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# THE GEOLOGY
# OF
# DUTCH PEAK AREA, SHEEPROCK RANGE TOOELE COUNTY, UTAH

by

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# THE GEOLOGY

of

# DUTCH PEAK AREA, SHEEPROCK RANGE

# TOOELE COUNTY, UTAH

A Thesis

submitted to

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In partial fulfillment

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Master of Science

by

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# ABSTRACT

The term Sheeprock group is proposed in this report for the complete succession of metamorphic rocks which are exposed in the Dutch Peak area. The Sheeprock group, similar in lithology to the Big Cottonwood series, is divided into two sequences which are separated by a thrust fault.

Quaternary alluvium represents the only unmetamorphosed sediments in the mapped area.

Erosion has exposed granite of the Sheeprock stock with its pegmatitic and hypabyssal differentiates. Intrusion of the stock produced metacrysts of actinolite and pyrite in the low-rank regional metamorphic rocks of the Dutch Peak area.

The major structural feature of the mapped area is the Sheeprock thrust fault. High-angle and reverse faults formed as a consequence of the Sheeprock thrust. Joints are a conspicuous feature in igneous and metamorphic rocks.

Mineral deposits of the Dutch Peak area have been explored and developed for copper, lead, silver, and tungsten metals. So far, no significant production has been realized from any of the properties. At present, the chief interest in metals in the mapped area is the large, low-grade beryllium deposit of the Sheeprock stock.

## CONTENTS

# LIST OF ILLUSTRATIONS

LIST OF TABLES

ACKNOWLEDMENTS

The writer expresses thanks to Drs. Kenneth C. Bullock and Lehi F. Hintze of the Brigham Young University Geology Department for helpful suggestions concerning field work and their criticisms of the thesis. The field assistance and companionship of Darrel L. Harris was greatly appreciated. Finally, special appreciation is accorded the writer's wife, Jeanne, for her encouragement and help.

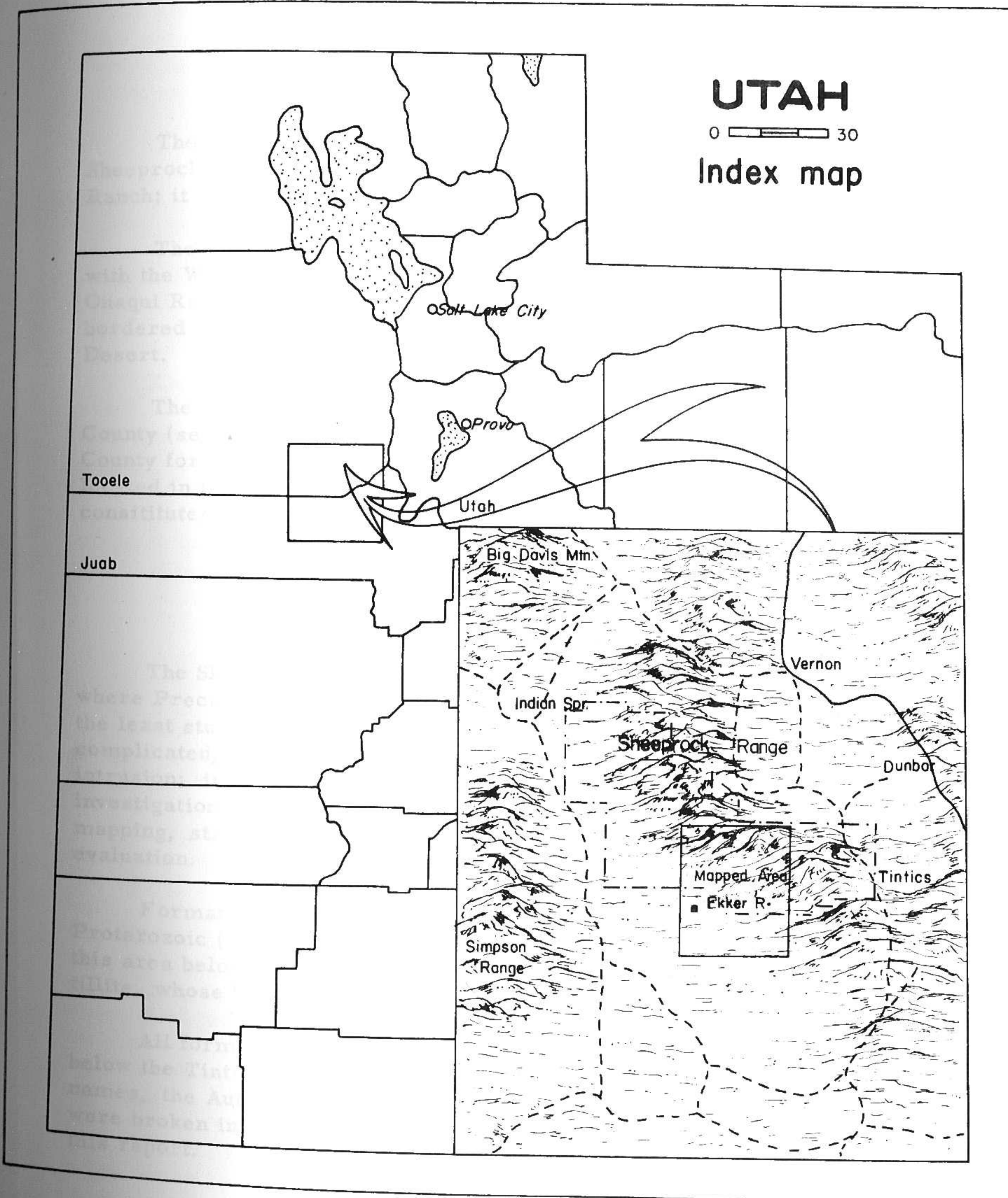
UTAH
0 30
Index map
Salt Lake City
Provo
Tooele
Utah
Juab
Big Davis Mtn.
Vernon
Indian Spr.
Sheeprock Range
Dunbar
Mapped Area
Tintics
Ekker R.
Simpson Range

Figure 1

# INTRODUCTION

## LOCATION AND SIZE

The area studied is located in the south-central portion of Sheeprock Range, in the vicinity of Dutch Peak and the Rick Ekker Ranch; it is for Dutch Peak that the area is named.

The Sheeprock Range, through a series of low-lying hills, merges with the West Tintic Mountains to the east; it is separated from the Onaqui Range to the north by a low-lying pass. Sheeprock Range is bordered on the west by the Simpson Range and on the south by the Sevier Desert.

The Dutch Peak area is situated, for the most part, in Tooele County (see figure 1); the southern portion of the area extends into Juab County for approximately two miles. More specifically, the area is located in townships 10 and 11 south, Range 6 west. The area mapped consititutes approximately 30 square miles.

## PURPOSE AND SCOPE

The Sheeprock Range constitutes one of the few areas in Utah where Precambrian rocks are exposed. To date, it is probably one of the least studied. The central portion of the Sheeprock Range has been complicated, geologically, by structural adjustment and igneous intrusion; it is this portion of the range with which the present investigation is concerned. Special emphasis has been given to geologic mapping, structural interpretation, lithologic description, and economic evaluation.

Formations exposed in the Dutch Peak area range in age from late Proterozoic (?) to early Cambrian. No formations had been named in this area below the Tintic quartzite, except for the unique Mineral Fork tillite, whose age and correlation are uncertain.

All formations mapped in the Dutch Peak area are stratigraphically below the Tintic quartzite. Two of the formations were given formal names, the Aut's Canyon and the Ekker formations. These formations were broken into units which are designated by letters on the map and in this report.

A detailed correlation of the stratigraphic section in the Dutch Peak area with sections of comparable age in other areas is beyond the scope of this investigation; however, the author has drawn from the works of those persons who are qualified by their field observations to make such correlations.

## ACCESSIBILITY

The Dutch Peak area can be reached via U. S. Highway 91 and 6 to Jericho and via the Indian Springs graded road to the Ekker Ranch. The road distance from Provo to the mapped area is approximately 95 miles. All roads to the area are passable by car.

The shortest route from Salt Lake City to the Dutch Peak area is via U. S. Highway 40 or 50, west, to the Mills Junction; from Mills Junction via U. S. Highway 36 to St. Johns Station; from St. Johns Station via U. S. Highway 73 to an improved road approximately one and one-half miles west of Willow Springs; and, from Willow Springs south, by way of graded roads, to Indian Springs and Ekker's ranch. The distance from Salt Lake City to the Dutch Peak area by the route just outlined is approximately 100 miles.

## PHYSICAL FEATURES

Sheeprock Range forms a narrow, crescent-like belt, trending generally north-south. The range is of moderate elevation, with only a few peaks rising over 7,000 feet above sea level (Loughlin, 1920).

Deep "V" shaped valleys, steep slopes, and narrow divides are found toward the crest of the range, creating a sharp contrast with the low-lying, rolling hills of the flanks. Loughlin (1920) describes these valleys as having a hanging character near the head of their watershed. Since there has been no known recent glaciation and since the base of the range is above the Lake Bonneville level, Loughlin concludes that the hanging character of the valleys is due to reoccurring fault action, which elevated the range faster than the agents of erosion could maintain their normal gradiant. The western flank of the Sheeprock Range in the Dutch Peak area is comprised of a pediment which has been dissected by erosion.

Most of the valleys contain small, perennial streams which originate as springs and seeps.

These streams, assisted by spring run-off, force of gravity, and zones of weakness caused by jointing and faulting, have developed a dendritic type of drainage, indicative of a mature stage of erosion. Alluvial fans have formed adjacent to the flanks of the range.

The most conspicuous physical feature of the mapped area is locally known as "Black Peak." Black Peak is made up of a series of brown to reddish brown quartzites and phyllitic quartzites which are relatively resistant to weathering, forming bold, rugged cliffs. This series of quartzites overlies a light-colored granite intrusive, creating a contrast in color and topography.

## METHODS

The field mapping of the Dutch Peak Area was accomplished with aerial photographs. Vertical contact prints with an approximate scale of 1/20,000 were used. Annotations were made directly on the photos. At present no topographic maps for the area are available; therefore, a base map was compiled from the aerial photographs by means of slotted templates and the Kail plotter. Townships, ranges, and sections were transferred from a planimetric map compiled by Robert E. Cohenour.

Stratigraphic sections were measured with a 200 foot steel tape, Brunton compass, and hand level, and by photogrammetric techniques. Underground workings were mapped with Brunton compass and steel tape. For a detailed plotting of mine workings and structural features the author used the plane table and alidade. Approximately four weeks were spent in the field.

All thin sections were made and studied by the author using the facilities provided by Brigham Young University. Quantitative mineralogical compositions were calculated by Rosiwal analysis.

## PREVIOUS WORK

Certain mineral deposits and general geologic features of the Dutch Peak area were mentioned and described by G. F. Loughlin in U. S. G. S. Professional Paper 111, published in 1920.

In 1940, Eardley and Hatch in a study on "The Proterozoic (?) Rocks of Utah" measured sections and correlated various Precambrian and lower to middle Cambrian rocks in Utah. They measured a section along the divide of the Sheeprock Range. Certain units described by Eardley are present in the Dutch Peak area; however, due to the reconnaissance nature of their study and the complexity of the structure, they did not describe certain other units found by the present study.

Shortly after commencing this investigation, it was brought to the author's attention that a study of the stratigraphy and general geology of the entire Sheeprock Range has been undertaken by Mr. Robert E. Cohenour. Mr. Cohenour is associated with the University of Utah as a candidate for the Ph. D. degree. It is not known exactly when this study will be completed.

## CLIMATE AND VEGETATION

A semi-arid climate prevails in the Sheeprock Range. The average annual precipitation for a period of 20 years (from 1911 through 1930), as recorded at Benmore weather station, was 13.80 inches; at Tooele, up to 1954, it was 16.61 inches. The maximum recorded temperature at Tooele weather station is 104 degrees F., and the minimum is -16 degrees F.

Representative flora include juniper, sagebrush, cacti, Rocky Mountain cedar, and various grasses and flowering plants. Aspen grow along the canyon streams and steep headward slopes. Small grpves of Douglas fir occur in the upper reaches of Pine Canyon.

# STRATIGRAPHY

## METAMORPHIC ROCKS

### GENERAL STATEMENT

With the exception of a possible equivalent of the Mineral Fork tillite, the lithologic units in the mapped area could not be correlated with any named formation; therefore, the author chooses to refer to the succession of lithologies exposed in the mapped area as the Sheeprock group, which is comprised of the Aut's Canyon formation and the Ekker formation, probably of Proterozoic (?) age. Rock types present are phyllites, phyllitic quartzites, quartzites, graywackes, graywacke conglomerates, graywacke conglomerate semischists, and tillites (?).

For the purpose of structural interpretation, contrasting lithologies were subdivided and similar lithologies were grouped and employed as mappable units, which are tentatively referred to as units A, B, C, etc. No correlation of individual units will be attempted; however, a general correlation of the Sheeprock group with other sections of Proterozoic (?) rocks in Utah will be discussed.

Low rank regional metamorphism and thermal metamorphism have produced varying degrees of mineral reconstitution and textural changes. Textural changes in the tillites, feldspathic quartzites, and graywackes of the Ekker formation are slight, but due to the presence of crystalloblastic actinolite, they will be discussed as metamorphic rocks.

## PRECAMBRIAN SYSTEM

### Aut's Canyon Formation

The term Aut's Canyon formation is proposed by the author for the succession of phyllites, phyllitic quartzites, quartzites, feldspathic quartzites, and graywacke conglomerate semischists that comprises the allochthon of the Sheeprock thrust in the Dutch Peak area. This succession of lithologies was measured and described by the author immediately north of Aut's Canyon (see plate 1). The beds of this group are well exposed in the eastern and northeastern portion of the mapped area.

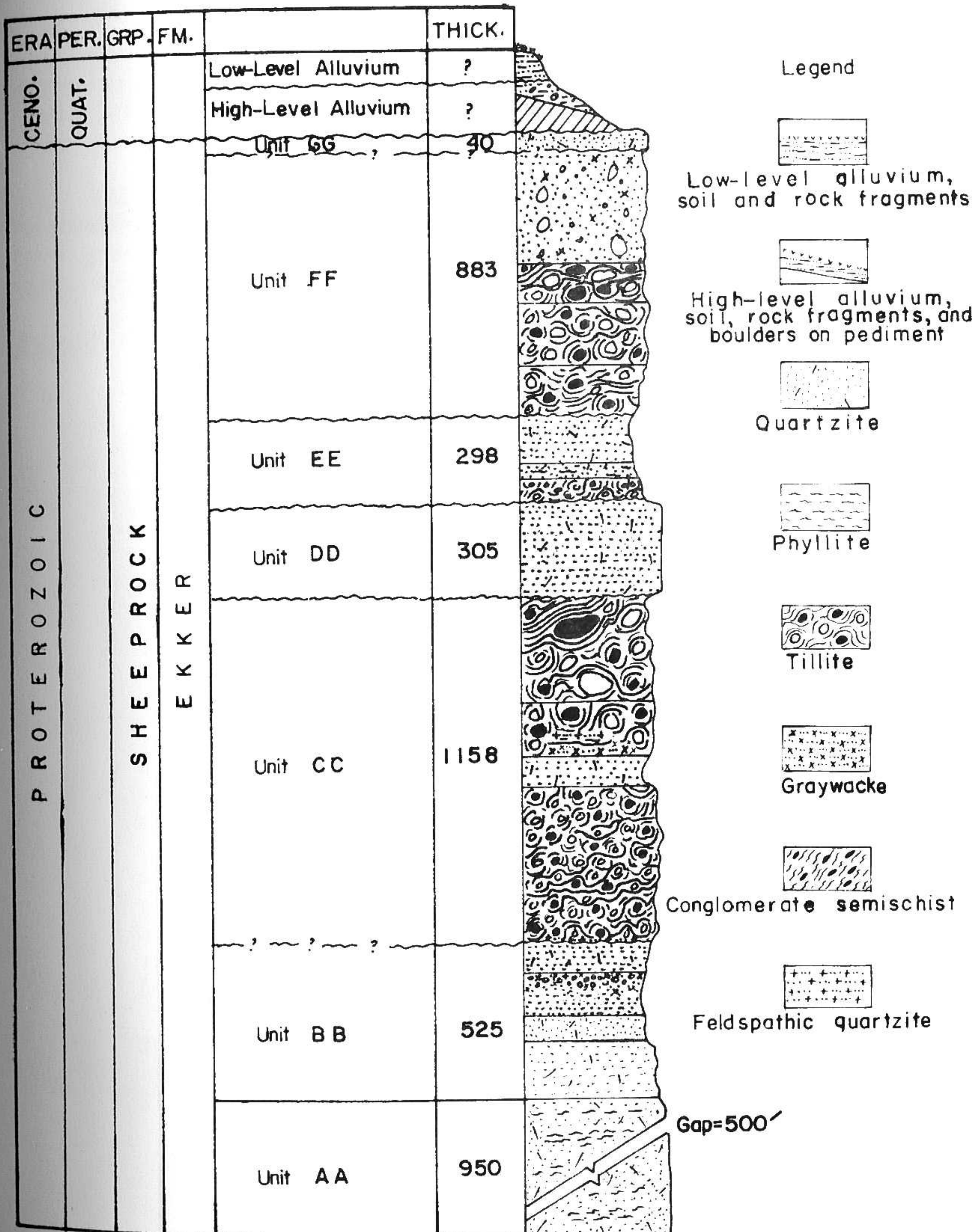


Fig. 2 COLUMNAR SECTION

| ERA | PER. | GRP. | FM. | | THICK. |
|---|---|---|---|---|---|
| PROTEROZOIC | | SHEEPROCK | AUT'S CANYON | Unit I | 309 |
| | | | | Unit H | 850 |
| | | | | Unit G | 600 |
| | | | | Unit F | 591 |
| | | | | Unit E | 270 |
| | | | | Unit D | 566 |
| | | | | Unit C | 279 |
| | | | | Unit B | 418 |
| | | | | Unit A | 1775 |

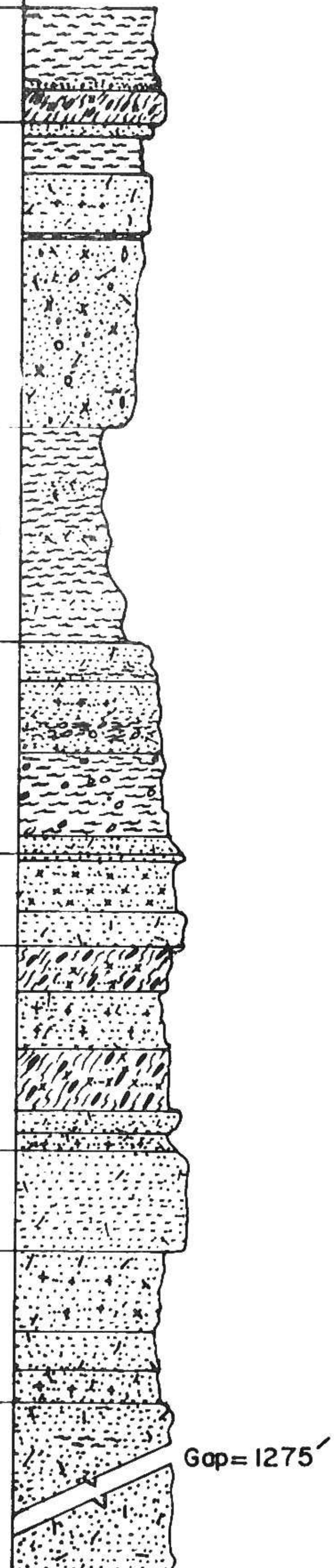


Fig. 2 (cont.) COLUMNAR SECTION

## Unit A

Near the head of Aut's Canyon, where measured and described, the lower boundary of unit A of the Aut's Canyon formation is the Sheeprock thrust, which has placed it in fault contact with unit AA of the Ekker formation. The upper contact is conformable with unit B.

