely of minerals common to low temperature deposits. Ore structure, where visible, commonly shows brecciation and open boxworks. Most of the deposits, exposed to a depth of greater than 80 feet, show a change in mineralogy with a marked decrease in the fluorite content. All these characteristics suggest that the deposits are epithermal.

The depth of burial of the ore bodies at the time of their formation varies, as the surface elevation of the East pipe of the Fluorine Queen is 1,200 feet above that of the Lucky Louie. If patches of the volcanic flows covered the Paleozoic sediments on Spors Mountain, it would be possible to calculate the amount of the sediments removed since the volcanic activity; but as neither the amount of erosion of the sediments nor the thickness of the volcanic sequence is known, it is impossible to estimate the original depth of formation of the various ore bodies.

Descriptions of individual deposits

The chief fluorite deposits in the Thomas Range were reported in 1950 by Staatz, Wilmarth, and Bauer (Thurston, and others, 1954), who described 24 deposits on 14 properties. Since 1950, 15 properties containing 27 deposits have been further developed, have started production, or have been recently discovered. These properties are described below. Six properties, the Dell, the Dell No. 5, the Eagle Rock, the Floride, the Nonella, and the Thursday, have had no further work done on them and therefore are not described here.

Bell Hill

Introduction.--The Bell Hill property is on the top of a group of hills 80 to 120 feet high that form the southeastern corner of Spors Mountain (fig. 2 and pl. 5). This property adjoins the Harrisite group of claims on the northwest and is in the SE1/4SE1/4 sec. 10, T. 13 S., R. 12 W. Total distance from the Bell Hill mine to Delta, Utah, is 47.5 miles.

The Bell Hill group of claims was located during July 1949 by H. J. Ruthiford, D. W. Searle, C. D. Searle, and H. E. Searle. The Spor brothers leased the property in 1950 and mined fluorite by open cut methods from the two largest ore bodies. By October, 1950, they had produced a total of 3,385 short tons of fluorite ore. From October 1950 through August of 1951 the property was under contract to the Harrises, who drove a 230-foot adit from the east side of the hill, to the largest ore body. Fifty feet from the main ore body the adit struck a smaller ore body, which was covered by alluvium on the surface and had not previously been discovered. The small ore body was stoped out to the surface, and some ore was also taken from the ore body at pit no. 2 (fig. 6). The Harrises shipped a total of 1,530 tons. From September 1951, Les Price and Earl Dalton mined the large ore body of the Bell Hill under contract, and stoped out ore from the adit level, from three sublevels above, and from four sublevels below. They produced 2,565 tons of ore during the remainder of 1951, and 4,466 tons in 1952. Total production of this property through 1952 is 11,946 short tons -/.

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The Bell Hill property contains two main ore bodies, and four smaller deposits besides numerous small veins and stock-works. Surface workings (fig. 6) consists of four large bulldozer trenches (trenches nos. 1, 2, 3, and 4) measuring 135 by 13 feet, 60 by 55 feet, 100 by 58 feet, and 130 by 7 feet, respectively, and two open pits; pit no. 1 is 160 feet long and as much as 50 feet wide and pit no. 2 is 170 feet long and 25 feet wide. Pit no. 1 on the largest fluorite body was 10 to 35 feet deep, when open pit mining was stopped, but was connected to the uppermost underground workings late in 1952 (pl. 26); pit no. 2 is 6 to 25 feet deep. In addition to the adit to the large ore body underground workings consist of a 78-foot long raise on the small ore body adjacent to the adit; a stope in the large ore body on the adit (87-foot) level, 106 feet long by 11 to 38 feet wide; one large and two small stopes on levels above the adit level; an inclined winze in the ore body starting from the west end of the adit level; four stopes on levels below the adit level; an inclined raise from the bottom of the winze up to the adit in the country

Plate 26.--Pit no. 1 on the Bell Hill property showing the connection with the underground workings.

rock; and several raises connecting the various levels (fig. 7). The winze is approximately 125 feet long and is inclined from 50 to 54 1/2 degrees to the northeast. Approximately 50 percent of the ore was mined by stoping out large rooms on the various levels leaving pillars to hold up the walls. The plan is to blast down pillars and remaining ore to the winze bottom, and then haul it to the adit through the raise in the country rock.

Diamond drilling. --In order to extend the reserves of this ore body, the U. S. Atomic Energy Commission drilled two diamond drill holes. The drilling was carried out by a United States Bureau of Mines crew of nine men under the direction of A. A. McKinney from September 25, 1951 to January 29, 1952.

The first hole (fig. 6) was started approximately 138 feet north of the northeastern end of the ore body and drilled at a 57 1/2 degree angle in a S. 26 1/2° E. direction. This hole was aimed at a point on the ore body approximately 270 feet below the surface. Unfortunately, the plunge of the ore body changed between 100 and 180 feet below the top of the open cut, and the ore body gradually turned until the plunge was southeast. No fluorite was hit in the drill hole, which was abandoned at a depth of 526 feet. The hole started in the Bell Hill dolomite, cut the slopemaker and black mottled members of the Floride dolomite and ended in the Fish Haven dolomite. The slopemaker member of the Floride dolomite is 119 feet thick and the black mottled member 100 feet thick, where it was cut in the drill hole.

The second hole was started 54.5 feet S. 80° W. of the first hole (figs. 6 and 8). It was drilled at a 51 degree angle in a S. 28° E. direction. This hole was aimed to hit the ore body higher and approximately 48 feet southwest of the expected target for the first hole. Ore was first encountered at 206 feet below the surface (fig. 7), and the drill left the fluorite body at 240 feet. In the center of the ore body a dolomite horse approximately 6 feet thick, was encountered. At the point where the drill entered the fluorite, the ore deposit was approximately 19 feet thick. The total length of the hole was 353.7 feet.

Diamond drilling proved to be a poor method for exploration, as almost the entire length of both holes had to be cemented at least once and part of it twice. Total length of cement core drilled from two holes, which had a combined length of 880 feet, was 1,368 feet. The direction of the holes was noted deviating in two places in each hole, where the drill did not follow its original path during the drilling of the cement. Core recovery was poor in the dolomite and was still worse in the fluorite. Cost for drilling was higher per foot than the cost of sinking the winze, which was being put down at the same time by the miners.

Geology.--The Bell Hill group of claims is crossed by outcrops of the Harrisite dolomite, the Bell Hill dolomite, and both members of the Floride dolomite. All the fluorite bodies are surrounded at the surface by Bell Hill dolomite; the largest ore body is surrounded in the deeper workings by the slopemaker member of the Floride dolomite. These dolomites strike N. 13°-54° E. and dip 25-44°NW.

Exposures are poor and the property is in part covered by a thin veneer of Lake Bonneville gravels. Along both sides of the small valley which has trench no. 1 (fig. 6) near its head, about 2 feet of Lake Bonneville conglomerate unconformably overlies the dolomite with angular discordance. The conglomerate strikes N. 71° E. and dips 7° SE.

The Bell Hill claims are crossed by numerous branching northeast-trending faults; this area is one of the most broken in Spors Mountain. Faults in the Bell Hill dolomite are extremely difficult to follow, unless they contain breccia, because except for the light-gray dolomite that makes up the upper 45 feet of the formation no distinctive marker beds exist. The size of faults represented by breccia zones is difficult to determine. Only where the faults cut other formations is the apparent horizontal displacement measurable. One of the largest faults that cuts this property passes through trench no. 1 and pit no. 2. It has a true displacement of approximately 175 feet; the south side moved down along slickensides that plunge 54° S. 62° E.

Ore deposits.--The Bell Hill has yielded ore from the two largest ore bodies (pits no. 1 and 2) and the small ore body to the east of pit no. 1 (see fig. 6). Four other ore bodies consisting of a vein or several veins have been exposed in trenches no. 1, no. 2, no. 3, and no. 4. None of these four ore bodies had been worked by the end of 1952, and are not as large or as high grade as the two large ones mined. Small veinlets of fluorite which range from a fraction of an inch to 4 inches in thickness, are common in several places on this property.

In trench no. 1, two bands of fluorite with a maximum width of 6 feet and one 6-inch stringer are found. Total length of bands is not known, but one of them has been traced for 60 feet. A prominent fault extends through the workings adjacent to these ore bodies. In trench no. 2, a poorly exposed ore body is at least 60 feet long and has a maximum width of 12 feet. The ore appears to contain considerable intermixed dolomite. In trench no. 3, fluorite has been exposed in two places (fig. 6), which may be either two separate ore bodies or part of the same ore body. The east exposure is 34 feet long and 26 feet wide; the west exposure is 9 feet long and as much as 2.5 feet wide. The ore is purple and contains considerable chert. A small irregular vein with a maximum width of 10 feet was uncovered in trench no. 4.

Pit no. 2 contains an irregular ore body in a fractured zone on the foot wall side of the same fault that passes through trench no. 1. The main part of the ore body is 45 feet long with a maximum width of 28 feet. Some fluorite extends along the fault plane. The outline of the ore body is in part controlled by a series of fractures parallel to the main fault. The ore body extends out several feet into the country rock along these breaks giving a serrate edge to the outline of the deposit. This ore body plunges 65° S. 58° E.

More than 85 percent of the production through 1952 has come from the large ore body at pit no. 1. On the surface this ore body has an H-shaped outline, with faults of unknown displacement along both uprights of the H. The 69-foot level cut only a single lenticular ore body; the two sides have coalesced between the surface and this level. At depth this lenticular ore body pinches in the center (figs. 7 and 9) and on the 168-foot level two separate ore bodies are found.

The north and south walls of the ore body are steep and irregular and show dips in both directions. The plunge of the ore body is quite variable. The largest change, however, occurs below the 87-foot level. The average plunge of the ore body from the surface to the 87-foot level is 52° N. 62° E.; the average plunge from the 87-foot level to the 168-foot level is 70° S. 81° E. This gives the ore body a hooked shape.

A small oval pipe is found 70 feet northeast of the large ore body. This pipe is 20 feet long and has a maximum width of 14 feet at the surface; on the 87-foot level, however, it has a length of only 15 feet and a maximum width of 8 feet. The pipe plunges 75° N. 74° E.

