UTAH GEOLOGICAL AND MINERALOGICAL SURVEY

AFFILIATED WITH

THE COLLEGE OF MINES AND MINERAL INDUSTRIES

UNIVERSITY OF UTAH

SALT LAKE CITY, UTAH

Sheeprock Mountains

TOOELE AND JUAB COUNTIES

Precambrian and Paleozoic Stratigraphy
Igneous Rocks, Structure, Geomorphology,
and Economic Geology

by

ROBERT E. COHENOUR

Bulletin 63 June, 1959

Price $5.00

UTAH GEOLOGICAL AND MINERALOGICAL SURVEY

The Utah Geological and Mineralogical Survey was authorized by act of the Utah State Legislature in 1931; however, no funds were made available for its establishment until 1941 when the State Government was reorganized and the Utah Geological and Mineralogical Survey was placed within the new State Department of Publicity and Industrial Development where the Survey functioned until July 1, 1949. Effective as of that date, the Survey was transferred by law to the College of Mines and Mineral Industries, University of Utah.

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2. "The survey of the geological formations of the State with special reference to their economic contents, values and uses, such as: the ores of the various metals, coal, oil-shale, hydro-carbons, oil, gas, industrial clays, cement materials, mineral waters and other surface and underground water supplies, mineral fertilizers, asphalt, bitumen, structural materials, road-making materials, their kind and availability; and the promotion of the marketing of the mineral products of the State.

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6. "The preparation, publication, distribution and sale of maps, reports and bulletins embodying the results of the work of the Survey. The collection and establishment of exhibits of the mineral resources of Utah.

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ARTHUR L. CRAWFORD, *Director*

UTAH GEOLOGICAL AND MINERALOGICAL SURVEY

College of Mines and Mineral Industries
University of Utah
Salt Lake City, Utah

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C O N T E N T S

I L L U S T R A T I O N S

PLATE

FIGURE

TABLES

F O R E W O R D

The Utah Geological Society completed in 1957 an ambitious re-evaluation of the "Geology of the East Tintic Mountains and the Ore Deposits of the Tintic Mining Districts." This is now available as "Guidebook to the Geology of Utah," No. 12 (1957).

For Guidebook No. 13 (in 1958), the Society sponsored the "Geology of the Stansbury Range," adjacent to the northwest.

West of Tintic and south of the Stansbury Range are the Sheeprock Mountains, the subject of the treatise detailed in the following pages.

As will become evident to the reader, the Sheeprock uplift forms a special link not only between the areas covered by the two guidebooks mentioned above, but between many other significant areas recently publicized or now undergoing study.

It stands as an outlier in the Great Basin, containing an extension of the Precambrian glacial deposits of the Wasatch Mountains, and a southern extension of other Precambrian glacial deposits exposed in the islands of Great Salt Lake, and in Promontory Point and elsewhere in northern Utah. Embedded in its ancient till are enigmatic apple-green erratics characteristic of a certain "quartz schist" member of the older and purer metaquartzite strata of Wyoming and northwestern Utah localities.

