BRIGHAM YOUNG UNIVERSITY RESEARCH STUDIES

Geology Series Vol. 3 No. 1 January, 1956

GEOLOGY OF THE NORTHERN ONAQUI MOUNTAINS, TOOELE COUNTY, UTAH

by

Mack G. Croft

Brigham Young University

Department of Geology

Provo, Utah

GEOLOGY OF THE NORTHERN ONAQUI MOUNTAINS
TOOELE COUNTY, UTAH

A Thesis
Submitted to the
Faculty of the Department of Geology
Brigham Young University

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

by
Mack G. Croft
January, 1956

ACKNOWLEDGEMENTS

The writer, in the preparation of this thesis, is grateful for the assistance and suggestions of Drs. J. Keith Rigby, Kenneth C. Bullock, and H. J. Bissell. The writer also wishes to acknowledge Roland B. Woodland and other faculty members and students of the Department of Geology, Brigham Young University.

TABLE OF CONTENTS

Page

LIST OF ILLUSTRATIONS

ABSTRACT

Approximately 45 square miles of the northern Onaqui Mountains were mapped and studied for this report. The area is located about 25 miles southwest of Tooele, Utah. The mountainous central portion is flanked by sloping bajadas, outlying hills and rock-cut plains which grade into Rush and Skull Valleys.

Paleozoic sedimentary rocks are approximately 9600 feet thick and consist of the Ordovician, Silurian, Devonian, Mississippian, and Pennsylvanian systems. Additional mapped units include unconsolidated Quaternary fanglomerate, Lake Bonneville deposits, sand dunes, and alluvium.

Structural features formed during the Laramide orogeny include north-south trending folds, eastward displaced allochthonous blocks, and various northwest-southeast and east-west high angle faults. Later Basin and Range normal type faults are roughly parallel the Laramide fold structures. The topography of the range is sculptured from the uplifted block.

Three species of Didymograptus were collected and are described in this report. Numerous Ordovician and Mississippian corals are also listed.

The development of water for agricultural use is the area's outstanding economic potentiality.

INTRODUCTION

LOCATION AND ACCESSIBILITY

The area considered in this report is located in southeastern Tooele County, Utah, approximately 17 miles south of Grantsville and 25 miles southwest of Tooele, in the eastern part of the Great Basin (Fig. 1).

Approximately 45 square miles were mapped and studied in Townships 5 and 6 South and Ranges 6 and 7 West, Salt Lake Base and Meridian. The meridian 112° 35' W. longitude and parallel 40° 20' N. latitude pass through the area.

The mapped area is located between Skull Valley on the west and Rush Valley on the east in the northern Onaqui Mountains. Utah Highway 58 traverses the northern periphery through Johnson Pass, connecting Rush and Skull Valleys. The region is easily accessible via graded and primitive roads branching south from Highway 58 in Rush and Skull Valleys.

PHYSICAL FEATURES

The Onaqui, Stansbury, and Sheep Rock Mountains comprise a more or less continuous range which trends north-south for approximately 50 miles and is roughly 10 miles wide. The Onaqui Mountains lie in the central part of this range and are separated from the Sheep Rock Mountains on the south by Point Look Out Pass and the Stansbury Mountains on the north by Johnson Pass. The Onaqui Mountains consist mainly of low rugged hills with a maximum altitude of 8980 feet above sea level on the summit of Grasshopper Ridge* (Figs. 2 and 3). The center of Skull Valley has a minimum elevation of approximately 4500 feet, and the center of Rush Valley to the east lies at nearly 4000 feet.

Grasshopper Ridge, the most striking topographic feature of the Onaqui Mountains, rises abruptly from the floor of the desert on the east, but grades into deeply dissected uplands on the west. Northward, Grasshopper Ridge gives way to a series of rugged hills and a large north-south trending strike valley is developed in folded Upper Mississippian shales. Numerous other strike valleys, developed on a smaller scale in the Long Trail shale, are present throughout the area. West of the large strike valley, the range is bounded by a prominent escarpment with steep "V" shaped canyons and precipitous cliffs, indicating a youthful stage in erosion.

---

*Names of physical features are from B. L. M. survey plats and names applied by local residents.

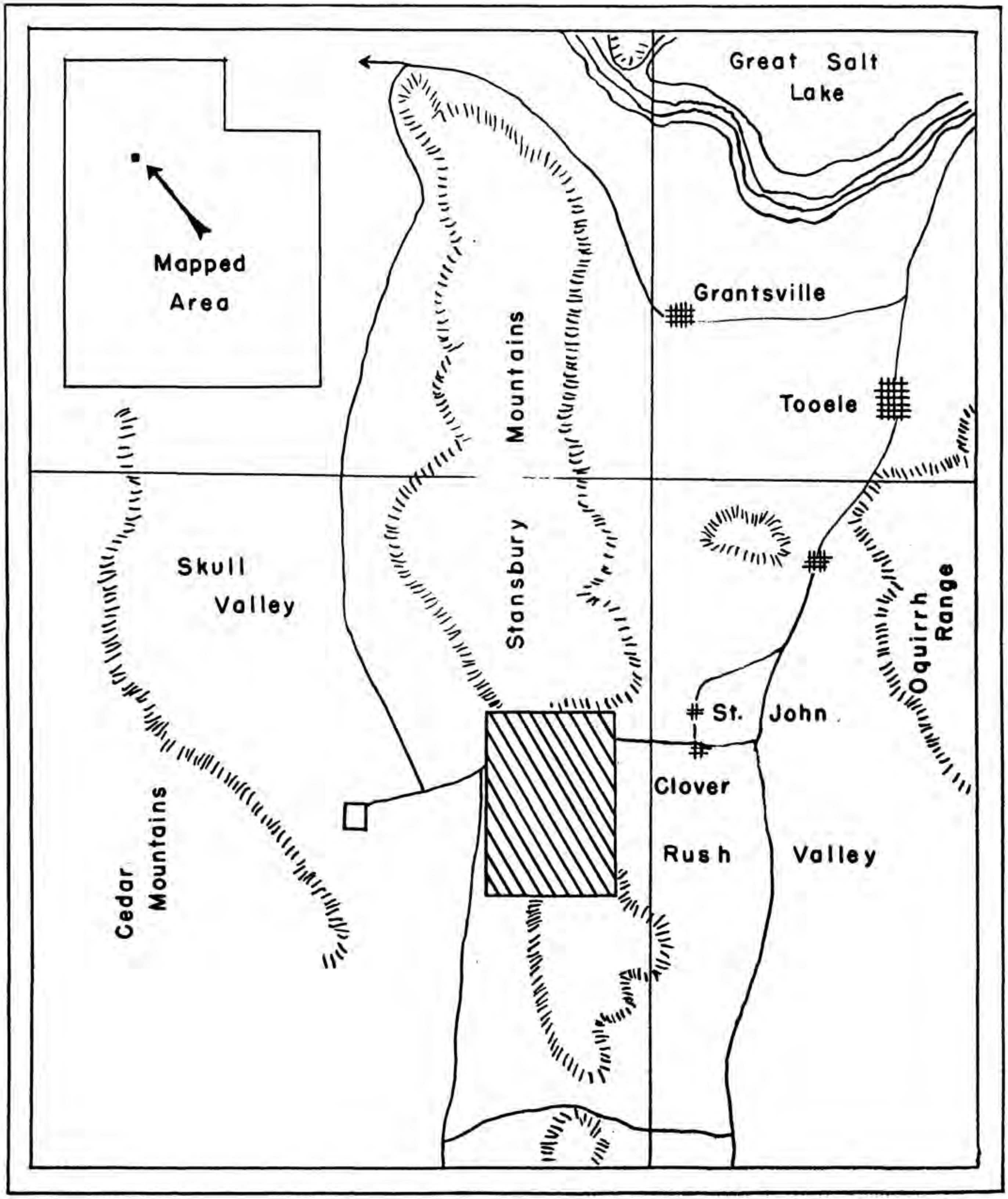


Fig. 1--Index Map of the Northern Onaqui Mountains

Fig. 2--East View of Northern Onaqui Mountains

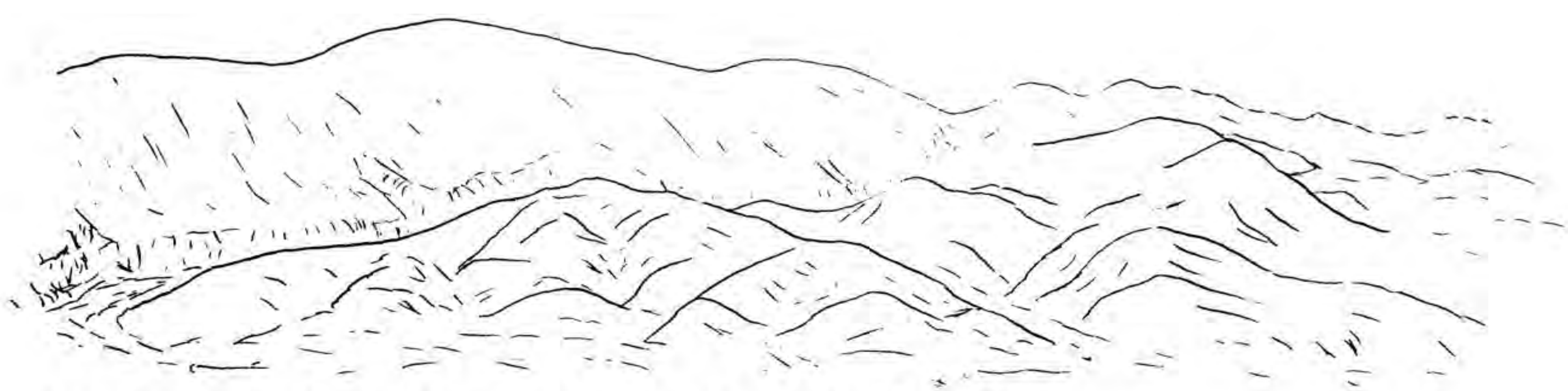


Fig. 3--View of Uplands West of Grasshopper Ridge

On both the east and west fronts of the range, extensive alluvial deposits coalesce to form bajadas in the valleys. Pediment slopes are also exposed on both sides of the range.

Shore line features and the smooth floor of the intermontane valleys are evidence of ancient Lake Bonneville. The valleys are veneered with the sediments deposited in the geologically recent lake. Sand dunes, probably derived from the desert west of the Cedar Mountains, are present on all the low hills in the northwestern corner of the area.

CLIMATE AND VEGETATION

An arid to semi-arid climate prevails in the northern Onaqui Mountains and adjacent parts of the Great Basin. The weather station located at Tooele records an average annual precipitation of 16.61 inches. This amount is probably applicable to most of the mapped area excepting the summit regions, where the annual precipitation may exceed 20 inches. The maximum recorded temperature at Tooele is 104° F. and the minimum is -16° F.

Vegetation representative of the upper Sonoran zone is widely distributed over the foothills and extends upward to 7200 feet. Representative flora include juniper, sagebrush, cacti, and various flowering plants and grasses. Above this zone, small stands of Douglas fir, aspen, Rocky Mountain cedar, and chokecherry occur.

The precipitation and plant cover restrict the agricultural industries to stockraising and dry land farming. However, a small area at Hatch Ranch in Skull Valley is irrigated by springs.

SUMMARY OF PREVIOUS INVESTIGATIONS

THE GREAT BASIN

Clarence King (1870) was among the pioneer geologists to postulate a theory to account for the origin of the mountain ranges of the Great Basin. He theorized that the ranges consisted of eroded anticlines, the valleys being synclines. After the publication of Gilbert's paper (1874) in which he emphasized uplift and monoclinal folds bordered by vertical movements, King (1878) modified these views, but emphasized that faulting was superimposed on an earlier system of folds. Dutton (1880) accepted the theory of faulting and an earlier period of flexing, but he did not believe that the present relief of the ranges is in any way associated with the folding. On the contrary, he states that the present mountains are uplifted fault blocks of a previously developed featureless platform, upon which the present relief has been carved by erosion.

Spurr, after a study of Basin and Range faulting in Nevada and California (1901), reported that faulting along the range fronts was very rare and that faulting present within the ranges is not reflected in the topography. He also reported that unfaulted Tertiary beds abut against older rocks in the mountains. He presents the challenging idea that the present arrangement of mountains and valleys is due to erosion.

Davis (1903-1905) developed the cycle of erosion and described the physiographic features present on youthful block mountains of the Basin and Range province.

Baker (1913), after a study in southern Nevada and California, suggested that some of the faults bordering the ranges are reverse, produced by compression. This suggestion is in opposition to the proposals of Gilbert (1928) and others, who believe that the limiting faults of the ranges are normal, due to tension. His conclusions were based on clear evidence of nearly vertical fault planes, some of which even dipped into the mountains. In addition, he reported there is close folding and overturning of the sedimentary rocks on the valley side of the ranges.

THE ONAQUI MOUNTAINS AND VICINITY

G. K. Gilbert and Howell (Wheeler 1875, pp. 26-27 and 238-239), writing in the report of the Wheeler Survey, mention briefly that the "Onaqui Mountains" (referring to the Onaqui and Stansbury Mountains) consist of the faulted west limb of an anticline. Also in the same report, Gilbert (pp. 88-89) named Lake Bonneville after Captain B. L. Bonneville, an early U. S. Army explorer of the Great Basin.