Unit A consists essentially of tan to buff, medium-bedded, fine- to medium-grained quartzite with intercalated thin-bedded, light gray-green beds of phyllitic and slaty quartzite. This unit is a ledge-former.

| Subunit | Description | Thickness (feet) |
|---|---|---|
| 6 | Quartzite: buff, weathers pinkish tan; thin-bedded, medium-grained, dense, glassy; small ledge-former, badly fractured. | 41 |
| 5 | Phyllitic quartzite: gray, weathers gray-green to gray; fine-grained, thin-bedded, flaggy, small ledge-former. | 165 |
| 4 | Quartzite: gray-tan, weathers tan; medium-grained, medium-bedded, ledge-former; fractured. | 362 |
| 3 | Quartzite: gray-green, weathers darker gray-green; fine-grained, slaty, thin-bedded, forms abundant talus slopes; weathers to saddle. | 170 |
| 2 | Quartzite: tan to buff, weathers tan; medium- to fine-grained; essentially medium-bedded ledge-forming quartzites with intercalated slaty quartzites; extremely fractured, especially near thrust fault. | 1037 |
| 1 | Sheeprock thrust fault. | |
| | Total measured thickness of unit A | 1775 |

## Unit B

Unit B conformably overlies unit A; it consists mainly of impure quartzites that are slaty and feldspathic. Generally, this unit forms small ledges.

| Subunit | Description | Thickness (feet) |
|---|---|---|
| 3 | Quartzite: subfeldspathic; buff, weathers tan to brown; medium- to coarse-grained; subangular to rounded quartz grains, some angular feldspars; poorly sorted, contains 5-10% feldspar; medium-bedded, ledge-former. | 217 |
| 2 | Quartzite: buff, weathers buff; fine-grained, glassy, well indurate, thin-bedded, flaggy, slope-former. | 102 |
| 1 | Quartzite: feldspathic and slaty; green-gray, weathers green to green-brown; chiefly quartz, with 10-20% streaked feldspar grains; generally medium-grained, some grains of granule size; contains intercalated tan quartzite beds; ledge-former. | 99 |
| | Total measured thickness of unit B | 418 |

Unit C

| Subunit | Description | Thickness (feet) |
|---|---|---|
| 1 | Quartzite: tan to buff, weathers tan; medium- to fine-grained, glassy, well indurated; massive, exhibits strongly developed joints; cliff-former. | 279 |
| | Total measured thickness of unit C | 279 |

Unit D

Unit D conformably overlies unit C. It consists of alternating quartzites, feldspathic quartzites, and graywacke conglomerate semischists. The quartzites form sharp cliffs that are in contrast to the knobby outcrops of the semischists, which generally weather to slopes between quartzite units.

| Subunit | Description | Thickness (feet) |
|---|---|---|
| 5 | Graywacke conglomerate semischist: spotted and streaked green-brown, weathers darker green-brown spotted gray; fragments chiefly | |

| | | |
|---|---|---|
| | of granite, quartzite, quartz and feldspar, with some gneiss, phyllite, and schist; fragments are chiefly of pebble size and comprise 50-60% of the rock; most of the rock and mineral fragments are aligned with their long direction in a common plane, some appear streaked and drawn out (see figure 3); matrix is chiefly of fine-grained quartz and argillite, some mica and chlorite present; crystalloblastic actinolite occurs in the matrix and as a reconstitution of certain rock fragments; subunit contains intercalated beds of feldspathic quartzite conglomerate semischist; forms cliffs and knobby outcrops. | 122 |
| 4 | Quartzite: feldspathic; tan, weathers tan to brown; coarse-grained, medium-bedded; contains intercalated beds of feldspathic quartz semischist and graywacke semischist similar to unit 3; forms small ledges. | 162 |
| 3 | Graywacke conglomerate semischist: spotted and streaked green and gray-white, weathers spotted green-brown and gray; mineral and rock fragments are aligned and range in size from sand to pebbles; rock fragments consist chiefly of quartzite and granite, feldspar and quartz grains abundant; matrix comprises about 40% of rock; crystalloblasts of actinolite are present; subunit becomes coarser-grained near top; ledge-former. | 176 |
| 2 | Quartzite: buff to tan, weathers pink; medium-grained; massive, cliff-former. | 60 |
| 1 | Quartzite: feldspathic, impure; gray to buff, weathers green-tan and brown; chiefly sub-angular to subrounded quartz sand grains with 10-15% feldspar; spotted by occasional small crystalloblasts of actinolite; coarse-grained, medium-bedded, ledge-former. | 46 |
| | Total measured thickness of unit D. | 566 |

## Unit E

Unit E conformably overlies unit D; it consists of two massive, tan quartzites that are separated by a black to gray-black quartz graywacke. The quartz graywacke subunit forms a plateau-like break between the two cliff-forming quartzites. The basal quartzite of this unit forms a steep cliff.

| Subunit | Description | Thickness (feet) |
|---|---|---|
| 3 | Quartzite: light-tan, weathers pink-tan; medium-grained, glassy, dense; massive, strongly jointed, cliff-former. | 16 |
| 2 | Feldspathic quartz graywacke: salt-and-pepper gray-white, weathers black to green-black; abundant quartz grains (40%) in a gray to green fine-grained matrix, possibly chlorite and argillite; medium-grained, massive, forms rounded cliffs and weathers to large boulders; upper portion grades to graywacke conglomerate semischist with rock fragments up to 4 mm. in diameter. | 160 |
| 1 | Quartzite: light-tan, weathers pink-tan; medium- to fine-grained; massive, strongly jointed, forms bold cliff; upper portion contains numerous quartz stringers that have healed joints and fractures. | 94 |
| | Total measured thickness of unit E. | 270 |

## Unit F

Unit F conformably overlies unit E; it consists primarily of quartzites and phyllites with intercalated beds of conglomeratic phyllite. This unit consistantly forms a slope which is in contrast to the steep cliffs formed by the massive quartzite of unit E.

| Subunit | Description | Thickness (feet) |
|---|---|---|
| 7 | Quartzite: tan beds dominant, some gray; medium-grained, medium- to thin-bedded, flaggy; forms abundant talus, slope-former. | 65 |

| | | |
|---|---|---|
| 6 | Phyllite: gray, weathers tan-gray; fine-grained, thin-bedded, slope-former. | 15 |
| 5 | Quartzite: gray to buff, weathers tan; medium-grained, somewhat friable on weathered surfaces; thin-bedded, flaggy, small ledge-former. | 12 |
| 4 | Phyllite: gunmetal-gray, weathers tan; fine-grained, thin-bedded, slope-former. | 6 |
| 3 | Quartzite: tan, weathers pink-tan; medium-grained, medium-bedded, contains interbeds of subarkosic grit and conglomeratic phyllite with scattered subrounded to rounded pebbles of quartzite; subunit forms slope. | 208 |
| 2 | Phyllite: conglomeratic; grayish tan, weathers tan to brown; contains scattered subrounded to rounded pebbles and granules of quartzite; weathers to saddle; lower portion covered by talus. | 232 |
| 1 | Quartzite: tan, weathers pink-tan; medium-grained, medium-bedded, small ledge-former; weathers to abundant talus. | 53 |
| | Total measured thickness of unit F. | 591 |

## Unit G

Unit G conformably overlies unit F; it consists of gray to tan phyllites with tan to brown interbeds of phyllitic quartzite. This unit is generally a slope former; however, phyllitic quartzite interbeds form conspicuous ledges which are in contrast to the slopes formed by the fissile phyllites. Talus from the phyllites forms slopes of brilliant cleavage slabs.

| Subunit | Description | Thickness (feet) |
|---|---|---|
| 1 | Phyllites and phyllitic quartzites: gray to tan, weathers tan to brown; phyllites are medium- to fine-grained, some beds slightly quartzitic, thin-bedded, schistosity nearly parallel to bedding; phyllitic quartzites are characterized by medium-grained quartz and micaceous partings, weathering surfaces sometimes slightly friable. | 600 |

Total measured thickness of unit G. 600

Unit H

Unit H conformably overlies unit G; it consists of alternating phyllites, quartzitic phyllites, and quartzites.

| Subunit | Description | Thickness (feet) |
| --- | --- | --- |
| 5 | Quartzite: buff, weathers tan-gray; fine-grained, glassy; medium-bedded, ledge-former. | 48 |
| 4 | Phyllite: quartzitic; gray-tan, weathers tan to brown; pronounced mica sheen on cleavage planes; ledge-former. | 82 |
| 3 | Quartzite: tan to light-gray, weathers buff to pink-tan; medium-grained, contains interbeds of coarse-grained subarkosic quartzite; upper portion mostly covered, subunit upholds ridge. | 174 |
| 2 | Phyllite: green-tan, weathers green-brown to brown; mostly covered, few good exposures; slope-former. | 15 |
| 1 | Quartzite: conglomeratic and impure; gray, weathers red-brown; grains range in size from two to ten mm.; chiefly of quartz with grains of feldspar and crystalloblasts of actinolite; most of subunit covered; scattered outcrops indicate intercalated beds of gray and tan phyllites and graywacke semischists; ledge-former. | 532 |
| | Total measured thickness of unit H. | 851 |

Unit I

Unit I conformably overlies unit H; it consists of basal phyllites overlain by a feldspathic quartz grit which grades to an upper subunit of coarse, dark, chlorite graywacke grit.

The dark colored, blocky ledges formed by the chlorite graywacke grit are in sharp contrast to the small ledges and slopes formed by the phyllite and the lighter colored subarkosic grit.

| Subunit | Description | Thickness (feet) |
|---|---|---|
| 3 | Phyllite: gray to gunmetal-gray, weathers gray-brown; coarse-grained, contains occasional quartz crystalloblasts; schistose, medium-bedded, forms slopes; bedding dips southwest, cleavage dip west. | 208 |
| 2 | Feldspathic quartz grit: gray to tan, weathers same; well indurated and glassy; chiefly quartz with 10-15% weathered feldspars; granitic looking; forms small ledge. | 5 |
| 1 | Chlorite graywacke conglomerate semischist: weathers green-black to black; grains range in size from granules to sand; rock fragments extremely altered, mostly to chlorite; matrix is also chloritic; crystalloblasts of actinolite occur as radiating aggregates up to six mm. in diameter, probably represent the recrystallization of basic igneous rock fragments or iron rich mudstones; blocky, weathers to boulders. | 96 |
| | Total measured thickness of unit I. | 309 |

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**Total measured thickness of Aut's Canyon formation.** 5,559

The beds of unit I are not the uppermost beds in the Aut's Canyon formation. The overlying beds have been eroded to a pediment which is now covered by a thin sheet of alluvium and foliage. The pediment has been dissected by stream valleys, creating low-lying hills and ridges that are upheld by bedrock. Isolated outcrops indicate the covered rocks to be, in the main, phyllitic quartzites, and phyllites.

## Ekker Formation

Beds of the Ekker formation, which comprise the autochthon of the Sheeprock thrust, crop out in the north and northeast portions of the mapped area. Lithologies present are phyllitic quartzites, quartzites, graywackes, feldspathic quartzites, and tillites. The only location where the complete succession of beds, as described by the author, can be seen fairly well exposed and in their proper relation is on the ridges east and west of Hard-To-Beat Canyon. Farther west of this locality units DD and EE are missing; their absence represents a disconformity between units CC and FF. East of Hard-To-Beat Canyon the rocks are so brecciated and the structure so complex that it is difficult to observe all of the beds in their proper relation.

With the exception of unit AA, which was measured on the ridge west of Sheeprock Canyon, all units of the Ekker formation were measured on the ridge west of Hard-To-Beat Canyon.

### Unit AA

The lower contact of unit AA, where measured by the author, is nonconformable with the Sheeprock stock. The upper contact is conformable with unit BB.

Unit AA consists of a thick, monotonous succession of red-brown to brown, iron stained quartzites with intercalated beds of phyllitic quartzites. Limonite forms rough coatings on weathered surfaces.

The precipitous cliffs of unit AA combined with its dark color cause it to be one of the most conspicuous features in the Dutch Peak area. One particular outcrop of unit AA on the west ridge of Sheeprock Canyon, where the author obtained the measured section, is so bold in relief and so dark in color that it is locally known as Black Peak (see figure 4).

| Subunit | Description | Thickness (feet) |
|---|---|---|
| 1 | Quartzite: tan to brown, weathers brown to red-brown, intensely iron stained; medium-grained to fine-grained; medium-to thick-bedded, strongly jointed, forms precipitous slopes and abundant talus slides; contains mica partings and intercalated phyllitic and slaty quartzites, most of which exhibit | |

| | | |
|---|---|---|
| | poor cleavage and only a slight sheen; some interbeds banded, similating lamellae or varves. | 950 |
| | Total measured thickness of unit AA | 950 |

Unit BB

Unit BB conformably overlies unit AA; it is comprised chiefly of gray quartzites, which contain interbeds of brown quartzite with micaceous partings and green-brown to gray-black conglomeratic graywackes. The medium-bedded, less massive, gray beds of unit BB create a pronounced contrast with the dark beds of unit AA.

| Subunit | Description | Thickness (feet) |
|---|---|---|
| 5 | Quartzite: buff, weathers tan to gray; medium-grained; medium-bedded; ledge-former; quartz stringers abundant. | 103 |
| 4 | Quartzite: green-brown, weathers green-brown to gray-black; fine-grained, slightly micaceous, thin-bedded; partly covered by talus; slope-former; grades to granular graywacke, spotted green-black and gray-green, weathers same, chiefly quartz granules with occasional pebbles in a dense green-black matrix, matrix comprised of fine-grained quartz, argillite, and chlorite. | 146 |
| 3 | Quartzite: tan, weathers tan to brown; medium- to fine-grained; glassy, some weathered surfaces slightly friable; medium-bedded, slope former. | 80 |
| 2 | Quartzite: brown, weathers brown to red-brown; medium-grained, contains micaceous partings; thin-bedded. | 4 |
| 1 | Quartzite: gray, weathers gray to tan; medium- to fine-grained, well indurated, glassy; medium-bedded, strongly jointed, forms ledges; abundant quartz veinlets in healed joints. | 192 |
| | Total measured thickness of unit BB. | 525 |

## Unit CC

Unit CC disconformably overlies unit BB; no angularity was observed.

Unit CC, where measured, consists of a lower fine-grained tillite separated from an upper coarser-grained tillite by a thin-bedded, fine-grained, buff quartzite; however, this succession of beds does not remain the same throughout the area. Farther west the interbedded quartzite subunit is either completely covered by tillite float, or it is missing from the section. The author is of the opinion that its absence indicates a disconformity.

| Subunit | Description | Thickness (feet) |
|---|---|---|
| 4 | Tillite: spotted green and tan, looks brown from a distance; rock fragments of many sizes range from two mm. to two and one-half feet in diameter (see figure 5); rock fragments are comprised of granite, quartzite, gneiss, and possibly slate; fragments are subrounded; matrix is green, comprised of chlorite, actinolite, quartz, feldspar, and argillite; matrix constitutes about 30-40% of rock; actinolite crystalloblasts weather out, leaving vugs up to three inches in diameter; subunit weathers to boulders, forms steep slopes and knolls. | 367 |
| 3 | Tillite: spotted gray and tan-green, from a distance looks brown; pebbles, granules, and matrix similar to subunit 1; contains lenses of feldspathic quartzite and graywacke; weathers to abundant talus, forms steep slope. | 166 |
| 2 | Quartzite: buff, weathers buff to tan; fine-grained, glassy; thin-bedded and flaggy; forms slope; partly covered by talus from overlying tillite subunit. | 87 |
| 1 | Tillite: spotted light-green, tan, and gray, weathers to spotted green-brown and gray; generally consists of unsorted rock fragments of quartzite and granite up to two inches in diameter in fine-grained matrix of quartz, chlorite, and argillite; contains crystalloblasts | |

| | | |
|---|---|---|
| | of actinolite; basal 20 feet is comprised of arkosic quartzite which grades to tillite; interbeds of graywacke occur as fine-grained and somewhat stratified lenses. | 538 |
| | Total measured thickness of unit CC. | 1158 |

## Unit DD

Unit DD disconformably overlies unit CC. To the west, this massive unit thins and eventually disappears; it appears to overlap on tillite.

Unit DD is a medium-grained, tan to buff, massive quartzite. Where measured, this formation forms sharp cliffs and outcrops and is in contrast to the poorly defined outcrops of the overlying and underlying tillites (see figure 6).

| Subunit | Description | Thickness (feet) |
|---|---|---|
| 1 | Quartzite: buff, weathers tan; medium-grained, dense, blocky; massive, exhibits strongly developed joints, forms sharp cliffs. | 305 |
| | Total measured thickness of unit DD. | 305 |

## Unit EE

Unit EE disconformably overlies unit DD; it consists of a basal spotted green and gray tillite, with rock fragments chiefly of pebble size, overlain by a dark-brown to sooty, banded phyllitic quartzite and a fine-grained, glassy, thin-bedded gray to buff quartzite. To the west, this unit is missing from the section, and at the northeastern portion of the mapped area it grades to a green-brown to gray-black graywacke, overlain by thin-bedded quartzites.

| Subunit | Description | Thickness (feet) |
|---|---|---|
| 3 | Quartzite: buff, weathers tan to buff; medium- to fine-grained; glassy; thin-bedded, weathers to slope and forms abundant talus slides. | 171 |

Figure 3. Photograph of semischist of unit D showing streaked and drawn-out rock fragments, X 2.

Figure 4. Photograph of Black Peak; note prominent joint system dipping to left of photo.

Figure 5. Photograph of tillite of unit CC; note large, gray boulder of phyllitic quartzite.

Figure 6. Photograph of massive quartzite of unit DD; beds dip into photo. Notice prominent joints.

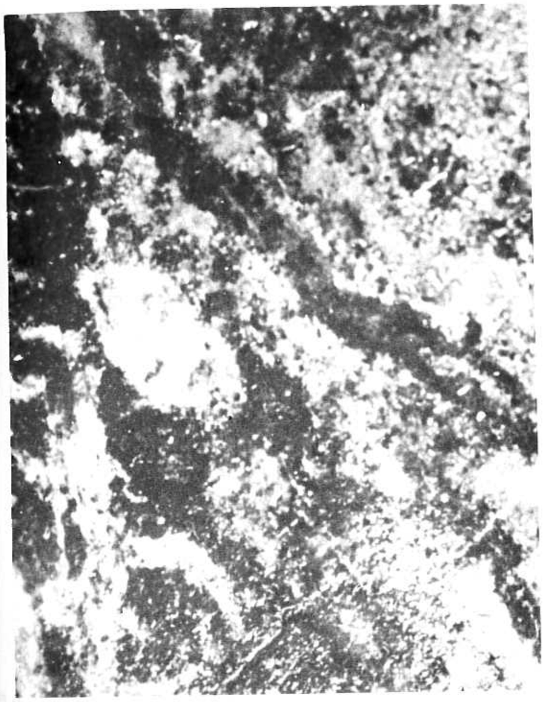


FIGURE 3

FIGURE 4

FIGURE 5

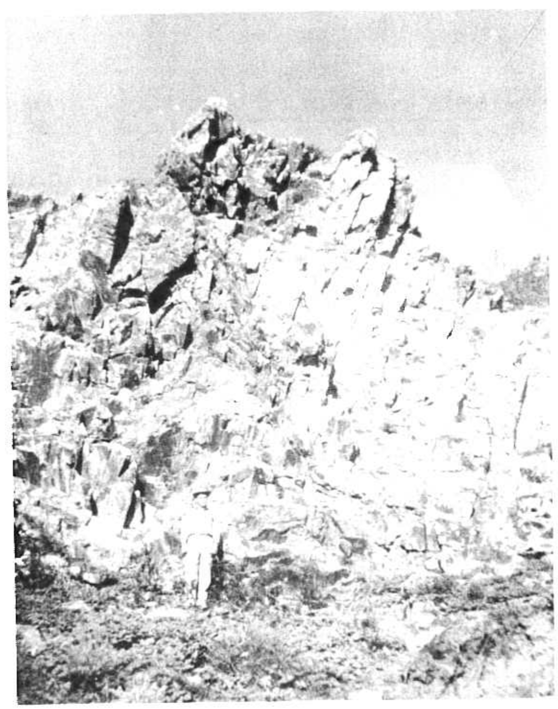


FIGURE 6

| | | |
|---|---|---|
| 2 | Phyllitic quartzite: dark green-brown, weathers dark-brown to sooty; medium-grained, micaceous partings; banded, possibly varved; weathers to slope. | 41 |
| 1 | Tillite: mottled white and light-green, weathers spotted dark-green and gray; numerous crystalloblasts of actinolite; rock fragments are chiefly of quartzite and granite, generally of pebble size; matrix is of fine-grained argillite with chlorite and actinolite; small ledge-and cliff-former; unit thickens west. | 86 |
| | Total measured thickness of unit EE. | 298 |

Unit FF

Unit FF disconformably overlies unit EE; to the west, unit FF rests on unit CC.