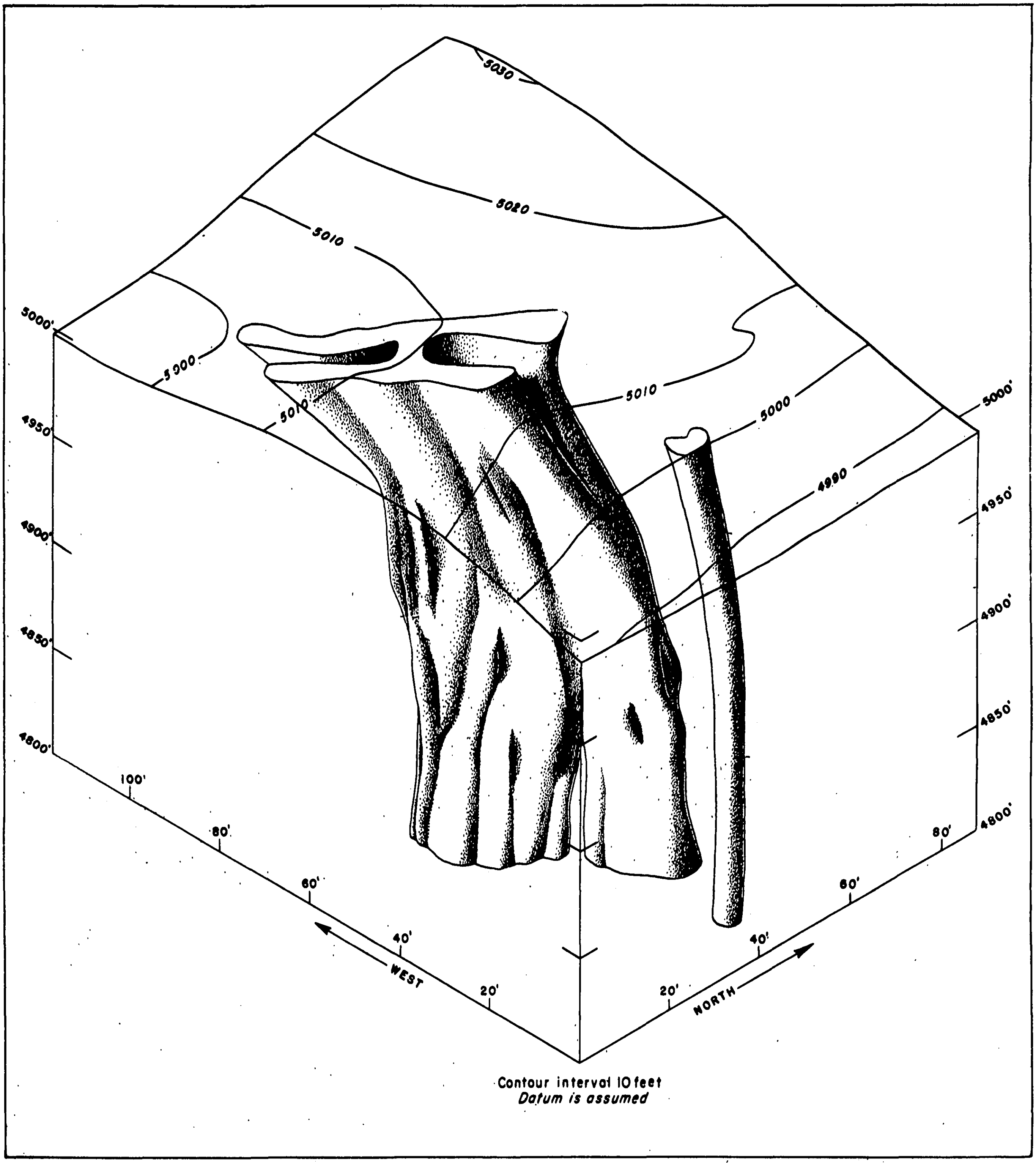

FIGURE 9.-BLOCK DIAGRAM SHOWING THE SHAPE OF THE LARGE PIPE ON THE BELL HILL PROPERTY

The fluorite bodies have replaced dolomite along faults or in the broken zones adjacent to faults in three deposits (trench no. 1, pit no. 1, and pit no. 2). In three other deposits (trench no. 2, trench no. 3, and trench no. 4) the ore occurs along a line which may represent a small fault. Replacement of the dolomite has given irregular outlines to the deposits, and in a few places blocks of dolomite have been left unreplaced in the fluorite. A block of dolomite, 6 feet in diameter and completely surrounded by fluorite, was removed from pit no. 1 by the Spor brothers. Replacement of the dolomite by the fluorite was usually preceeded by brecciation of the dolomite, and the brecciated structure is still apparent in some of the ore from the large ore body. A cup coral (pl. 22) entirely replaced by fluorite was found near the center of pit no. 1 (fig. 6).

The ore in the large pipe is cut on the 87-foot and lower levels by irregular bands of tuffaceous volcanic material (pl. 27, A and B). These bands are chiefly in the ore but also follow the contact of the ore body with the dolomite, and in a few places extend a few inches into the country rock. The bands of volcanic material range from a fraction of an inch to several feet in thickness and are highly irregular (pl. 27, B). The material is fine-grained, dark brown, and extremely friable and appears to be made of rounded unconsolidated sand. Under the microscope 73 percent of it is highly altered and is now made up of a clay mineral, zeolites, and sericite flakes. The unaltered part can be roughly divided into 15 percent clear sanidine, 5 percent smoky quartz, 3 percent magnetite, and 2 percent each of chalcedony and topaz. The rock is designated an intrusive rhyolitic tuff and was probably formed by early consolidation of some of the minerals, which were rounded and altered as they were forced up into the ore body by hot gases.

The fluorite is soft and pulverulent and ranges in color from white to dark purple. Most of the ore in trench no. 1 is white; most of the ore in pit no. 2 is a dark purple. The large ore body in pit no. 1 has both white and purple ore, and the color varies irregularly throughout the body. Impurities consist of a waxy clay, cream-colored dolomite, and quartz. Waxy brown clay from the stope on the 87-foot level of the large pipe was identified by E. W. Tooker as being chiefly a Ca-Mg montmorillonite with a small amount of another unidentified clay mineral. The ore changes some with depth, and on the 150-foot level a hard

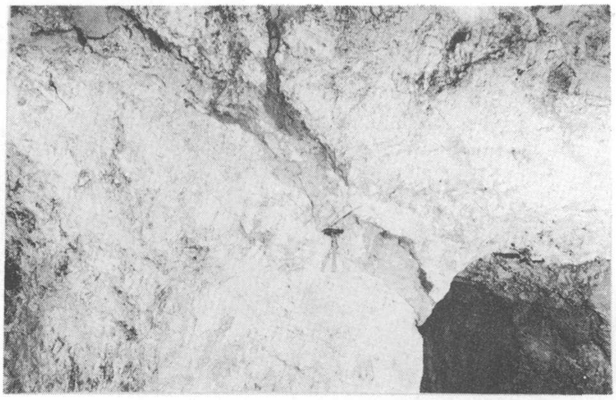

Plate 27A.--Intrusive rhyolitic tuff band cutting fluorite ore body on 87-foot level of the Bell Hill mine.

Plate 27B.--Irregular band of intrusive rhyolitic tuff cutting the fluorite ore body on 168-foot level of the Bell Hill mine.

vuggy material made chiefly of light colored dolomite and quartz occurs with a little fluorite at the east end of the large ore body. More of the same material is found around the edges of the ore body on the 158-foot level, and 25 feet down the small winze driven southwest from this level the siliceous dolomitic material occurs near the center of the ore body. The fluorite ore, which includes this material, is too low grade to sell as direct shipping ore at 1952 prices.

Analyses were made for the CaF_2 content of ore from the large ore body. Three samples taken from the open cut ranged from 78.5 to 90.1 percent fluorite (table 8). Composite samples made of 4 to 6 channel samples from each level showed the fluorite content of the 69-foot level to be 80.8 percent, of the 87-foot level to be 63.0 percent, of the 108-foot level to be 67.6 percent, of the 129-foot level to be 89.5 percent, of the 150-foot level to be 84.8 percent, and of the 168-foot level to be 84.8 percent. Samples avoided any rhyolitic tuff bands and siliceous dolomite material, which is most common on the lower levels. Samples on the same level from different parts of the ore body show considerable variance. The composite sample of the 87-foot level is probably low, as five samples taken from the ore bin containing ore which came from this level, ranged from 72.5 to 88.8 percent fluorite. Fluorite content of drill hole samples from the lower part of the ore body is recorded in table 8. These results should be used with extreme caution as the amount of sample was small and the core recovery was poor.

Thin yellow coatings on gray dolomite adjacent to the ore body in pit no. 1 gave an x-ray powder pattern that matches the standard powder pattern for carnotite. Not all of the uranium, however, occurs in carnotite, as the analyzed sample from pit no. 1 contained 0.26 percent uranium and 0.03 percent vanadium. The uranium content exceeds by approximately twice the amount needed if all the vanadium was in carnotite. No other uranium mineral was noted in the ore or in heavy mineral separates from it.

The uranium content of the various deposits on the Bell Hill property varies considerably at the surface. Three parallel bodies are exposed in trench no. 1. The small, northern 6-inch stringer shows no abnormal radioactivity; the central vein composed of white fluorite has a radioactivity equivalent to less than 0.01 percent uranium; and the southern vein composed of white and purple fluorite contained 0.029 and 0.059 percent uranium in two channel samples.

The poorly exposed ore body in trench no. 2 is composed of white to purple fluorite. One channel sample, 5.5 feet long, cut across the center of this body contained 0.012 percent uranium.

Two separate bodies (or a single irregular body) of purple fluorite are exposed in trench no. 3. Two samples taken from the larger eastern body contained 0.036 and 0.038 percent uranium; one sample taken from the smaller western body contained 0.010 percent uranium.

An irregular vein of white to purple fluorite is exposed in trench no. 4. One channel sample, 4.0 feet long, across the center of this vein contained 0.006 percent uranium.

Pit no. 2 contains the darkest purple fluorite found on the Bell Hill property. Three channel samples cut around the sides in the upper 15 feet of the pit contained 0.052, 0.061, and 0.064 percent uranium. A chip sample around the entire body contained 0.073 percent uranium.

The large ore body exposed in pit no. 1 is the best samples ore body in the district, with a total of 64 samples (table 8). The uranium content of these samples ranged from 0.008 to 0.33 percent. The lowest analyses came from ore recovered in the drill hole, where the samples were small and the ore was commonly intermixed with wall rock. The lowest analysis, excluding those obtained on drill hole core, showed 0.029 percent uranium. Analyses of fluorite ore from several spots on the same level show considerable variance. The various levels, however, have approximately the same range in grade. The surface material exposed in the open cut has a higher uranium content than that exposed in the underground workings. The ore from the open cut ranges from 0.093 to 0.33 percent uranium. The highest grade figure obtained from 57 samples taken from below the open cut was 0.21 percent uranium.

Blowout

Introduction.--The Blowout mine is on the east side of Spors Mountain, near the crest (pl. 28 A) and would be in sec., 21, T. 12 S., R. 12 W., if this township were subdivided (fig. 2). The Blowout mine adjoins the Lost Sheep No. 1 mine on the east. The ore body has been developed by an open cut and a haulage adit, both of which are connected to the main haulage road along the east side of Spors Mountain.

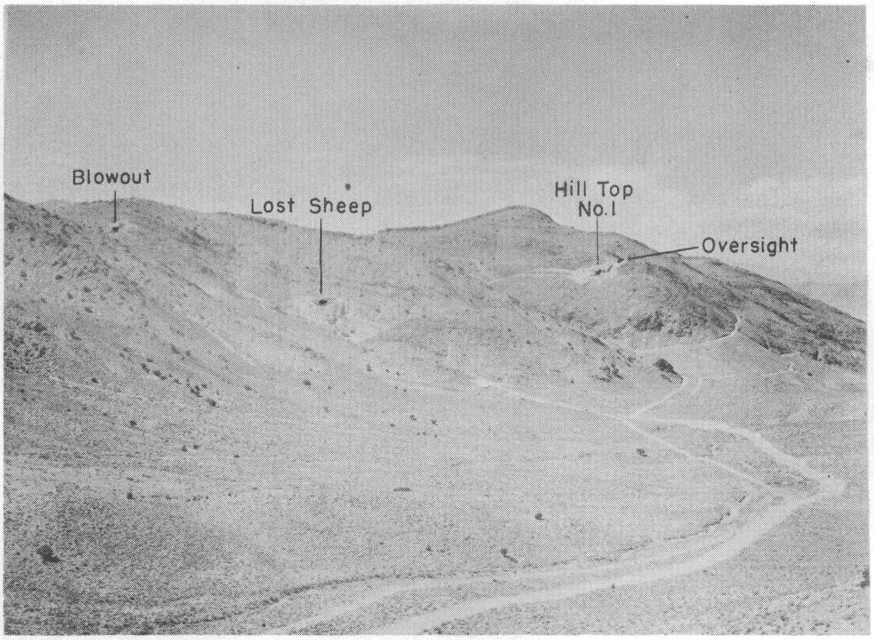

Plate 28A.--East side of the north end of Spors Mountain showing the location of the Blowout, Lost Sheep, Hilltop no. 1 and Oversight mines.