S. F. Emmons in Kings Fortieth Parallel Report (1877, pp. 456-457) believed that the "Aqui" Mountains (the Stansbury and Onaqui Mountains) consist of an upfaulted west limb of an anticline. He also described the stratigraphy in the vicinity of Reynolds Pass (Johnson Pass) as belonging to what he termed the Paleozoic "Wasatch formation." Also included in the report is a reconnaissance geologic map (Map III) which covers the area mapped in this report.

Gilbert (1890, pp. 149-151) described the Lake Bonneville embankment in Rush and Skull Valleys. Also in the same Monograph (pp. 341-342 and 352) he discusses the fault along the western flank of the "Aqui" Mountains and its relationship to similar displacements in the Oquirrh and Wasatch ranges.

Butler (1920) completed the Geologic Map of Utah to accompany U. S. G. S. Professional Paper 111. He shows carboniferous rocks outcropping in the Onaqui Mountains.

Gilluly (1932) studied in detail the Oquirrh Range. He defined the Upper Mississippian and Pennsylvanian stratigraphic terminology which is used in this report. Terminology is also used for rocks of the Ordovician, Silurian, and Devonian systems as described by Nolan (1935) in the Gold Hill district.

Hubert C. Lambert (1941) made a reconnaissance study of the south and central Stansbury Range adjacent to the north of the area studied in this report. He outlined most of the major structural features which extend into the Onaqui Mountains from the north.

FIELD WORK AND LABORATORY STUDIES

The field work for this report was started in June of 1955 and finished the following autumn.

Geologic mapping was done on aerial photographs taken in 1940 for the U. S. Forest Service (scale 1:20,000) and on photographs taken in 1953 for the U. S. Geological Survey (scale 1:35,000). Photostatic copies of the original land survey plats were obtained from the Bureau of Land Management and were an aid in locating section corners for ground control and served as a base for the final map. Altimeter traverses were made by automobile and foot to obtain elevation control.

Formation limits and fault traces were plotted by walking the contacts where vegetation and terrane permitted, but were interpreted from the aerial photographs where not accessible. Stratigraphic sections were measured with a steel tape and Brunton compass. Fossils were collected during the measurement of the sections.

The base map and geology were compiled from the aerial photographs by means of Kial plotters operated by Mr. Roland B. Woodland and the writer. The final map was drafted from this base.

GENERAL GEOLOGY

SEDIMENTARY ROCKS

Paleozoic rocks exposed in the area under consideration represent the Ordovician, Silurian, Devonian, Mississippian, and Pennsylvanian systems. They aggregate a total stratigraphic thickness in excess of 9600 feet, consisting of limestone, dolomite, sandstone, and shale facies, deposited in the miogeosynclinal Millard belt (Kay 1951, pp. 9-13).

Valley fill and veneer in the stream valleys, consisting in the main of unconsolidated Quaternary fluvial, lacustrine, and aeolian deposits, were derived from the uplifted Paleozoic sequence.

Refer to Figure 4 for a graphic representation of the stratigraphic column.

ORDOVICIAN SYSTEM

Swan Peak Quartzite

Exposures of the Swan Peak quartzite crop out in the northern Onaqui Mountains on the north side of Johnson Pass above Los Ricos Station in Section 35, Township 5 S., Range 7 W. (see geologic map). In the Johnson Pass area the Swan Peak consists of orthoquartzite, shale, and limestone conformably overlying the Pogonip (?) group. Upward it is unconformably overlaid by the Fish Haven dolomite.

Sand dunes and alluvium extensively conceal the formation, but the writer was able to correlate the formation by means of fossils and distinctive lithology with other localities, particularly with a stratigraphic section measured by Dr. H. J. Bissell, Kenward McKinney, and Morris Petersen in Section 11, Township 5 S., Range 7 W. The writer has prepared the following description from field notes loaned to him of this section, which was measured several miles to the north.

(5) Fish Haven dolomite.

Unconformable contact

(4) The upper unit of the Swan Peak consists of medium-thin bedded dolosiltite and interbedded black shale. The thickness of the unit is 25 feet. The writer believes this unit may correlate with the dolomite member

described by Hintze (1951, pp. 21-22) as occurring above the Swan Peak in western Utah. However, for lack of conclusive evidence indicating a post-Swan Peak age, the writer includes this unit here.

(3) The middle unit consists of an upper and lower black to very dark-brown and brown-gray shale, separated by argillaceous limestone and shaly dolosiltite. The limestone is medium to thin bedded and the shale possesses slaty cleavage; the upper shale of this unit contains lingulid brachiopods and an excellent graptolite fauna. The thickness is 164 feet.

(2) The lower Swan Peak, not exposed above Los Ricos, consists of interbedded limestone, argillite, and flesh colored orthoquartzite. Bissell, Petersen, and McKinney measured 107 feet of this unit farther north.

Conformable contact

(1) Pogonip (Garden City [?] formation) group.

In northeastern Utah (Ross 1949, pp. 477-478) the Swan Peak, of Chazyan age, is composed of two members, an upper quartzite and a lower fossiliferous shale, which separate the older Garden City formation and the younger Fish Haven dolomite. In western Utah (see Fig. 5) the two members are separated by the intervening Lehman formation and are discussed by Hintze (1951, pp. 20-21), who makes the following statement:

> This same relation obtains in central Utah where the Kanosh shale appears to be almost identical in fauna as well as in lithology with the lower Swan Peak of northeastern Utah. The Swan Peak (?) quartzite of central Utah is also almost identical lithologically with the upper quartzite member of the Swan Peak formation of northeastern Utah. However, the intervening Lehman formation of central Utah has no counterpart, either in lithology or fauna, in the northeastern Utah sections. It is impossible to trace the upper quartzite member of the Swan Peak formation southward from the type area as it thins to disappear, probably by erosion, in the central Wasatch, Lakeside, Stansbury, and Tintic ranges, although the lower shaly member persists at Lakeside and Stansbury.

Fossils collected from unit 3 (text) include *Didymograptus patulus* (?) (Hall), *Didymograptus nitidus* (Hall), and *Didymograptus murchisoni* (Beck). Fossils identified from the section measured by Bissell, Petersen, and McKinney include *D. nitidus*, *D. murchisoni*, *Orthis michaelis*, and *Westonia* (?) sp. *Orthis michaelis* was identified from zone M by Hintze (1951, pp. 20-21), and *Didymograptus nitidus* occurs in the Swan Peak at Logan Canyon (Clark 1935, pp. 240-241). On this basis the writer correlates the Swan Peak in the northern Onaqui Mountains with the Swan Peak of Promontory Point and in northeastern Utah (Ross 1949).

Fig. 4--Erosional Column of the Stratigraphic Section in the Northern Onaqui Mountains.

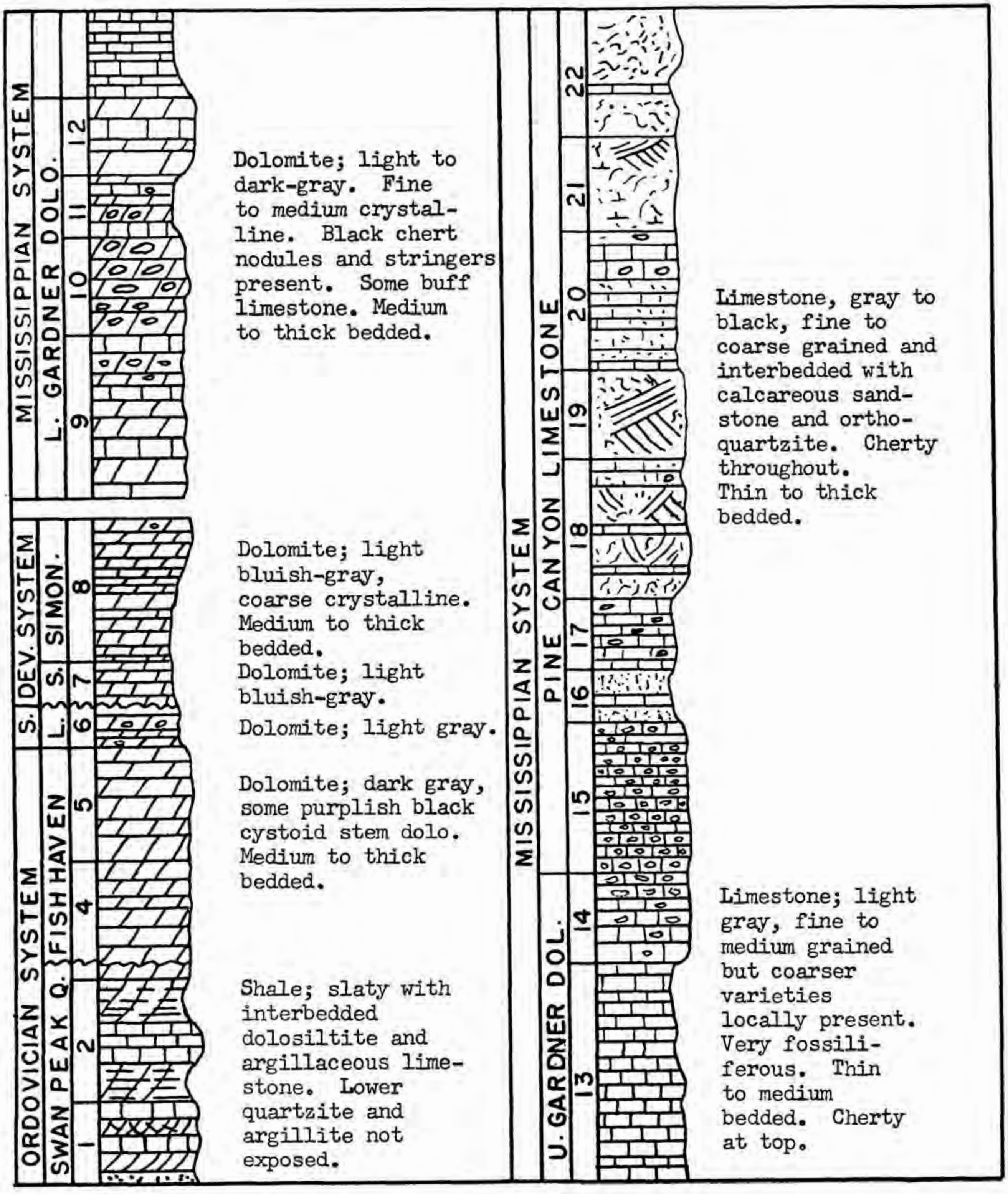


Fig. 4--Erosional Column of the Stratigraphic Section in the Northern Onaqui Mountains (Continued).