Unit FF consists of spotted green and brown tillites with intercalated graywacke lenses which often exhibit stratification and graded bedding. Near the top of formation FF, the tillite becomes fine-grained, grading to graywacke. Unit FF weathers to boulders and irregular cliffs. The graywacke subunit near the top of the formation weathers to a topographic low.

| Subunit | Description | Thickness (feet) |
|---|---|---|
| 4 | Conglomeratic graywacke: green, weathers yellow-green to green-brown; essentially fine- to medium-grained; matrix is of argillite, chlorite, and actinolite; occasional subrounded pebbles of quartzite and granite are imbedded in the matrix; subunit weathers to slope. | 382 |
| 3 | Tillite: gray-tan, spotted green and gray, weathers spotted green-brown and gray (see figure 8); rock fragments mostly of pebble size, occasional cobbles; composition of rock fragments and matrix is essentially the same as unit 2; contains vugs caused by weathering out of actinolite crystalloblasts (see figure 9); subunit 2 differs from subunit 3 mainly in color and size of rock fragment. | 134 |

| | | |
|---|---|---|
| 2 | Tillite: spotted green, green-brown, and white; weathers spotted brown and buff; coarse-grained, contains numberous rock fragments which range in size from granules to boulders two feet in diameter (see figure 7) and are comprised of quartzite, gneiss, granite, phyllitic quartzite, phyllite; matrix is of green indurated quartzitic argillaceous material which contains chlorite and crystalloblastic actinolite; matrix constitutes about 25% of rock; unit forms steep slopes and cliffs. | 206 |
| 1 | Tillite: splotched and mottled green, white, and brown, weathers same; rock fragments range in size from pebbles to cobbles, pebbles dominant; rock fragments of quartzite, granite, gneiss, and phyllite are held in a fine-grained matrix of chlorite, actinolite, quartz, and argillite; subunit forms steep slope. | 161 |
| | Total measured thickness of unit FF. | 883 |

## Unit GG

Unit GG overlies unit FF, because of talus, the exact nature of the contact is indefinite. Farther west Eardley measured 75 feet of light gray quartzite immediately overlying the tillite sequence as compared to the 40 feet measured by the author (see section on correlation). Probably, the contact of the quartzite with the tillite is disconformable.

Unit GG consists of a light-gray, glassy, fine-grained, thin-bedded, strongly jointed quartzite which is uniform in character throughout.

| Subunit | Description | Thickness (feet) |
|---|---|---|
| 1 | Quartzite: light-gray, weathers gray to buff; fine-grained, glassy; strongly jointed, weathers to abundant talus; thin-bedded; ledge-former. | 40 |
| | Total measured thickness of unit GG | 40 |

. . . . . . . . . . . . . . . . . . . . . . . . . . .

Total measured thickness of the Ekker formation 4, 159

## Tillite or Graywacke Conglomerate

Rudaceous beds of questionable origin occur in the mapped area. F. F. Hintze in 1913 observed a similar succession of beds in the Big Cottonwood area and postulated a glacial origin (Crittenden, 1952, page 5). F. F. Hintze (1913, p. 100) credits the first recognition of tillites in Utah to F. J. Pack.

Blackwelder (1932, p. 289-304) made a special study of the tillite outcrops at Little Mountain, Three-Mile Canyon, Landing Rocks, Fremont Island, Hat Island, Dolphin Island, Stansbury Island, and Promintory Point. He says:

> "By way of justifying my use of the term tillite, with its implication of glacial origin, it may be said that the deposits have many distinctively glacial features. In a few cases soled or faceted pebbles with parallel grooves and scratches still visible on them have been found in the tillite."

Crittendon (1952, p. 5) in justifying his naming of the Mineral Fork tillite states the following:

> "The glacial origin of much of this unit, first pointed out by Hintze in 1913, is attested by the presence of striated cobbles and boulders, and by the general character of the till, which in thin section is virtually indistinguishable from modern tills, and from Precambrian tillite in other parts of the world. The smooth profile of the basins and the polished surface of the underlying rocks suggest ice action, though fossil striae have not been observed."

From the author's present examination, no evidence to prove or disprove glacial deposition in the Dutch Peak area was recognized. The general character of the rock and mineral fragments and the matrix of the Sheeprock tillites, as examined megascopically and microscopically, could as well be attributed to environments of graywacke and conglomerate deposition as glacial deposition. Figure 10 shows typical texture and composition of the matrix of the Sheeprock tillites (?). The author is of the opinion that if tillites occur elsewhere in Utah in a similar stratigraphic position, then glacial deposition probably accounts for the rudaceous beds of the Ekker formation.

Eardley (1940, p. 823) from his study of the stratigraphy of the Sheeprock Range concluded that

Figure 7. Photograph of tillite of unit FF; notice rock fragments.

Figure 8. Photograph of tillite of unit FF showing spotted nature and weathering habit. Beds dip into photo. Joint surfaces are conspicuous.

Figure 9. Photograph of tillite of unit FF showing crystalloblasts of actinolite (dark spots).

Figure 10. Photomicrograph of tillite showing matrix of quartz, feldspar, and argillite, crossed nicols, X 10.

FIGURE 7

FIGURE 8

FIGURE 9

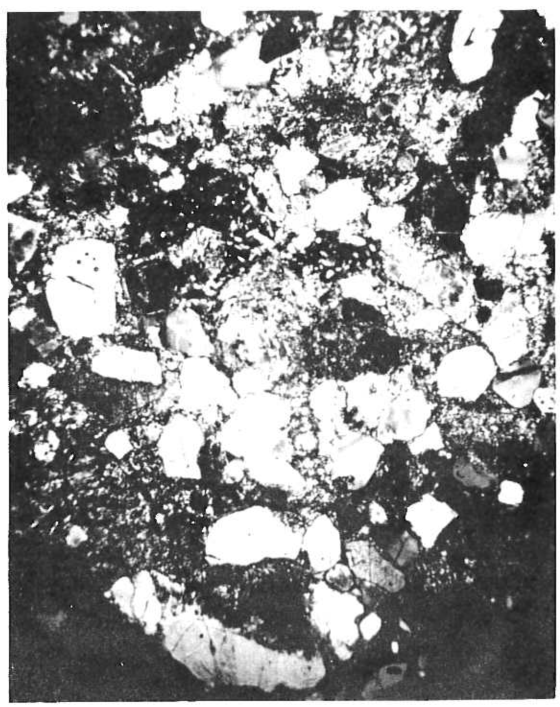


FIGURE 10

> "The conglomerate that Loughlin recognizes as of glacial origin is in all respects, except for composition of pebbles and boulders, the same as the tillites of the Central and northern Wasatch."

Therefore, until evidence is found to disprove glacial deposition in Utah during the late Proterozoic or early Cambrian, the author chooses to conform with the views just presented and regard the beds of units CC and FF and part of unit EE as tillites.

## Correlation

Eardley (1940, p. 795-844) measured and described the major exposures of Proterozoic (?) rocks in Utah. The greater part of the stratigraphic sequence in the Dutch Peak area was labeled a hiatus by Eardley because insufficient time was available to work out the proper relation of beds; nevertheless, his study is the only one known to the author that attempts a correlation of the stratigraphy of the Sheeprock Range. Eardley's measured section is as follows (the uppermost units measured by him are not pertinent to this investigation; consequently, they have been deleted):

| Unit | Description | Thickness |
|---|---|---|
| 26. | Limestone, black. Beds 1 to 8 feet thick. Irregular tan stringers enclosing 1/4- to 1/2-inch spheroidal bodies . . . . . . . . . . . . . . | 80 |
| 25. | Shale, olive tan, smooth, nonmicaceous. Trilobites and brachiopods as follows: Glossopluera producta (Hall and Whitfield), a species of Elrathia, and a species of Lingulella, probably L. ella (Hall and Whitfield) . . . . . . . . . . . . . . . . . . | 25 |
| 24. | Shale, olive tan, hard, sandy, micaceous. Thin drab quartzite beds intercalated . . . . . . . | 75 |
| 23. | Quartzite, light gray, fine- to medium-grained. Weathers very rusty. . . . . . . . . . . . | 250 |
| 22. | Quartzite, light pink white is dominant; also pink and olive gray. Generally fine-grained, with sugary appearance . . . . . . . . . . . . . . | 350 |

| | | |
|---|---|---|
| 21. | Quartzite, light purple, medium- to coarse-grained, beds 1 to 4 inches thick . . . . . . . . | 2600 |
| 20. | Quartzite, pink, coarse- to fine-grained, uneven texture. . . . . . . . . . . . . . . . . | 100 |
| 19. | Slate and quartzite, interbedded olive-tan slate and creamy olive-tan quartzite. Small flutings and mottles on bedding surface. . . . | 225 |
| 18. | Conglomerate. Large boulders in a siltstone slate. Drab to olive tan. Possibly a tillite. No angular unconformity observed. . . . . . . | 50 |
| 17. | Quartzite, light pink, fine-grained, granular but slightly glassy. . . . . . . . . . . . . | 75 |
| 16. | Phyllite, dark gray changing to light gray near top. Thin bedded and fissile . . . . . . . . | 400 |
| 15. | Quartzite, light gray, fine-grained. . . . . . | 250 |
| 14. | Tillite, brown to dark-gray matrix--looks purple in distance. Matrix has quartzitic tendencies. . . . . . . . . . . . . . . . | 250 |
| 13. | Tillite, light-gray quartzitic matrix. Pebbles and boulders are mostly broken homogeneously with matrix to produce smooth joint surfaces. Lenses of quartzite, quartzitic grit, and quartzitic conglomerate occur. . . . . . . . | 600 |
| 12. | Tillite, purple matrix. Weathers to saddle. . . | 250 |
| 11. | Quartzite, in part friable sandstone, clean whitish tan. . . . . . . . . . . . . . . . . | 100 |
| 10. | Quartzite, ocher to brownish gray. Weathers dark brown. Generally laminated. Near contact of Laramide stock is micaceous and in part schistose. . . . . . . . . . . . . . . . | 50 |
| 9. | Hiatus. Complex folding and Laramide intrusion. Succession not worked out. . . . . . . . . . | 500 |

| | | |
|---|---|---|
| 8. | Quartzite with some interbedded phyllites. Gray beds dominant, some brown. . . . . . . | 1500 |
| 7. | Conglomerate with intercalated quartzite layers. Conglomerate in part stratified and hence water-laid, but in part so irregular as to resemble fanglomerate or perhaps tillite. Has sandy matrix with boulders less than 18 inches long. Foliation of boulders not in common plane. Pebbles and boulders are of granite, gneiss, quartzite and phyllite. . . . . . . . . . . . . | 50 |
| 6. | Quartzite, light gray, medium-grained. . . . . | 250 |
| 5. | Phyllites and quartzites interbedded, dark purple. | 600 |
| 4. | Phyllite, gray, partly speckled white and varved. Weathers rusty brown. Cleavage at right angles to bedding. . . . . . . . . . . . . . . . . | 400 |
| 3. | Quartzite, light gray, generally massive. Medium-grained with granular texture. A green variety of quartzite, occurs somewhat like unit 10 of Willard Canyon. A porphyry sill in quartzites of this unit occupies a saddle here. Porphyry similar to Laramide stock of unit 9. . . . . . . | 1000 |
| 2. | Phyllite and shale, gray and dark gray. Some conspicuously varved specimens are silty argillites. A thin tillite occurs at the base, and several thin quartzite beds are intercalated.. . . | 400 |
| 1. | Quartzite, dominantly gray, fine-grained and granular with glassy luster. . . . . . . . . . | 1900 |

The lowest paleontologically datable bed (Eardley's unit 25) in the Sheeprock Range is about 4,000 feet higher stratigraphically than the tillites in the Dutch Peak area. Fossils collected from this unit by Eardley were identified by Resser as Middle Cambrian and identified with those in the Ophir shale of the Oquirrh Range (Eardley, 1940, p. 826).

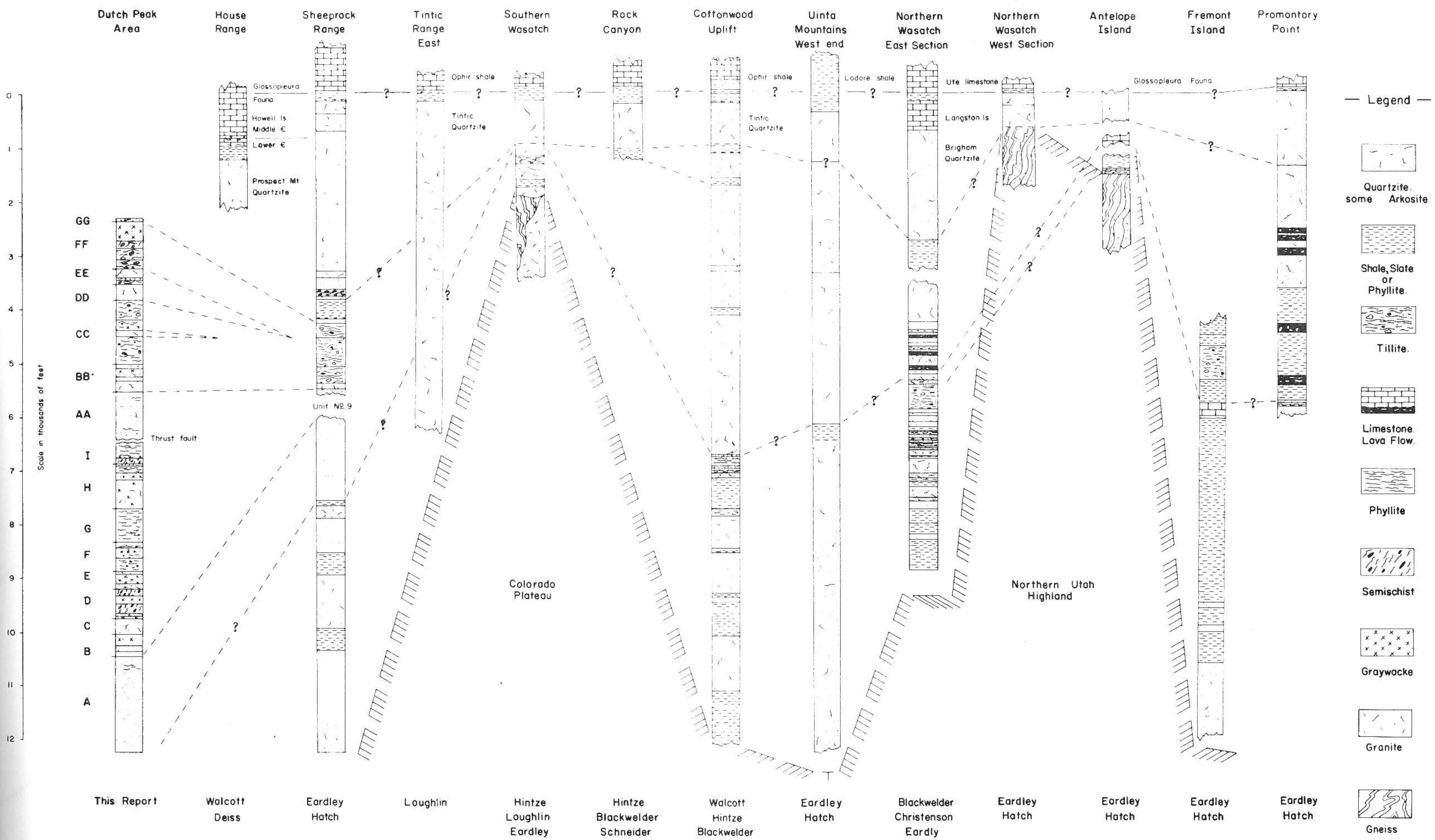
The hiatus of Eardley's unit 9 represents most of the Aut's Canyon formation and the greater part of unit AA of the Ekker formation. Eardley's unit 8 immediately below the hiatus, except for thickness, is essentially the same as unit A of the Aut's Canyon formation, as measured by the author; consequently, all of the beds below Eardley's unit 8 are older than any beds that occur in the mapped area. For a comparison of the lithologies of the Dutch Peak area and the Sheeprock Range with Proterozoic (?) rocks of other areas, see figure 11. The author has added a stratigraphic section of the Dutch Peak area to Eardley's correlation chart of Proterozoic (?) rocks of Utah. The perspective diagram (figure 12) shows the relationship of the Sheeprock trough to the Fremont trough and the relation of both troughs to the source areas of sediments, as postulated by Eardley. The auxilliary diagrams show the two interpretations of the Fremont trough; notice the position of the Sheeprock trough.

## Conditions of Deposition

Original sediments ranged from well sorted muds and sands to sediments containing unstable mineral and rock fragments in an argillaceous matrix; this indicates a varied depositional environment. The accumulation of the clean quartz sands that formed the quartzites and the mudstones that formed the phyllites connotes a depositional environment of relative stability, moderate proximity of source areas, and intense sorting action, thought by Eardley (1940, p. 833) to have transpired on extensive shorelines. According to Pettijohn (1949, p. 284) the deposition of aluminous shales and orthoquartzites indicates a slight uplift of a nearly peneplained area, causing a partial destruction of the regolith.

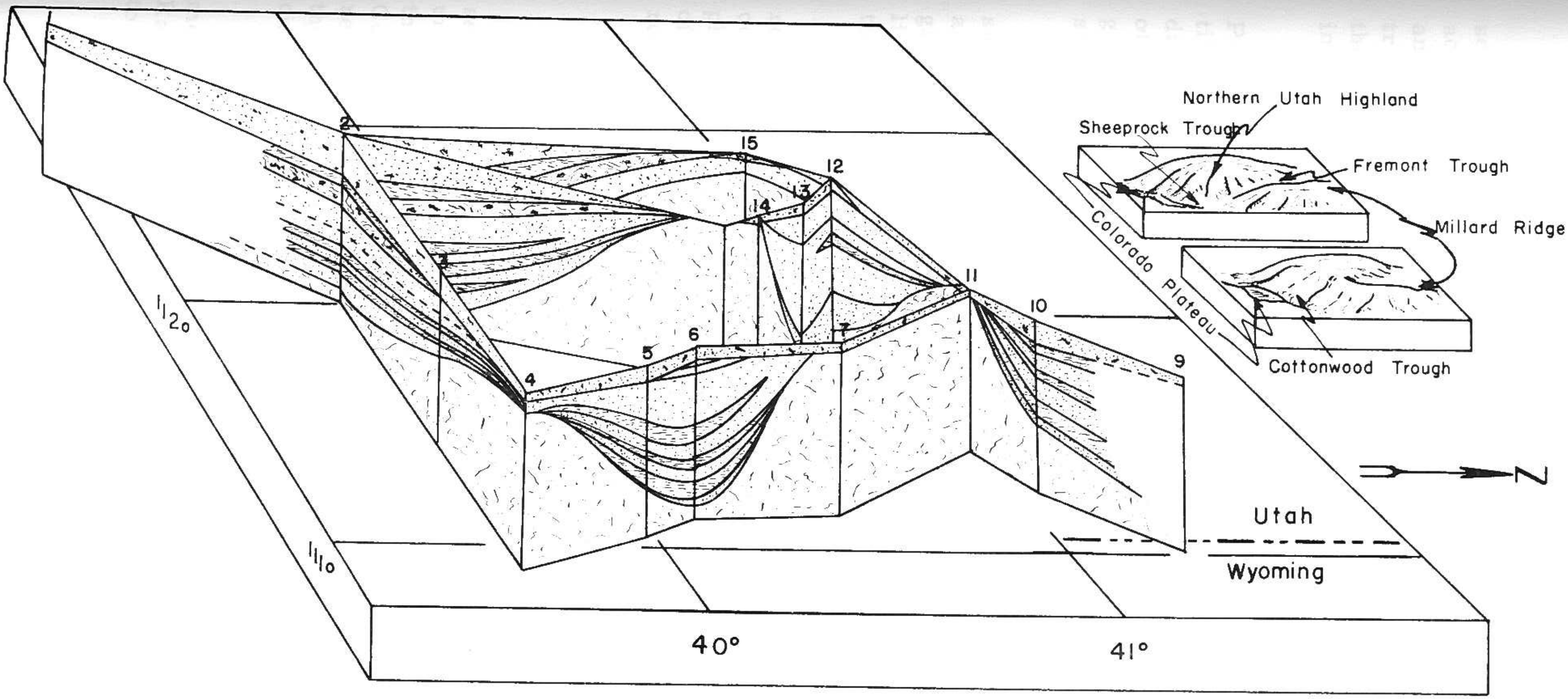
In the phyllitic and slaty quartzites of unit AA of the Ekker formation, the author observed narrow alternating light and dark beds that may be varves. Blackwelder (1932, p. 291-292) observed varves in the slates of the Little Mountain locality west of Ogden and interpreted them to be similar to the stratification found in glacial lakes. If glacial deposition did occur in Utah, it is possible that the varves (?) of the Ekker formation may be of glacial origin; however, the author feels, at present, that the varves (?) might just as well represent seasonal variations in deposition in the Sheeprock trough that were not associated with glacial lakes.

In contrast with the depositional environment of muds and clean quartz sands is the depositional environment of graywacke and graywacke conglomerates. Poor sorting and abundance of unstable rock and mineral fragments indicates a period of activity in which old areas were uplifted, and/or new source areas were formed. The uplifting of the adjacent land masses allowed for rapid erosion of the regolith as well as the exposed crystalline rocks, forming sediments which contain mineral and rock fragments in a clay matrix.




A Correlation Chart (after Eardley, 1940, p828.)