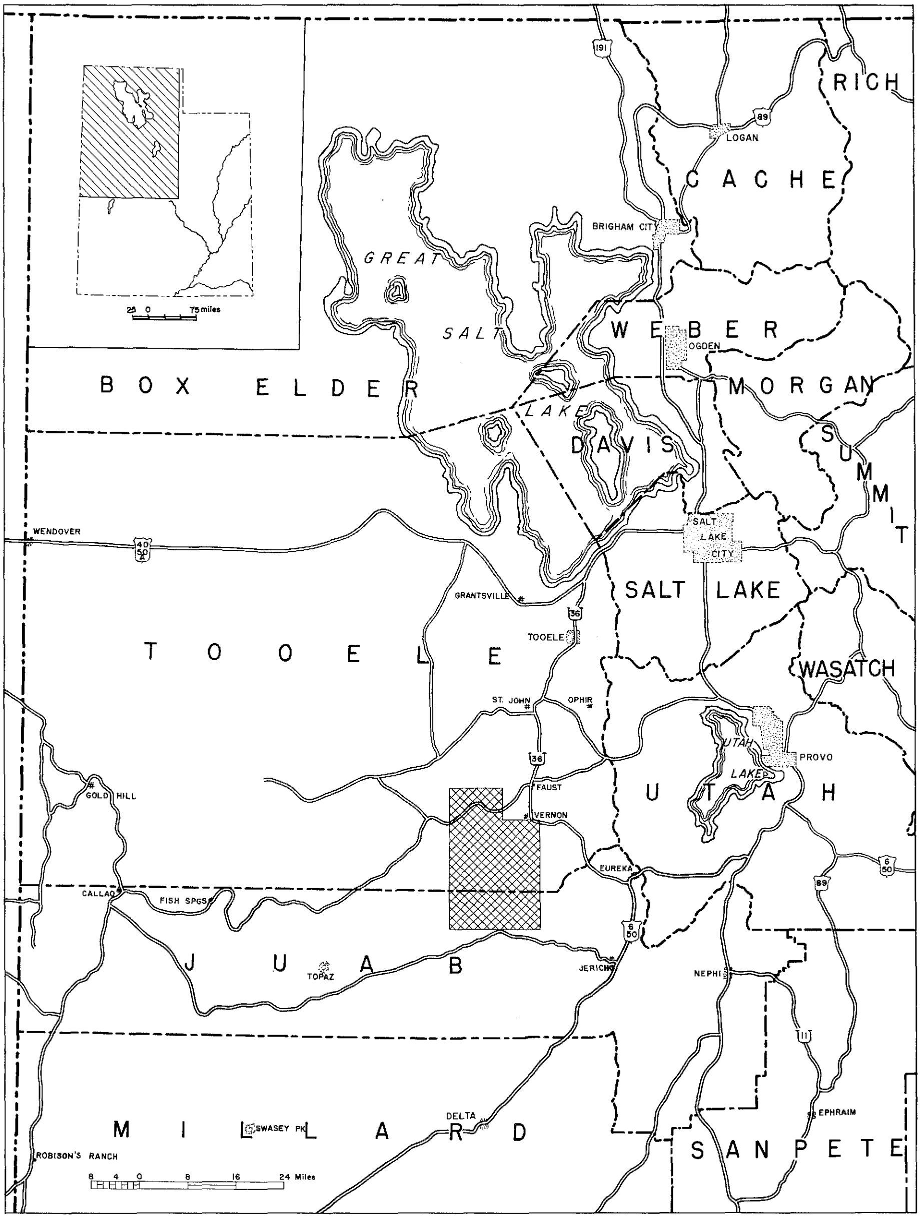
The Cambrian, Ordovician, and Silurian rocks of the Sheeprock Mountains link with and give significant evidence to amplify the data obtained by Hintze (Bulletins 39 and 48), by Rush (Bulletins 38 and 52), and by Webb (Bulletin 57). The structure of the Sheeprock Range sheds further light on that found in the Lake Mountains (Bullock, Bulletin 41), in the Selma Hills (Rigby, Bulletin 45), and in the Lakeside Mountains (Young, Bulletin 56). In the Sheeprock uplift, the uppermost Paleozoic formation is the Oquirrh, so amply exposed to the northeast (see Nygreen, Bulletin 61), and the intrusive history of this uplift and of its ore deposits are reminiscent of the story revealed in the Notch Peak Intrusive (Gehman, Bulletin 62) in Millard County, to the southwest.

In other words, we are all aware that geology is a patchwork of only partially preserved records. It has been the policy of the Utah Geological and Mineralogical Survey to seek out and to help publish key studies in strategic areas which may form stepping stones and anchor points from which we can carefully wade out from the imperfectly known shore to the unchartered sea still before us unfathomed.