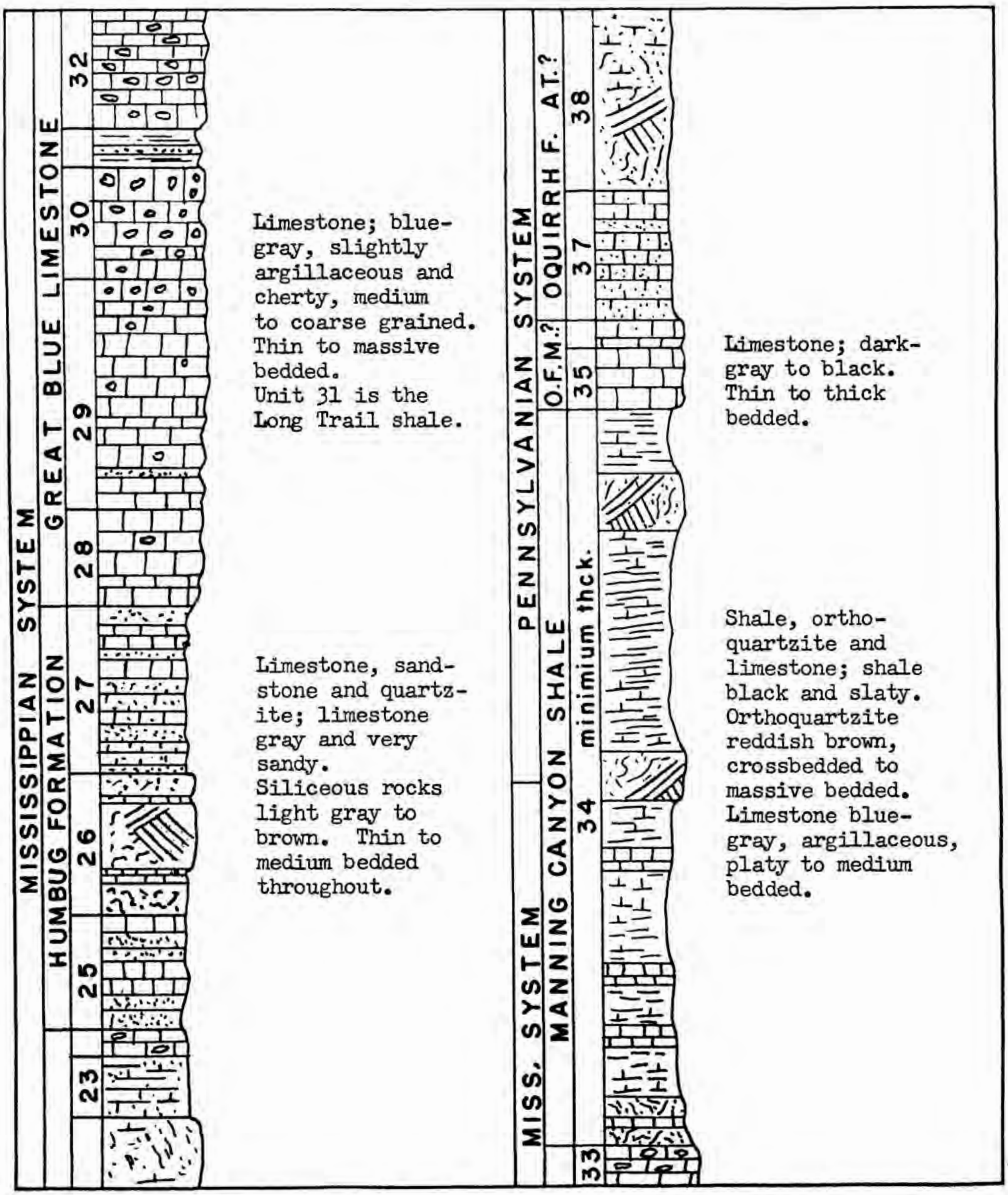
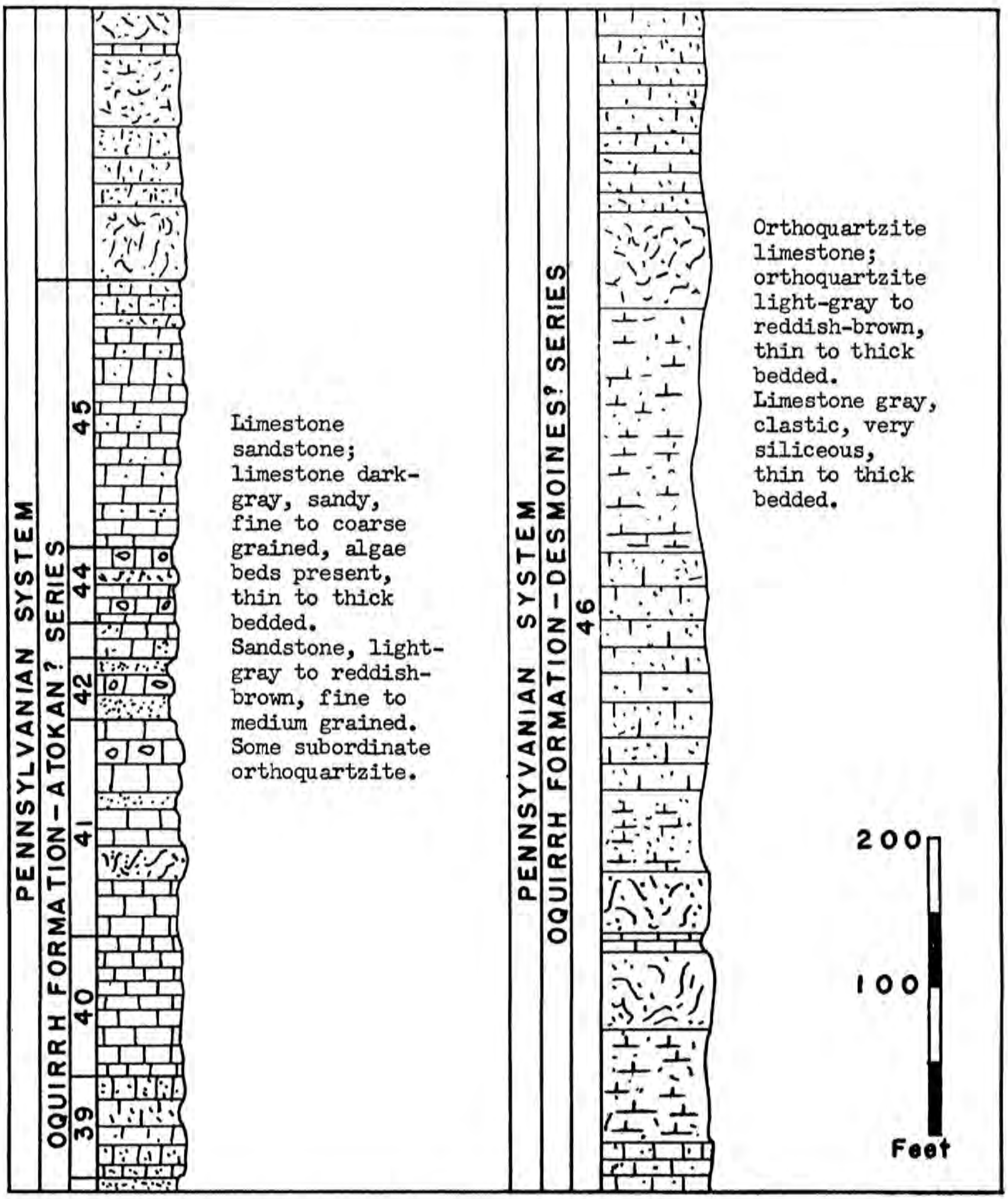


Fig. 4--Erosional Column of the Stratigraphic Section in the Northern Onaqui Mountains (Continued).



Age	Zone	Northeastern Utah (Ross 1949)		Ibex Area (Hintze 1951, p. 29)	
CHAZYAN	O			Dolomite Member	
				Swan Peak Quartzite	
	N		Upper Quartzite	POGONIP GROUP	Lehman Formation
	M	Swan Peak Quartzite	Lower Shale		Kanosh Shale
U. CANADIAN	L	Upper Garden City Formation			Juab Limestone
	K				Upper Wahwah Limestone

Fig. 5--Correlation of the Swan Peak Quartzite

Tintic District (Lovering 1949)			Tentative Revision*		
Age	Blue Bell Dolomite	Thck.		Thck. (?)	Age
L. to U. ORDOVICIAN	"Noah Dolomite"	290	Simonson Dolomite	290	DEVONIAN
	"Dora Dolomite"	212	Sevy Dolomite	272	
	"Beecher Dolomite"	212	Laketown Dolomite	152	SIL.
	"Eagle Dolomite"	180	Fish Haven Dolomite	180	U. ORD.
L. ORDOVICIAN	Opohonga Limestone	825	Opohonga Limestone	825	L. ORDOVICIAN
	Ajax Limestone	625	Ajax Limestone	625	

*Oral communication, Dr. H. J. Bissell, 1955

Fig. 6--Tentative Revision of the Blue Bell Dolomite

Pre-Upper Ordovician Unconformity

Various writers have described, throughout northern and central Utah, a major unconformity which occurs in the lower Paleozoic rocks, due probably to nondeposition and (or) possible erosion. In the south-central Wasatch Range, Perkins (1955, p. 14) clearly demonstrates the absence of Ordovician, Silurian, and Devonian rocks. In the Tintic district (see Fig. 6) the writer has observed Upper Ordovician rocks resting on the Lower Ordovician Opohonga limestone. On Promontory Point, Webb (1953, p. 189) describes the Upper Ordovician Fish Haven resting unconformably (?) on the Swan Peak. An alledged positive area in the Lower Paleozoic is described by Stokes (1952, p. 1300) in northwestern Utah and adjoining states, although the lack of Lower Paleozoic rocks may be due to later uplift.

An unconformity exists in the Oquirrh Range,* where there is a thin wedge of Ordovician rocks in minor angular discordance with the overlying Lower Mississippian carbonates.

In the Gold Hill area, Nolan (1935, p. 16) recognizes an unconformity at the base of the Upper Ordovician.

> The variable thickness of the Chokecherry dolomite in the Deep Creek Mountains and its apparent absence on Dutch Mountain indicate an unconformity between it and the overlying Fish Haven dolomite, of Upper Ordovician age.
>
> This unconformity has been reported from three other localities--Eureka, Nev., northern Utah, and southeastern Idaho. In all three the unconformity is shown by the varying thickness of an underlying quartzite, which is, in the Utah and Idaho localities of Chazy (?) age. The quartzite in Nevada is probably of about the same age. The hiatus represented by the unconformity is thus much greater at Gold Hill than it is to the north or south, but whether the absence of the high Lower Ordovician beds is due to erosion or nondeposition is not clear. The latter hypothesis is perhaps more probable in view of the lack of conglomerate or other clastic rocks at the base of the Upper Ordovician sediments.

The unconformity in the northern Onaqui Mountains is represented by the Fish Haven resting unconformably, with no visible discordance, on the Swan Peak quartzite. Hintze (1951, p. 21) and Webb (1953, p. 85) attribute the absence of the upper quartzite member of the Swan Peak and the Eureka quartzite to possible nondeposition or removal by later erosion.

Fish Haven Dolomite

The Fish Haven dolomite crops out in the northern Onaqui Mountains

---

*Personal communication, Dr. H. J. Bissell and Dr. J. K. Rigby.

above Los Ricos Station on the north side of Johnson Pass. The formation is 290 feet thick, consisting of thick beds of dark dolomite, which upon weathering form rugged cliffs. The Fish Haven unconformably overlies the Swan Peak and grades upward into the Laketown dolomite.

The small area of outcrop and numerous faults deterred the writer from measuring the formation. However, Dr. H. J. Bissell, Kenward McKinney, and Morris Petersen loaned the writer field notes of a stratigraphic section measured in Section 11, Township 5 S., Range 7 W., upon which the following description is based.

(4) Laketown dolomite.

Conformable contact

(3) The upper unit of the Fish Haven consists of light-gray to medium dark-gray dolomite, interbedded with light-gray, finely crystalline dolomite. Beds of black to purplish-black cystoid stem bearing dolomite are also present. On weathering the unit develops massive ledges and a meringue surface. The unit is medium to thick-bedded and is 156 feet thick. In the Johnson Pass area the writer collected several genera of corals from this unit.

(2) The lower unit consists of interbedded dolosiltite and typical dark-gray to purplish-black, finely crystalline Fish Haven dolomite, with cystoid stem fragments. The unit is 134 feet thick.

Unconformable contact

(1) Swan Peak quartzite.

Hintze (1951, p. 23) states that the Upper Ordovician rocks, typically a dark dolomitic facies, is one of the most persistent units in the eastern Great Basin. Accordingly it has been recognized in northeastern Utah (Richardson 1919, pp. 409-410), where the name Fish Haven was first used and extended to the Gold Hill district by Nolan (1935, pp. 16-17) on the basis of similar age and lithology. In the Tintic district, Lovering (1951) grouped the rocks of lower and upper Ordovician age in the Blue Bell formation. However, the following revision is anticipated in the near future (see Fig. 6).

On the basis of similar lithology, stratigraphic position, and age, as indicated by the following corals, the writer correlates the Fish Haven with the Fish Haven at the type locality and elsewhere.

<u>Favistella</u> <u>aveolata</u> (Goldfuss)
<u>Halysites</u> <u>gracilis</u> (Hall)
<u>Streptelasma</u> 2 species

SILURIAN SYSTEM

The Laketown Dolomite

The Laketown dolomite conformably overlies the Fish Haven and is gradational with it in the northern Onaqui Mountains. The formation is exposed as a narrow, highly faulted band north of Johnson Pass in Section 35, Township 5 S., Range 7 W. Because of the close proximity of the formation to major fault systems, the small area of exposure, and localized outcrops which occur on only one ridge, the formation was not measured. An estimate of the exposed thickness is 50-60 feet.

The Laketown consists of medium to light-gray, thin to medium-bedded dolomite, which appears banded in the lower part of the unit. The texture is fine to coarse (sucrose) crystalline. Thin stringers and nodules of white chert are distributed throughout the section as well as fragments of pentamerid brachiopods and favositid corals.

The Fish Haven-Laketown boundary is gradational and occurs in an unfossiliferous zone. The contact was chosen where the typically darker dolomite of the Fish Haven grades upward into the light-gray banded dolomite of the lower Laketown. The upper contact with the Devonian rocks was drawn where the light-gray of the Laketown grades upward into a light-bluish-gray dolomite having a fine to microcrystalline texture.

At the type locality of the Laketown (Richardson 1913, p. 410), the formation consists of massive, gray-white dolomite intercalated with lenses of sandstone, the formation being 1000 feet thick. A Silurian age was assigned to the beds on the evidence of poorly preserved fossils. Light-gray dolomitic rocks are also present at Gold Hill (Nolan 1935, pp. 34-35) and in the Tintic district (see Fig. 5), where they are also of Silurian age. MacFarland (1955, pp. 34-35) made an extensive study of the Laketown and its equivalents throughout the eastern Great Basin from which he made the following conclusions and proposals:

(1) The Laketown dolomite was formed under shallow water conditions, punctuated by brief intervals of subaerial erosion. The dark dolomite was probably formed in deeper water than the light dolomite or was subject to less reworking of the sediment.

(2) Slow subsidence permitted extensive reworking of the Laketown sediments with the attendant loss of organic material, thus giving rise to the light dolomite.

(3) Conditions in the Silurian sea favored syngenetic dolomitization.

(4) The Laketown dolomite can be traced as a distinctive unit throughout the eastern Great Basin, thus the name Laketown should be applied to rocks of Silurian age in the area.

The writer correlates the Laketown in the northern Onaqui Mountains with the Laketown in the Gold Hill area (Nolan 1935, pp. 18-19) and adjacent parts of the Great Basin on the basis of similar lithology and stratigraphic position.

DEVONIAN SYSTEM

Sevy-Simonson Dolomite (Undifferentiated)

Rocks of Devonian age crop out in the area under consideration on a ridge crest north of Johnson Pass between Los Ricos Station and Devils Gate (Section 35, Township 5 S., Range 7 W.). Due to the extreme brecciation of the rock and the small area of exposure, the Sevy-Simonson were not studied in detail.