Fig. 11




# Perspective correlation diagram (after Eardley, 1940, p 830.)

Fig. 12

1. House Range
2. Sheeprock Range
3. Tintic Range, East
4. Southern Wasatch
5. Rock Canyon
6. Cottonwood Uplift
7. Hardscrabble Canyon
8. Uinta Mountains
9. Blacksmith Fork Canyon
10. Northern Wasatch, East
11. Northern Wasatch, West
12. Promontory Point
13. Fremont Island
14. Antelope Island
15. Bird Island

More difficult to explain than the source of the graywacke type sediments is a manner of deposition that will allow rock fragments to accumulate with clays. Perhaps mass erosion by means of mudflows and landslides was responsible, or turbidity currents might have transported rock fragments to sites of mud accumulation. Whatever the agency, deposition probably followed epeirogenic activity, resulting in a "poured in" type of sediment.

A general discussion of the occurrence of tillites in the Dutch Peak area has already been presented. If these sediments are truly tillites, then their manner of deposition is easily understood. More difficult to explain is the deposition of so unsorted a sediment by means other than glacial. The other depositional alternative is that they are graywacke conglomerates and, consequently, represent deposition similar to that proposed for graywackes.

Graywackes exhibiting graded bedding occur in the tillites as small discontinuous lenses which often terminate laterally and abruptly against coarse tillite. These lenses of graywacke possibly represent glacio-fluvial deposition. Graywacke and slaty, chloritic, hornfels-like beds also occur interstratified with the tillite, and, in some cases, they show a gradational relationship.

From the composition of the rock fragments contained in the rocks of the Dutch Peak area, the existence of a highland or highlands comprised chiefly of granite and quartzite associated with gneiss, phyllite, and schist is indicated. Only one boulder, which consisted of wollastonite (see figure 13) gave evidence of carbonates as source rocks.

## Disconformities

The presence of tillite or conglomerate in a succession of sedimentary rocks indicates a depositional environment of considerable unrest, possibly giving rise to disconformities and the thinning and thickening of beds; such is the case with the Ekker formation. Between Cottonwood and Pine Canyons, unit FF of the Ekker formation apparently rests directly on unit CC. This disconformable relation is inferred by the absence of the massive quartzite of unit DD and the tillite and quartzite of unit EE, combined, being about 600 feet thick.

A little farther west, near Bennion Peak, Eardley (1940, p. 823) measured 1100 feet of what he called "the main tillite unit of the Sheeprock Range." This sequence of tillite apparently rests on a quartzite similar to the author's unit BB, and it is overlain by a quartzite similar to the author's unit GG (see section on correlation). This disconformity represents either the gradual thinning of units EE and FF to the west where a continual sequence of tillite was deposited, or it represents the deposition of a fairly uniform thickness of units DD and EE followed by uplift and erosion and the deposition of unit FF upon the erosional surface developed on unit CC.

# IGNEOUS ROCKS

## GENERAL STATEMENT

The igneous rocks of the Dutch Peak area are composed of plutonic and hypabyssal bodies that are felsic in composition. The largest and most important rock type is porphyritic granite which composes the Sheeprock stock. A rhyolite dike, which trends northwest, cuts the Sheeprock stock on the western flank of the range. Small pegmatitic dikes occur sporadically throughout a localized zone in the Dutch Peak area (see plate I). The pegmatitic dikes are neither large nor continuous enough to be mapped on the scale used by the author.

## SHEEPROCK STOCK

### Distribution and Topographic Expression

The Sheeprock stock is situated along the western flank of the Sheeprock Range. The southern-most exposure of the stock is in Aut's Canyon (see plate I), where it occurs as an isolated outcrop separated from the main granite body. The Sheeprock stock parallels the trend of the Sheeprock Range and comprises the steep and irregular ridges of the western slope. The stock extends northward beyond the confines of the mapped area. To the west, the granite passes into low-lying hills which are mostly covered by alluvium. Well developed joint systems give the granite a bedded or sheeted character (see figure 34) that has aided in the formation of the rugged cliffs and small, sharply terminated outcrops that characterize exposures of the stock.

### Lithology

Megascopically and microscopically, the Sheeprock stock is classified as a granite. In hand specimen the relative paucity of plagioclase feldspar and mafic constituents and the abundance of orthoclase and quartz is quite apparent.

Generally, the weathered granite is oyster-white in color, grading to a stained rusty tan near the contact. This relation of finer grain size and darker color near the contact has resulted in the recognition by local ranchers and prospectors of a white granite and a red granite. The red granite is more severely jointed and appears bedded. The author is of the opinion that the lighter colored granite which contains pegmatitic differentiates represents a second phase of igneous intrusion, probably originating from a magmatic reservoir which was common to both phases. With the exception of the pegmatitic differentiates, the granite is characteristically a medium- to fine-grained phanerite. Euhedral to subhedral pheocrysts of orthoclase up to one inch in length are abundant; occasionally, large phenocrysts of quartz are also present.

Thin sections reveal a hypautomorphic-porphyritic texture (see figure 15). Essential minerals include orthoclase, oligoclase, microperthite, and quartz. All of the essential minerals occur as phenocrysts and as constituents of the groundmass; however, the largest and most abundant phenocrysts are comprised of orthoclase and microperthite. Phenocrysts of oligoclase are the least abundant. The oligoclase is twinned according to the albite law and exhibits no Carlsbad twinning. Carlsbad twins are found in some of the orthoclase phenocrysts and as relicts in grains of microperthite. Myrmekitic intergrowths of quartz in microperthite and oligoclase are common (see figure 16). Several grains of microcline are present in the slides examined, and it is possible that some of the microperthites are partially comprised of microcline; however, the similarity of the microcline twinning and the microperthitic texture makes positive identification uncertain.

Accessory minerals include biotite, zircon, apatite, and magnetite. Biotite is the most abundant accessory and often contains small inclusions of zircon. Apatite and magnetitie are present in small amounts and occur in association with biotite.

The feldspars have been severely altered to kaolonite and sericite. Specularite occurs along zones of disruption, such as joints, dikes, and faults and has been emplaced by dueteric action of later solutions (see figure 17).

Rosiwal analyses of three slides with three traverses per slide gave the following results (see table I). Approximately 400 mineral grains were measured.

## Age and Contact Relations

All contacts observed between the granite and metamorphic rocks are discordant in nature. The metamorphic rocks of the autochthon and the allochthon have been intruded by the Sheeprock stock; consequently, the field relations of the granite disclose it to be younger than the thrusting that has placed the two metamorphic rock sequences in fault contact.

Table I

Mineralogical Composition of Thin Sections of

The Sheeprock Stock

| Slide # | D. H. #21 | D. H. #115 | D. H. #25 |
|---|---|---|---|
| Orthoclase | 34.8% | 26.8% | 26.9% |
| Oligoclase | 9.2 | 12.8 | 9.2 |
| Quartz | 30.8 | 31.2 | 33.8 |
| Microperthite | 17.6 | 23.8 | 29.5 |
| Biotite | 6.7 | 4.3 | .6 |
| Zircon | .2 | .1 | ---- |
| Magnetite | .4 | .7 | ---- |
| Apatite | ---- | .3 | ---- |
| Microcline | .3 | ---- | ---- |
| Total | 100.0% | 100.0% | 100.0% |

The average mineralogical composition of the granite as calculated from the three slides is shown in Table II.

Table II

Average Mineralogical Composition of

The Sheeprock Stock

| | |
|---|---|
| Orthoclase . . . . . | 29.5% |
| Plagioclase . . . . | 10.4% |
| Quartz. . . . . . . | 31.9% |
| Microperthite . . . | 23.7% |
| Biotite. . . . . . . | 3.9% |
| Zircon. . . . . . . | .1% |
| Magnetite . . . . . | .4% |
| Apatite . . . . . . | .1% |

Figure 13. Photograph of woolastonite boulder in tillite of unit FF.

Figure 14. Photograph of jointed granite; note bedded appearance.

Figure 15. Photomicrograph of Sheeprock granite, crossed nicols, X 10.

Figure 16. Photomicrograph of myrmekite, quartz intergrowth in microperthite, crossed nicols, X 50.

FIGURE 13

FIGURE 14

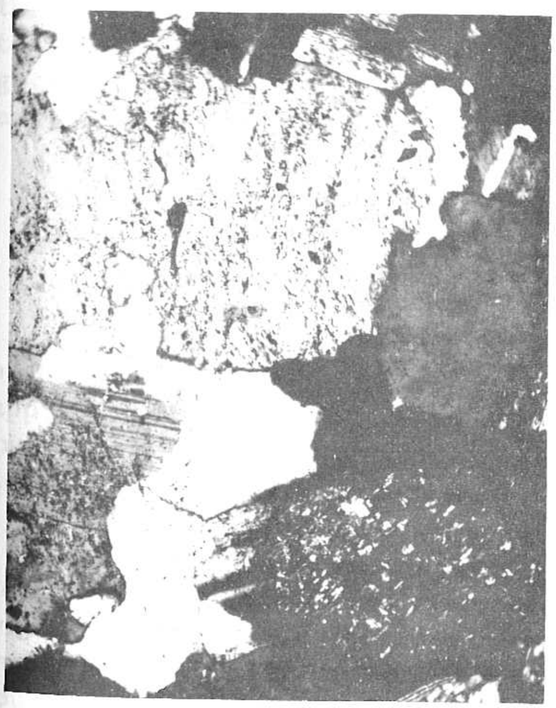


FIGURE 15

FIGURE 16

Mrs. Rich Ekker, a rancher informed the author that samaraskite panned from the intrusive was used by T. S. Lovering of the U. S. Geological Survey to secure a date on the granite. Mrs. Ekker stated that Lovering informed her that the intrusive was dated as being approximately 40,000,000 years old. This date places the intrusion as late Eocene or early Oligocene.

## IGNEOUS DIKES

### Distribution and Character

A rhyolite dike that trends north 50 degrees west and dips approximately 40 degrees to the southwest is best exposed immediately below the granite ridges between Sheeprock and Burnt Canyons. The dike cuts the granite and can be traced eastward to where it disappears under the phyllitic quartzites and alluvium of the pediment. To the northwest, the dike becomes covered by alluvium and foliage in the vicinity of Sheeprock Creek but reappears on the ridge north of the Flying Dutchman shaft. The dike again becomes covered by alluvium as it is traced to the northwest.

Several closely spaced joint systems have developed in the dike causing it to exhibit a flaggy, sheeted weathering habit; consequently the dike is less resistant to weathering than the granite. The dike is topographically expressed as a saddle or rhyolite talus slope. Few good exposures can be found. The dike varies somewhat in width, usually being from 10 to 15 feet wide.

### Lithology

The rhyolite is grayish tan on weathered surfaces and light-gray on fresh surfaces. In hand specimen it is dominantly aphanitic with approximately 15 to 20% phenocrysts. The phenocrysts range in size from mere specks to about two millimeters. Quartz grains are the dominant phenocrysts. Some feldspar phenocrysts are present.

Thin section studies show an aphanitic texture. The groundmass could not be resolved into mineral constituents. Rock identification was affected by field occurrence, megascopic appearance, and microscopic identification of phenocrysts. The phenocrysts were found to be comprised of quartz, orthoclase (possibly sanidine), oligoclase, and biotite. Quartz and orthoclase are dominant. Only a few grains of biotite and oligoclase are present. The groundmass is composed of glass. The most striking feature of the rock when studied in thin-section is the corroded crystals of quartz, orthoclase, and plagioclase that were originally euhedral, but now can be seen in all stages of reabsorption (see figure 18). Close examination reveals numerous small mineral fragments that have been left as remnants of larger grains. Small grains of magnetitie occur as fringes around biotite.

### Age and Genesis

The emplacement of the rhyolite dike was structurally controlled by an earlier formed joint system. Reference to figure 30 will show the relative importance of this system. Since the point diagram method of resolution of joints measures only relative abundance, it is pertinent that the joint system that controlled the emplacement of the dike is one that is particularly well defined and, probably, deep-seated.

Genetically, then, contraction during crystallization formed a joint system along which magma could move, causing the emplacement of granitic magma into a cooler zone.

It is probable that a disruption in chemical equilibrium was instigated in the injected magma because of its removal from the magmatic chamber. Such inequilibrium could explain the pronounced re-absorption of earlier formed crystals.

## PEGMATITES

The Sheeprock stock contains a zone of granite with scattered pegmatitic differentiates (see area X of plate I). The pegmatites occur as dikes and as loci of selective crystal growth. No pegmatitic bodies were found to cut the metamorphic rocks.

### Distribution and Character

The pegmatite dikes of the Dutch Peak area range in width from about two inches to one foot and in length from a few feet to several hundreds of feet. No well exposed dike could be traced as a continuous outcrop for over 50 feet; however, quartz float enabled the author to follow one dike for several hundred feet. The weathering of the pegmatites is similar to that of the granite.

Occurrence

On the basis of mineralog y, four separate types of pegmatites can be recognized.

1. Pegmatite dikes comprised of quartz, feldspar, and muscovite, with some samaraskite. Pegmatites of this type are dominantly of massive, white quartz. Feldspar occurs as large pink and flesh-colored crystals scattered at random through the dike. Muscovite is scarce; it occurs as small flakes and crystals. Samaraskite is present in some of the dikes. The pegmatites of this nature are the largest in the area, being about a foot wide. One of them is traceable for several hundred feet. Three pegmatites of this type were examined by the author in detail.

2. Pegmatite dikes comprised chiefly of quartz, feldspar, mica and minor amounts of wolframite. Pegmatites of this type give a rough similation of zoning. From thin section studies a border zone chiefly of fine-grained quartz, feldspar and biotite with minor amounts of muscovite can be recognized. The contact between the border zone and the granite is gradational and is recognized chiefly by grain size, abundance of biotite, and the absence of phenocrysts. This zone averages about two inches in width. Progressing inward from the border zone, the abundance of feldspar gradually decreases until the rock is wholly comprised of fine-grained quartz. This inner zone is approximately one-half inch wide.

   From the inner zone the grain size of the quartz gradually increases to form a core of large quartz crystals up to one-half inch wide and two inches long that project inward to the center of the dike. The homogeniety of the interlocking quartz crystals of the core is broken by sporadically scattered wolframite. The wolframite grains range up to one-half inch in size. The core varies from two to four inches in width.

3. Pegmatite dikes comprised chiefly of quartz, feldspar, and beryl. These pegmatites exhibit no apparent zonation. The mineralogy consists mainly of quartz and feldspar. Beryl usually is present but occasionally may be missing. In some instances, beryl is the only mineral present. Beryl occurs as isolated prismatic crystals and as radiating clusters of crystals of the rosette type. Crystals of beryl up to one-half

inch wide and several inches long were observed by the author. The beryl is acquamarine but, unfortunately, contains considerable amounts of foreign matter; however, it is noteworthy that the Rich Ekker family has found a few small (1 mm. wide and about 6 mm. long), euhedral, transparent aquamarine that, except for a few minor crystal flaws, approach gem quality.

Pegmatites of this mineralogy are the most abundant type in the area; however, they are quite small, ranging in width from one to four inches, and rarely over twenty feet long.

4. Occurring throughout area X (see plate I) in a seemingly structurally uncontrolled manner are rosettes of beryl. The beryl is not evenly distributed. Areas of beryl concentration are separated by exposures of granite that appear completely barren.

The beryl occurs in the granite as an aggregate of prismatic crystals which radiate from a center, creating a sunburst effect. From the center of growth the beryl crystals gradually increase in length and width, forming beryl rosettes up to two feet wide at their expanded end. Most beryl rosettes observed by the author expanded from a point of beginning to a maximum width that varied from four to eight inches. The length of the rosettes varied considerably, and there appears to be no pronounced correlation between the length of a rosette and its width. Beryl crystals up to eight inches long and in excess of one-half inch wide have been observed in the beryl rosettes.

The relation of the beryl rosettes to the granite is unique and rather perplexing. The granite in this general area is medium- to fine-grained, with large phenocrysts of orthoclase and microperthite. In general, no perceptible change in texture or composition is visible in the granite in the immediate vicinity of the beryl accumulation. A few exceptions were observed where a halo of fine-grained granite with a little more biotite than normal surrounded the beryl.

It is noteworthy that none of the large crystals of feldspar and quartz which usually accompany beryl concentrations are associated with the beryl within or around the rosettes. The only indications of pegmatitic growths are the loci of large crystals of beryl that protrude from an otherwise normal granite.

Thin section studies show that the beryl crystals contain many impurities. Numerous subhedral to anhedral grains of quartz and orthoclase with minor amounts of oligoclase (possibly some albite), biotite, and muscovite occur as inclusions and embayments within the beryl crystals, especially near the granite-beryl contacts (see figure 19). The beryl is euhedral and exhibits sharp contacts with other beryl crystals.

Cusp and carries relations between quartz and beryl are common (see figure 20). Not quite so common, but noticeable, is this same relation between the feldspars and beryl.

Impurities, then, exist in the beryl as inclusions formed by penecontemporaneous crystallization and as embayments caused by incomplete replacement of the rock silicates by beryl.

## Structural Control

Field observations show that the pegmatite dikes are structurally controlled by joints, most of which trend northeast. The structural control of the beryl rosettes will be discussed in the following section on Genesis.

## Genesis

The genesis of pegmatites is best explained by a period of magmatic differention during which residual fluids are enriched in volatiles and rare earth elements. If these residual fluids cool and crystallize in place, a massive zoned pegmatite core is formed within the intrusive; however, if fracturing has occurred the residual fluids may escape and fill fissures or forcibly inject themselves along places of weakness, forming pegmatite dikes similar to those found in the Dutch Peak area.

In general, pegmatites are either of a complex mineralogy and exhibit a zonal structure, or they are of simple mineralogy and heterogenous throughout. The occurrence of beryl in pegmatites associated with feldspar, quartz, muscovite, lithium minerals, and numerous rare earths, has long been known to mineralogists. The author is not aware of any occurrence cited in literature where pegmatite minerals are found as monomineralic crystal aggregates that are in direct contact with normal granite.

Goldschmidt and Peters (Rankama and Sahama, 1952, p. 444) reported an average of 3.6 grams of Beryl per ton of granite. They also point out (Rankama and Sahama, 1952, p. 445) that "...enrichment

Figure 17. Photomicrograph of specularite in granite, plain light, X 50.

Figure 18. Photomicrograph of rhyolite showing corroded crystals of quartz and feldspar, plain light, X 50.

Figure 19. Photomicrograph of inclusions in beryl. Beryl is at extinction position. Inclusions are of quartz, orthoclase, and plagioclase, crossed nicols, X 50.

Figure 20. Photomicrograph of cusp and carries contact of beryl with quartz; note embayments of quartz in beryl grain not at extinction. Large grain of beryl is at extinction position, crossed nicols, X 60.

FIGURE 17

FIGURE 18

FIGURE 19

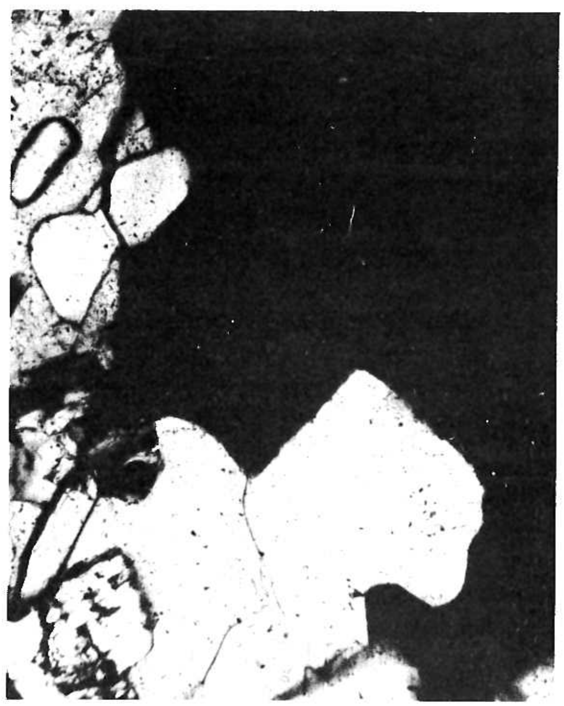


FIGURE 20

is evidently due to the small size of the beryllium ions, which consequently are not capable of hiding in the structure of common rock-making minerals but become, instead, enriched in the residual solution." Wickman (Rankama and Sahama, 1952, p. 445) states that another cause for residual concentration of beryllium is the low charge of the beryllium ion.

If the beryllium content in granites is somewhere near the concentration reported by Goldschmidt and Peters (3.6 grams per ton), then, any concentration of beryl within an igneous body necessitates a previous phase of crystallization differentiation. For this reason, and because the crystals are large and euhedral, the author feels that the beryl rosettes occurring in the Sheeprock stock are definitely pegmatitic in origin. Pertinent also is the occurrence of beryl as an accessory mineral in the granite in the immediate vicinity of the beryl rosettes.