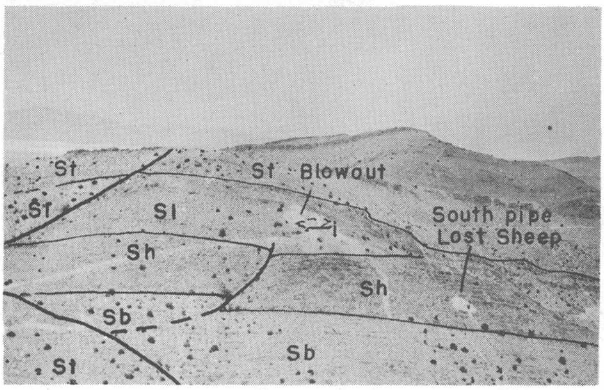

Plate 28B.--Blowout (center) and south ore body of Lost Sheep (right). (St-Thursday dolomite, Sl-Lost Sheep dolomite, Sh-Harrisite dolomite, Sb-Bell Hill dolomite, and i-intrusive breccia.)

The claim, located May 19, 1948 by T. A. Claridge and Rex Claridge of Delta, Utah, was named the "Blowout" because fluorite veinlets were first discovered in an intrusive plug next to the fluorite pipe. A road was built up the west side of Spors Mountain and mining began at the surface. The adit was started in 1950 and was driven jointly by the owners of the Blowout and Lost Sheep properties; the portal is located on the Lost Sheep group of claims. Mining ceased in the open cut in the fall of 1950, when large blocks of dolomite, as much as 20 feet across, caved into the cut. Approximately 3,000 tons of ore averaging 75 percent CaF_2 had been mined. During the fall of 1950 and winter of 1951, mining was carried out by a series of stopes above the adit level under contract to the Centennial Development Company of Eureka, Utah. This ore contained considerable clay and the grade was lower than at the surface. The road leading up to the open cut from the west side of Spors Mountain was washed out by cloudbursts during the summer of 1951. Work during the summer of 1952 consisted of constructing a road from the adit portal up the east side of Spors Mountain to the open cut, removing the loose material from the open cut, and extending the tunnel from the ore body for about 50 feet to the west (not shown in fig. 9). Production to the end of 1952 is 5,896 short tons [1].

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The open cut (fig. 10) is 140 feet long and 25 feet wide with a 40-foot by 12-foot projection to the northeast along the north contact of an intrusive plug. The haulage adit, about 500 feet long, intersects the ore pipe 240 feet below the outcrop. Three raises and a stope enter the ore body from the haulage level. Bauer (1952, p. 28) states that stoping was hampered by caving, as blocks of dolomite obstruct the raises.

Two small bodies of fluorite crop out about 800 feet north of the open pit. These bodies were intersected by a drift from the haulage level (fig. 10), but they proved too high in free silica to mine (Bauer, 1952, p. 30).

Geology.--The Blowout claim is crossed by the outcrops of the Bell Hill, Harrisite and Lost Sheep dolomites (pl. 28, B). The open pit is in the gray member of the dolomite; the ore body on the haulage level is in Harrisite dolomite. A mass of Teritary (?) intrusive rhyolite and breccia adjoins the fluorite pipe at the surface but was not seen underground. This suggests that the fluorite pipe and intrusive mass plunge at divergent angles, or that the intrusive mass is not continuous in depth. A larger mass of intrusive breccia (pl. 3 and fig. 10) lies 470 feet east of the ore pipe; it is best seen in the walls of the haulage adit.

At the surface, the dolomites strike northeast, and dip 33° to 40° NW; dip of beds on the haulage level ranges from 40° to 51° NW. No large faults are known in the immediate vicinity of the Blowout, but a fault of small displacement trends south from the rhyolite intrusion. Bauer (1952, fig. 4) mapped six small steeply dipping faults within a few hundred feet of the Blowout open pit. The rectangular outcrop pattern of the ore body suggests a control by fracturing, but no offset of beds can be seen (fig. 10).

The rhyolite and breccia plug is well exposed in the walls of the open cut. The altered iron-stained rhyolite contains small smoky quartz crystals less than three sixteenths of an inch in diameter and remnants of feldspar crystals less than half an inch in size. The breccia consists of blocks of rhyolite porphyry and small pieces of chert, probably derived from the Lost Sheep dolomite.

Ore deposits.--At the surface the Blowout ore body forms a crude rectangle about 100 feet long by 30 feet wide, with an extention to the northeast 40 feet by 13 feet in size. On the 240-foot level the ore body is only about 47 feet long by 16 feet wide. The ore body plunges 71° N. 49° E.

The fluorite is lavender to purple in color and is crumbly though it has a well-defined boxwork structure (pl. 24). The spaces in the boxwork are angular and reach a maximum size of 1-1/2 inch. Some of the openings contain small, colorless fluorite crystals. Bauer (1952, pl. 1) described a series of three specimens taken within a distance of two feet which showed a gradation from dolomite with minute fluorite veinlets, through fluorite enclosing angular remnants of dolomite, to boxwork fluorite. Relict bedding, in apparent continuity with bedding in nearby Lost Sheep dolomite, is visible in the eastern part of the open pit. These facts strongly suggest replacement of brecciated dolomite by fluorite. The ore body changes texturally and mineralogically with depth, as it is not as porous and contains more clay and water on the haulage level.

Two individual samples and one composite sample were taken in the open cut and analyzed for CaF_2 (table 8). The grade of these three ranged from 79.6 to 92.0 percent CaF_2. One sample taken from the haulage adit contained 72.1 percent CaF_2. Average fluorite content of ore on the haulage level is lower than that in the open cut due to considerable admixture of montmorillonite.

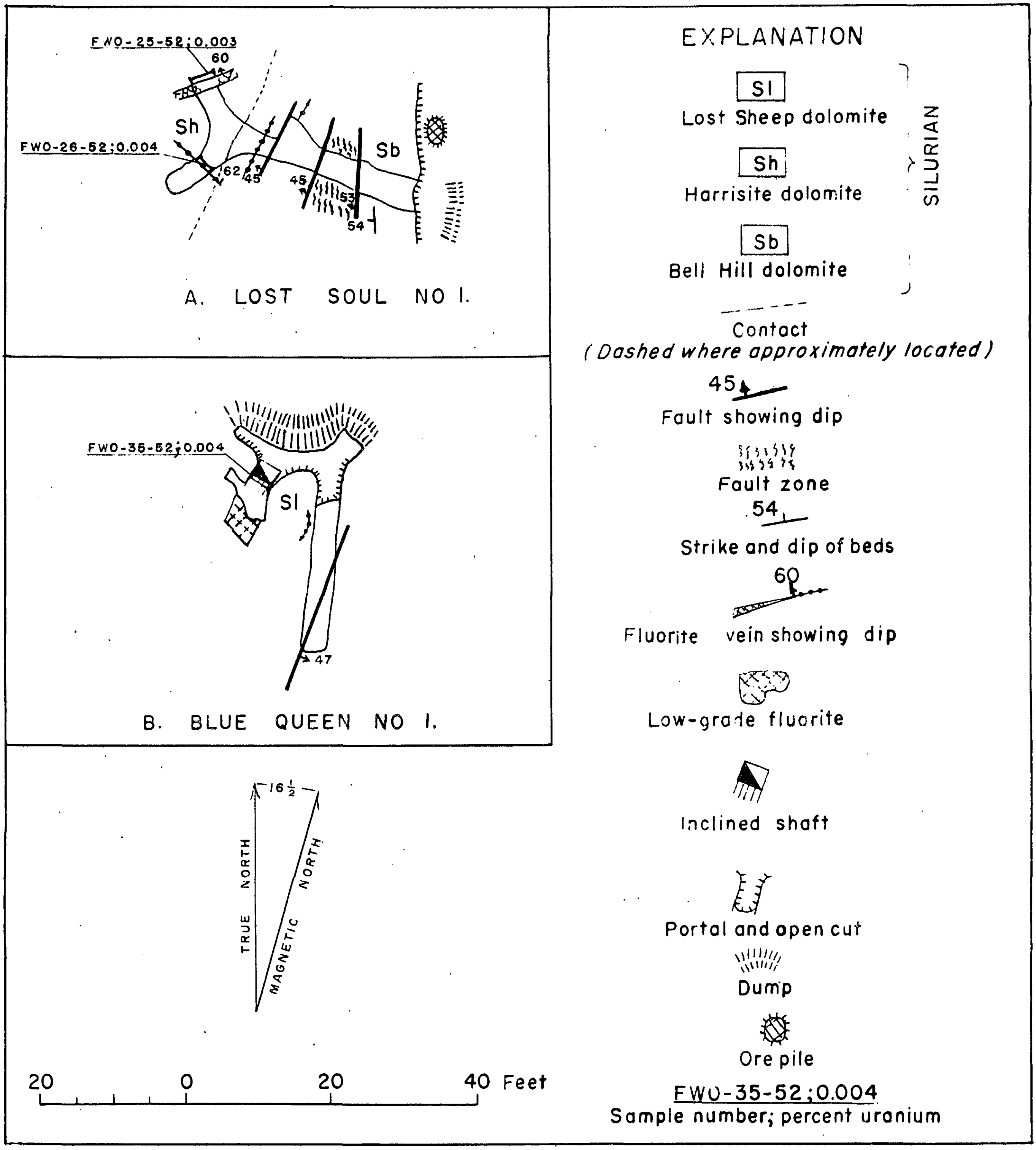
Five samples from the fluorite ore body in the open cut and four from the haulage level were analyzed for uranium (table 8). Samples from the open cut ranged from 0.005 to 0.033 percent uranium, and those from the haulage level from 0.004 to 0.013 percent.

Blue Queen No. 1

The Blue Queen No. 1 is located on the south face of a steep canyon, on the west side of Spors Mountain (fig. 2). It is about 3,000 feet south of the Thursday prospect, and adjoins the Blue Queen No. 2 on the south and Blue Queen No. 3 on the west. The claim was staked April 1, 1952, by Wesley Sampson, Harold Goodwin, and Archie A. Searle, all of Delta, Utah. The workings consist of an incline, an adit, and several small pits. Most of the workings are in the gray member of the Lost Sheep dolomite, though two shallow trenches about 100 feet east of the dump showed a red dolomitic intrusive breccia. The Lost Sheep dolomite strikes N. 40° E. and dips 30° NW.

The adit (fig. 11) showed a few fine-grained purple fluorite masses in dolomite along the west wall near the portal. Most of the fluorite filled fractures and lined vugs. The adit crossed a fault, and no more fluorite was noted.

The incline (fig. 11) is about 12 feet deep and plunges 50° south. Dark gray Lost Sheep dolomite contains irregular masses of fine-grained purple fluorite, which replace some of the chert nodules as well as the dolomite. The fluorite is restricted to a zone in dolomite which strikes N. 22° E. and dips 52° southeast, and which contains about 25 percent fluorite. The zone was followed to a depth of about 12 feet. A few small pieces of green crystalline fluorite were scattered on the dump, but none was found in place. A chip sample made up of uniform size pieces at 6-inch intervals across the face contained 0.004 percent uranium. A stockpile of purple fluorite ore, probably handpicked, measured 14 feet long by 8 feet wide by a maximum of 4 feet high, in August 1952.



Geology by F. W. Osterwald, July 1952.

FIGURE 11.—UNDERGROUND GEOLOGIC MAPS OF THE BLUE QUEEN NO. 1 AND LOST SOUL NO. 1, JUAB COUNTY, UTAH.