According to Dr. H. J. Bissell, Morris Petersen, and Kenward McKinney, from field notes loaned the writer, the Sevy and the Simonson are 59 and 193 feet thick, respectively, as measured several miles north of Johnson Pass in Section 11, Township 5 S., Range 7 W. They describe the Sevy as consisting of very light-gray to faint bluish-gray, microcrystalline to fine-crystalline dolomite. It is doloarenaceous to slightly sandy in the upper few feet and is thin to medium bedded throughout. The Simonson consists of dark-gray, dark-bluish-gray, and faint brownish-gray, microcrystalline to coarse (sucrose) crystalline dolomite. Bedding is medium to thick. The uppermost unit forms ledges on weathering and contains silicified corals of the genera: Cladopora, Striatopora, and Favosites.

On the basis of similar age, lithology, and stratigraphic position, the writer correlates the Sevy-Simonson with the Sevy and Simonson dolomite in the Gold Hill (Nolan 1935, pp. 18-19) and the Tintic districts (see Fig. 6).

MISSISSIPPIAN SYSTEM

Gardner Dolomite

In the northern Onaqui Mountains the Gardner formation is exposed on the east flank of Grasshopper Ridge and on the lower slopes of the western escarpment in the vicinity of Johnson Pass. Two distinctive lithologic units were recognized and studied: a lower member consisting of massive-bedded dolomite and an upper thin-bedded fossiliferous member. The upper member is 530 feet thick; the thickness of the lower member could not be determined as the base is not exposed. The distinctive curley bed was not recognized as separating these two members as it was by Clark (1954, p. 28) in Utah County.

The lower Gardner consists of massive to thin-bedded, light to dark-gray dolomite and light-gray and buff clastic limestone. The texture of the dolomite varies from fine to medium crystalline and the limestone ranges from fine to coarse grained, the coarser varieties consisting of crinoid hash. Black chert nodules and stringers are abundant, especially in the lower part of the unit. Corals of the genera Syringopora and Caninia are present throughout the lower member.

Light-gray, thin to medium bedded limestone dominates the upper member. It is typically fine to medium grained, but coarse varieties are locally present, consisting mainly of fossil hash and crinoid stems. One outstanding feature is the fossiliferous character of the beds. Many of the fossils are silicified and stand in relief above the surface, thus enabling the writer to identify the following forms in the field:

Syringopora sp.
Lithostrotionella sp.
Multithecopora sp.
Caninia sp.
Euomphalus sp.

Clark (1954, p. 45) arrived at the following conclusions concerning the Gardner formation in Utah County, Utah.

(1) The dolomite present within the formation is secondary, i.e., it is the result of marine and post-lithification dolomitization.

(2) The Gardner formation represents a stable shelf deposit, the upper member having been deposited upon slightly more unstable conditions than the lower.

(3) The fauna of the lower member is Lower Kinderhookian age and the fauna of the upper member is Upper Kinderhookian and Lower Osagean.

The fossils identified by the writer are essentially congeneric and conspecific with those listed from the Gardner by Clark (1954, p. 7), indicating a similar age.

Gilluly (1932, pp. 20-24) used the term Madison for rocks similar in lithology to the upper Gardner in the Oquirrh Range. Various other writers have also used this terminology for fossiliferous limestones of lower Mississippian age in the central Wasatch Mountains (see Fig. 7). In this report the writer used the term Gardner because of the close lithologic similarity to the Gardner dolomite of the Tintic district as defined by Lingren and Loughlin (1919, pp. 39-40) and revised by Lovering et al. (1951). The sequence of fossiliferous, thin-bedded limestone and massive-bedded dolomite is strikingly similar to the Gardner in the type locality. On this basis the writer correlates rocks with the Gardner in the Tintic district.

The Pine Canyon Limestone

The Pine Canyon limestone crops out on the east face of Grasshopper Ridge and in the cliffs of the northern part of the western escarpment. The formation conformably overlies the Gardner and is composed of two

	Standard Section	Oquirrh Basin Sadlick (1955)	South Central Wasatch Mountains*	Onaqui Mountains (This paper)
Pennsylvanian	Des Moines Series	Oquirrh Formation: Sandy Unit	Oquirrh Formation: Des Moines Series	Oquirrh Formation: Des Moines Series
Pennsylvanian	Atoka Series	Oquirrh Formation: ? — ?	Oquirrh Formation: Atoka Series	Oquirrh Formation: Atoka Series ? — ?
Pennsylvanian	Morrow Series	Oquirrh Formation: Limestone Unit	Oquirrh Formation: Morrow Series	Oquirrh Formation: ? — ? Morrow Series
Pennsylvanian	Springer Series	Manning Canyon	Manning Canyon Shale	Manning Canyon Shale
Mississippian	Chester Series	Great Blue ls.: Upper Limestone; Long trail Shale	Great Blue Limestone	Great Blue Limestone
Mississippian	Meramec Series	Great Blue ls.: Lower Limestone; Humbug Formation	Humbug Formation	Humbug Formation; Pine Canyon Limestone
Mississippian	Osage Series	Deseret Limestone	Deseret Limestone	Pine Canyon Limestone; Gardner Dolomite
Mississippian	Kinderhook Series	Madison Limestone	Madison Limestone	Gardner Dolomite

*A. A. Baker (1947), Stratigraphy of the Wasatch Mountains in the Vicinity of Provo, Utah, U. S. G. S., Oil and Gas Investigations, Preliminary Chart 30.

FIG. 7--(Proposed) Correlations of the Mississippian and Pennsylvanian Rocks

distinctive lithologic units. The lower member consists of interbedded chert and black limestone which upon weathering forms high rugged ledges. The upper member, by far the thickest, consists of interbedded orthoquartzite, sandstone, and limestone which typically weather into alternating slopes and cliffs. The formation as measured on Grasshopper Ridge is 1381 feet thick.

The lower member, unit 15 (see Fig. 4), is 203 feet thick, consisting mainly of black, thin to thick bedded, clastic limestone. Abundant irregular nodules and stringers of black and brown chert, averaging 2-6 inches thick, are characteristically bedded throughout and stand in relief above the limestone. Examples were noted where the chert has replaced colonies of Syringopora, indicating that much of the chert may be secondary. The lower member is much thinner on the western escarpment, being less than 100 feet thick.

The upper member, 1178 feet thick and comprising the remainder of the units, consists of lenticular, calcareous sandstone and orthoquartzite interbedded with gray and black, fine to coarse-grained clastic limestone. The limestone facies is generally encrinal, and contains a large quantity of admixed sand and chert. The latter, not as plentiful in the upper member as the lower, occurs randomly as thin stringers and nodules paralleling the bedding. Beds of dense orthoquartzite and quartzitic sandstone cemented by various amounts of silica, show prominent crossbedding and weather dull reddish-brown. Friable, thin-bedded calcareous sandstone forms a large part of the section, but is not well exposed as it weathers to benches strewn with talus from ledges of more resistant limestone and quartzite.

The contact with the overlying Humbug formation on Grasshopper Ridge was chosen at the top of a 35 foot unit (unit 24, Fig. 4) of black, thin-bedded limestone which marks the highest bed of chert. It also contains several genera of corals. Above this unit the Humbug consists of lenticular beds of sandstone and limestone. In the western escarpment the boundary was chosen at the highest bed in which black chert occurs with the coarse-grained sandy limestone.

The type locality for the Pine Canyon limestone is Pine Canyon in the Tintic district, defined by Lingren and Loughlin (1919, pp. 40-41), with which the writer correlates this section. There the formation consists of black, thin-bedded limestone with abundant chert banding and an upper unit of coarse grained sandy limestone. It separates the Gardner dolomite and the limestone and sandstone facies of the Humbug. The Deseret limestone (Gilluly 1932, pp. 25-26) in the Oquirrh Range, with which a tentative correlation is made, is almost lithologically identical to the Pine Canyon and the stratigraphic sequence is also similar. The Deseret overlies cherty and fossiliferous limestone of Kinderhookian and lower Osagean age and is stratigraphically below the Humbug sand and limestone facies.

Lingren and Loughlin (1919, p. 41) state that the lower part of the Pine Canyon is Madison age and that the upper coarse-grained limestones are upper Mississippian age. In respect to series, the Pine Canyon can probably be regarded as upper Osagean and lower Meramecian age. This is substantiated by species of the genus Endothyra collected by Calderwood (1951, p. 39) from the upper 100 feet of the Pine Canyon in the Cedar Valley Hills.

The forms were tentatively assigned to lower Meramecian by Thomas and Zeller. The stratigraphic values of corals collected by the writer from the upper 35 feet of the formation have not been determined but elsewhere they occur in lower and upper Mississippian rocks. These corals, identified by the writer, are as follows:

Trilophyllites subcrassus (Easton & Gutschich)
Diphyphyllum inconstans (Okulitch & Albritton)
Lithostrotion whitneyi (Meek)
Lithostrotionella af. *L. americana* (Hayasaka)
Ekvasophyllum (?) sp.

The Humbug Formation

The Humbug formation conformably overlies the Pine Canyon, which grades into the former in the northern Onaqui Mountains. The formation crops out as narrow bands on the east face of Grasshopper Ridge and in the southern part of the western escarpment, east of Hatch Ranch. Topographically the Humbug forms a series of alternating ledges and slopes which, from a distance, appear light brown in contrast to the massive-bedded, blue ledges of the overlying Great Blue limestone.

The Humbug consists of intercalated orthoquartzite, calcareous sandstone, and clastic limestone, totaling 575 feet thick. Most of the sandstone and the quartzite are lenticular and when traced laterally grade into other rock types. Although not always obvious, crossbedding and ripple marks are characteristically present throughout the siliceous material. Corals are abundant and according to Livingston (1955, pp. 25 and 33) are the most abundant macrofossil present, suggesting deposition in less than 100 feet of water.

The limestone facies of the Humbug varies from light to dark-gray, and upon weathering typically forms ledges. It is mainly clastic, composed of fossil fragments and other organic debris with a considerable amount of admixed quartz sand. The texture of the limestone is fine to coarse grained and should appropriately be termed encrinal.

Siliceous detrital rocks of the Humbug consist of red weathering calcareous sandstone and quartzite cemented with varying amounts of silica. The calcareous sandstone is less resistant to weathering and forms slopes and benches in contrast to the ledge forming quartzite. Livingston (1955, p. 10) concluded that the majority of the sand can be classified on the Wentworth scale as medium to fine grained. The degree of rounding suggested to him that the sand had undergone more than one cycle of erosion.

The boundaries of the Humbug formation are gradational with the underlying Pine Canyon and the overlying Great Blue limestone. The upper contact is the more obvious, being drawn at the highest mappable sandstone bed. The lower contact is the top of the highest bed containing cherty limestone.

Tower and Smith (1897, p. 625) named the formation from outcrops in the vicinity of the Humbug mine in the Tintic district. In central and northern Utah the Humbug has been recognized and studied at many localities. Emmons (King 1877, p. 442) had previously mapped the formation in the Pelican Hills east of Lake Mountain and in the Oquirrh Range, where it was included as part of the Lower Intercalated Series. Livingston (1955) completed a detailed study of the formation and extended it into the Stansbury and Lakeside Mountains. Gilluly (1932, p. 28) recognized and studied it in the Oquirrh Range.

Mr. Del E. Davis and the writer collected several genera of corals from the Humbug on Grasshopper Ridge, of which a partial list follows. A more complete treatment will be presented by Mr. Davis at a later date.

Ekvasophyllum sp.
Lithostrotion whitneyi (Meek)
Diphyphyllum (?) sp.

Weller (1948, chart 5), Livingston (1955, p. 28), and others assign an upper Meramecian age to the Humbug, but they point out that in the Cottonwood area of the Wasatch Range the Humbug may be younger. The stratigraphic value of corals collected by Mr. Davis and the writer has not yet been determined.

On the basis of similar lithology and stratigraphic position, the writer correlates the Humbug with the Humbug in the Oquirrh Range (Gilluly 1932, p. 28) and adjoining areas.

The Great Blue Limestone

The name Great Blue, a miner's term, was adopted by Spurr (1895, p. 375) for exposures in the Mercur mining district of the Oquirrh Range. In the area under consideration the formation occurs as westerly dipping strata on the west face of Grasshopper Ridge and extends northerly into the southern Stansbury Mountains on the western escarpment. In outcrops the formation typically occupies the high crestline and forms steep talus slopes. The upper and lower boundaries are gradational with the Humbug and the Manning Canyon shale.

The Great Blue is divided into three members by the Long Trail shale (Gilluly 1932, p. 291). The medial carbonaceous shale member is typically olive-green to black and is intercalated with beds of friable, fine-grained sandstone and dense orthoquartzite. The writer had considerable difficulty in accurately tracing it on Grasshopper Ridge and on the western escarpment. This difficulty may be partially explained by talus accumulations which cover the outcrops. Consequently only the approximate position of the Long Trail is shown in these areas on the geologic map (see Plate 2).

As measured on the western escarpment above Hatch Ranch, S. 12, T. 6 S., R. 7 W., the lower member is 745 feet thick and the upper member is 200 feet thick. The position of the Long Trail was located by float in talus on a slope beneath ledges of blue-gray limestone. From measurements at this locality and observations in other areas, the Long Trail appears to be approximately 55 feet thick. These figures may not be accurate as the

Great Blue limestone has been faulted, thickened, and thinned throughout much of its extent.