While in the field, the author searched for clues to a structural control for the emplacement of the beryl rosettes. In only a few instances were structural features seen that could possibly have controlled their emplacement. In one instance a rosette was located in a beryl vein controlled by a joint. In another instance, a rosette of beryl crystals was located at the intersection of two joints. Even though this joint-intersection relation was not found in most cases, the author feels that stresses formed similar zones of weakness that could act as loci for crystal growth. The fact that the beryl crystals are euhedral and contain inclusions of the common rock-forming silicates indicated that crystallization was still ensuing. The granite probably was a mesh of crystals that contained interstitial or intergranular residual liquids enriched in beryllium. In such a physical state the granite body would act plastically when subjected to stresses. It seems tenable, then, that such stresses could produce zones where crystals might grow by selective ionic movements aided by replacement and possibly by physical movement of residual liquids. Ions of beryllium would be relatively free to circulate because of their small size. Also, the presence of accessory beryl disseminated in the granite could be rationalized as crystallization in situ.

It may appeal more readily to certain lines of reasoning to think of the loci of crystal growths as filled cavities that formed due to contraction of the granite as cooling and crystallization took place. Even so, selective crystal growth supported by ionic transfer in an interstitial liquid would still need to be active.

Any theory proposed to explain these beryl concentrations must rationalize the occurrence of a typically permatite mineral as monomineralic crystal aggregates. Also, the evidence of penecontemporaneous crystallization supported by the numerous inclusions must be accounted for. In conclusion, the author fees that the occurrence of beryl in this manner warrants a more detailed study.

# SEDIMENTARY ROCKS

## GENERAL STATEMENT

The sedimentary rocks of the Dutch Peak area consist of quaternary alluvium, which has been differentiated to high-level alluvium and low-level alluvium.

## QUATERNARY SYSTEM

### High-Level Alluvium

Erosion during Quaternary time carved a pediment along the western flank of the Sheeprock Range in the Dutch Peak area. Alluvium in transit to the intermountain valley now mantles the erosional surface; this alluvium was mapped as high-level alluvium. The age of the pediment is not definite; it probably is related to early Basin and Range faulting which initially elevated the range. More recent faulting has further elevated the range, resulting in the dissecting of the pediment. The pediment is now topographically expressed as low-lying hills which form an overall gentle gradient from the valley floor to the exposed bedrock of the range. The pediment was eroded in granite as well as in the sequence of metamorphic rocks found in the area.

The high-level alluvium consists of an unsorted debris of soil and rock fragments, many of which are boulders. The boulders are similar in lithology to the exposed formations which crop out higher up on the range and to the underlying bedrock, as is inferred from scattered outcrops.

### Low-Level Alluvium

The low-level alluvium consists of silt, clay, and rock fragments which form the alluvial fans and the valley fill. The alluvium of the valleys and the fans appears to be relatively thin.

# METAMORPHISM

## GENERAL STATEMENT

The rocks of the Dutch Peak area exhibit textural and mineralogical changes caused by low-rank regional metamorphism and thermal metamorphism.

Deep burial, heat, and stresses have resulted in an alignment of mineral grains and a reconstitution of certain constituents into new minerals, resulting in a weak foliation and a moderate schistosity. Not all rocks in the Dutch Peak area exhibit to the same degree the effects of regional metamorphism; the rocks of the Aut's Canyon formation have been subjected to greater metamorphism.

The intrusion of the Sheeprock stock has produced thermal metamorphism, resulting in unoriented crystalloblasts of contact metamorphic minerals.

## REGIONAL METAMORPHISM

### PHYLLITES

The occurrence of thick successions of phyllite, phyllitic quartzites and quartzites in the Dutch Peak area gives evidence of regional metamorphism. This regional metamorphism has not progressed beyond the low rank stage, for the phyllites only occasionally contain quartz meta-crysts, and usually show only a slight foliation. Schistosity, however, is quite well developed in certain beds, and in the phyllites of the Aut's Canyon formation a brilliant sheen of sericite is exhibited on cleavage surfaces.

### PHYLLITIC QUARTZITES

Regional metamorphism of argillaceous sandstones resulted in the formation of phyllitic quartzites which exhibit mica partings and incipient sericite crystallization in and around quartz grains. The sericite has become oriented at an angle to the bedding planes, creating a weak cleavage. The quartz grains also have been slightly drawn out and oriented in the same plane as the sericite.

## QUARTZITES

The pure quartzites of the mapped area appear glassy, hard, and dense. In thin sections no outlines of original mineral grains are evident. Recrystallization has been complete, and the cement is in optical continuity with the quartz grains, creating a mosaic of quartz (see figure 21).

## IMPURE QUARTZITES, GRAYWACKE CONGLOMERATES, SEMISCHISTS AND TILLITES

Regional metamorphism of these rocks is not constant but varies with the different beds. The rocks of the allochthon have suffered more from regional metamorphism than those of the autochthon. The graywacke conglomerates of the allochthon have been regionally metamorphosed to semischists; stresses have been sufficient to orient the coarse rock fragments, creating a slight foliation and a weak cleavage. Under the differential pressures, slight slippage may have occurred, for some of the grains appear streaked and drawn out. Chemical reconstitution has not progressed very far; most of the rock fragments exhibit only an incipient crystallization of sericite, especially at the expense of the feldspars (see figure 22) and, occasionally, of quartz. Certain rock fragments (probably of basic igneous rocks) have been changed to chlorite, with interspersed magnetite grains. Clinozoisite was observed in thin-sections of some of the semischists as a recrystallization of matrix (see figure 23). Inter-reaction between rock fragments and matrix often produces hazy and streaked grain outlines.

The impure quartzites, graywacke conglomerates, and tillites of the autochthon show little effects of regional metamorphism; the coarse rock fragments have not been oriented; however, micaceous partings and orientation of grains can be observed in the interbedded phyllitic quartzites.

The chief regional metamorphic minerals that have formed in the Dutch Peak area are:

micas (mostly sericite and muscovite)
chlorite
clinozoisite
quartz (?)

## THERMAL METAMORPHISM

The intrusion of the Sheeprock stock into the low-rank regional metamorphosed, high-silica rocks of the Dutch Peak area produced mineralization and alteration at the contact and metacrysts in the surrounding rocks.

The contact of the granite with the metamorphic rocks is characterized by a zone of chloritic and micaceous alteration which is often associated with iron and manganese oxides. The width and distinctness of this zone varies with the granite. Where the granite is in direct contact with a clean quartzite, the only effect is a slight staining of the quartzite near the contact and a more glassy and dense character in the surrounding rock. Where the granite is in contact with phyllitic and impure quartzites the effects of metamorphism are more pronounced. Near the contact, these rocks contain mica (mostly muscovite) and abundant fine-grained chlorite. Occasionally pods of iron and manganese oxides have developed along the contact. On the ridge between Hard-To-Beat and Sheeprock Canyons, where the contact is nearly horizontal, a zone of intense chloritic and micaceous alteration with minor amounts of manganese and iron mineralization nearly 5 to 10 feet thick has been exposed by erosion. This particular outcrop was thought to carry some lithium; the author found no evidence to confirm its presence.

A less obvious but more wide-spread effect of the granite intrusion is the development of crystalloblastic actinolite, which upon first glance may be mistaken for chlorite. The development of the actinolite appears to have been dependent on two criteria:

1. The supply of heat and, possibly, gases by the cooling magma.

2. The presence of chemically favorable constituents in the adjacent rocks for recrystallization to actinolite.

The crystalloblasts of actinolite occur as reconstituted matrix (see figure 24) and as a recrystallization of certain rock fragments (see figure 25). Since actinolite occurs mainly in the impure type of sediment, the author has concluded that argillaceous matrix and shaly, slaty, or phyllitic rock fragments have been the recipients of actinolite crystallization. It is noteworthy that the actinolite of the matrix usually shows no preferred orientation, and where recrystallization has been

Figure 21. Photomicrograph of quartzite showing mosaic of quartz, crossed nicols, X 50.

Figure 22. Photomicrograph of sericite (bright flecks and laths) in semischist of unit D. Sericite is forming at the expense of feldspar, crossed nicols, X 50.

Figure 23. Photomicrograph of clinozoisite in matrix of semischist of unit D. Clinozoisite occurs as aggregates of grains with high relief and gray color, plain light, X 50.

Figure 24. Photomicrograph of actinolite (bright flakes and laths) in matrix of semischist of unit D, crossed nicols, X 50.

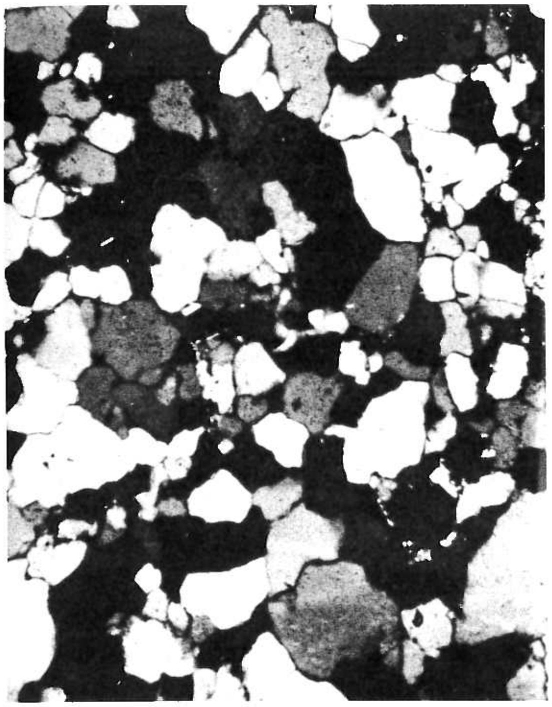


FIGURE 21

FIGURE 22

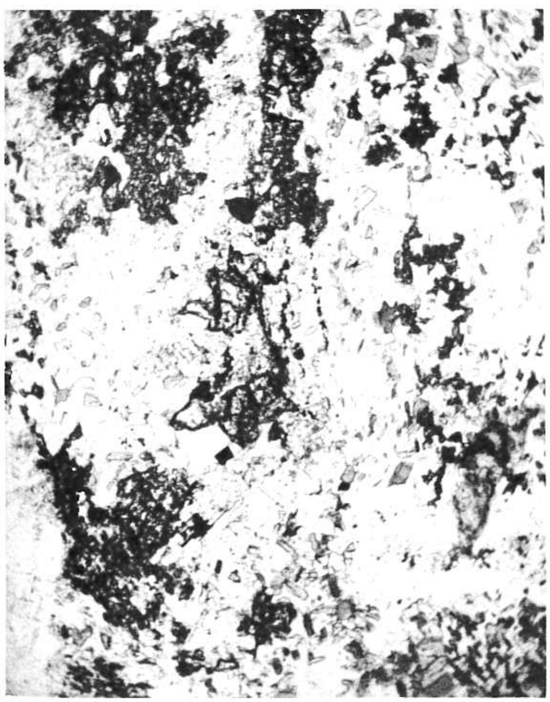


FIGURE 23

FIGURE 24

intense, rosettes of actinolite form in the matrix as well as in the rock fragments. Pods of actinolite up to several inches across have weathered out of the tillite, and, in one instance, the author found two aggregates, each about one foot across, of large euhedral crystals that had developed in a fractured zone in a graywacke conglomerate semischist (see figure 26).

Not so obvious as the crystalloblasts of actinolite is the spotted character of the phyllite and phyllitic quartzites. In thin section the light brown spots are found to be limonite which has altered from small pyrite metacrysts and has spread into a larger spot as a stain and as a cement (see figure 27). Small pyrite flecks can still be observed in some of the limonite grains. The emplacement of pyrite metacrysts and their alteration to limonite helps explain the red-brown, and brown colors that characterize some of the beds in the Dutch Peak area.

The chief contact metamorphic minerals in the Dutch Peak area are:

actinolite
pyrite
chlorotoid

## S T R U C T U R E

### GENERAL STATEMENT

The Dutch Peak area has been subjected to major crustal adjustments. Centered in the area under consideration is the western limit of the Sheeprock thrust, along which strike-slip or tear fault displacement has occurred, placing two metamorphosed sequences in juxtaposition. To the east, at the head of Aut's Canyon, this same fault displays a thrust relationship.

Folding previous to or penecontemporaneous with the thrusting has produced steep (40-80 degrees) dips in homoclinal structures in both the autochthon and allochthon. These homoclines dip in opposite directions.

High-angle oblique and reverse faults resulting from thrusting have, through a series of "steps", offset the autochthonous sequence to the north.

Joints, most of which developed from igneous intrusion, are strongly expressed in granite and metamorphic rocks.

### FOLDS

No complete folds occur in the mapped area. Two homoclinal structures are separated from each other by a thrust fault. The beds of the Ekker formation (the autochthon) strike north about 40-50 degrees west and dip to the northeast, while the beds of the Aut's Canyon formation strike north about 10-20 degrees west and dip southwest. Both homoclines dip, in their respective directions, on the average, about 50 degrees.

A possibility exists that these two homoclines are limbs of a large fold that broke under compression, allowing the southwestern limb to over-ride the other. Still another possibility is that the homocline of the autochthon might have been caused by drag as the allochthon rode over.

## SHEEPROCK THRUST

In the early stages of field investigation, the author felt that the discontinuity between the Ekker formation and the Aut's Canyon formation, as observed at the head of Joe's Canyon, might possibly be an angular unconformity; however, as the field mapping progressed, the pattern of displacement on the high-angle faults in the Ekker formation strongly indicated a compressive force from the southwest. Upon close examination of the disconformable contact at the head of Aut's Canyon, sufficient fault breccia was found to confirm the presence of a thrust fault. According to Robert Cohenour (1957, personal communication) the Sheeprock thrust can be traced through a series of fensters to where it is better known as the West Tintic thrust.

In the central portion of the mapped area, at the head of Joe's Canyon, the discontinuity between the Ekker formation and the Aut's Canyon formation exists as a tear fault. The two formations are placed in juxtaposition and not in the over-riding attitude one would expect in a thrust; however, at the head of Aut's Canyon and along the eastern margin of the mapped area the converse relation is true.

In general, brecciation along the fault plane is not severe; however, the rocks of both the authochthon and the allochthon are considerably more fractured in the vicinity of the thrust.

Just how far the allochthon has been translated, the author is not at present able to say; however, because of the similarity of the lithologies of the rock sequences, the author feels that there is not a great deal of stratigraphic separation between them.

## RIDGE FAULT

Near the head of Bennion Canyon (see plate I) unit BB of the Ekker formation has been completely faulted out by the Ridge fault. The hanging wall has moved up relative to the footwall, placing unit AA near the base of unit CC. Ridge fault trends north 55 to 65 degrees west and dips about 50 degrees to the southwest. Assuming that unit BB maintains somewhat of a constant thickness, the minimum stratigraphic displacement of the Ridge fault at this point is 589 feet. Calculations based on this assumption give a throw of about 460 feet, a heave of about 380 feet, and a displacement along the plane of the fault of about 600 feet.

The fault plane is an intense zone of brecciation which in places is up to 50 feet wide. Pneumatolytic solutions have mineralized the fault breccia quite heavily with iron. Original mineralization was chiefly magnetite with minor amounts of specularite and, possibly, pyrite. Oxidation and hydration have converted most of these minerals to limonite. In thin section the replacement of the quartzite by the iron oxides is quite well pronounced (see figure 28). Because of the cementation of the fault breccia by iron oxides, it stands more resistant than the jointed and shattered quartzites through which it passes. One exceptional outcrop of the mineralized fault breccia was found that occurs as a vuggy, iron-stained monolith nearly 15 feet high (see figure 29).

## HIGH-ANGLE FAULTS

A system of high-angle reverse faults traverses the autochthon in a step-like pattern. The faults trend, generally, north-south and possess dips that are near 90 degrees. These faults are especially concentrated near the plane of the Sheeprock thrust. It is evident that the stresses exerted as the allochthon rode over and wrenched past the autochthon caused this system of faults. The autochthon was crowded and pushed to the north along the planes of these faults.

Because of the extreme fracturing, talus is unusually abundant; consequently, near the thrust, fault planes are poorly exposed. Some faults were inferred from slickensides and zones of brecciation, others by mineralized streaks and prospect holes. The direction of movement along the high-angle faults has been inferred by stratigraphic displacement and breccia orientation. In general, the author believes that the hanging wall moved up in an oblique manner with a considerable strike-slip component.

## SLUMP BLOCKS

West of Hard-To-Beat Canyon and near the granite are two slump blocks (see plate I). Units EE and DD have been repeated down section from their original position, as they are now lying on units BB and CC. The larger slump block exhibits a reversal of dip to the south, evidently incurred during slumping. Elsewhere evidences of slumping are nil.

Figure 25. Photomicrograph of rosette of actinolite in semischist of unit I, crossed nicols, X 50.

Figure 26. Photograph of crystals of actinolite from unit I, X 2.

Figure 27. Photomicrograph of phyllitic quartzite of unit AA showing limonite spots caused by the oxidation of pyrite metacrysts, plain light, X 10.

Figure 28. Photomicrograph of mineralized fault breccia from Ridge Fault. Dark material is limonite which is replacing quartzite breccia, plain light, X 10.

FIGURE 25

FIGURE 26

FIGURE 27

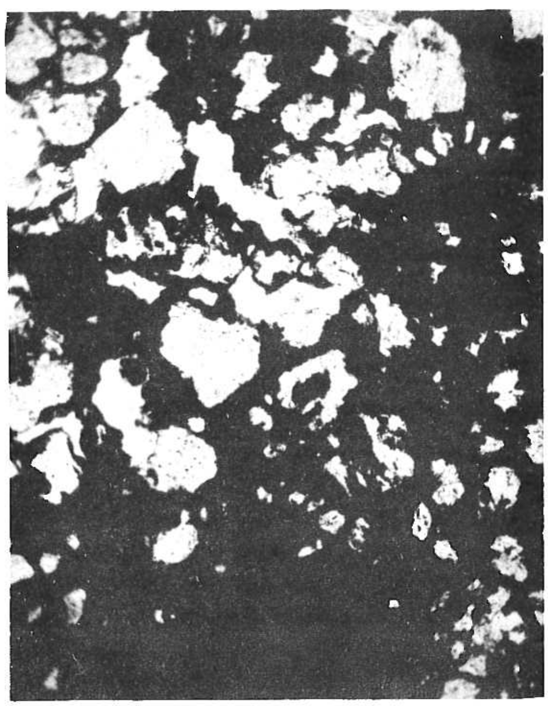


FIGURE 28

## JOINTS

The rocks of the Dutch Peak area exhibit very strongly developed joints. In the field, the pronounced jointing frequently renders the attitude of the beds undefinable, unless the contact between two strikingly different lithologies can be observed. Three different point diagrams of the poles of joints have been prepared and contoured, showing the relative abundance of the joints that occur in the Sheeprock stock, the authochthon, and the allochthon (see figures 30-32).

## INTERPRETATION OF JOINT DIAGRAMS

A qualitative and quantitative study of the joints in an area involves a consideration of the joints which possess not only the same trend but also the same degree of dip; consequently, a graphical representation must show relative concentration of joints that are of the same attitude.

In order to depict the different joint systems and their relative concentration within the localities chosen, the author has employed the point diagram method as outlined by Billings (1954, pp. 108-114). This method makes possible the representation of both the strike and the dip of a joint by a single point oriented by north-south east-west coordinates and plotted on the lower half of a sphere. To resolve the strike and dip of a joint to an oriented point, the poles of the joint are plotted, and since it is customary to use only the lower half of the sphere, only one pole is plotted.

To plot the pole, the strike of the joint is plotted by the co-ordinates. The pole is located along a line from the center drawn perpendicular to the strike and in the opposite direction of the dip, at a distance from the co-ordinate intersection which is proportional to the amount of dip. A horizontal joint is represented by a point which lies near the center of the circle, and a vertical joint is represented by a point which lies near the periphery of the circle.

A grid comprised of intervals which are one-tenth the radius of the large circle is prepared and superimposed on the circle. A counter, which consists of a hole one-tenth the diameter of the circle, cut in cardboard, is moved across the circle one interval at a time. The number of points that fall within the area of the counter is recorded at line intersections of the grid as a percentage of all points plotted on the diagram.

The points that fall on the periphery of the circle are counted by a special method. The peripheral counter consists of two holes, the centers of which are separated by a distance equal to the diameter of the circle, that are cut in a strip of cardboard. The center of the peripheral counter revolves around an axis which passes through the intersection of the co-ordinates. The number of points which fall within both end counters are added, and the percentage which they represent is placed at the line intersection within each end counter.

After the counting proceedure has been completed, the circle which is covered by numbers is contoured as one would contour a topographic map. In this manner, centers of concentration can be depicted.

To interpret the diagrams, then, one reads directly the concentration of a joint system as a percentage of all the joints plotted on that circle. The amount of dip can be determined by scaling off the distance of that system of joints from the co-ordinate intersection; 0 degrees at the center and 90 degrees at the periphery. The strike and direction of dip must be obtained by projecting a line from the co-ordinate intersection at right angles to the line that passes through the area of concentration. The direction of dip, then, is towards the opposite quadrant.