Fluorine Queen

Introduction.--The Fluorine Queen property is located astride a 6,220-foot saddle on the central ridge of Spors Mountain. This property is the highest of any producer in the Thomas Range and has two producing pipes, one about 500 feet west of the saddle and the other 300 feet northeast of it. The Fluorine Queen is near the center of Spors Mountain and would be in the NE 1/4 sec. 34, T. 12 S., R. 12 W., if this township were subdivided (fig. 2). A steep mountain road, approximately 1 mile long connects the property with the main ore haulage road along the east side of Spors Mountain. The mine road climbs 730 feet from the valley bottom, and the ore is trucked down it from the ore bin at the mine by a four-wheel drive Dodge power wagon to a second ore bin at the bottom, where it is loaded into larger ore trucks and taken to Delta.

The Fluorine Queen was located in March 1948 by W. E. Black and F. B. Chesley of Delta, Utah. The road to the mine was built, and the first ore was shipped in 1948.

From 1948 to the spring of 1950 all the ore was mined by open-pit method from the pipe on the west side of the saddle (west pipe). The pit has nearly vertical walls, 21 to 45 feet high, and was entered by a cut in its southern end. From 1950 until the fall of 1952 all production came from the east pipe. At that time the cut into the west pipe was deepened about 10 feet and a carload of ore was shipped. In 1951 a tunnel (fig. 12) was driven under the ore body from the road level, 34 feet below the lower edge of the pit, and a raise was driven up into the center of the ore body. Ore was then slushed into the raise and trammed out the tunnel.

Total production through 1952 amounted to 17,119 short tons [1]. Mr. Chesley reported that railroad carloads of ore mined from the main part of the west pipe assayed from 65 to 75 percent CaF_2; the southeast end, however, contained around 90 percent CaF_2. The east pipe contained 74 to 83 percent CaF_2. Mr. Chesley reported the grade of the ore increased slightly with depth.

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Geology.--The Fluorine Queen ore bodies are in Bell Hill dolomite.

Both ore bodies occur in the same fault block (pl. 3). The largest fault with a minimum lateral displacement of at least 680 feet crosses the saddle, and its northeastern extension passes close to the canyon bottom south of the fluorite pipes. This fault commonly contains a 1 to 6-foot band of brownish travertine. Several smaller faults cross the saddle, and the entire area appears to be a zone of shattering with many small shears.

Ore deposits.--The west fluorite pipe, which is 105 feet long and ranges from 13 to 55 feet wide, is irregular in shape and has almost vertical walls. The contact of the fluorite with the dolomite is sharp; the dolomite is not altered, even at the edge of the ore body. A map of this pipe has previously been published (Thurston, and others, 1954), and as little work has been done since the map was made in September 1950, the ore body was not re-examined.

The east pipe is shaped like an irregular parallelogram, with the long diagonal measuring 155 feet and the short diagonal 106 feet (fig. 12). The outline of this pipe is now entirely exposed, and, therefore, its shape has been somewhat modified from that previously reported (Thurston, and others, 1954). To the south of the main eastern ore body (fig. 11) two smaller adjoining pipes have recently been uncovered. The first one, 7 feet to the south, has a length of 22 feet and a maximum width of 13 feet; the second ore body, 26 feet to the south, has a length of 32 feet and a maximum width of 20 feet. Neither of these two smaller ore bodies had been mined in November 1952. The adit driven under the main east ore body struck a large horse of dolomite (fig. 12) in the western half of the ore body, which considerably diminishes the amount of fluorite on that level. The pipe has an average plunge of 82 degrees to the east.

The ore is soft and friable and white to dark purple in color. The chief impurity is a white waxy clay (montmorillonite). Quartz stringers and crystals are found in a few places. Scott Chesley reports that car-load lots of fluorite from the west pipe contained from 65 to 90 percent CaF_2. A powdery yellow mineral, probably carnotite, occurs in a streak of hard fluorite, approximately 40 feet long and 1 foot wide, in the center of the west pipe. Two channel samples cut on either side of the west pipe pit bottom (table 8) contained 0.018 and 0.039 percent uranium. The latter sample also contained 0.04 percent V_2O_5 and 2.64 percent MgO. The vanadium is present in about the right amount for carnotite, which has been identified by X-ray methods on the Eagle Rock and Bell Hill properties. The MgO content, which is more than 2 percent higher than that obtained from other properties, suggests a high clay content as there was no visible dolomite.

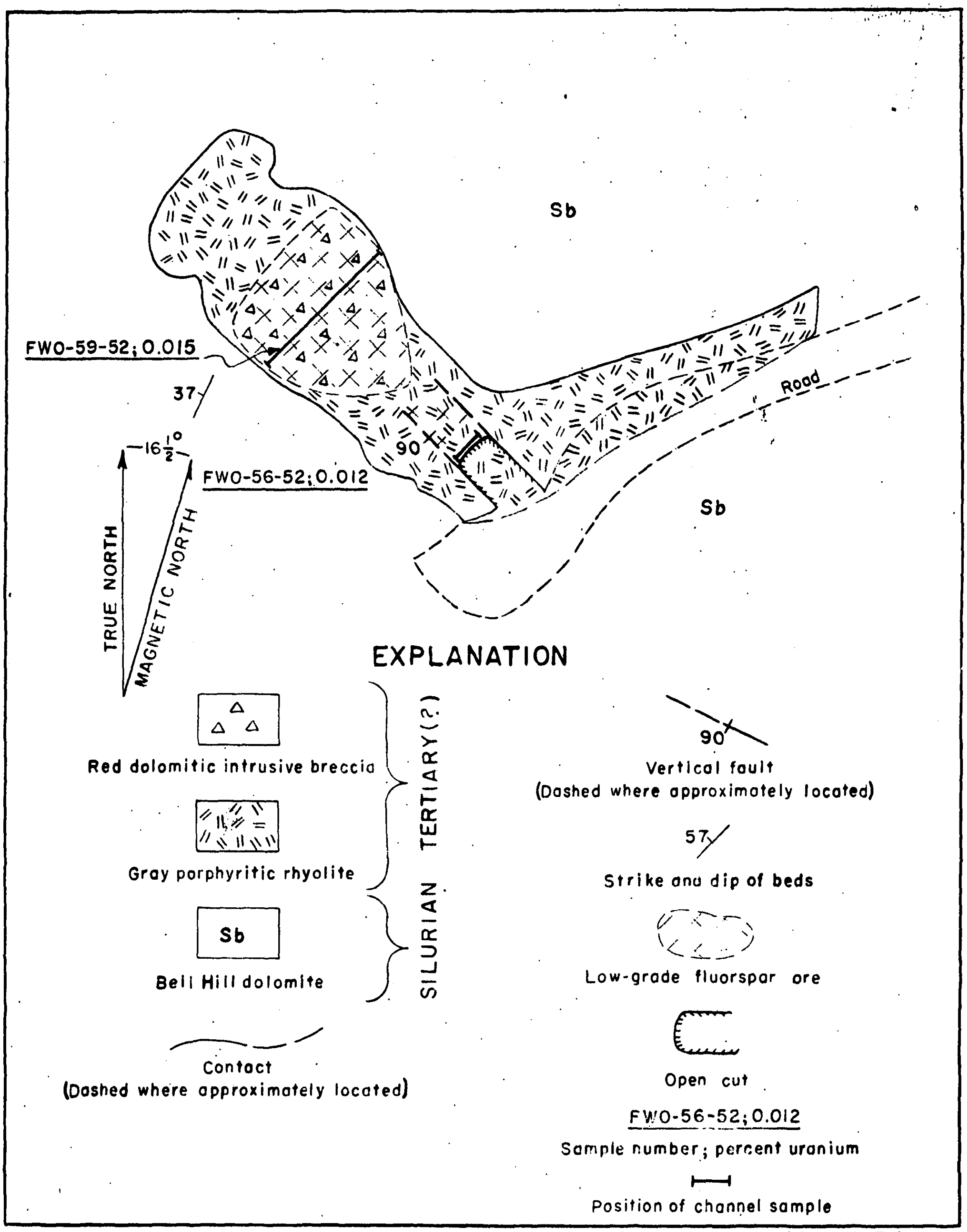
Two samples were taken close to the surface of the east pipe, soon after the first development work was done. These samples contained 0.011 and 0.020 percent uranium and 61.0 and 71.3 percent fluorite. A third sample from a deeper part of the open cut contained 0.023 percent uranium. Three samples were later taken from the three parts of the ore body on the tunnel level, and they contained 0.006, 0.008, and 0.010 percent uranium, and 82.5, 72.6, and 68.0 percent fluorite, respectively. The average of these samples at the various elevations (fig. 12) shows a marked decrease in the grade of the uranium with depth. The fluorite content of the ore, however, rises. This later observation has been borne out by carload shipments.

A sample taken at the surface of the small ore body 26 feet to the south of the east pipe contained only 0.010 percent uranium.

Fluorine Queen No. 4

The Fluorine Queen No. 4 is about 1,200 feet southwest of the Fluorine Queen east pipe, on the southeast slope of a high ridge (fig. 2). It may be reached by a private road 1,400 feet long from the east pipe of the Fluorine Queen. The property was located in March 1948 by W. E. Black and F. B. Chesley of Delta, Utah. An open pit 20 feet long, 12 feet wide and 7 feet deep has been cut into a porphyritic rhyolite intrusion, and the surface of the entire plug has been stripped by bulldozer.

An irregular rhyolite plug, about 130 feet long by 40 feet wide with a projection to the east about 80 feet long and 15 feet wide, cuts the Bell Hill dolomite (fig. 13). The long dimension of the plug trends northwest. The intrusive rock is gray with a fine-grained matirx containing smoky quartz crystals as much as three-sixteenths of an inch in diameter. In the center of the intrusive, a roughly circular mass of red



Geology by F. W. Osterwald and L. F. Emmett
August 1952

FIGURE 13. —GEOLOGIC MAP OF THE FLUORINE QUEEN NO. 4, JUAB COUNTY, UTAH

dolomitized breccia about 40 feet in diameter contains low-grade fluorspar. Two small faults about 10 feet apart extend southeast from the intrusive breccia; between them is altered rhyolite with siliceous fluorite, some of which has a boxwork-like structure. In the northeast wall of the cut, rounded masses of gray rhyolite up to 1 foot in diameter are embedded in a clay matrix (fig. 13), probably as a result of alteration proceeding laterally from cracks. Montmorillonite, some of which is stained yellow, coats fractures in the rhyolite in the northwest corner of the open cut. An analysis of the highest grade ore contained 57.3 percent CaF_2, and the uranium content of ore is also low (table 8). In the rhyolite plug three samples of siliceous fluorite in rhyolite contained from 0.012 to 0.022 percent uranium. Low grade fluorite from the intrusive breccia contained 0.015 percent uranium.

Harrisite

Introduction.--The Harrisite mine is on the south end of some low hills that form the southern end of Spors Mountain (pl. 3). This property adjoins the lucky Louie mine on the west and the Bell Hill mine on the southeast and is in the E 1/2 SW 1/4 sec. 10, T. 13 S., R. 12 W. (fig. 2). The main workings are in a small dry stream bed, and the property is connected to the road around the southern end of Spors Mountain by two fairly level private roads.