The upper and lower members of the Great Blue are composed of a monotonous sequence of thin to massive-bedded, nearly homogeneous limestone, devoid of any distinctive key beds. The limestone is typically clastic and slightly argillaceous, fine to medium grained with randomly distributed beds of medium to coarsely crystalline limestone throughout. Several forms of bryozoans are present throughout the section but were not identified. Several lenticular beds of sandstone crop out about 150 feet from the base of the section but they are not everywhere present at this horizon. Stringers and irregular nodules of black chert, up to 8 inches in diameter, occur parallel to the bedding and are abundant in certain parts of the section, especially the upper part of the lower limestone member. Case-hardening is common throughout, and closely resembles the chert. In the upper member chert is generally red and black and occurs as stringers which are not as thick as those in the lower member. Corals, which are often distorted, occur rather profusely in some areas of Great Blue. The following species were collected from the lower member:

<u>Caninia</u> (?) 2 species
<u>Ekvasophyllum</u> <u>inclinatum</u> (Parks)
<u>Ekvasophyllum</u> <u>turbineum</u> (Parks)
<u>Lithostrotion</u> <u>whitneyi</u> (Meek)

Gilluly (1932, p. 30) who mapped the formation in the Oquirrh Range, collected a large and varied fauna throughout the section and assigned it to Upper Mississippian. A more recent study by Weller (1948, pp. 91-96) agrees with Gilluly's age assignment but places it as Lower Chesterian. The corals collected by the writer agree with this age assignment. The same species have been reported from the Brazer in northern Utah (Parks 1951), which is regarded as Upper Mississippian.

The writer correlates the Great Blue limestone of the Onaqui Mountains with the Great Blue of the type area in the Oquirrh Range (Gilluly 1932, p. 30) on the basis of similar fauna, lithology, and stratigraphic position.

MISSISSIPPIAN AND PENNSYLVANIAN SYSTEMS

<u>Manning Canyon Shale</u>

The Manning Canyon shale was named by Gilluly (1932, p. 31) in the Oquirrh Range. Rocks of similar lithology and stratigraphic position are also present in the northern Onaqui Mountains.

A thick, structurally complex section of the Manning Canyon is poorly exposed in a wide valley which extends northward from Grasshopper Ridge to Victory Canyon in the southern Stansbury Mountains. Elsewhere partial sections crop out in Big Hollow and in the uplands west of Grasshopper Ridge. Because of thrust faults and the ease with which the shale is reduced to slopes by weathering, continuous exposures are not available in the area. An accurate stratigraphic measurement can not be made but a minimum thickness of 1000 feet is suggested by the map pattern.

The Manning Canyon shale consists of black shale which possesses slaty cleavage, intercalated and lenticular units of dense reddish-brown orthoquartzite, orthosiltite, and argillaceous and blue-gray clastic limestone. The clastic limestone is medium to thick bedded and contains thick black and red stringers of chert. The chert is usually absent in the thin, platy and yellow argillaceous limestone. Ellipsoidal concretionary nodules, present locally in the shales, are lined with euhedral crystals of pyrite and pseudomorphs of limonite after pyrite.

The lower boundary of the Manning Canyon is gradational with the Great Blue and was mapped at the first bed of quartzite or shale which could be traced laterally. The upper contact is defined by the regularly bedded sand and limestone facies of the Oquirrh.

In the Oquirrh Range (Gilluly 1932, pp. 32-33) and in the Gold Hill districts (Nolan 1935, pp. 31-33), the Manning Canyon shale straddles the Mississippian-Pennsylvanian time boundary. This was also concluded by MacFarland (1955, p. 12), after identification of numerous fossil forms, and he states that the age of the formation is upper Chester and Springer. The following fossils also suggest this to be true in the northern Onaqui Mountains:

<u>Triplophyllites</u> <u>ellipticus</u> (?) (White)
<u>Triplophyllites</u> sp.
<u>Schiziophoria</u> sp.
<u>Spirifer</u> <u>missouriensis</u> (Swallow)
<u>Dictyoclostus</u>, 2 species
<u>Marginifera</u> sp.
<u>Nucula</u> sp.
<u>Yoldia</u> <u>longifrons</u> (?) (Conrad)
<u>Derbyia</u> sp.
<u>Sochkineophyllum</u> (?) sp.

On the basis of similar age, lithology, and stratigraphic position the writer correlates the Manning Canyon with the Manning Canyon in the Gold Hill (Nolan 1935, pp. 31-33) and the Oquirrh Range (Gilluly 1932, pp. 32-33).

PENNSYLVANIAN SYSTEM

The Oquirrh Formation

The Oquirrh formation was named by Gilluly (1932, pp. 34-35) in the Oquirrh Range for a thick sequence of alternating limestones and sandstones which are in excess of 15,000 feet. This formation is reported to be 26,000 feet thick in Central Utah (Thompson, Verville, and Bissell 1950, p. 430), of which 16,200 feet is referred to the Pennsylvanian and

9,800 feet to the Permian. The Oquirrh forms by far the thickest stratigraphic unit in the northern Onaqui Mountains. Outcrops are well exposed in a series of low rugged hills in the northeastern part of the area and on thrust blocks overlying the Manning Canyon shale west of Grasshopper Ridge. Differential erosion of the limestone and the interbedded siliceous facies develops a ledge and talus slope topography, the latter concealing many ledges of resistant quartzite.

Because of the great thickness of the formation, the writer subdivided it into three mappable units on lithic breaks: a lower black limestone unit, a middle sandy limestone unit, and an upper predominantly siliceous limestone and orthoquartzite unit. Their ages probably correspond closely to the Morrow, Atokan, and DesMoines series, respectively, as mapped in the Oquirrh Range by MacFarland (1955, pp. 13-14), in the south central Wasatch Mountains by Olsen (1955, pp. 11-13), and others. The lithologic sequence of the rocks in the mapped area is similar to the sequence in these other areas.

The Morrowan (?) rocks crop out as a thin band, 85 to 120 feet thick, extending roughly south from Clover Creek to the vicinity of Grasshopper Ridge where they are covered by an overthrust of the Manning Canyon shale. The limestone of the unit is typically dark-gray to black, finely crystalline and devoid of fossils, excepting an algal biostrome, one to two feet thick which occurs at the top of the section. Irregular black chert nodules are randomly distributed throughout, as well as thin laminar stringers of fine grained quartz sand.

The Atokan (?) series, 1596 feet thick where measured in S. 32, T. 5 S., R. 6 W., consists of intercalated and lenticular beds of reddish-brown sandstone, orthoquartzite, and gray clastic limestone. The alternating sandstone and limestone produces a ledge and slope topography. The siliceous detrital rocks, most abundant in the lower part of the series, are fine to medium-grained and cemented with varying amounts of calcium carbonate and silica. The limestone is thin to thick bedded and consists of fossil hash and algal bodies with a high proportion of admixed quartz sand and occasional chert nodules. At the base of the measured section in Johnson Pass, greenish-black shales are interbedded in the sandy limestone, but were not observed elsewhere in the area. The following fossils were collected and identified from the Atokan (?) rocks:

Tabulipora sp.
Linoproductus sp.
Rhombopora sp.
Spirifer sp.
Fenestrellina sp.

An incomplete section of the DesMoines (?) rocks, composed of at least 1970 feet as calculated from the outcrop width on the map, is predominantly gray, siliceous limestone and light reddish-brown orthoquartzite. Numerous beds of intraformational limestone conglomerate occur locally in the unit, consisting of pebble-size limestone and chert (?) fragments which are tightly cemented. Fusulinids collected several hundred feet above what was mapped as the Atokan-DesMoines boundary were examined by Dr. M. L. Thompson. In a letter dated December 7, 1955, he makes the following statement:

> Four of the slides, . . . contain specimens which if mature probably belong to the genus Profusulinella. These may possibly be young of Fusulinella. Three other slides, . . . contain what looks like Fusulinella. Three slides . . . contain fusulinids, but I am not certain as to the genus, probably either Fusulinella or Profusulinella.

This indicates that the bed from which they were collected, providing the forms were all Fusulinella, is lower DesMoines or upper Atokan (Thompson, Verville, and Bissell 1950, p. 433, and Thompson 1948, pp. 22-23).

West of the Onaqui Mountains in the Gold Hill district (Nolan 1935, pp. 33-36), rocks of the Oquirrh formation containing the genus Fusulina, occur stratigraphically immediately above the Manning Canyon. The genus Fusulina, according to Thomas, Verville, and Bissell (1950, p. 435) and Thompson (1948, pp. 22 and 69), occurs in rocks of DesMoines age, thus indicating an unconformity exists between the basal beds of the Oquirrh and the Manning Canyon in the Gold Hills area. The writer believes this unconformity may exist in the northern Onaqui Mountains but probably with a shorter hiatus, for southeast of Hatch Ranch rocks of typical Atokan lithology appear to rest normally upon the Manning Canyon (Fig. 8). However, the lack of Morrow rocks may be explained by unmapped faults or a possible facies change. Because of the uncertain age of the rocks and the complex structure, the Oquirrh formation was not differentiated in this area on the geologic map.

QUATERNARY SYSTEM

Quaternary deposits, consisting of fanglomerate, Lake Bonneville sediment, alluvium and sand dunes, unconformably overlie the older, uplifted Paleozoic sequence.

Pre-Lake Bonneville Fanglomerate

Pleistocene fans spread apron-like from the base of the western escarpment and in the piedmont adjacent to Rush Valley. The fans are indented with wave-cut terraces and beaches and are unconformably overlain with lacustrine sediments, thus defining them as pre-Lake Bonneville. The fanglomerate is composed of poorly sorted debris, derived mainly from the uplifted Paleozoic sequence in the adjoining mountains. The material consists of admixed angular boulders, cobbles, sand, and silt, and is unconsolidated except where locally cemented by caliche. The fans in the vicinity of Clover, several miles east of the area, are at least 1000 feet thick (Carpenter 1913).

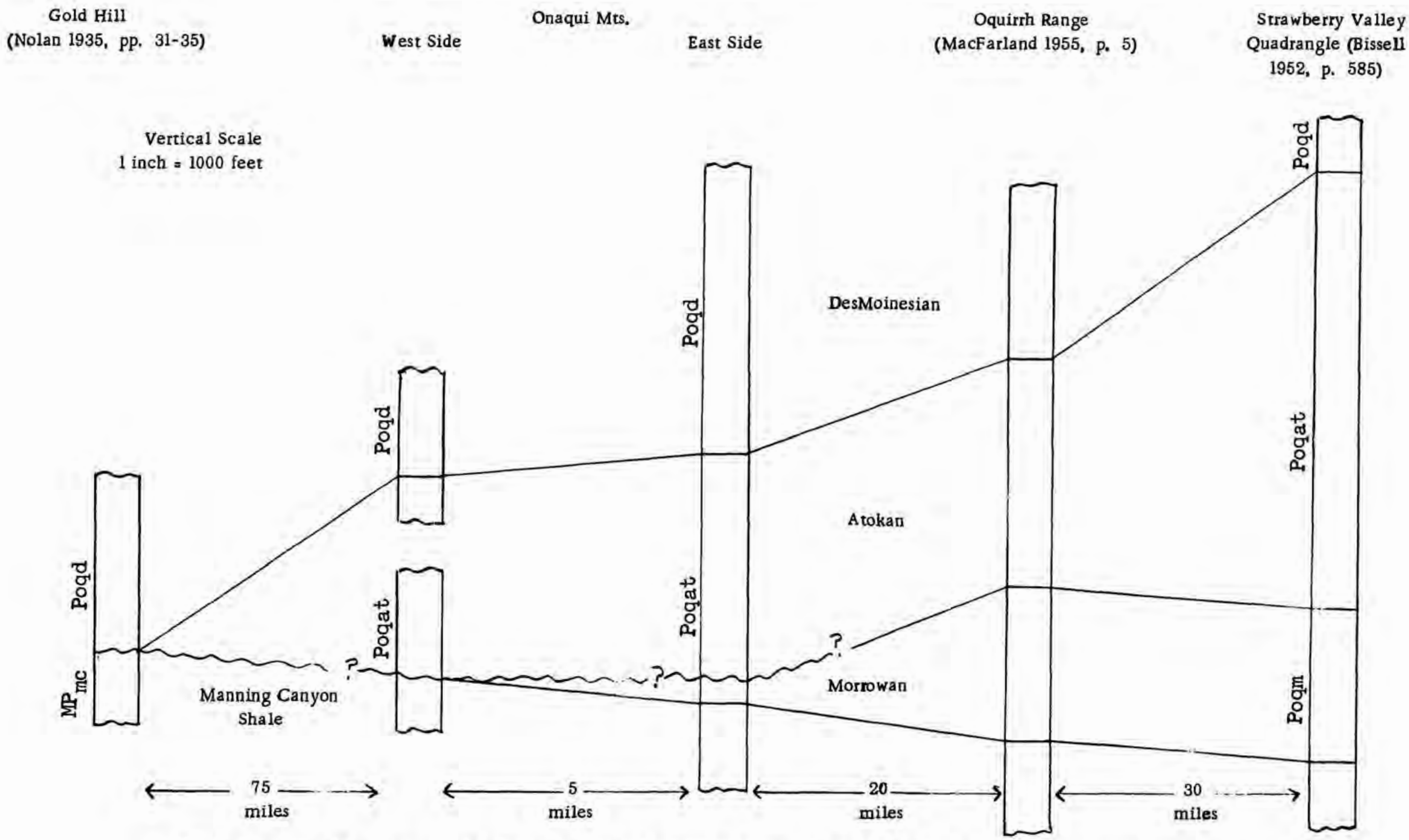


Fig. 8--Diagram of the Lower Oquirrh Formation from the Gold Hill District to the South Central Wasatch Mountains, Utah.