## JOINTS IN GRANITE

The four most prominent joint systems that have developed in the Sheeprock stock are listed below in Table III. These joint systems are listed in the order of their abundance.

Table III

Joints in Granite

| System | Attitude of Joints | Abundance |
|---|---|---|
| A | Strikes north 45-55 degrees east<br>Dips 70-80 degrees northwest | 11% |
| B | Strikes north 45-55 degrees west<br>Dips 55-60 degrees southwest | 8% |
| C | Strikes east-west<br>Dips 60-65 degrees south | 8% |
| D | Strikes north 65-70 degrees west<br>Dips 70-80 degrees southwest | 6% |

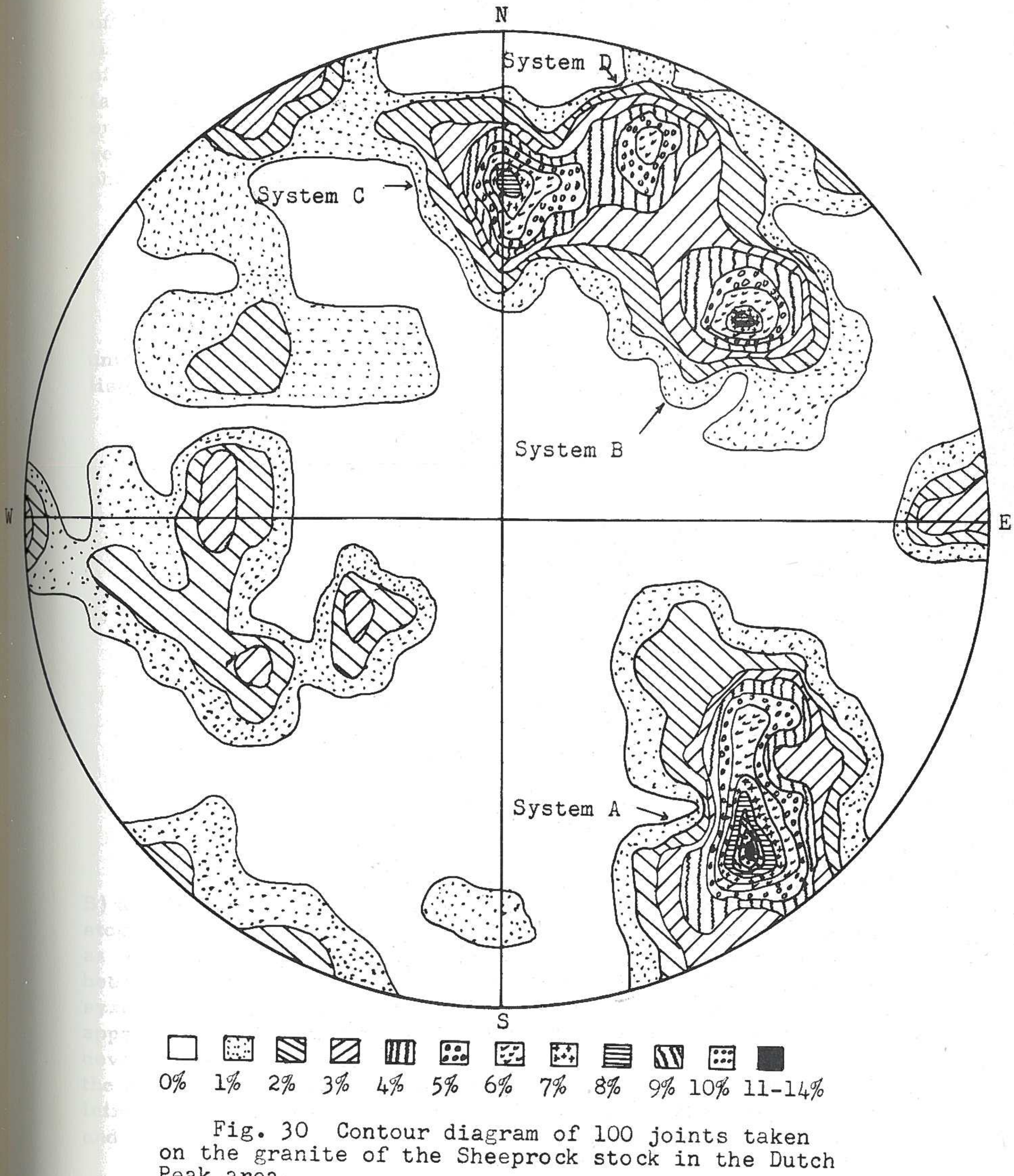



Fig. 30 Contour diagram of 100 joints taken on the granite of the Sheeprock stock in the Dutch Peak area.

As is illustrated by figure 30, joints of System A are the most often occurring joints in the granite of the Dutch Peak area; however, in the field the most obvious joints are of system B. Either the joints of system B are deeper seated than the others, or they are more favorably related genetically; for this system of joints controlled the emplacement of the rhyolite dike and the later hydrothermal copper veins. The dominance of joint system A is most easily seen on aerial photographs, where it produces well defined lineations.

## JOINTS IN AUTOCHTHON

The four most prominent joint systems that have developed in unit AA of the Ekker formation near the head of Sheeprock Canyon are listed in Table IV.

Table IV

Joints in the Autochthon

| System | Attitude of Joints | Abundance |
|---|---|---|
| A | Strikes north 55-65 degrees east<br>Dips 70-80 degrees northwest | 6% |
| B | Strikes east-west<br>Dips 70-75 degrees south | 6% |
| C | Strikes north 55-65 degrees east<br>Dips are essentially vertical | 5% |
| D | Strikes north 20-30 degrees west<br>Dips 25-30 degrees southwest | 5% |

The two dominant joint systems of the autochthon (systems A and B) are essentially the same as joint systems A and C of the Sheeprock stock. The joint systems B and D of the Sheeprock stock do not appear as independent systems in the autochthon; they seem, rather, to have been replaced by a minor system intermediate in attitude to both systems (compare figures 30 and 31). From these comparisons, it is apparent that the two dominant joint systems of the autochthon have developed as a result of igneous intrusion. Joint systems C and D of the autochthon, apparently, have developed independent of the intrusion and probably were formed during a previous phase of folding and faulting.

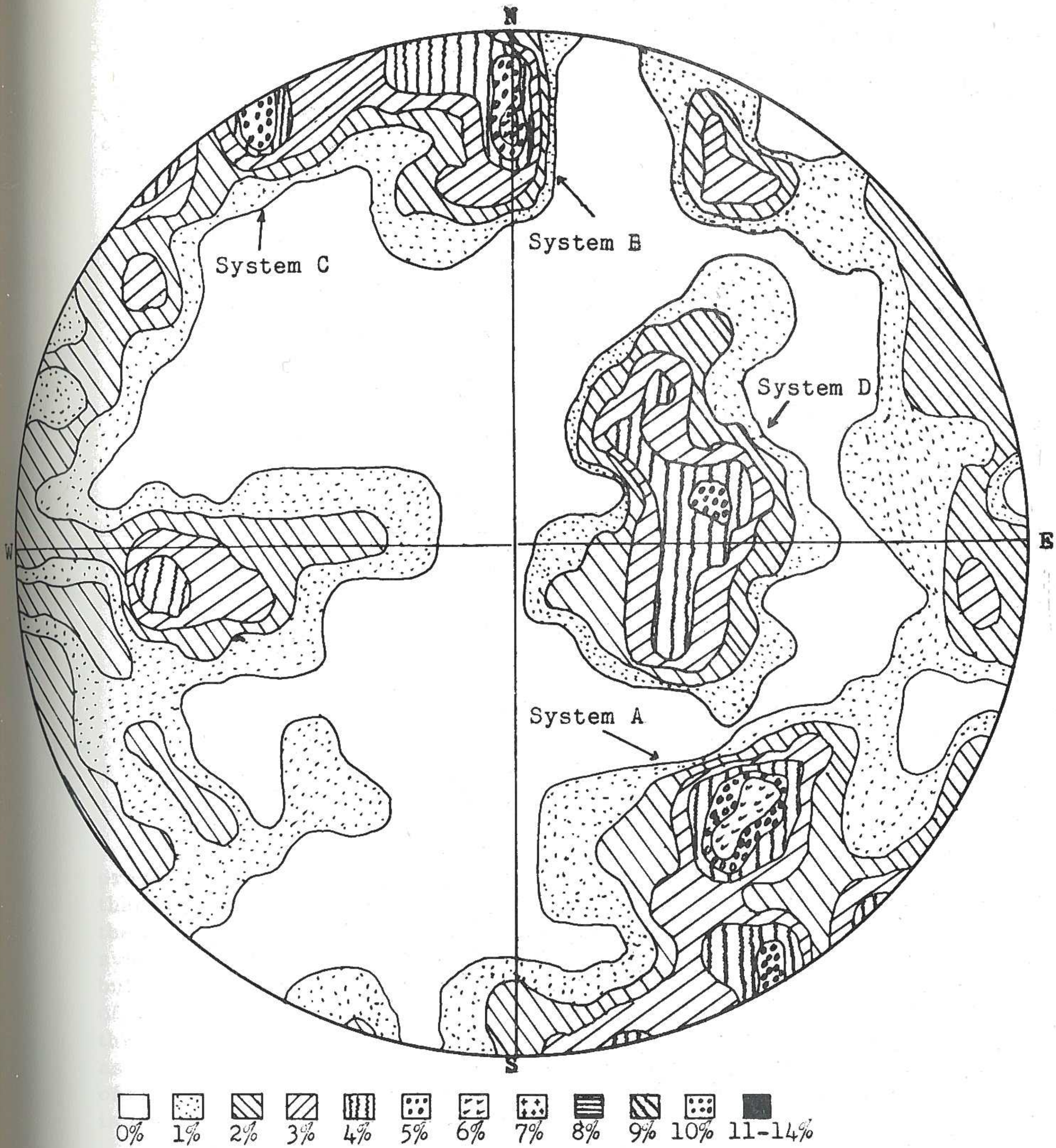



Fig. 31 Contour diagram of 100 joints taken on the autochthon of the Sheeprock thrust near the head of Sheeprock Canyon in the Dutch Peak area.

## JOINTS IN THE ALLOCHTHON

The three most prominent joint systems of the allochthon in the vicinity of Aut's Canyon are listed below in Table V, followed by a description of three not so dominant systems which are equally well developed among themselves.

Table V

Joints in the Allochthon

| System | Attitude of Joints | Abundance |
|---|---|---|
| A | Strikes north-south<br>Dips about 65 degrees east | 13 % |
| B | Strikes east-west<br>Dips 80-85 degrees south | 8 % |
| C | Strikes north 60-65 degrees west<br>Dips 60-65 degrees northeast | 8 % |
| D | Strikes north 55 degrees west<br>Dips 60-65 degrees southwest | 6 % |
| E | Strikes east-west<br>Dips 10-15 degrees south | 6 % |
| F | Strikes north 40 degrees west<br>Dips 35-45 degrees northeast | 6 % |

As is illustrated by the joint diagram of figure 32, the joints present in the allochthon are better oriented into well defined systems than the joints of the autochthon or the intrusive. Joint system A of the allochthon shows a greater concentration than any other joint system in the mapped area. Notice that this system is rather subdued but present in both the autochthon and the granite. Systems E and D of the allochthon are represented as quite well defined systems in all three localities. Systems E and F of the allochthon are not present as isolated poles in either the autochthon or the intrusive. System C of the autochthon is missing in the allochthon, and it is quite subdued in the granite (see figures 34-36).

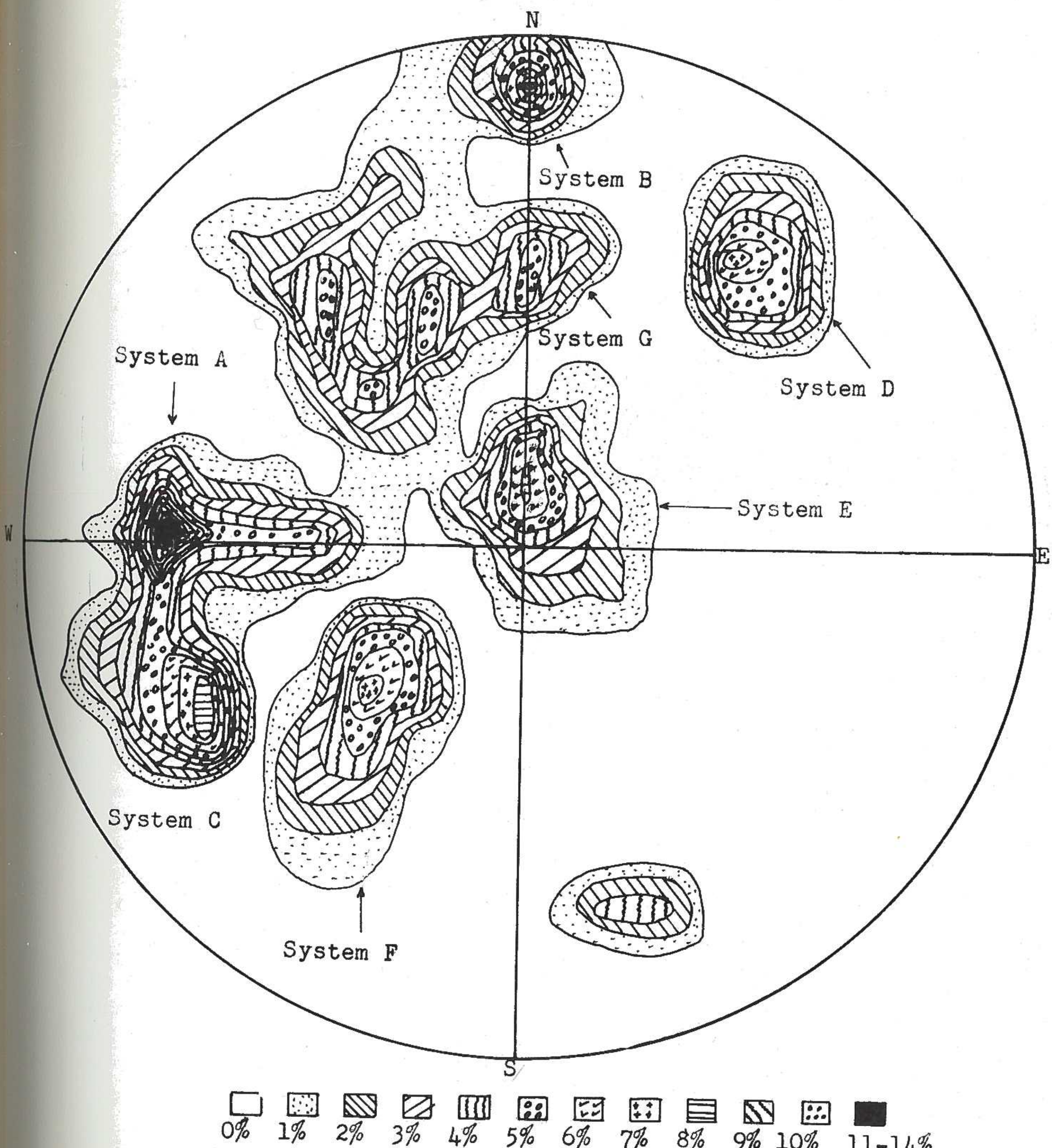



Fig. 32. Contour diagram of 60 joints taken on the allochthon of the Sheeprock thrust in the vicinity of Aut's Canyon in the Dutch Peak area.

# CONCLUSIONS

In conclusion, the author classifies the joints of the Dutch Peak area as follows:

1. Joints caused by igneous intrusion, some of which are present in the allochthon and the autochthon of the Sheeprock thrust.

2. Joints caused by stresses generated by the Sheeprock thrust, which are present in both the autochthon and and the allochthon.

3. Joints that probably were formed independent of the Sheeprock thrust and the igneous intrusion and are present in either the allochthon or the autochthon but not in both.

## SUMMARY OF GEOLOGIC HISTORY

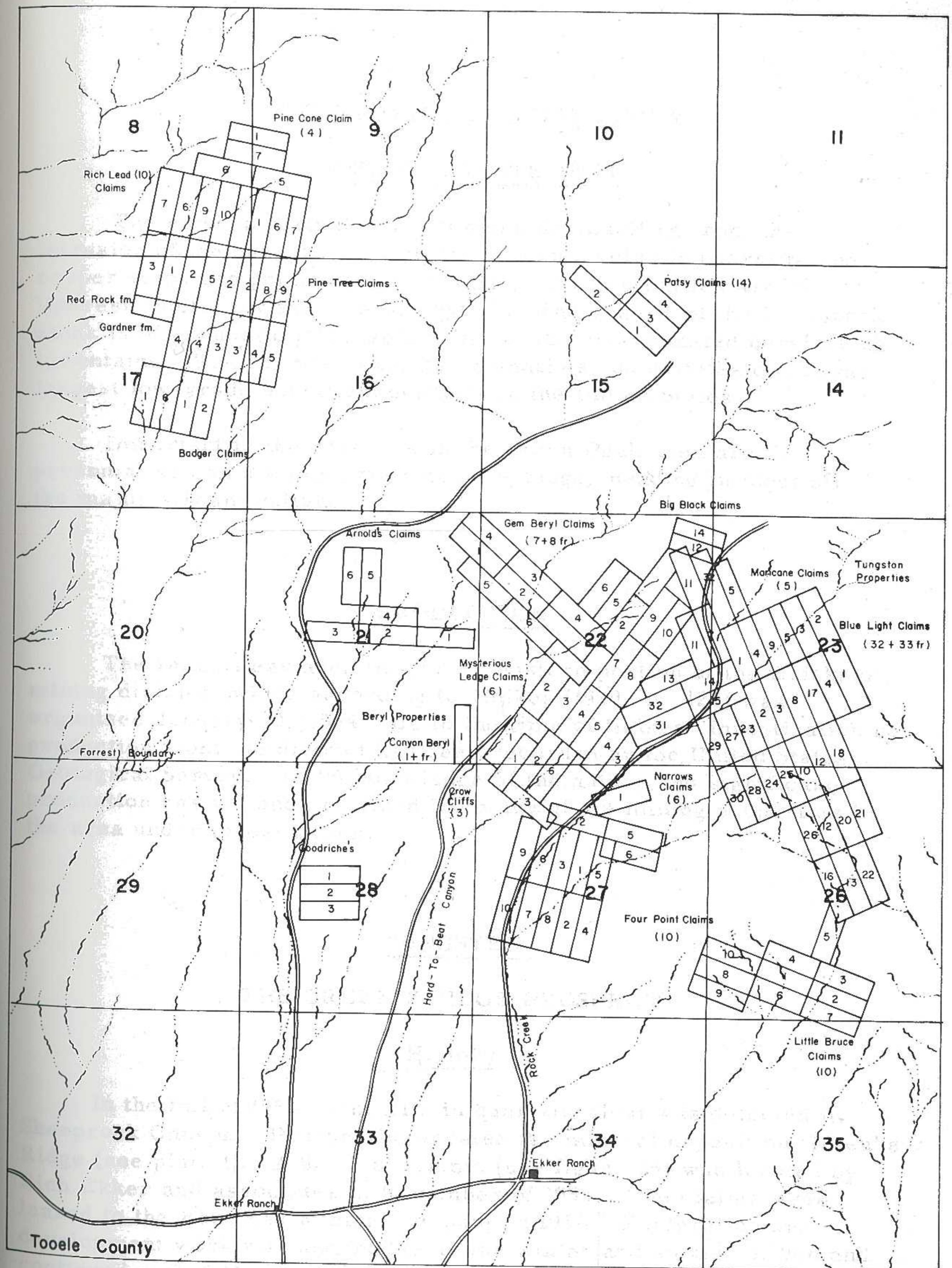
During Precambrian time, probably early Proterozoic, the Sheeprock trough came into existence. Two crystalline highlands, one to the northwest, and the other the pre-Paleozoic crystalline complex of the Colorado Plateau to the south, served as source areas for abundant detrital debris (Eardley, 1940, p. 840).

Depositional environments varied considerably. Stable periods of deposition allowed the formation of clays and silts. The abundance of clean quartzites testifies of a closer proximity of source areas and to a vigorous sorting action. Periods of rapid accumulation and poor sorting of sediments gave rise to the impure quartzites and graywacke conglomerates, indicating less sorting and more rapid sinking of the Sheeprock trough. The action of piedmont glaciers may have been responsible for the formation of an unsorted rudite, which is generally considered to be of glacial origin. The widespread deposition of tillite is considered by Blackwelder (1932, p. 289-304) to have transpired sometime during late Proterozoic and early Cambrian time, and probably represents the break between these two periods.