The Harrisite was located on May 10, 1949, by E. D. Harris, E. T. Harris, Rex Harris, and Mark Harris of Delta, Utah. Through 1950, the workings consisted of one bulldozer trench along the bottom of a dry wash, one bulldozer trench along a hillside, a long narrow trench, 40 feet long by 5 feet wide, and several small pits. Fluorite was observed in the narrow trench and in the bulldozer trench along the wash; in the trench scattered pits were dug from time to time exposing several small fluorite pipes. During June 1951 the Harrises sunk on two of these small pipes. The largest, which was 10 feet across and highly irregular, was followed to a depth of approximately 8 feet. The other pipe which was 6 by 4 feet at the surface and narrowed with depth, was followed for 23 feet. Up to the end of 1952 one carload of ore (approximately 55 tons) was shipped, which according to Mr. E. T. Harris, contained 78 percent fluorite and 4 percent silica. In August 1951 a cloudburst filled all the workings with gravel and water. No further work was done until November 1951, when the property was leased to the Davis brothers, who excavated a large trench along the dolomite-latite contact where fluorite occurs in the altered latite. As this fluorite was too low grade to ship, the working was abandoned. Next they excavated a trench about 15 feet deep in the central part of the wash. A flat fault (fig. 14) was uncovered, showing fluorite masses which at intervals extend up toward the surface. Below this fault only small stringers of fluorite were noted. An inclined shaft, 64 feet deep, was sunk from the bottom of the excavation beneath the fault and under the largest of the two small pipes. Except for a few small stringers near the top, no fluorite was encountered.

Geology.--The contact between the Tertiary (?) latite and the Silurian dolomites crosses the Harrisite claim. These rocks are in part overlain by gravels and conglomerate formed by old Lake Bonneville.

Owing to considerable faulting, the Harrisite dolomite, the upper cherty and lower gray members of the Lost Sheep dolomite, and the Thursday dolomite are all present on the Harrisite claim. The beds strike from N. 6° W. to N. 29° E. and dip 25°-42° NW.

In the southern part of the claim augite-enstatite latite is intruded into dolomite. This rock consists chiefly of dark green phenocrysts of enstatite and augite in a dark fine-grained groundmass containing numerous plagioclase microlites. Along its contact with the dolomite, the latite contains calcite and clay minerals, and the color has changed from dark gray to light gray probably due to reaction of the latite with the dolomite along its periphery.

The dolomite is cut by numerous faults having a northeast-trend and dipping 60°-75° SE; the largest of these faults has a vertical displacement of at least 250 feet. A northwesterly-trending fault offsets one of the strike (northeasterly) faults about 65 feet north of the workings in the wash and has a horizontal offset of 34 feet. A flat thrust fault was exposed in the excavation in the wash. Most fault movement took place before the emplacement of the latite, but a trench shows sheared latite along a strike fault.

Ore deposits.--Fluorite is localized in the altered latite, on a fault between the latite and the dolomite, and in shattered zones in the dolomites.

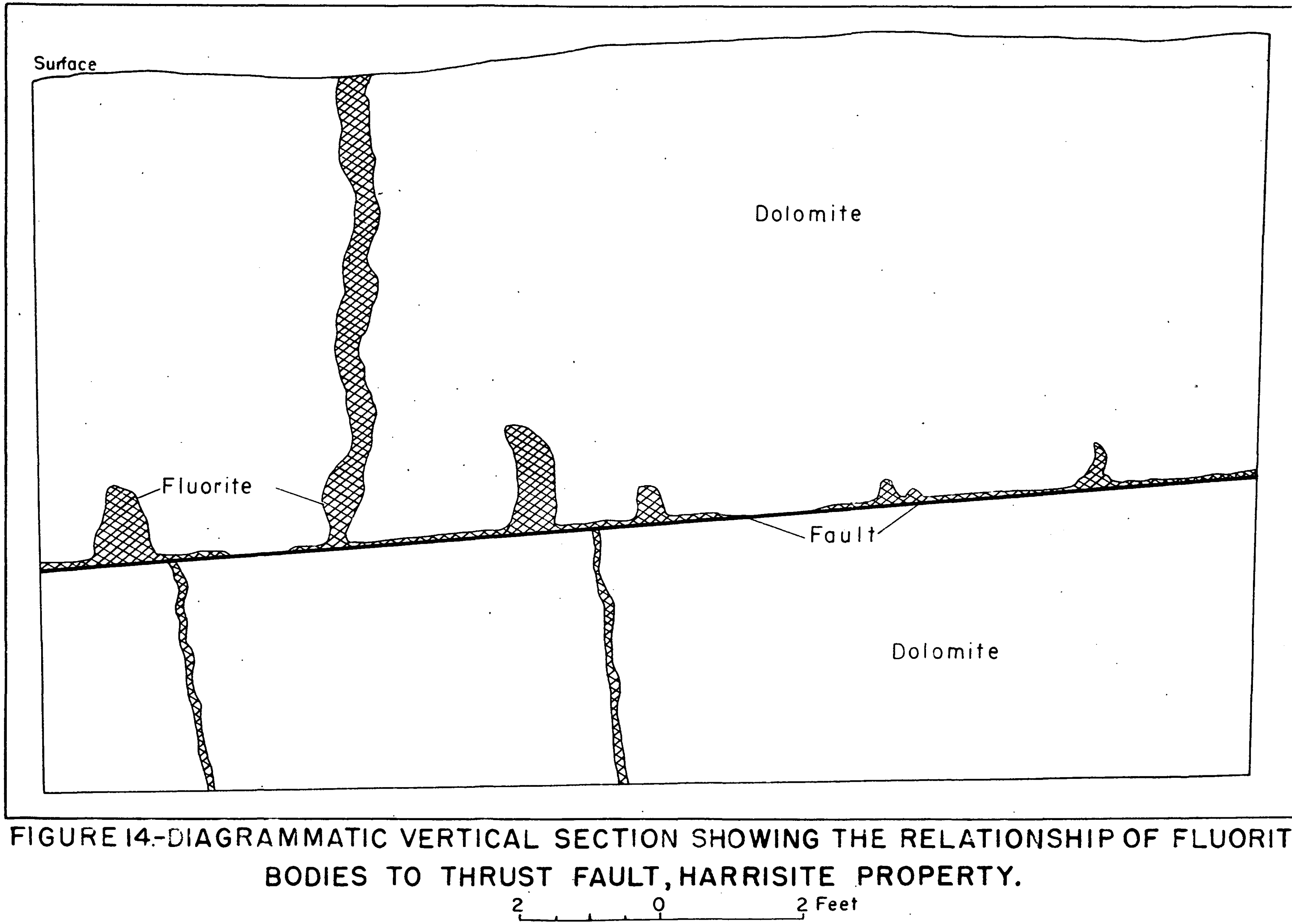


FIGURE 14.-DIAGRAMMATIC VERTICAL SECTION SHOWING THE RELATIONSHIP OF FLUORITE BODIES TO THRUST FAULT, HARRISITE PROPERTY.

In the latite the fluorite veins cut this soft altered rock and veinlets separate the altered mineral crystals. The grade is low and does not exceed 30 percent CaF_2. A channel sample taken across a 4-foot vein contained 0.094 percent uranium, and a composite chip sample from several pits with fluorite veinlets cutting altered latite contained 0.039 percent uranium.

A fault separates Lost Sheep dolomite from latite and contains a small vein of light- to dark-purple fluorite. This irregular vein, 1/2 to 3 feet wide, is exposed for 20 feet along a narrow trench and dips 74° to the east. The fluorite, whose chief impurity is clay, replaces both the dolomite and the altered latite. A yellow uranium mineral was found along shear planes in the altered latite porphyry adjacent to the fluorite vein. This mineral has uranium and silicon as its major constituents; however, an X-ray powder pattern of it did not match that of any known uranium mineral. A sample of this altered porphyry showing the yellow uranium minerals contained 0.011 percent uranium; the adjacent fluorite, which had no visible uranium minerals, contained 0.084 percent.

A zone of fracturing, which cuts the Thursday dolomite, the cherty and gray members of the Lost Sheep dolomite and the Harrisite dolomites, contains a series of small veins and two small pipes of fluorite. The veins are small, irregular, and as much as 3.5 feet thick. Staatz, Wilmarth, and Bauer (Thurston and others, 1954) reported one large ore body and several small stringers. The exposures at that time (1950) consisted of a series of small pits in fluorite, which gave the appearance of one large connected ore body. Actually, when the gravel was cleared off, two small pipes and several small veins were found. The pipes and veins are extremely irregular with frequent horses of dolomite. The larger pipe has a 10-foot diameter, and the smaller one is 4 feet wide by 6 feet long and plunges 65° S. 62° E. It lies along a fault that dips 62 to 75° southeast. The deep cut made in the dry creek bed by the Davis brothers shows that the larger pipe and the veins do not extend below a flat thrust fault. Only small 1- to 3-inch stringers of fluorite were noted below the thrust. This fault is older than the fluorite bodies, as a thin vein is found in some places along it with small ore bodies extending upwards from it (fig. 14). The fault appears to have acted as a passageway along which the fluorine-bearing fluids rose towards the surface. Small stringers of fluorite below the fault suggest downward movement of a small part of the fluorine-bearing fluids.

The soft friable ore ranges from dark purple to white in color. The chief impurity is a green waxy clay identified by E. W. Tooker as a Ca-Mg montmorillonite. Three samples taken in 1950 from the larger pipe and two veins contained 0.16, 0.095, and 0.17 percent uranium, respectively. All three of these bodies bottom on the thrust fault and are now completely worked out. Another sample taken in 1952 across a 2-foot vein, 80 feet to the west of the large excavation, contained 0.073 percent uranium.

Hilltop No. 1

The Hilltop No. 1 mine is near the top of the southeast side of a steep ridge (pl. 3), 400 feet above the valley bottom. It adjoins the Oversight mine to the north, in what would be NE 1/4 sec. 21, T. 12 S., R. 12 W., if the township were subdivided (fig. 2). A steep private road, 550 yards long, connects the mine workings with the north end of the road built by the U. S. Bureau of Public Roads.

The property was located by P. W. Watts, E. J. Hamblin, W. B. Hamblin, and Lee McCallister of Delta, Utah, on September 18, 1948. In 1951 a bulldozer cut exposed several small veins. Two small pipes were discovered above this cut on the hillside, and a narrow cut was driven at right angles from the bulldozer working through the first small pipe to the second. This narrow cut was 18 feet deep at the back of the second pipe by November 1952. Production through 1952 from these two pipes is not known, but from the size of the workings approximately 2 carloads or about 100 tons of fluorite were mined.

The Harrisite dolomite surrounds the fluorite pipes at the surface. Southwest of the pipes is a small fault with approximately 50 feet horizontal displacement, and to the north and east is a small irregular intrusive breccia pipe. This rock (pl. 28, B) is made up of angular fragments of white aphanitic rhyolite, one thirty-second to three-quarters of an inch across, embedded in an extremely fine-grained hematitic red matrix. The rhyolite contains quartz and orthoclase phenocrysts and chalcedony rosettes.

The smaller pipe is irregular in cross section and has a maximum dimension of 5 feet. The larger pipe has an almost rectangular cross section, 16 feet long by 5 feet wide with almost vertical walls.

The ore consists chiefly of a brown fluorite boxwork, similar to that found on the Oversight property. The voids in the boxwork were formed by leaching out of dolomite fragments, and a few small quartz crystals are seen on this boxwork. Some of the ore is high grade, but a sample chipped from along the sides of the north pipe contained only 59.5 percent CaF_2.

Uranium content of the two pipes is low. A chip sample from the south pipe (table 8) contained 0.011 percent; two chip samples from the north pipe contained 0.006 and 0.010 percent uranium.

Lost Sheep

Introduction

The Lost Sheep group of claims is on the east side of Spors Mountain, in the south-central part of T. 12 S., R. 12 W. The claims would be in section 21, if the township was subdivided (fig. 2). The property was located May 10, 1948, by Albert and Earl Willden of Delta, Utah. The claims adjoin the east line of the Blowout property.