Lake Bonneville Group

Lacustrine sediments are represented by the Lake Bonneville group in Skull Valley. The group consists of three formations which are in the order of their deposition: the Alpine, the Bonneville, and the Provo (Hunt, Varnes, and Thomas 1953, and Bissell 1952). The former two are present in the area, but due to the difficulty in distinguishing the Bonneville level, the group was not subdivided. The sediments consist of unconsolidated fine gravel, sand, silt, and clay.

The group contains buried soil profiles which have been correlated with similar soil profiles in the LaSal Mountains and ancient Lake Lahontan. The Lake deposits are dated as Pleistocene, largely Wisconsin, by Bissell (1948) and Hunt, Varnes and Thomas (1953).

Recent

Sand Dunes

Sand dunes, in the northwestern corner of the area, unconformably overlie the Lake Bonneville group, thus dating them as post-Lake Bonneville or Recent. The fine quartz sand was blown in from the western desert through the gap in the Cedar Mountains (King 1877, p. 462).

Alluvium

Modern day alluvial fans overlie the Lake Bonneville group and the stream beds are veneered with gravel sand, silt, and clay. Numerous talus slides are present beneath many of the steep ledges throughout the area.

STRUCTURE

GENERAL FEATURES

The northern Onaqui Mountains were involved in several phases of the Laramide Orogeny, as well as the Basin and Range disturbance. The chief structural elements, folds, thrusts, and normal and high angle faults, plus the presence of an ancient erosion surface indicate the area has been subjected to intense diastrophism.

FOLDS

The strata composing the northern Onaqui Mountains are folded into two major structures, the Clover Syncline and the Onaqui fold system. Numerous other folds, many of them too small to show on the map, are present.

Clover Syncline: The Clover Syncline, the dominant structural feature of the northeastern part of the area, extends from the southern Stansbury Mountains south of Johnson Pass where it plunges and disappears beneath the alluvium. It is nearly symmetrical, excepting the strata on the west flank in Victory Canyon which are sharply overturned. In Johnson Pass the axis is displaced by a series of steeply dipping parallel faults which trend northeast.

Onaqui Fold System: The Onaqui fold system is a group of open subparallel folds which extend northward from Grasshopper Ridge into the western escarpment. The strata on the flanks of the folds are gently dipping, rarely exceeding 35 degrees. The poor exposures and the diversely oriented joints of the quartzite in the Manning Canyon shale made it difficult to map the structures. The two folds in S. 23, T. 6 S., R. 7 W. are probably genetically related to the Onaqui fold system as they have the same northwest trend and open type folding.

In general the folds are subparallel and trend approximately N. 15° W. to N. 25° W. They approximately parallel the ridge crests and the borders of the range. The trend is also similar to the trend of the folds in the Oquirrh Range (Gilluly 1932, Plate 12) and those in Lake Mountain (Bullock 1951, p. 12).

FAULTS

There are three principal types of faults which are represented in the area: (1) older high angle faults, (2) thrust faults, and (3) Basin and Range normal faults.

High angle faults: There are numerous high angle transverse faults in the area with various stratigraphic displacement. The fault in S. 19, T. 6 S., R. 6 W. has over 1800 feet of stratigraphic displacement and a similar fault north of Johnson Pass in S. 36, T. 5 S., R. 7 W. has over 1000 feet of stratigraphic displacement. The latter is overridden by the Manning Canyon shale, definitely dating it as prethrusting. The group of faults in S. 1, T. 6 S., R. 7 W. have a stratigraphic displacement of several hundred feet.

The faults were probably formed during the folding and are referred to by Marsell (1932, p. 88) as the "older" faults to distinguish them from the Basin and Range faults. The poor exposures rendered it impossible to determine the dip of the fault planes.

Thrust faults: There are two major thrust faults and numerous allochthon blocks within the area. The largest is the Devils Gate overthrust which juxtaposes the Manning Canyon shale and the Great Blue limestone against the Pine Canyon in Johnson Pass. South of S. 6, T. 6 S., R. 7 W., the fault trace, over four miles long, is poorly exposed excepting where the plates of the Manning Canyon shale have overridden the lower black limestone of the Oquirrh formation. The fault trace probably extends southward from this point into the piedment east of Grasshopper Ridge, but it is covered by alluvium and could not be mapped.

The second major thrust, the Los Ricos, juxtaposes the Pine Canyon limestone and the Gardner formation upon the Great Blue in Johnson Pass. The thrust has ridden up over the Devils Gate and may be traced southward into the western escarpment. The fault plane, dipping about 30-40 (?) degrees, is marked by extensive brecciation and is highly mineralized with calcite. About 1/2 mile north of Los Ricos Station, strata of the Ordovician, Silurian, and Devonian systems on the upper thrust plate have overridden the Gardner formation. The dip of the fault plane is probably less than 25 degrees.

The largest allochthonous blocks are located in the uplands west of Grasshopper Ridge where plates of the Oquirrh formation have overridden the Manning Canyon shale, the latter probably acting as a lubricant between the two blocks.

Basin and Range faults: Basin and Range faults are parallel to the older Laramide trends and are clearly reflected in the topography. Well developed scarps, fault-line scarps, facets, and youthful canyons show linear and en echelon alignment traceable for many miles on the northwestern and southeastern fronts of the range.

The Stansbury fault system, herein named, is probably the fault described by Gilbert (1890) as occurring on the west face of the "Aqui" Mountains. The map accompanying U. S. G. S. Professional Paper 111 (Butler 1920) shows a fault on the west flank of the Stansbury and Onaqui Mountains, although Butler did not describe it. Numerous other writers, including Lambert (1941) who mapped it in part, have discussed it.

The Stansbury fault system consists of a group of parallel and subparallel faults that trend approximately N. 15° W. along the west face of the northern Onaqui Mountains (see geologic map). The system consists of normal faults with hanging wall blocks on the west. Near the southern termination of the fault system in S. 25, T. 6 S., R. 7 W. the writer measured over 850 feet of displacement in the Manning Canyon shale. Northward in S. 12, T. 6 S., R. 7 W. the cliffs rise steeply over 1500 feet with mature topography developed on the summit, indicating that the movement increases to the north. The trace of the fault across gullies is nearly straight and measurements by the writer of several joint systems near the fault zone indicate a nearly vertical movement, the plane dipping 75-80 degrees to the west.

The Grasshopper Ridge fault is on the east face of Grasshopper Ridge and extends for a distance of over four and one-half miles within the mapped area, trending N. 30° W. Davis (1935, 1927) and Gilbert (1927) believe that along mountain fronts where facets are practically undissected and fan development is small, slope of the lower part of the facet conforms closely to the fault plane. Measurements of several fairly intact facets approximated the measurements of joints parallel the fault, and indicate an easterly dip of 60 to 70 degrees.

Outcrops of Manning Canyon shale are exposed in the lower part of the escarpment and on a pediment surface east of the base (see geologic map). Rocks of the Pine Canyon formation, Humbug formation, and Great Blue limestone are exposed on the west block of the Grasshopper Ridge fault indicating approximately 2900 feet of movement.

AGE OF STRUCTURAL FEATURES

Direct evidence bearing on the age of the epics of folding and faulting is not present in the area studied. However, much data have been accumulated by Eardley (1951, pp. 315-391 and 484-485) and Spieker (1946, pp. 117-167), who have contributed greatly to the understanding of the several phases of the late Cretaceous and early Tertiary orogenies in the central Wasatch Mountains. Longwell (1950) believes these phases are waves of deformation which began in California and western Nevada during Jurassic or possibly late Paleozoic time. They advanced eastward throughout the remainder of Mesozoic and Cenozoic time to the Rocky Mountain region.

According to Eardley, the Cedar Hills orogeny was the first phase of deformation to occur in Central Utah. It occurred in early or mid Cretaceous (Colorado) time and resulted in an uplifted area in western Utah, which was the probable source of the coarse clastics of the Indianola group. The next compressive phase, the early Laramide orogeny of middle and late Montana time produced extensive folding and the large Bannock, Willard and Nebo overthrusts in the central Wasatch Mountains. This phase was probably responsible, in part at least, for the folds and the thrusts in the northern Onaqui Mountains.

The Middle Laramide Orogeny during late Montana and Paleocene time was probably an epeirogenic uplift following the Almy and Knight conglomerate which overlap the Bannock and Willard thrust sheets. Following this orogeny was the late Laramide Orogeny, the Eocene phase, which superposed a system of broad gentle north-south trending folds on the older and divergently trending folds and thrusts. Thus the intermontane valleys and ranges were defined for the first time. The last orogeny, the Absarakon in late Eocene and Oligocene time, was characterized by igneous activity and deformation.

Immediately following the Absarakon orogeny, the inception of Basin and Range faulting began and has been intermittent down to the present. However topographically expressed faults probably date back only to late Pliocene or early Pleistocene (Nolan 1943, p. 184) and Eardley states this is the age of the main movement on the Wasatch fault. The Stansbury and the Grasshopper Ridge fault systems probably had their inception in early Pleistocene or possibly late Pliocene time and have been intermittent since.

GEOMORPHOLOGY

GENERAL FEATURES

The north-south trending Onaqui Mountains are the second major range west of the eastern boundary of the Great Basin in central Utah. The drainage on the west is into Great Salt Lake and on the east into the enclosed basin of Rush Valley.

The present topography of the area, excluding the pre-block fault erosional surfaces, is the result of erosional and depositional processes which followed the blocking out of the range during the Basin and Range disturbance. Six principal land forms are present within the area: (1) scarps, (2) upland surfaces, (3) pediments, (4) bajadas, (5) lacustrine landforms, and (6) wind deposits.

Scarps

Two major faults, the Stansbury and the Grasshopper Ridge which are marked by dissected scarps, border the tilted and uplifted blocks, generally separating them from a previously developed rock-cut plain. Several other scarps are present, but they do not have the attending features so highly developed.

The western escarpment, formed by the Stansbury fault, rises abruptly 1500 feet from the piedmont where the valley fill is in direct contact with the bedrock of the mountain pass. Youthful V-shaped canyons and steep slopes have a pattern which is perpendicular to the trace of the fault. The fault-line-scarp associated with the Hatch Ranch fault, S. 24, T. 6 S., R. 7 W., forms the west wall of a valley developed in shales on the down-dropped block of the Stansbury fault.

The scarp on the east face of Grasshopper Ridge rises approximately 3000 feet and interrupts a rock-cut plain. Facets, slopes and steep canyons, the latter eroded rather deeply into the uplifted block, suggest a long period of intermittent uplift (see Fig. 10).

Upland Surfaces

The summit area of the northern Onaqui Mountains possesses a submature to mature topography which may be traced southward from Johnson Pass along the east slopes of the western escarpment and onto the crest of Grasshopper Ridge. The mature topography represents a residual erosion surface which undoubtedly was developed prior to the uplift of the fault block. This ancient erosion surface is probably correlative to similar surfaces on Lake Mountain (Bullock 1951, pp. 37-38) and on the Wasatch

Range, which Eardley (1951, p. 484) states was developed in Pliocene time.

Flanking the old erosion surface are deeply dissected uplands, low outlying hills, and rock-cut plains.

Pediments

Gently sloping surfaces, usually etched in shale, are exposed on the flanks of the range. They are thinly veneered with alluvium, but sufficient exposures are available to demonstrate that a rock-cut plain probably flanks the main mountain mass, in some instances extending over a mile from the mountain front.

The best developed rock-cut plain or pediment occurs at the base of Grasshopper Ridge, numerous outcrops being located adjacent to the Grasshopper Ridge fault and on the crests of the easterly extending ridges. The pediment is separated from Grasshopper Ridge by the Grasshopper Ridge fault. The surface is generally dissected by shallow gullies, and veneered with alluvium and fanglomerate which thickens and spreads apron-wise as fans in Rush Valley. Over the remainder of the area, fans generally conceal the pediment, but outcrops of the erosional surface are present southeast of Big Hollow and in the southwestern part of the mapped area.

Bajadas

Rush and Skull valleys, bordering the northern Onaqui Mountains, are structural basins buried under alluvium derived from the adjacent ranges. Large coalescing fans, termed bajadas, spread apronwise in the valleys and are at least 1000 feet deep at Clover in Rush Valley (Carpenter 1913). The fans are generally separated from the mountain fronts by flanking, alluvium veneered pediments, excepting two large fans in Rush Valley which encroach upon the range in Big Hollow and Victory Canyon. On the west side of the range, a large encroaching fan extends into Johnson Pass as far as Los Ricos Station.

Lacustrine Landforms

The topographic features associated with Lake Bonneville are wave-cut beaches, wave-built terraces, and lacustrine deposits on the floor of Skull Valley. A minimum of six terraces are indented on the bajadas and the pediment surfaces. The highest is the Bonneville shoreline which occurs at an elevation of 5135 feet mean sea level. The Alpine level, a short distance below, is at an elevation of approximately 5100 feet, the remaining terraces being minor. The associated lacustrine deposits are composed of small pebbles, sand, silt, and clay.

Fig.9--View of Western Escarpment with fans at base

Fig.10-- East view of Grasshopper Ridge with Pediment at base

Wind Deposits

Wind deposits, consisting mainly of fine-grained quartz sand, are scattered throughout the northwestern part of the area. The sand is piled up in small scattered dunes and dune ridges, effectively concealing the Lake Bonneville features.