Field relations disclose the Sheeprock thrust to be post-Precambrian and pre-Oligocene. The author believes that the thrust, genetically, is of the same compressional forces that caused the Bannock, Willard, and Nebo thrusts. Eardley (1952, p. 332-338) considers this period of thrusting as part of the early Laramide Orogeny, of Montana time.

Igneous intrusion occurred during late Eocene and early Oligocene time, producing complex jointing in the cooling granite and the adjacent metamorphic rocks. Pegmatites developed from residual fluids, forming dikes and centers of crystal growth. Pneumatolytic and hydrothermal solutions and gases mineralized faults and fissures, some of which extend into the country rock.

The hanging character of the stream valleys and the abrupt rising of the mountain give evidence of probable Basin and Range faulting that has experienced recent movement. A gently sloping pediment which is mantled by alluvium has been dissected by Quaternary and Recent erosion, creating a mature erosional topography.




—— Claim Map ——

Fig. 33

# ECONOMIC GEOLOGY

## GENERAL STATEMENT

The most important mineral deposits resulting from the intrusion of the Sheeprock stock are tungsten veins in quartzite and copper veins and pegmatites in granite. The pegmatites are of interest chiefly for their beryl content. The granite of the Sheeprock stock is of economic interest because of the disseminated beryl which it contains. The granite, with its pegmatites, constitutes one of the largest low-grade beryllium deposits in the United States.

Important to the ranchers in the Dutch Peak area are the perennial streams which originate as springs, heading in most of the major stream valleys.

## PRODUCTION

The Dutch Peak area lies in the eastern portion of the Erickson mining district, which according to Heikes (1920, p. 426) was organized January 30, 1894. Up to the time of Heikes' investigation no production from the district had been recorded by the United States Geological Survey. To the knowledge of the author, no significant production has yet been realized from any of the mining properties in the area under investigation.

## TUNGSTEN

### THE GREEN'S RIDGE PROSPECT

#### History

In the fall of 1954, scheelite in quartzite float was detected in Sheeprock Canyon. Prospecting located the mineral deposit on Green's Ridge (see plate I). A block of claims (see figure 35) was located by Rich Ekker and associates in November of 1954. The claims were leased to the Ran Rex Mining Company in 1956. Exploration and development work was undertaken in the winter and spring of 1956 and continued until fall of that year. A few tons of ore were mined, but none was shipped. At the present, Ran Rex Mining Company holds the lease on these claims.

## Mineral Deposit

The Green's Ridge prospect consists of iron and tungsten minerals which occur in a large fractured and slightly brecciated zone in the quartzite of unit AA of the Ekker formation. This zone exhibits no definite, constant trend but averages approximately south 40-50 degrees east. The dip ranges from nearly vertical to about 60 degrees to the southwest. The minerals occur as scattered, non-continuous pods and stringers which range in size from a streak to pods several feet in length and two to three feet in width (see figure 38). The character of the mineralized areas suggests a cavity filling and a replacement process of mineralization.

## Mineralogy

The mineralogy of the deposit consists mainly of massive limonite, numerous limonite pseudomorphs after pyrite, pyrite as relicts of larger altered crystals, pockets of magnetitie, and abundant chlorite.

The author did not find wolframite or huebnerite in the samples selected from the vein; however scheelite, detected by ultraviolet light, occurs as fine flecks in the altered quartzite. Assays on the vein material taken by the Ran Rex Mining Company reported as high as 17 per cent $WO_3$ (Einar C. Erickson, personal communication). The geologist for Ran Rex Mining Company, Einar C. Erickson, believed the tungsten content to be due to the presence of huebnerite. It is very possible that huebnerite is present in the vein; however, the limited investigation of the author failed to disclose its presence.

## Genesis

The Green's Ridge tungsten deposit appears to have been emplaced by a pneumatolytic phase of the Sheeprock stock. A pre-intrusion structural adjustment in the quartzite created a fractured and porous zone that served as an avenue of escape for the ascending gases which emanated from the intrusive. No zonation within the mineralized zone is evident; consequently, the order of mineral emplacement is not definite. The presence of abundant euhedral quartz and limonite pseudomorphs probably indicates an early formation of pyrite and quartz. The emplacement of the magnetite and the tungsten minerals may have been concurrent with the quartz and pyrite. The chlorite appears to be later, for it fills only the larger pockets and does not occur in the thin seams.

The emplacement of the primary minerals was followed by extensive oxidation which converted most of the pyrite and magnetite to massive limonite and limonite pseudomorphs. Euhedral quartz crystals and fragments of incompletely altered quartzite are interspersed in limonite. Boxworks of cubes are present in certain oxidized areas.

## Workings

The first development work on the tungsten property consisted of a shallow, slightly inclined shaft about 20 feet deep, which was driven on an outcrop approximately one-third the way up the ridge. The first and richest ore was taken from this working. The relative inaccessibility of the shaft and the inconveniences of shaft mining resulted in the driving of an adit (see figure 36) to intersect an ore body. The adit was located in the granite near the base of the ridge and driven towards the granite-quartzite contact. The contact failed to yield ore; the tunnel was driven about 35 feet towards the shaft before being abandoned. Exploration of the vein above the shaft was undertaken; however, only low-grade isolated pockets of ore were located, and eventually work ceased. For a plan view of the prospect workings see figure 36.

## Economic Possibilities

At the present price of tungsten, the economic possibilities of the Green's Ridge Mine are not good. The nature of the deposit does not present any evidence of larger and more uniform ore bodies at depth; consequently, if in the future the price of tungsten were to improve, any mining or exploration operation on the property should be motivated by the present occurrence of ore.

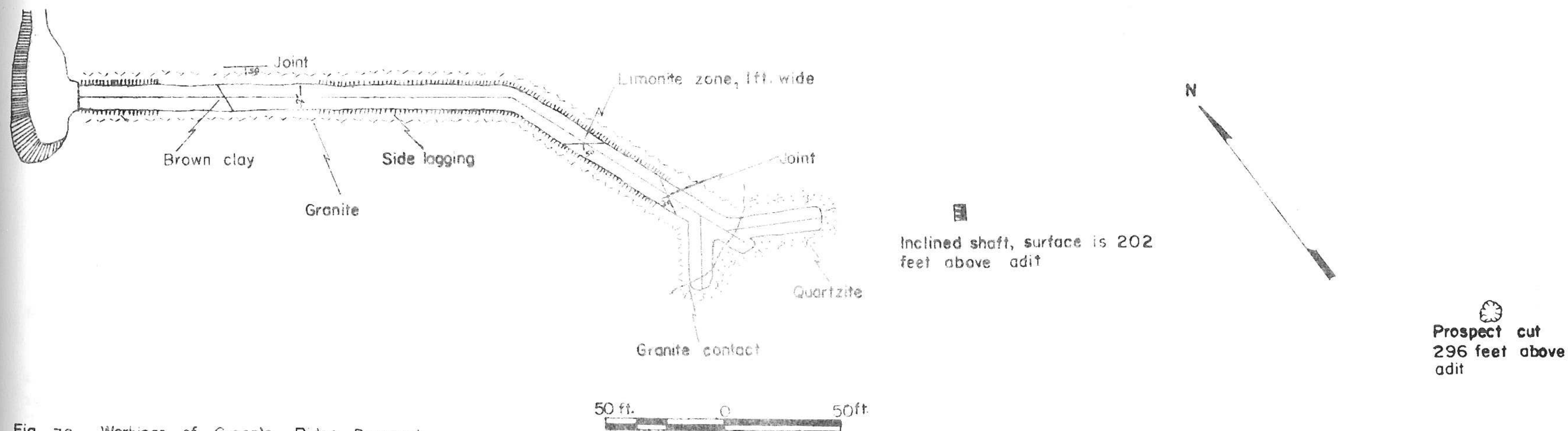



Fig. 36. Workings of Green's Ridge Prospect

# BERYLLIUM

## MINERAL DEPOSIT AND PROSPECT

### History

Mineral properties containing beryl were located in the Dutch Peak area by Rich Ekker and associates in 1942. In 1952, the claims (see figure 33) covering the beryl properties were leased to the Brush Beryllium Corporation, who, with the aid of a D. M. A. loan from the U. S. Bureau of Mines, core-drilled an area on the west ridge of Hard-To-Beat Canyon. Associated with Brush Beryllium Corporation at that time was Dr. Norman C. Williams of the University of Utah. Acting as representative for the U. S. Bureau of Mines was William Young. In 1954, Brush Beryllium Corporation turned the claims back to Ekker because of the low-grade beryllium content of the granite. In 1956, Ran Rex Mining Company leased the claims from Ekker, and at the present time they are holding the lease. The claims covering the beryl are unpatented lode claims.

### Economic Possibilities

The occurrence and genesis of beryl in the Sheeprock stock are discussed under the section on pegmatites.

Area X (see plate I) limits the occurrence of visible beryl concentrations in the Dutch Peak area; however, beryl as an accessory mineral in the granite is probably not restricted to that area. Throughout area X, occurring as pegmatitic differentiates, are various types of beryl concentration: pegmatites of beryl, feldspar, and quartz; rosettes of beryl; veinlets of beryl; and disseminated beryl. The pegmatites and veinlets of beryl are small, and the rosettes are scattered, creating an overall low-grade deposit. Because of the sporadic occurrence of the high-grade beryl, the Brush Beryllium Corporation purposely extracted from their cores any megascopically visible beryl which appeared to have come from a rosette or localized high-grade accumulation (Williams, personal communication). Therefore, the BeO, as calculated by them, can be considered as a minimum BeO content for the large mass of granite in the Dutch Peak area. Young (personal communication) recalls the BeO content of the granite to be about .01 . Just how much the sweetening of the high-grade accumulations will affect the tenor of the areas in which they occur is yet to be determined. The author is of the opinion that the isolated high-grade areas themselves are marginal.

At present economic conditions, a deposit containing .01% BeO is not of commercial grade. If the beryl of the Dutch Peak area is to be of economic value, areas must be blocked out which contain a higher BeO concentration than the normal granite. Einar C. Erickson, geologist for Ran Rex Mining Company, informed the author that an open pit mining operation in conjunction with a milling process which involves a flotation procedure worked out by the U. S. Bureau of Mines can very profitably mine an ore body of .25% BeO. This operation is based on the present price of beryllium at $50 per unit for a concentrate containing 10% BeO.

Nininger (1955), pp. 102 & 106) cites the Sheeprock area as one of the main reserves of beryllium in the United States. Young (personal communication) stated that although the BeO content of the granite of the Sheeprock stock is not commercial today, the Sheeprock area would probably be exploited in a national emergency.

At the present time, concerns interested in the development of the beryl properties in the Dutch Peak area are the Ran Rex Mining Company, Bountiful, Utah, and the Gayle Sherry Leslie Corporation, Los Angeles, California.

## COPPER

### QUARTZ-FLUORITE VEINS

#### History

In the early 1900's prospecting in the Dutch Peak area led to the discovery of copper veins in granite. According to Loughlin (1920, p. 426-429), the principal workings on the copper veins are those of the Copper Jack Mining Company, which operated the Copper Jack and the Flying Dutchman shafts (see fig. 41). Other properties worked were those of the White Rat (formerly the New Utah) Mining Company and the Right Bower Mining Company. No shipment of ore from these properties had been recorded by the U. S. G. S. (Loughlin, 1920. 426).

The workings on the copper veins were idle at the time of Loughlin's examination, and it is doubtful if they have been worked since. The claims covering the copper veins are patented. At present, they are owned by Rich Ekker. The claims were leased in 1956 to Ran Rex Mining Company; to date, no development work has been attempted.

Figure 29. Photograph of vuggy monolith comprised of mineralized fault breccia on Ridge Fault.

Figure 34. Photograph of cut on tungsten property above adit of Green's Ridge prospect; note pods and stringers of iron mineralization in fractured quartzite.

Figure 35. Photograph of portal to adit of Green's Ridge prospect.

Figure 37. Photograph of Flying Dutchman Incline.

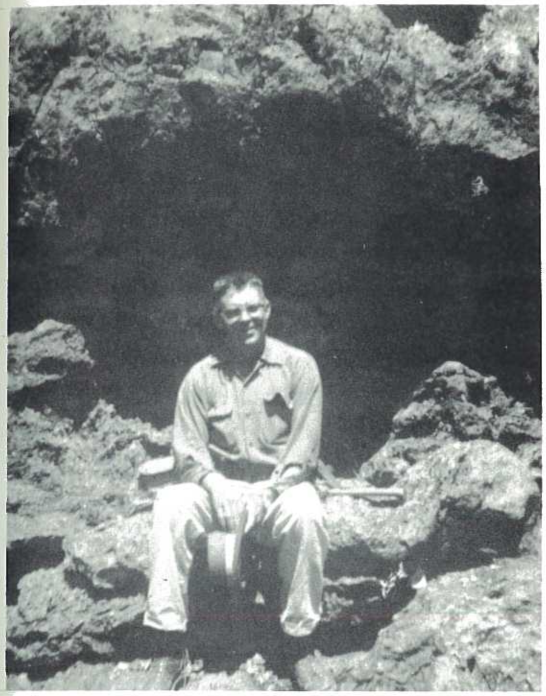


FIGURE 29

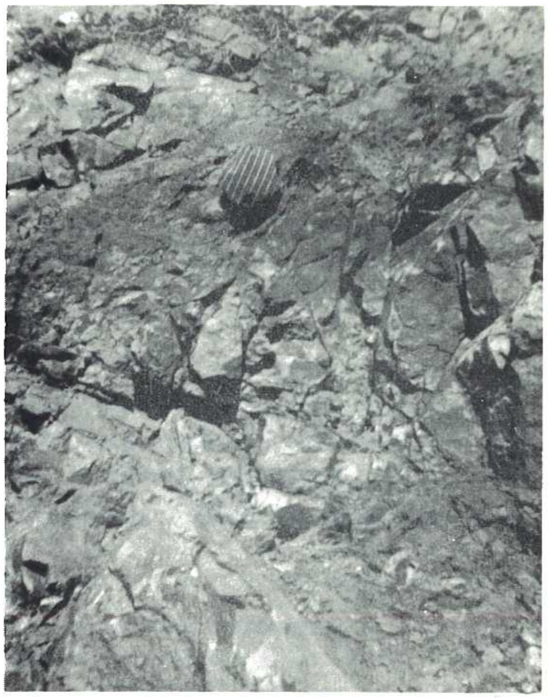


FIGURE 34

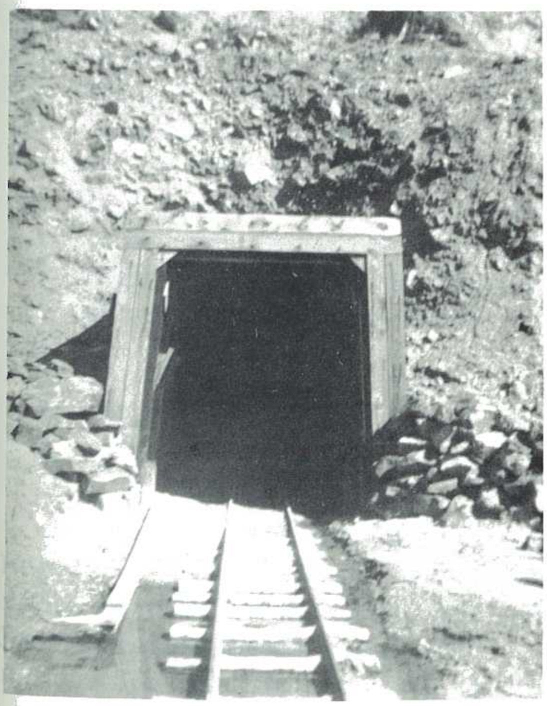


FIGURE 35

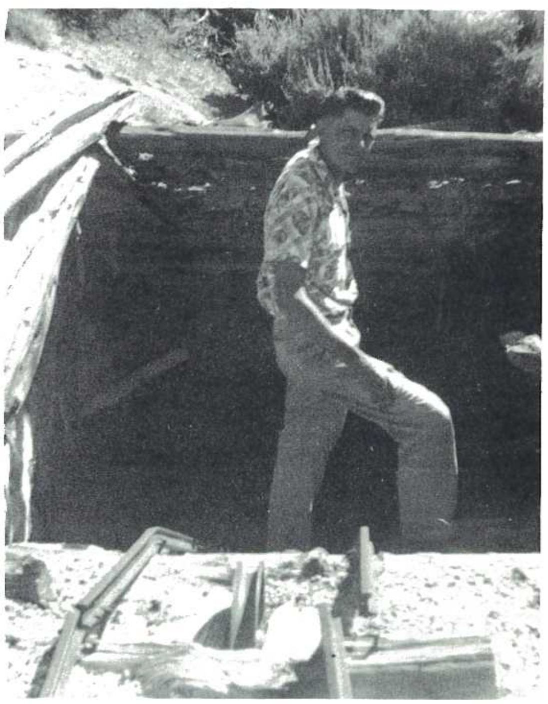


FIGURE 37

## Ore Deposits

The copper veins trend north 30-40 degrees west and dip about 50 degrees southwest. Several veins extend through the granite. None of the workings on the veins are accessible, for water has flooded most of the workings and, in some cases, stands within 15 feet from the surface. Surface outcrops of the veins range in width from a mere streak to about four feet. The smaller veins or veinlets branch and coalesce, representing mineralized zones.

The main vein is about three feet wide and was worked by the Copper Jack Mining Company at two different places which are about one-half mile apart. The outcrop of the vein is mostly covered between these workings; therefore, nothing can be said regarding the size or continuity of the vein along its strike. Loughlin (1920, p. 428) has this to say regarding the properties:

> "According to C. C. Grigs, president of the company, the Copper Jack shaft is 140 feet deep and follows a 3-foot vein which averages 6 per cent copper. The Flying Dutchman claims have two inclined shafts, one of which is about 240 feet long with a slope of about 40 degrees and follows a vein considerably richer in copper than the Copper Jack. Its width is 3 to 15 feet. The Copper Jack shaft struck a strong flow of water at about 80 feet, and water was standing within 20 feet of the surface when seen by the writer. The water surface in the Flying Dutchman shaft is said to stand about 100 feet down the incline. Four veins are said to run lengthwise (average trend, N. 30 degrees W.) through the property. Their average copper content is 3 to 5 per cent, but one 100-foot portion of the Copper Jack vein carries 7 to 8 per cent and includes considerable high-grade material running 20 to 3 per cent. The silver ranges from 1 to 7 ounces per ton."

## Mineralogy

The copper veins consist chiefly of quartz and fluorite, with chalcopyrite and pyrite. Oxidation of the pyrite and chalcopyrite has produced abundant limonite and some malachite, which have permeated along crystal and cleavage faces, staining the outcrops brown and green. Specularite often occurs as flakey, thin sheets on the granite walls. The mineralogy of the veins is not constant; the abundance of the different minerals varies within the vein and from vein to vein.

Hydrothermal alteration of the granite wall has changed the quartz and feldspar to a fine-grained, gray- to yellow-green complex of silica, probably sericite and kaolinite.

## Genesis

The copper veins of the Dutch Peak area represent a hydrothermal phase of the Sheeprock stock. Mineralization was preceeded by complex jointing, which in certain areas is so closely spaced as to appear sheeted. Apparently the northwest trending system of joints (system B, see figure 30) is deeper-seated or more favorably related genetically to the mineralization, for the copper veins consistently parallel this system of joints. The Copper Jack vein has been structurally controlled by sheeted jointing. Fragments of altered but not completely replaced granite occur within the vein, giving evidence for the hydrothermal replacement which probably occured along the sheeted joints. The granite wall vein contact is distinct but no planer, suggesting replacement of the wall.

Following the hydrothermal alteration of the granite wall, specularite was emplaced as non-continuous thin sheets and flakes. From thin section and polished section studies, Loughlin (1920, p. 428) concluded that the minerals crystallized in the following order: pyrite, fluorite, chalcopyrite, quartz. However, he states that the periods of crystallization overlapped and that some quartz was crystallizing before all the pyrite.

Incomplete oxidation has altered some of the pyrite to limonite and some of the chalcopyrite to limonite and malachite. This alteration is not far advanced, for most of the sulfides are relatively fresh and unaltered. The malachite stains the fluorite along cleavage traces, giving an illusion of high copper carbonate content.

## Economic Possibilities

The greatest hindrance to the profitable mining of the Copper Jack vein is the shallow depth to water. The tenor and size of the deposit are not sufficient to offset the expense of mining, pumping of water, and marketing.

## LEAD-SILVER

### ALLISON PROSPECT

At the head of Joe's Canyon, a lean vein of galena in altered quartzite is exposed. The vein trends about north 50-60 degrees east and dips nearly vertical. The property is claimed by Bill Allinson.

Development work by Allinson in the summer and fall of 1956 resulted in a short drift along the vein; however, when the property was visited by the author, in the summer of 1957, operations had ceased.