Three fluorite pipes crop out on the Lost Sheep property; one large body called the main pipe (pl. 29), a smaller one 700 feet south of the main pipe and 300 feet east of the Blowout pit (pl. 28, B), and a very small pipe 75 feet south of the main pipe. The main pipe can be reached from the haulage road built by the U. S. Bureau of Public Roads, by a private road 500 yards long. The adit portal of the south pipe, which crops out a hundred feet higher than the main pipe, is located on the haulage road to the Blowout pit, 500 yards from its junction with the main pipe haulage road (pl. 3).

The property was discovered in 1948, when the Willden brothers, following stray sheep, found fluorite at the entrance to a badger hole in the south pipe (Bauer, 1952, p. 32). The fluorite is soft and crumbly and therefore mining is very easy. In November 1952 the main pit was 71 feet deep. In plan view the pit is an oval about 130 feet by 60 feet (fig. 15, pls. 29 and 30).

The south pipe is also oval and measures 28 feet by 16 feet at the surface. The ore body was intersected by an 86-foot haulage adit 45 feet below the surface, and a raise was driven to the surface from the adit. The ore is shoveled down the raise and trammed out the adit to an ore bin above the road. The pit was 34.5 feet deep in November 1952.

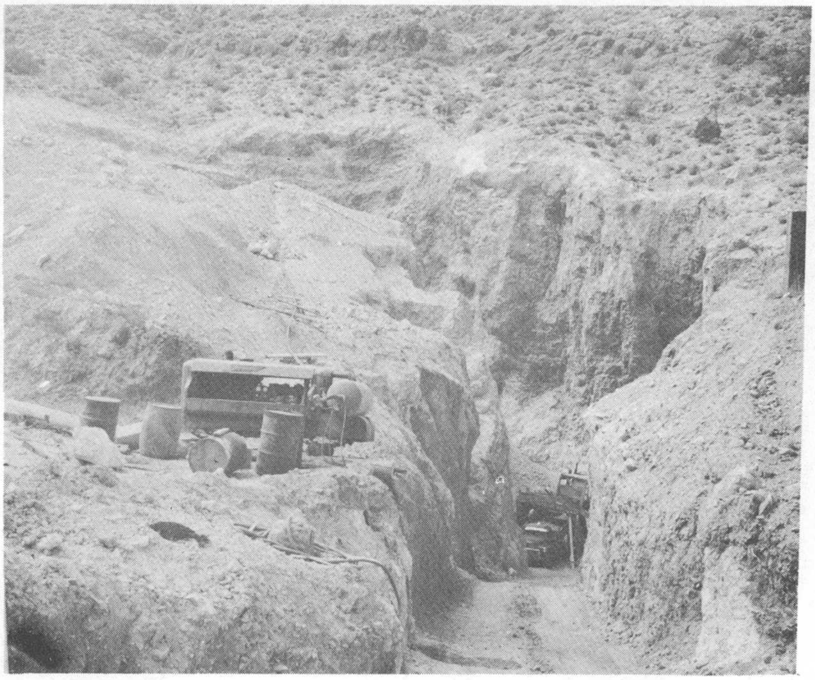


Plate 29.--Main pit on the Lost Sheep property. Back of pit is over 70 feet high.

Plate 30.--Open cut on the main Lost Sheep ore body. Dump (left background) is from adit to Blowout ore body.

Production from the two pipes to the end of 1952 is 22,373 short tons[1].

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Geology

Main pipe.--The main pipe and the small one near it crop out in the Lost Sheep dolomite. The beds strike northeast and dip 42°-44° NW. The main pipe is at the west edge of a large rhyolite intrusive breccia, and about 500 feet south of a major southeast-dipping fault. A southeast-trending fault of small displacement is cut off by the intrusive about 150 feet southwest of the main pipe. The pipe is irregular in plan view, and its long dimension trends about west-northwest. The ore body is 145 feet long and has a maximum width of 73 feet; the ratio of length to average width is 2.9/1. A small southward-trending lobe at the west end of the ore body did not crop out but was discovered in 1952, during mining. The contact between fluorite and intrusive breccia appears to be gradational; a transitional zone of fluorite and cherty breccia separates the two rocks (Bauer, 1952, p. 32). The ore is white to deep purple and in most places is soft and friable; locally, however, it contains hard pieces, which commonly have a boxwork structure. Four channel samples (table 8) taken in the open cut contained from 78.6 to 88.5 percent CaF_2. A carload lot averaging 94.9 percent CaF_2 is reported by Fitch, Quigley, and Barker in 1949 (p. 66).

The uranium content of this large pipe is low, ranging from 0.009 to 0.029 percent uranium in seven samples (table 8).

An irregular vein of fluorite as much as 8 feet thick cuts the intrusive breccia 25 feet east of the narrow part of the haulage cut (fig. 15). This vein, which averages less than 5 feet thick, has the highest uranium content of any fluorite body found on the Lost Sheep property. The one sample cut across the entire vein at its thickest place contained 0.033 percent uranium.

South pipe.--The south pipe is a rough oval whose (fig. 15) long axis trends north-northeast. The ratio of length to average width is 2.2 to 1. The pipe measured 16 feet by 28 feet at the surface but on the haulage level was 13 feet in diameter. The plunge of the pipe is almost vertical. Thirteen feet from the portal, which is in Bell Hill dolomite, the adit enters Harrisite dolomite. At the portal a 6-inch to 3-foot dike of reddish-brown clay-like material with dolomite fragments up to one-fourth inch in diameter cuts the Bell Hill dolomite. This dike probably is an intrusive breccia.

The south pipe is about 220 feet south-southwest of the large intrusive breccia plug. No faults can be observed on the surface, but a fault of small displacement was cut by the adit. A large northeast-trending fault lies 710 feet south of the pipe.

The ore of the south pipe is similar to that of the Blowout pipe and the Lost Sheep main pipe. It is of particular interest that the Harrisite dolomite cut by the haulage adit contains thin irregular layers of chert along bedding planes, which form small resistant ledges. These resistant ledges pass without interruption into layers of more resistant fluorite in the ore body. This relict bedding in ore suggests replacement of dolomite by fluorite.

A sample taken at the surface contained 66.7 percent CaF_2 and 0.014 percent uranium; a second sample taken at the back of the small adit contained 82.5 percent CaF_2 and 0.009 percent uranium.

Lost Soul No. 1

The Lost Soul No. 1, owned by Wesley Sampson and Sherman Perkins of Delta, Utah, is located on the west side of Spors Mountain, approximately 4,300 feet south-southwest of the Thursday prospect (fig. 2).

The workings--a long bulldozer bench on a steep hillside with a 40-foot branching adit, and a small 7-foot adit--may be reached from the road along the west side of Spors Mountain by a 1,250-yard rough jeep trail partly in a dry wash and partly on a steep slope.

The open cut and adit portals are in the upper gray member of the Bell Hill dolomite. The face of the 40-foot adit is in Harrisite dolomite. Between 8 feet and 15 feet from the portal the longer adit (fig. 11) passed through a zone of fracturing, which changed the strike of the beds from N-S near the portal to N. 15° E. at 15 feet. These facts suggest a fault near the top of the Bell Hill dolomite. All observed fluorite is near the contact between the Bell Hill and Harrisite dolomites. Fluorite fills fractures near the base of the Harrisite dolomite at the surface.

In the northern branch of the adit a zone 1.8 feet wide contains 10 to 60 percent fluorite. Most of the material is a boxwork of dark purple fine-grained fluorite and white dolomite. The adjacent dolomite country rock contains irregular masses of purple fluorite.

The south branch of the adit cuts an 8-inch zone of dolomite with less than 10 percent fine-grained purple fluorite as coatings along fractures and as irregular masses. Near this zone the dolomite is brecciated with individual blocks as much as 3 feet in size.

A stockpile of hand-picked fluorite ore approximately 6 feet long, 4 feet wide, and 2-1/2 feet high, had been collected prior to August 1952.

The fluorite at the Lost Soul No. 1 contains little uranium. A sample taken across the vein in the north branch of the adit had only 0.003 percent uranium, and another sample taken in the south branch of the adit had 0.004 percent.

Lucky Louie

The Lucky Louie mine is on the south end of some low hills that form the south-central part of Spors Mountain (pl. 5), in the W 1/2 SW 1/4 sec. 10, T. 13 S., R. 12 W. (fig. 2).

The Lucky Louie claim was located on December 12, 1948, by James Quigley, Ehard Snell, H. E. Carlson, and Hyrum Schmidt. It was explored by several bulldozer trenches, and an area about 8 feet wide containing some fluorite was exposed at the site of the present workings. Several large fluorite boulders were found about 700 feet to the east in the Lake Bonneville sediments. Except for assessment work, no mining was attempted until the fall of 1951, when the owners began to do exploratory work. An oval pipe, 35 feet long with a maximum width of 14 feet, was uncovered. The first ore was shipped in January 1952, and through October 1952 the pipe was actively mined; at that time the pipe had been mined to a vertical depth of 120 feet.

Production through December 1952 amounted to 1,432 short tons [1].

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Although the Lucky Louie claim is in a highly-faulted area, the pipe itself is near the center of a fault block, approximately 90 feet from the nearest fault (pl. 5). The pipe crops out in the gray cherty member of the Lost Sheep dolomite and plunges approximately 60^{o} N. 89^{o} E. Hence, the lower half of the workings are in the gray member of the Lost Sheep dolomite.

The ore body becomes smaller with depth (fig. 16). About 50 feet below the surface the hanging-wall side of the pipe becomes steeper. At the bottom of the workings, the long dimension of the pipe has decreased from 35 to 7.5 feet and the short dimension from 14 to 10 feet. The character of the ore also changes. In the upper part, the ore consists of soft white to purple fluorite with a little residual chert derived from the gray cherty wall rock. At about 90 feet from the surface, large pieces of black angular hydrothermal chalcedony, which resembles chert, appear in the the ore; at 120 feet from the surface this chalcedony makes up the entire central part of the ore body, with narrow 18-inch bands of fluorite on both sides.

A composite assay compiled from individaul carload assays by the operators shows the ore to contain 81.6 percent CaF_2 and 5.2 percent silica. Three samples taken at the surface, 6 feet below the surface, and 59 feet below the surface ranged from 60.4 to 78.6 percent CaF_2 and from 0.049 to 0.078 percent uranium. The uranium content of the ore was moderately high for producing properties and was exceeded only at the Bell Hill and the Harrisite mines.

Oversight

Introduction. -- The Oversight mine is on the top of a steep ridge (pl. 3), 450 feet above the valley separating Spors Mountain from the eastern part of the Thomas Range; it adjoins the Hilltop No. 1 claim to the southeast and would be in sec. 21, T. 12 S., R. 12 W., if this township were subdivided (fig. 2).