PALEONTOLOGY

INTRODUCTION

Numerous fossils, now in the Brigham Young University stratigraphic collection, were collected and identified for this report. Three species of *Didymograptus* are described and illustrated. The corals, mainly Mississippian, will be described by Mr. Del E. Davis at a later date.

The three species of *Didymograptus* were collected from unit 2 of the Swan Peak in Section 35, T. 5 S., R. 7 W. The same species are in association with the brachiopods *Orthis Michaelis* (Clark) and *Westonia* (?) sp. collected by Dr. H. J. Bissell from Section 11, T. 5 S., R. 7 W.

Ruedemann (1947, p. 106) briefly summarizes the graptolite horizons in Utah by the following statement:

> T. H. Clark has more recently reported from . . . the Swan Peak formation in Utah *Didymograptus nitidus* (Hall) from near base and *D. bifidus* (Hall) from top of series.
>
> A small faunule from the northwest face of Grantsville Peak, Standburg* Range in Utah (U. S. N. M. loc. 211Y) contains *Didymograptus patulus* (Hall) and *D. nitidus* (Hall). These faunules indicate the presence of Deepkill horizons in Utah.

According to Hintze (1951, pp. 20-21 and 29) the Swan Peak in the Stansbury Mountains and northeastern Utah is of Chazyan age and is referred to fossil zone M (Ross 1949, pp. 472-492).

Systematic Paleontology

Phyllum	CHORDATA
Subphyllum	STOMOCHORDA Dawydoff 1948
Class	GRAPTOLITHINA Bronn 1846

---

*Stansbury Range.

DIDYMOGRAPTUS NITIDUS (Hall)

Plate 1 Figs. 1a-c

1858. Graptolithus nitidus Hall, Geo. Survey Canada, Rept. for 1857, p. 129.

1868. Didymograptus nitidus Nicholson (Pars) Geol. Soc. London, Quart. Jour. Vol. 24, p. 135.

Description: The specimens collected are only partial branches; however, the longest is over 8 cm. The stipes are 1.6 mm. wide and contain 13 thecae in 10 mm. The thecae are slightly curved, inclined to axis at an angle of approximately 40 degrees, and in contact about 3/4 of their length. The aperature margin is normal and slightly concave.

Occurrence: This species is common in unit 2 of the Swan Peak (Fig. 4) in the northern Onaqui Mountains. A similar horizon is reported from the Swan Peak near Logan Utah by Clark (1935).

DIDYMOGRAPTUS MURCHISONI (Beck)

Plate 1 Fig. 2

1839. Graptolithus murchisoni Beck, Murchison's Sil. System, Pl. 26, Fig. 4.

1861. Didymograptus murchisoni Bailey, Geol. Soc. Dublin, Jour., Vol. 9, Pl. 4, Figs. Ya-c.

1947. Didymograptus cf. murchisoni Ruedemann, Graptolites of North America, Geol. Soc. Am., Mem. 19, Pl. 54, Fig. 36.

Description: Two partial branches of D. murchisoni were collected, each about 4 cm. in length. The stipes maintain a constant width of 3 mm. and contain 13-14 thecae in 10 mm., which are inclined at an angle of 45 degrees to the branch. The thecae are slightly curved, 3 to 4 times as wide and are free about 1/4 of their length. The aperature margin is distinctively concave, with an acute denticule.

Occurrence: The species occurs in unit 2 of the Swan Peak (Fig. 4).

Remarks: The character of the branch and the thecae agree well with the original description, but differs in a specimen illustrated as D. cf. murchisoni by Ruedemann (1947, Pl. 54, Fig. 36) in the number of thecae, 11 in 10 mm. Otherwise the forms are strikingly similar.

The above form described by Ruedemann (1947, p. 337) is from the Yellville limestone in Arkansas where it is associated with D. bifidus. This is the only occurrence of D. murchisoni which Ruedemann listed from North America.

DIDYMOGRAPTUS PATULUS (?) (Hall)

Plate 1 Figs. 3a-d

1858. Graptolithus patulus Hall, Geol. Survey of Canada, Rept. for 1857, p. 131.

1893. Didymograptus patulus Mathew, Royal Soc. Canada, Proc. Trans., Vol. 10, p. 98.

Description: This form is by far the most abundant specimen collected from the shales in the mapped area. Several well preserved specimens are illustrated.

The rhabdosome is straight and the branches horizontal, diverging from a broad short (about 1.5 mm.) sicula. The nema is very short if present. The branches widen gradually from about 1 mm. or less to approximately 2 mm. within 1.5 cm. The thecae are closely arranged, 14 to 16 in 10 mm., the first originating at approximately the middle of the sicula. The thecae are curved, inclined at an angle of 40 degrees to the axis of the branch, about 4 times as long as wide, and in contact about 2/3 to 3/4 of their length. The aperature margin is straight to slightly concave, mucronate on ventral margin, and forms an angle of 40 to 50 degrees with the axis of the thecae.

Occurrence: This species occurs in unit 2 of the Swan Peak (Fig. 4) in association with D. nitidus. Ruedemann (1947, p. 341) states that typical specimens occur in the Marathon limestone in western Texas, in association with D. nitidus.

Remarks: Excepting the rather closely spaced thecae and slightly narrower width of the branches, the characteristic features of the thecae and the general outline agree with D. patulus (Hall). The thecae number 10-12 in 10 mm. in the original descriptions.

The form is easily distinguished from D. nitidus, which it closely resembles, by the larger number of mucronate thecae and the greater width.

PLATE I

ORDOVICIAN GRAPTOLITES

Figs. 1a-b. _Didymograptus nitidus_
1a. x2
1b. x5

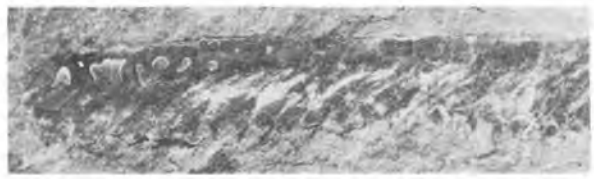
Fig. 2. _Didymograptus murchisoni_
2. x5

Figs. 3a-3d. _Didymograptus patulus_ (?)
3a. x2
3b. x5
3c. x2
3d. x5

PLATE I

1a

1b



2

3b

3a

3d

3c

ECONOMIC POSSIBILITIES

GENERAL STATEMENT

At the present time, the economic potentialities of the northern Onaqui Mountains are limited to the development of water for the expansion of agricultural industries. It is unlikely that there will be any major development of metallic or nonmetallic deposits, for none are known to exist in the mapped area.

WATERSHED

The northern Onaqui Mountains comprise an important watershed which drains into Skull and Rush Valleys. Many springs rise from the alluvial fans which skirt the range and greatly influence the development of the agricultural settlements of St. John, Clover, and Hatch Ranch.

Clover Creek, the only major stream in the area, is fed by springs which issue from the coalescing fans in Johnson Pass. According to Carpenter (1913), the creek discharges 14 second-feet in the spring and $3\frac{1}{2}$ second-feet in the fall of the year. The water is used at Clover and St. John to irrigate approximately 600 acres. The surface water is partially supplemented by several wells.

Numerous springs, developed by the proprietors of Hatch Ranch, furnish water for the irrigation of about 150 acres in Skull Valley. The springs rise from shallow fans below the western escarpment and appear to be seepage from a perched water table. The impervious barrier is probably a tightly cemented zone of caliche conglomerate which outcrops over much of the area.

Other springs rising mainly from within the Manning Canyon shale, have been developed and used as watering sites for livestock.

MINE PROSPECTS

Numerous prospect pits and shafts are present in the mountains, generally located along faults or folds where the bedrock is brecciated or slightly mineralized. West of Devils Gate the hills are pitted with holes and shafts, which according to the reports of residents in the area were dug on surface indications of lead and gold, some of which assayed several hundred dollars a ton. However, to the knowledge of the writer, ore has not been shipped from the district.

SAND AND GRAVEL

Sand and gravel, obtained from alluvial fans, has been exploited along the paved highway, traversing the northern periphery of the area. The material is used for road repairs but, in most instances, appears to be of inferior quality.

SELECTED BIBLIOGRAPHY

Baker, C. L. (1913), "The Nature of the Later Deformation in Certain Ranges of the Great Basin," Jour. Geology, Vol. 27, pp. 273-278.

Bissell, Harold J. (1948), Pleistocene Sedimentation in Southern Utah Valley, Utah, Unpublished Ph.D. Dissertation, State University of Iowa.

_______, (1952), "Stratigraphy and Structure of the Northeast Strawberry Valley Quadrangle, Utah," Bull. Am. Assoc. Petroleum Geol., Vol. 36, pp. 575-634.

_______, (1952), "Stratigraphy of Lake Bonneville and Associated Quaternary Deposits in Utah Valley, Utah," Geol. Soc. Am. Bull., Vol. 63, p. 1358.

Bullock, Kenneth C. (1951), "Geology of Lake Mountain," Utah Geol. and Mineral. Surveys, Bull. 41.

Butler, B. S., Loughlin, G. F., and Hikes, V.C. (1920), "The Ore Deposits of Utah," U. S. Geol. Survey, Prof. Paper 111.

Calderwood, Keith W. (1951), Geology of the Cedar Hills Area, Utah, Unpublished Masters Thesis, Dept. Geol., Brigham Young University.

Carpenter, Everett (1913), "Groundwater in Boxelder and Tooele Counties, Utah," U. S. Geol. Survey, Water Supply Paper 333, p. 77.

Clark, David L. (1954), Stratigraphy and Sedimentation of the Gardner Formation in Central Utah, Unpublished Masters Thesis, Dept. of Geol., Brigham Young University.

Clark, T. H. (1935), "A New Ordovician Graptolite Locality in Utah," Jour. Paleontology, Vol. 9, No. 3, pp. 239-246.

Davis, W. M. (1903), "The Mountain Ranges of the Great Basin," Harvard College Museum Comp. Zoo. Bull., Vol. 24, pp. 127-177.

_______, (1905), "The Wasatch, Canyon, and House Ranges, Utah," Harvard College Museum Comp. Zoo. Bull., Vol. 49, pp. 13-56.

Dutton, C. E. (1880), Geology of the High Plateaus of Utah, "U. S. Geog. and Geol. Survey, Rocky Mtn. Region," cited by Nolan, T. B. (1943), "The Basin and Range Province in Utah, Nevada, and California," U. S. Geol. Survey Prof. Paper 197-D, p. 178.

Eardley, A. J. (1939), "Structure of the Wasatch-Great Basin Region," Geol. Soc. America Bull., Vol. 50, pp. 1277-1310.

________, (1951), Structural Geology of North America, Harper and Brothers, New York City.

Gilbert, G. K. (1874), U. S. Geog. and Geol. Surveys W. 100th Mer. Progress Rept. 1872, cited by Nolan, T. B. (1943), "The Basin and Range Province in Utah, Nevada, and California," U. S. Geol. Survey Prof. Paper 197-D, pp. 178.

________, (1928), "Studies of Basin Range Structure," U. S. Geol. Survey Prof. Paper 153.

________, (1890), "Lake Bonneville," Monographs of the U. S. Geol. Survey, Vol. I.

Gilluly, James (1932), "Geology and Ore Deposits of the Stockton and Fairfield Quadrangles, Utah," U. S. Geol. Survey Prof. Paper 173.

Hintze, Lehi F. (1951), "Lower Ordovician Detailed Stratigraphic Sections for Western Utah," Utah Geol. and Mineral Survey, Bull. 39.

Hunt, C. B., Varnes, H. D., Thomas, H. E. (1953), "Lake Bonneville Geology of Northern Utah Valley, Utah," U. S. Geol. Survey Prof. Paper 257-A.

Kay, Marshall (1951), "North America Geosynclines," Geol. Soc. Am. Memoir 48.

King, Clarence (1877), "Report of the Geological Exploration of the Fortieth Parallel," Prof. Papers of Engineering Dept. U. S. Army, No. 18, Vol. 11.

________, (1870), "U. S. Geological Exploration," Fortieth Parallel Rept. Vol. 3, pp. 451-473, cited by Nolan, T.B. (1943), "The Basin and Range Province in Utah, Nevada, and California," U. S. Geol. Survey Prof. Paper 197-D, p. 178.

Lambert, Hubert C. (1941), Structure and Stratigraphy in the Southern Stansbury Mountains, Tooele Co., Utah, Unpublished Masters Thesis, Dept. Geol., University of Utah.

Lingren, W., and Loughlin, G. K. (1919), "Geology and Ore Deposits of the Tintic Mining Districts, Utah," U. S. Geol. Survey Prof. Paper 107.

Livingston, Vaughn E. Jr. (1955), Sedimentation and Stratigraphy of the Humbug Formation in Central Utah, Unpublished Masters Thesis, Dept. of Geol., Brigham Young University.

Longwell, C. R. (1950), "Tectonic Theory Viewed from the Basin Ranges," Geol. Survey Bull., Vol. 61, pp. 413-434.

Lovering, T. S. (1949), "Rock Alteration as a Guide to Ore, East Tintic District Utah," Monograph I, Economic Geology, p. 7.

Lovering, et al. (1951), "Upper Ordovician, Silurian, and Devonian Stratigraphy of the Tintic Mining District, Utah," Geol. Soc. Am. Bull., Vol. 62, pp. 1505-1506.