Lead-silver minerals occur along a fractured zone which is near the vicinity of the Sheeprock thrust and is, probably, complimentary to it. Galena occurs as sparsely scattered seams and clusters in the soft, bleached yellow, fractured quartzite. Occasional seams of specularite are also present.

The Allinson prospect is very small, low-grade, and not of economic value. The author is of the opinion that further development of this property is unwarranted.

### PARK UTAH PROSPECT

From 1925 to 1930, the Park Utah Mining Company excavated an adit in unit BB of the Ekker formation (Rich Ekker, personal communication). According to rancher Rich Ekker, some lean silver veins were cut by the adit; however, no commercial ore was discovered. The adit is said to extend into the quartzite for one and one-fourth miles. The author did not visit the underground workings. At the time of the author's investigation, nearly a second-foot of water was flowing from the tunnel.

The only evidences of hydrothermal mineralization seen by the author were a few pieces of altered quartzite, found on the dump, which contained pyrite crystals interspersed in fine-grained chlorite.

## WATER

Springs, headward in the major canyons, furnish a perennial flow of water. On the west slope of the mountain, these streams are utilized by ranchers as irrigation water. In the mapped area, Hard-To-Beat and Cottonwood Canyons contain the largest streams. Most of the water in Hard-To-Beat Canyon comes from the adit excavated by Park Utah Mining Company. A small portion of the water of the Sheeprock Creek comes from the adit excavated in the granite at the base of Green's Ridge. The water in the granite is apparently controlled by joints, as is shown by the water problems encountered on the copper veins.

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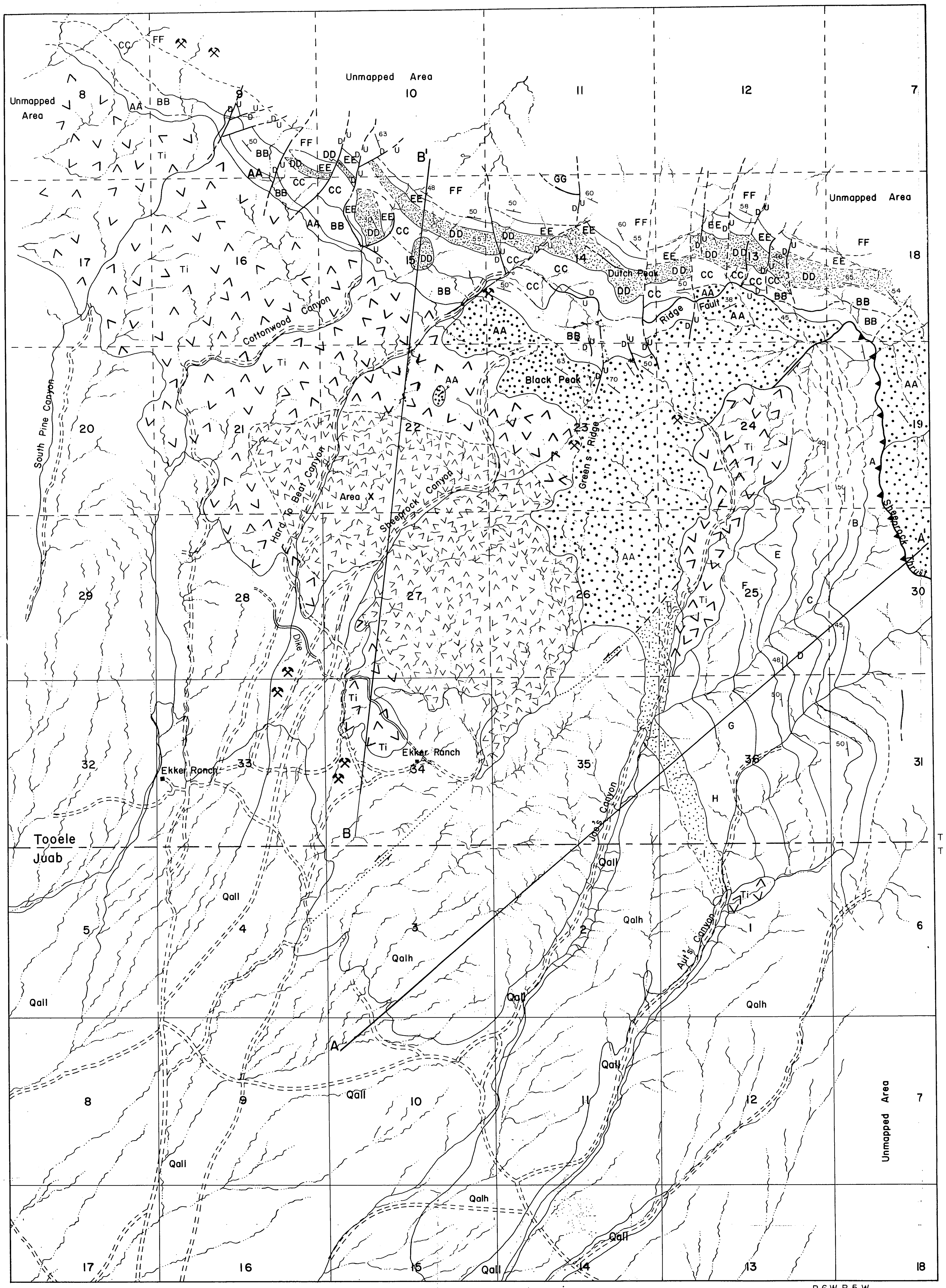
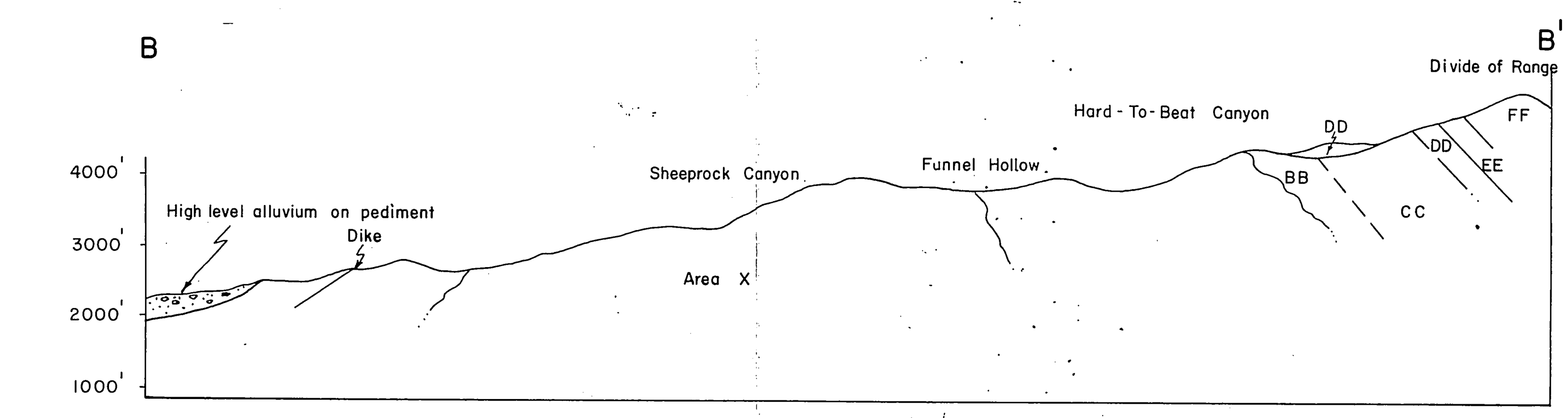
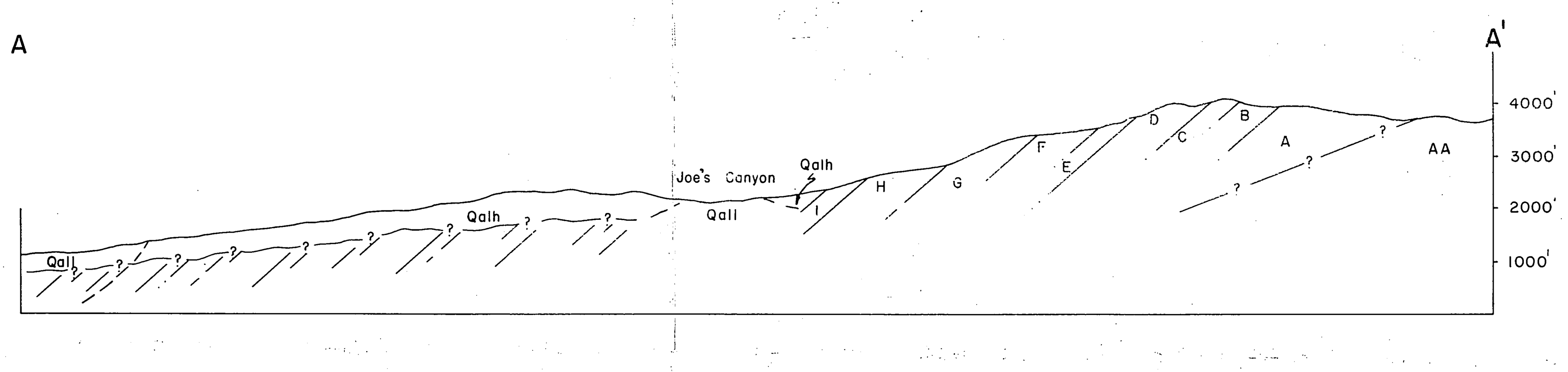



## Explanation

*Sedimentary Rocks*

Quaternary

- Qall — Alluvium, low-level soil and rock fragments
- Qalh — Alluvium, high level soil rock fragments and boulders

*Igneous Rocks*

Tertiary

- Dike — Rhyolite dike
- Ti — Sheeprock Granite
- Area X — Granite contains pegmatitic and apalitic differentiates second phase of intrusion

*Metamorphic Rocks*

Precambrian — Sheeprock Group

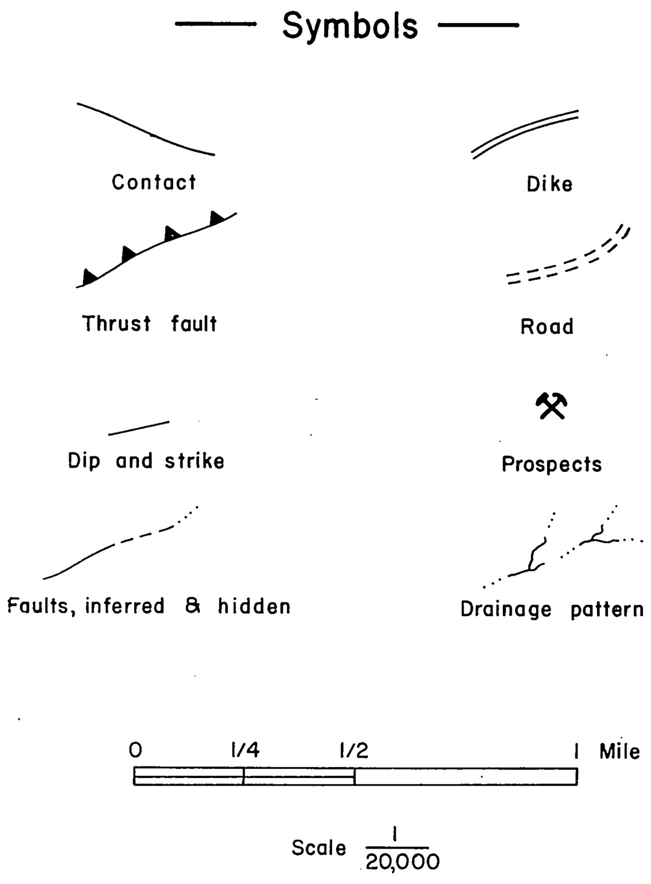
Ekker formation

- GG — Gray quartzite
- FF — Tillites intercalated graywacke lenses
- EE — Tillites at base overlain by dark brown phyllitic quartzites and gray quartzite
- DD — Massive tan quartzite
- CC — Tillite contains interbedded buff quartzite
- BB — Gray quartzite
- AA — Massive tan quartzite

Aul's Canyon formation

- Basal chlorite graywacke semischist overlain by feldspathic quartz grit and phyllites
- H — Phyllites
- G — Interbedded phyllites and phyllitic quartzites
- F — Interbedded quartzites and phyllitic quartzites, intercalated conglomeratic phyllites
- E — Massive, tan quartzites; interbed of gray-black quartz graywacke
- D — Interbedded quartzites, feldspathic quartzites, and graywacke semischists
- C — Massive, tan quartzites
- B — Impure quartzites, slaty and feldspathic
- A — Medium-bedded tan quartzites with intercalated slaty quartzites

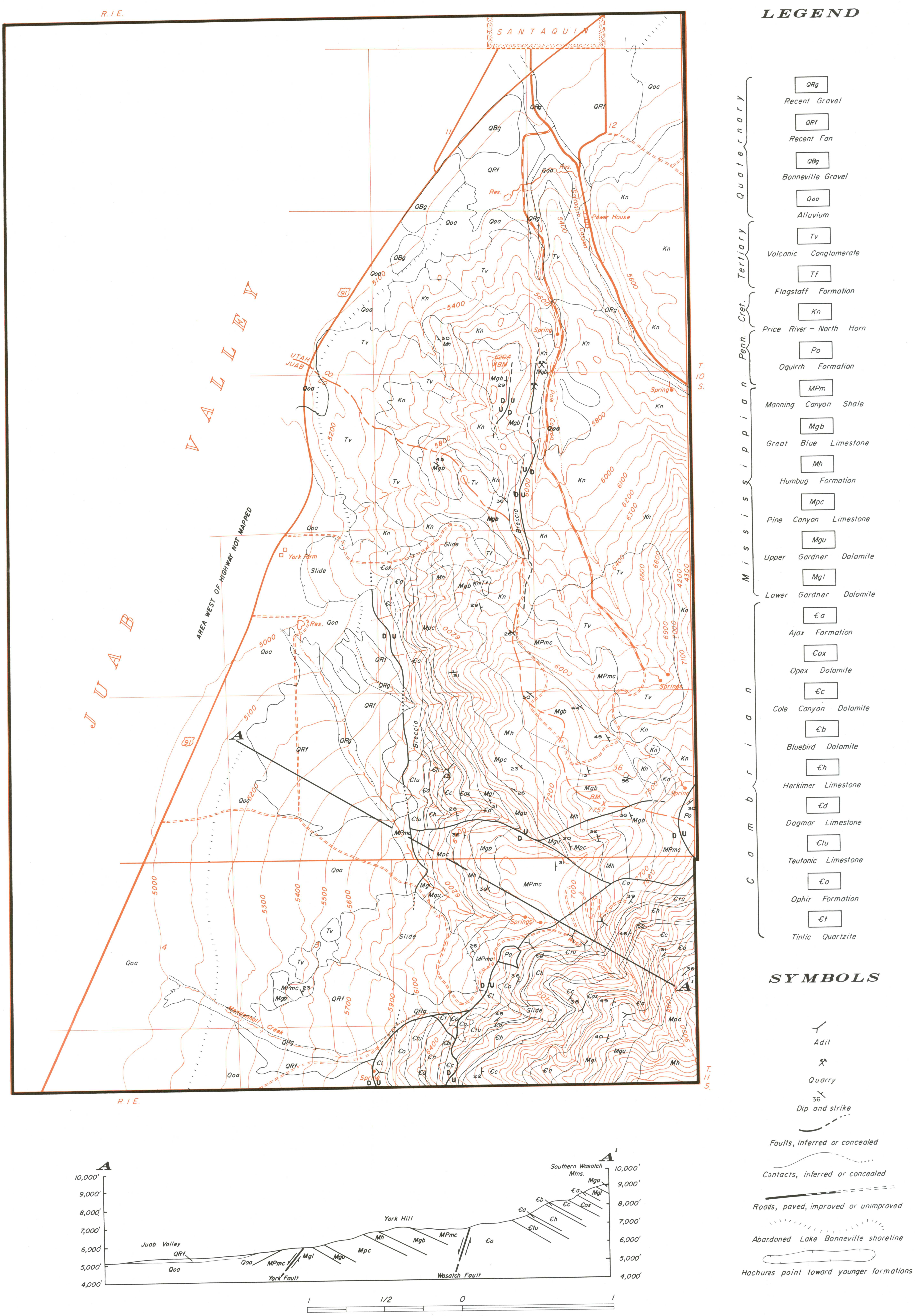
## Symbols




# Geology of the Dutch Peak Area, Sheeprock Range, Tooele County, Utah.

DeVerle P. Harris

1958



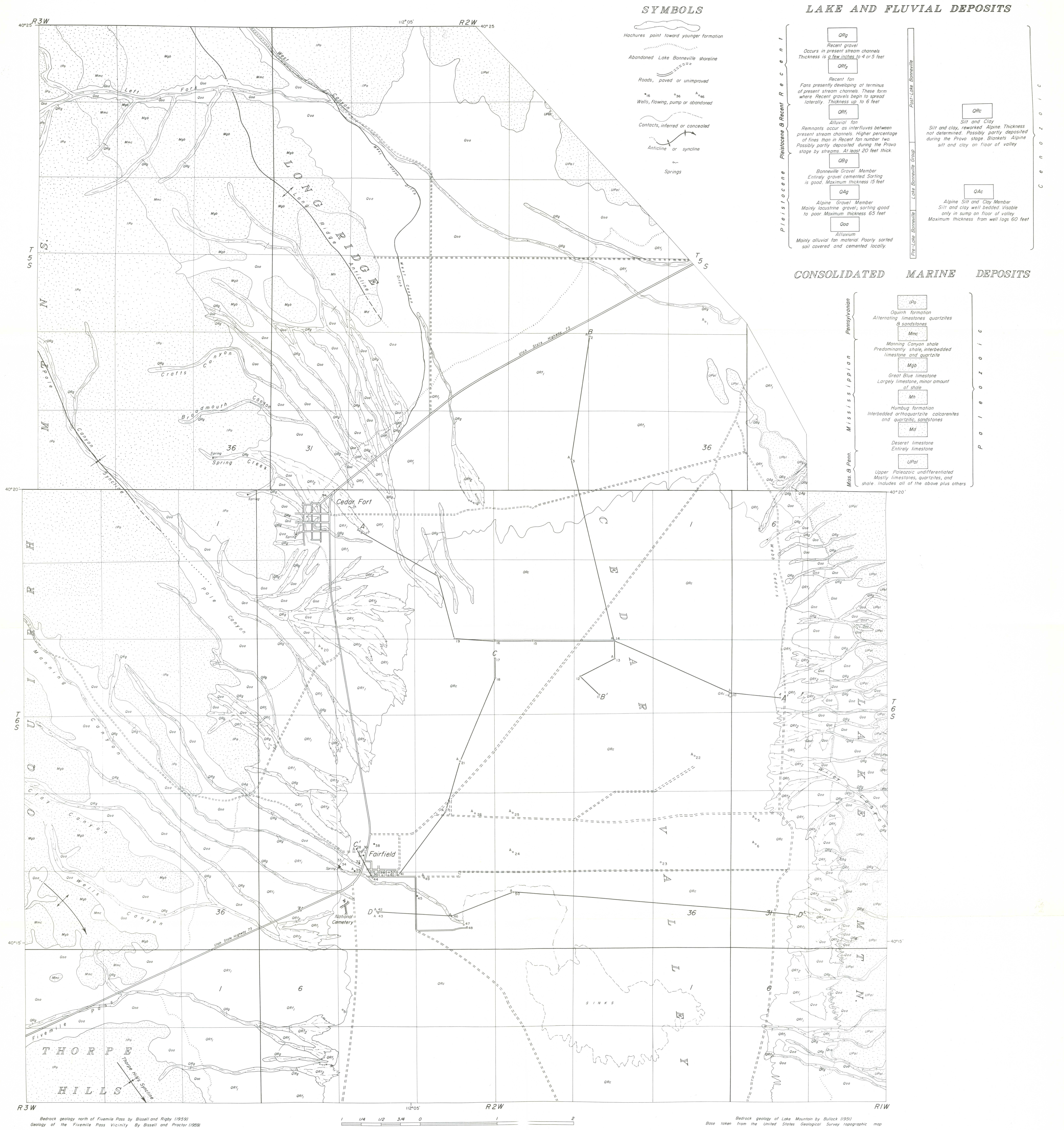

# GEOLOGIC MAP AND CROSS SECTION OF THE WASH CANYON AREA

# UTAH AND JUAB COUNTIES, UTAH

By

**DELL R. FOUTZ**

**1960**




Bedrock geology north of Fivemile Pass by Bissell and Rigby (1959)
Geology of the Fivemile Pass Vicinity By Bissell and Proctor (1959)

Bedrock geology of Lake Mountain by Bullock (1951)
Base taken from the United States Geological Survey topographic map

# GROUND WATER GEOLOGY AND WELL LOCATION MAP OF NORTHERN CEDAR VALLEY, UTAH

Norbert W. Larsen

1960

## PLATE I