The property was located during July 1948 by Frank Lowder, Fred Staats, and Harold Stephensen. Early work consisted of bulldozer trenches along the top of the ridge, several small pits, and a cut 4 feet wide by 20 feet long. In the face of the cut, there was exposed a 3- to 4-foot thick ore body, which appeared to be a vein, but which actually was an apophysis from a circular pipe. Further work uncovered

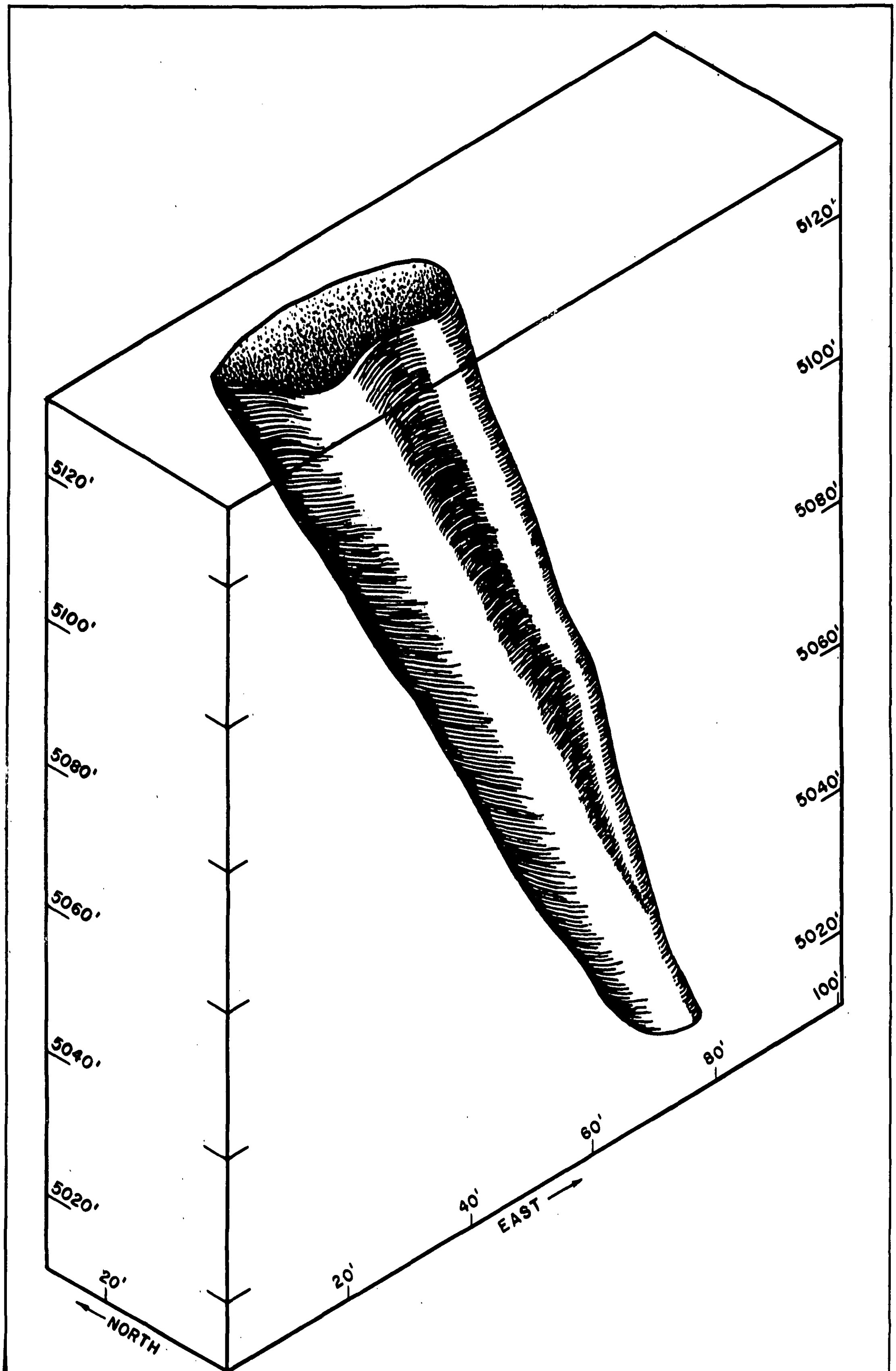

FIGURE 16 - BLOCK DIAGRAM SHOWING SHAPE OF THE LUCKY LOUIE PIPE.

this main pipe, and ore was first mined in 1951 by sinking a circular winze 15 feet in diameter. The winze was sunk on a 79 degree angle for 80 feet (Bauer, 1952, p. 36). A smaller pipe, approximately 10 feet southeast of the main pipe, was mined by driving a short crosscut from the winze, 24 feet below the surface, and raising. The main ore body became smaller with depth and at 80 feet mining ceased. Then a 200-foot long adit was driven south from the road level. Several small stringers were encountered and a boxwork of fluorite surrounding large pieces of dolomite was found on what was thought to be a downward extension of the main pipe. No ore was mined and work stopped in the spring of 1952.

Production —/ through 1952 amounted to 598.5 tons of fluorite ore ranging from 82.3 to 89.8 percent CaF_2 and from 2.2 to 4.2 percent SiO_2.

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Geology.--All the fluorite pipes on the Oversight property crop out near the center of the gray member of the Lost Sheep dolomite and occur in the central part of a fault block in one of the most faulted areas in the northern part of Spors Mountain. The most numerous faults trend northwest with the main ore body 65 feet north of the closest one. An intrusive breccia pipe made up of rhyolite fragments crops out on the Hilltop No. 1 property 150 feet southeast of the main Oversight ore body, and several small intrusive breccia pipes occur approximately 250 feet to the northwest.

Ore deposits.--The main ore body and several smaller bodies crop out in a group on the top of the ridge. The main ore body is approximately circular with a vein-like apophysis extending for a short distance to the north at the surface. The ore body is approximately 15 feet in diameter and plunges 79° in a south-easterly direction. At about 60 feet below the surface the ore body splits into two smaller shoots. A crosscut 80 feet from the top of the winze showed the two small ore shoots to be only a few feet in diameter (Bauer 1952, p. 36).

The second largest ore body is southeast of the main ore body. It is oval in cross section, 12 feet long, with a maximum width of 6 feet. This oval pipe plunges 70° N. 83° E., and has been mined to the depth of 24 feet.

Several smaller pipes, from 1 to 5 feet in diameter, are found to the south and west of the main ore body. These bodies are very irregular and have been prospected to a depth of only a few feet. Fluorite minerals are present also along the northwest-trending fault south of the ore body.

The fluorite at the Oversight mine shows the best boxwork structure of any ore in the Thomas Range district. It is chiefly gray to brown, which in a few places has a pale purple tinge and occurs in a coarse angular boxwork (pl. 23) surrounding voids an eighth of an inch to 2 inches across. In addition to fluorite small quartz crystals less than 1 mm long commonly line the cavities of the boxwork. Small white rhombohedral dolomite crystals, 1 to 2 mm across, also coat the boxwork in places.

The boxwork was formed by shattering of the dolomite country rock, filling of the cracks with fluorite, and leaching of the dolomite out of the central parts. In one place along the side of the pipe a white vein-type dolomite instead of fluorite fills the cracks in the shattered dolomite country rock (pl. 25). This rock is very limited in extent and apparently was not subjected to later leaching, as the dolomite country rock still remains. In two small drifts off the long adit two adjacent stockworks were noted. These consisted of fractured dolomite country rock, surrounded by thin veinlets of brown fluorite, and resemble the upper part of the ore body except that the dolomite country rock has not been leached out of the boxwork.

The fluorite at this deposit contains little uranium (table 8). A chip sample cut across the main ore body at the surface contained only 0.006 percent; a sample of an ore pile, which came from the winze, contained 0.007 percent; and a sample of the fluorite separated from the dolomite out of the two stockworks on the adit level contained 0.003 percent. A sample from the ore body southeast of the main ore body contained 0.005 percent uranium.

Unnamed adit

Approximately 500 feet south of the Thursday prospect (fig. 2) a 240-foot adit has been driven N. 13° E., into a steep hillside. It apparently follows a thin zone of low-grade purple fluorite along a fault in Lost Sheep dolomite (fig. 17).

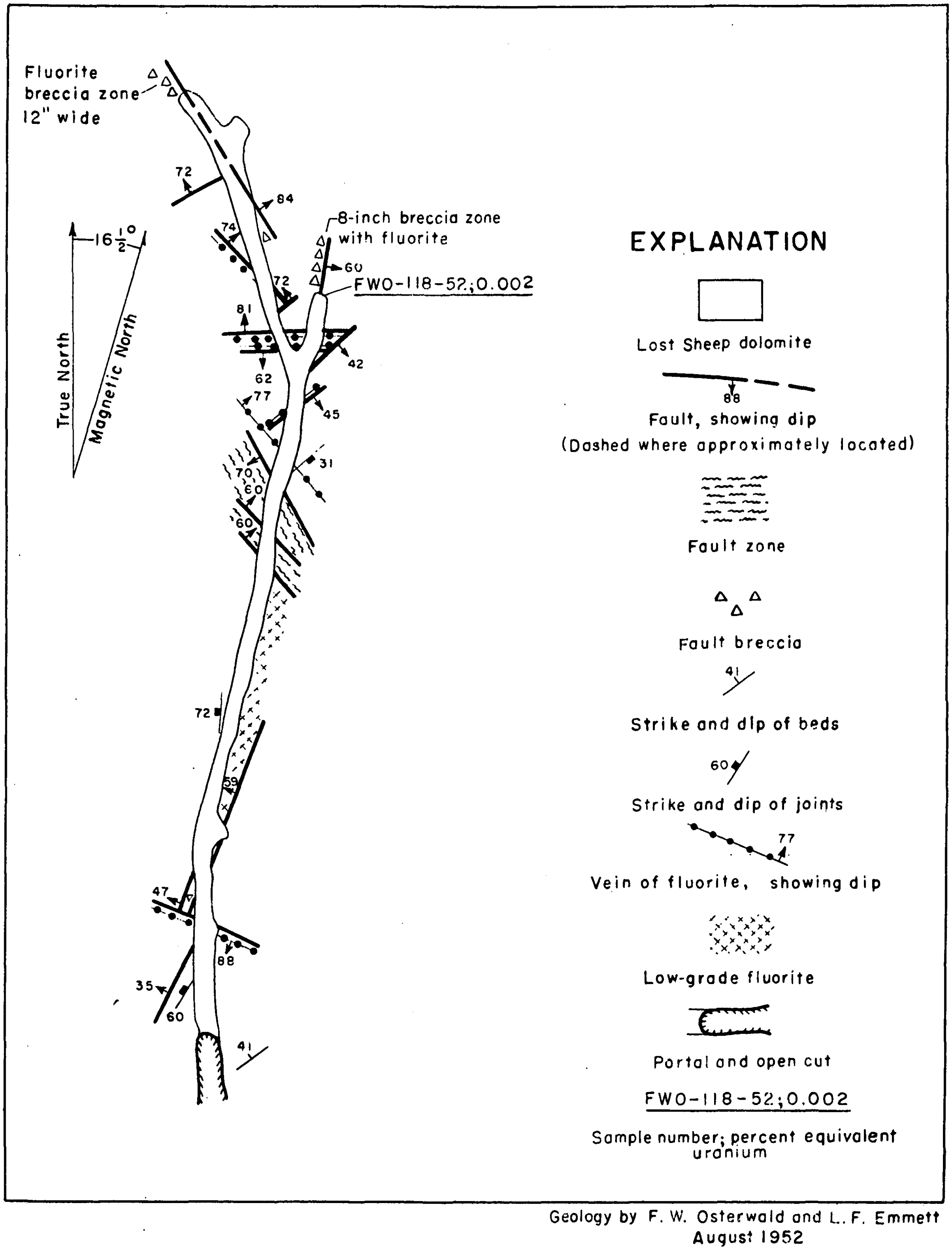

FIGURE 17.—UNDERGROUND GEOLOGIC MAP OF ADIT SOUTHEAST OF THE THURSDAY PROSPECT, JUAB COUNTY, UTAH

The dolomite strikes N. 39° E. and dips 41° NW. Several other narrow low-grade veins of purple fluorite were partially explored; most were zones of fault breccia containing a little fluorite. All of the fluorite contains chalcedony. A 2-foot channel sample across the vein showing the best purple fluorite contained 0.002 percent equivalent uranium.