MacFarland, Carl (1955), Geology of the West Canyon Area, Northwestern Utah County, Utah, Unpublished Masters Thesis, Dept. of Geol., Brigham Young University.

MacFarland, James J. (1955), Silurian Strata of the Eastern Great Basin, Unpublished Masters Thesis, Dept. of Geol., Brigham Young University.

Marsell, R. E. (1932), Geology of the Jordan Narrows Region, Traverse Mountains, Utah, Unpublished Masters Thesis, Dept. of Geol. University of Utah, p. 88.

Nolan, T. B. (1935), "The Gold Hill Mining District, Utah," U. S. Geol. Survey Prof. Paper 177.

________, (1943), "The Basin and Range Province in Utah, Nevada, and California," U. S. Geol. Survey Prof. Paper 197-D.

Parks, James M. Jr. (1951), "Corals from the Brazer Formation of Northern Utah," Jour. Paleontology, Vol. 25, pp. 171-186.

Perkins, Richard F. (1955), Structure and Stratigraphy of the Lower American Fork Canyon - Mahogany Mountain Area, Utah County, Utah, Unpublished Masters Thesis, Dept. of Geol., Brigham Young University.

Richardson, G. B. (1913), "Paleozoic Stratigraphic Section in Northern Utah," Am. Jour. Science, Fourth ser., Vol. 36, p. 410.

Richmond, G. M., Morrison, R. B., and Bissell, H. J. (1952), "Correlation of the Late Quaternary Deposits of the La Sal Mountains, Utah and the Lake Bonneville and Lahontan by Means of Interstadial Soils," Geol. Soc. Am. Bull., Vol. 63, p. 1369.

Ross, J. R. Jr. (1949), "Stratigraphy and Trilobite Faunal Zones of the Garden City Formation, Northeastern Utah," American Jour. Sci., Vol. 247, pp. 472-492.

Ruedemann, Rudolf (1947), "Graptolites of North America," Geol. Soc. Am., Memoir 19.

Sadlick, Walter (1955), "Carboniferous Formations of Northeastern Uintah Mountains," Tenth Annual Field Conf., Wyoming Geol. Ass. Guidebook.

Spieker, E. M. (1946), "Late Mesozoic and Early Cenozoic History of Central Utah," U. S. Geol. Survey, Prof. Paper 205-A.

Spurr, J. E. (1895), "Economic Geology of the Mercur Mining District, Utah," U. S. Geol. Survey, Sixteenth Ann. Rept., Part 2, pp. 374-376.

_______, (1901), "Origin and Structure of the Basin Ranges," Geol. Soc. Am., Vol. 12, pp. 217-270.

Stokes, W. L. (1952), "Paleozoic Positive Area in Northwestern Utah," Geol. Soc. Am. Bull., p. 1300.

Thompson, M. L. (1948), "Studies of American Fusulinids," University of Kansas Paleontological Contributions, Art. 1.

Thompson, M. L., Verville, G. L., and Bissell, H. J. (1950), "Pennsylvanian Fusulinids of the South-Central Wasatch Mountains, Utah," Jour. Paleontology, Vol. 24, pp. 430-465.

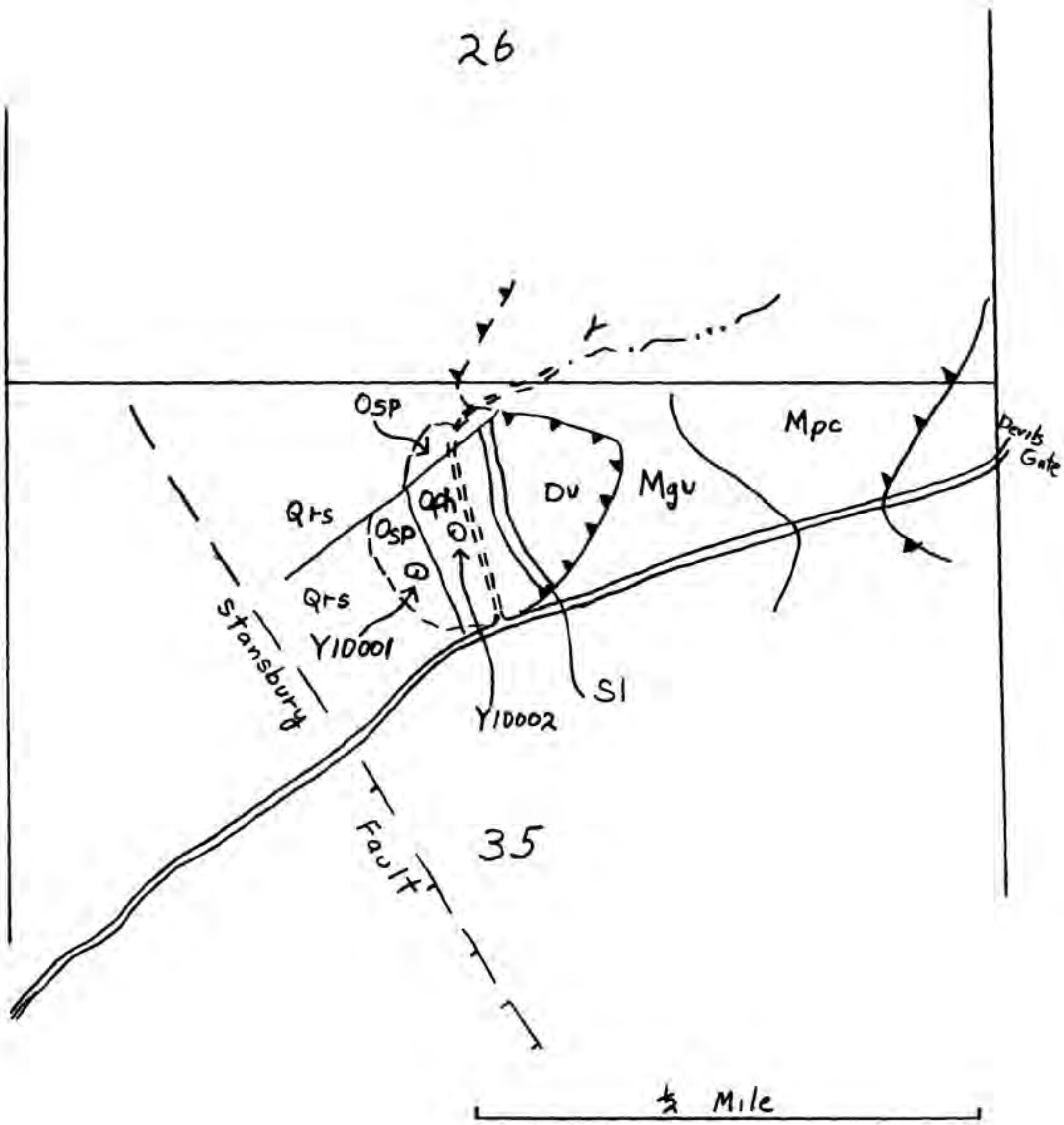
Tower, G. W. Jr., and Smith, G. O. (1898), "Geology and Mining Industry of the Tintic District, Utah," U. S. Geol. Survey, Nineteenth Ann. Rept., Pt. 3, pp. 601-785.

Untermann, G. E., and Untermann, B. R. (1954), "Geology of Dinosaur National Monument and Vicinity, Utah-Colorado," Utah Geol. and Mineral. Survey, Bull. 42.

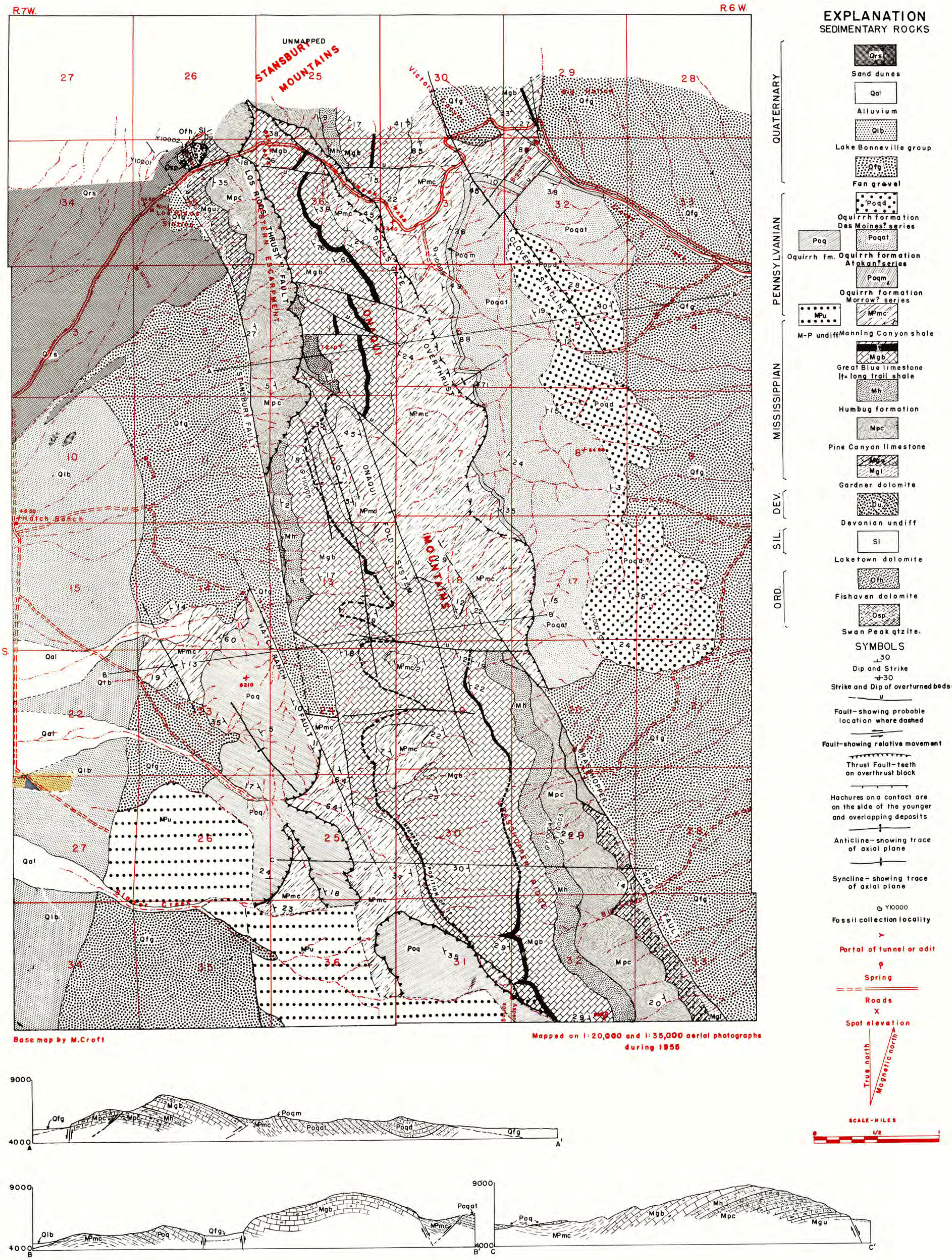
Webb, Gregory W. (1953), Middle Ordovician Stratigraphy in Eastern Nevada and Western Utah, Unpublished Ph.D. Dissertation, Columbia University.

Weller, J. Marvin, et al. (1948), "Correlation of the Mississippian Formations of North America," Geol. Soc. Am., Vol. 59.

Wheeler, Lieut. G. M. (1875), United States Geographical Survey West of the 100th Meridian, Government Printing Office, Washington, Vol. 3.



Geologic Map of the area north of Johnson Pass in sections 26 and 35, T. 5S., R. 7W. (See Geologic map of the Northern Onaqui Mountains.)



R.7W.
R.6 W.
UNMAPPED
STANSBURY MOUNTAINS
ONAQUI MOUNTAINS
LOS ROSES THRUST FAULT
WESTERN ESCARPMENT
STANSBURY FAULT
CLOVER SYNCLINE
Hatch Ranch
6 S
EXPLANATION
SEDIMENTARY ROCKS
QUATERNARY
Qrs Sand dunes
Qal Alluvium
Qlb Lake Bonneville group
Qfg Fan gravel
PENNSYLVANIAN
Poqd Oquirrh formation Des Moines? series
Poq Oquirrh fm.
Poqat Oquirrh formation Atokan? series
Poqm Oquirrh formation Morrow? series
MPu M-P undiff
MPmc Manning Canyon shale
MISSISSIPPIAN
Mgb Great Blue limestone
lt= long trail shale
Mh Humbug formation
Mpc Pine Canyon limestone
Mgu Mgl Gardner dolomite
DEV.
Du Devonian undiff
SIL.
Sl Laketown dolomite
ORD.
Ofh Fishaven dolomite
Osp Swan Peak qtzite.
SYMBOLS
Dip and Strike
Strike and Dip of overturned beds
Fault–showing probable location where dashed
Fault–showing relative movement
Thrust Fault–teeth on overthrust block
Hachures on a contact are on the side of the younger and overlapping deposits
Anticline–showing trace of axial plane
Syncline–showing trace of axial plane
Y10000 Fossil collection locality
Portal of tunnel or adit
Spring
Roads
Spot elevation
True north
Magnetic north
SCALE–MILES
0
1/2
1
Base map by M.Croft
Mapped on 1:20,000 and 1:35,000 aerial photographs during 1955
9000
4000
A
A'
B
B'
C
C'