Deposits in tuff

Introduction.--A few localities along the west side of Spors Mountain contain lumps of fine-grained pale purple fluorite scattered through tuff. Some of these small low-grade deposits are discussed below because they are unique among the fluorite deposits of the Thomas Range.

Deposit No. 1.--Deposit No. 1 is located 2,000 yards west of the Bell Hill mine (fig. 2). The only working on the claim is a bulldozer cut 200 feet south of a private road leading to a prospect from the west-side haulage road.

The area in which tuff crops out is very small; the west end of the bulldozer cut is in gray rhyolite that overlies the tuff. The northern and eastern limits of the tuff are covered by Quaternary Lake Bonneville sediments. The bulldozer cut is near the intersection of northeast and north-northwest-trending faults. Six hundred feet northwest of the cut is a larger area of tuff, but it contains no visible fluorite and only a little calcite.

Nodular fine-grained purple fluorite masses are embedded in hard massive cream-colored calcareous tuff. Most of the fluorite is associated with small fragments of fine-grained volcanic rock. The tuff contains 10 to 15 percent fluorite and 0.007 percent uranium was revealed by analysis.

Thin sections of tuff from deposit no. 1 show angular fragments and subhedral crystals of quartz, sanidine, and scattered plagioclase, as well as rare pieces of biotite, set in a fine-grained glassy fragmental matrix. An approximately equal amount of sub-angular rock fragments is associated with the crystal fragments; both types of pieces are as much as 2 by 6 mm in size. The rock fragments are mostly glass and show minute vesicles and well-defined flow structure. A few rounded pieces of sedimentary dolomite and chert are scattered through the slide, and one piece of Swan Peak quartzite was seen. Fine-grained and microcrystalline fluorite is distributed along the few layers rich in clay, particularly around dolomite and chert fragments. One well-rounded dolomite fragment is almost completely fluoritized. Some of the glass pieces contain minute dolomite euhedra. A little fine-grained fluorite was found in tuff that contained no megascopically visible fluorite.

Deposit No. 2.--Deposit No. 2 is 2,500 yards northwest of the Bell Hill pit no. 1 and 1,950 yards north-northeast of tuff deposit no. 1. A small area of white fine-grained altered volcanic rock crops out through Bonneville gravels. Areas of Paleozoic sediments nearby (pl. 3) are cut by several faults, which may pass close to the fluoritized area. The grade of fluorite is very low.

Rainbow No. 2.--The Rainbow No. 2 claim is west of Spors Mountain, along a wash 1,800 feet east-northeast from the west-side haulage road (fig. 2). The claim was staked July 27, 1949, by O. L. Turner, La Vee Turner, Russell Knight, and Eloyne Turner and is developed by a small adit which was full of water in August 1952. Light-colored rhyolitic tuff crops out on the north side of the wash and is separated by a fault from a dark-gray to purplish spherulitic rhyolitic glass with prominent flow structure on the south side of the wash. The tuff contains fragments of volcanic rocks, chert, and clay, which range between one-eighth of an inch and 2 inches in size. Purple fluorite has replaced tuff, chiefly around fragments, but makes up less than 15 percent of the rock (pl. 21). As shown on plate 3, the prospect is near the intersection of two faults, one is 20 feet southeast of the adit and one 110 feet north-northwest.

LITERATURE CITED

Alling, A. N., 1887, On the topaz from the Thomas Range, Utah: Am. Jour. Sci., 3d ser., v. 33, p. 146-147.

Barth, T. F. W. B., 1952, Theoretical petrology, John Wiley and Sons, Inc., New York, 387 p.

Blair, M. M., 1944, Elementary statistics, Henry Holt and Co., New York, 648 p.

Butler, B. S., Loughlin, G. F., Heikes, V. C., and others, 1920, The ore deposits of Utah: U. S. Geol. Survey Prof. Paper 111, 672 p.

Campbell, G. S., 1951, Stratigraphy of the House and Confusion Ranges, Millard County, Utah: Utah Geol. Mineralog. Survey, Guidebook to the geology of Utah, no. 6, p. 19-25.

Cloos, Hans, 1928, Ueber antithetische bewegungen: Geol Rundschau, band 19, p. 246-251.

____________, 1939, Hebung-Spaltung-Vulcanismus: Geol. Rundschau, band 30, p. 405-519.

Coffin, R. C., 1921, Radium, uranium, and vanadium deposits of southwestern Colorado: Colorado Geol. Survey Bull. 16, 231 p.

Cross, C. W., 1886, On the occurrence of topaz and garnet in lithophyses of rhyolite: Am. Jour. Sci., 3d ser., v. 31, p. 432-438.

____________, 1887, On the occurrence of topaz and garnet in lithophyses of rhyolite: Colorado Sci. Soc. Proc. 2, p. 61-70.

Daly, R. A., 1914, Igneous rocks and their origin, New York, 563 p.

Donovan, J. T., 1951, Devonian rocks of the Confusion Basin and vicinity: Utah Geol. Mineralog. Survey, Guidebook to the geology of Utah, no. 6, p. 47-53.

Emmons, R. C., and others, 1953, Selected petrogenic relationships of plagioclase: Geol. Soc. America Mem. 52, 142 p.

Fitch, C. A., Quigley, James, and Barker, C. S., 1949, Utah's new mining district: Eng. and Min. Jour., v. 150, p. 63-69.

Frondel, J. W., and Fleischer, Michael, 1952, A glossary of uranium- and thorium-bearing minerals: U. S. Geol. Survey Circ. 194, 25 p.

Gabriel, A., and Cox, E. P., 1929, A staining method for the quantitative determination of certain rock minerals: Am. Mineralogist, v. 14, p. 290-292.

Geikie, Archibald, 1897, Ancient volcanoes of Great Britain, v. 2, McMillan and Co., Ltd., London, 492 p.

Gilbert, G. K., 1928, Studies of Basin-Range structures: U. S. Geol. Survey Prof. Paper 153, 92 p.

Gilluly, James, 1932, Geology and ore deposits of the Stockton and Fairfield quadrangles, Utah: U. S. Geol. Survey Prof. Paper 173, 171 p.

Grout, F. F., 1932, Petrography and petrology, McGraw-Hill Book Co., 522 p.

Hansen, G. H., and Bell, M. M., 1949, The oil and gas possibilities of Utah: Utah Geol. Mineralog. Survey, 341 p.

Hatch, F. H., Wells, A. K., and Wells, M. K., 1949, The petrology of the igneous rocks, 10th ed., Thomas Murby and Co., London, 469 p.

Hillebrand, W. F., 1905, Red beryl from Utah: Am. Jour. Sci., 4th ser., v. 19, p. 330-331.

Hintze, L. F., 1951, Lower Ordovician detailed stratigraphic sections for western Utah: Utah Geol. Mineralog. Survey, Bull. 39, 99 p.

Ives, R. L., 1951, Pleistocene valley sediments of the Dugway area, Utah: Geol. Soc. America Bull., v. 62, p. 781-797.

Jones, A. J., 1895, Topaz crystals of Thomas Mountain, Utah: Iowa Acad. Sci. Proc. 2, p. 175-177.

Kunz, G. F., 1885, Precious stones: Mineral Resources U. S., 1883-1884, p. 723-782.

____________, 1893, Precious stones: Mineral Resources U. S., 1892, p. 756-781.

McAllister, J. F., 1952, Rocks and structure of the Quartz Spring area, northern Panamint Range, California: California Div. Mines Special Rept. 25, 38 p.

Montgomery, Arthur, 1934, A recent find of bixbyite and associated minerals in the Thomas Range, Utah: Am. Mineralogist, v. 19, p. 82-87.

Niggli, Paul, 1936, Ueber Molekularnormen zur Gesteinsberechnung: Schweizer min. pet. Mitt., band 16, p. 295-317.

Nolan, T. B., 1935, The Gold Hill mining district, Utah: U. S. Geol. Survey Prof. Paper 177, 172 p.

Palache, Charles, 1934, Minerals from Topaz Mountain, Utah: Am. Mineralogist, v. 19, p. 14-15.

Patton, H. B., 1908, Topaz-bearing rhyolite of the Thomas Range, Utah: Geol. Soc. America Bull., v. 19, p. 177-192.

Penfield, S. L., and Foote, H. W., 1897, On bixbyite, a new mineral and notes on the associated topaz: Am. Jour. Sci., 4th ser., v. 4, p. 105-108.

Pettijohn, F. J., 1949, Sedimentary rocks, Harper and Brothers, New York, 526 p.

Rankama, Kalervo, and Sahama, T. G., 1950, Geochemistry, Univ. Chicago Press, Chicago, 912 p.

Richardson, G. B., 1913, The Paleozoic section in northern Utah: Am. Jour. Sci., 4th ser., v. 36, p. 406-416.

Richardson, G. B., 1941, Geology and mineral resources of the Randolph quadrangle, Utah-Wyoming: U. S. Geol. Survey Bull. 923, 54 p.

Rogers, A. F., and Kerr, P. F., 1933, Thin-section mineralogy, McGraw-Hill Book Co., 311 p.

Ross, H. J., Jr., 1951, Stratigraphy of the Garden City formation in northeastern Utah and its trilobite faunas: Peabody Mus. Nat. History, Bull. 6, 161 p.

Rust, G. W., 1937, Preliminary notes on explosive volcanism in southeastern Missouri: Jour. Geology, v. 45, p. 48-75.

Simpson, J. H., 1876, Report of exploration across the Great Basin of the Territory of Utah for a direct wagon-route from Camp Floyd to Genoa in Carson Valley in 1859: Engineer Dept., U. S. Army, Washington, 518 p.

Staatz, M. H., Wilmarth, V. R., and Bauer, H. L., Jr., 1954, Deposits in Thomas Range District, Juab County in Thurston, W. R., and others, 1954, Fluorspar deposits of Utah: U. S. Geol. Survey Bull. 1005, 52 p.

Turner, F. J., and Verhoogen, Jean, 1951, Igneous and metamorphic petrology, 1st ed., McGraw-Hill Book Co., New York, 602 p.

Ulrich, E. O., and Cooper, G. A., 1938, Ozarkian and Canadian Brachiopoda: Geol. Soc. America Special Paper 13, 323 p.

Wahlstrom, E. E., 1947, Igneous minerals and rocks, John Wiley and Sons, New York, 367 p.

Walker, R. T., 1928, Mineralized volcanic explosion pipes: Eng. and Min. Jour., v. 126, p. 895-898, 939-942, 976-984.

Wentworth, C. K., and Williams, Howell, 1932, The classification and terminology of the pyroclastic rocks: Rept. Comm. Sedimentation 1930-1932, Nat. Research Council Bull. 89, p. 19-53.

Westgate, L. F., and Knopf, Adolph, 1932, Geology and ore deposits of the Pioche district, Nevada: U. S. Geol. Survey Prof. Paper 171, 79 p.

Williams, J. S., 1948, Geology of the Paleozoic rocks, Logan quadrangle, Utah: Geol. Soc. America Bull., v. 59, p. 1121-1163.

UNPUBLISHED REPORTS

Bauer, H. L., Jr., 1952, Fluorspar deposits north end of Spor Mountain, Thomas Range, Juab County, Utah: Univ. Utah, unpublished thesis.

Bauer, H. L., Jr., and Staatz, M. H., 1951, Uranium occurrence on the Autunite no. 8 claim, east side of the Thomas Range, Juab County, Utah: U. S. Geol. Survey Trace Elements Memo. Rept. 220.

Muessig, S. J., 1951, Geology of part of Long Ridge, Utah: Ohio State Univ., unpublished thesis.