In its efforts to perform its function as thus conceived, the Survey wishes to acknowledge the wholehearted cooperation of the geological departments of the universities in Utah and of the universities in other states which have worked in Utah.

The present study by Dr. Cohenour is an outstanding illustration of such a cooperative contribution. The Survey takes more than passing pride in presenting this publication since Dr. Cohenour is a former member of our staff. His part-time work with us helped to make it possible for him to stay at the University of Utah long enough to do such a comprehensive study and to write such a finished scholarly treatise as this bulletin on "The Sheeprock Mountains."

Arthur L. Crawford, Director
UTAH GEOLOGICAL AND MINERALOGICAL SURVEY



INDEX MAP SHOWING LOCATION OF SHEEPROCK MOUNTAINS AREA

FIGURE 1

S H E E P R O C K   M O U N T A I N S

TOOELE AND JUAB COUNTIES, UTAH

Precambrian and Paleozoic Stratigraphy, Igneous Rocks, Structure, Geomorphology and Economic Geology[1]

by Robert E. Cohenour[2]

ABSTRACT

The Sheeprock Range, Tooele and Juab Counties, Utah, is composed chiefly of consolidated sedimentary rocks of Precambrian and Paleozoic age. Several areas of both intrusive and extrusive rocks are present. Unconsolidated sediments related to late Tertiary and Quaternary episodes cover much of the flanks of the range as pediment gravels, lake deposits and alluvium.

Nearly 11,000 feet of Precambrian metasediments, largely slates and quartzites similar to late Precambrian formations in central and western Utah, crop out in the central part of the area. Tillites similar to those found locally in the Wasatch Mountains are the thickest and most distinctive of the Precambrian rocks. Twenty-seven formations having a combined thickness of approximately 20,000 feet represent the Paleozoic era and include rocks of all Paleozoic periods excepting(?) Permian. Over 80 percent of the Paleozoic rocks are of marine origin, the remainder are continental-interior-shelf and shoreline deposits. Limestone, dolomite, quartzite, and shale typical of miogeosynclinal environment constitute the Paleozoic rock types. Excepting minor hiatuses, continuous sedimentation prevailed from Precambrian into Pennsylvanian.

All formations were strongly folded and broken by thrust faults during the Laramide orogeny. Rock units necessary for precise relative dating of Laramide and later orogenic events are not present in the Sheeprock Range, but the relationships of preserved structures permit the establishment of a sequence of deformational phases as follows: (1) Cedar Hills orogeny (?)-Mid-Cretaceous phase, (2) Early Laramide orogeny - Montana phase, (3) Mid-Laramide orogeny(?) - Paleocene phase. (4) Late Laramide orogeny, and (5) Basin and Range phase. Structures formed during these phases include folds, thrust faults and imbrications, and normal faults, and the structures of each successive phase are superposed upon those of earlier phases.

Igneous activity which began in early Tertiary and continued into Miocene formed monzonitic and granitic intrusions and extensive andesitic and rhyolitic flows. A single small area of basalt of undetermined age is present.

The resulting structure of the Sheeprock Range is essentially a northward-dipping homocline modified by several folds, major thrusts, and intrusions.

Normal faulting of the Basin and Range orogenic phase, concomitant with and following the igneous activity, affected both Tertiary and older rocks and is primarily responsible for the present topography and outline of the Sheeprock Range.

Lake Bonneville shoreline features along the western part of the area and a questionable morainal deposit at the mouth of North Oak Brush Canyon represent Pleistocene events.

Mineral deposits fall into two major groups: (1) deposits associated with the West Tintic monzonite cutting Precambrian and Paleozoic rocks have yielded minor quantities of commercial ores of lead, zinc, silver, gold, and tungsten; (2) deposits associated with the Sheeprock granite have yielded ores and protores of beryllium, lead, silver, tungsten, thorium, and uranium, but none of these has achieved commercial significance.

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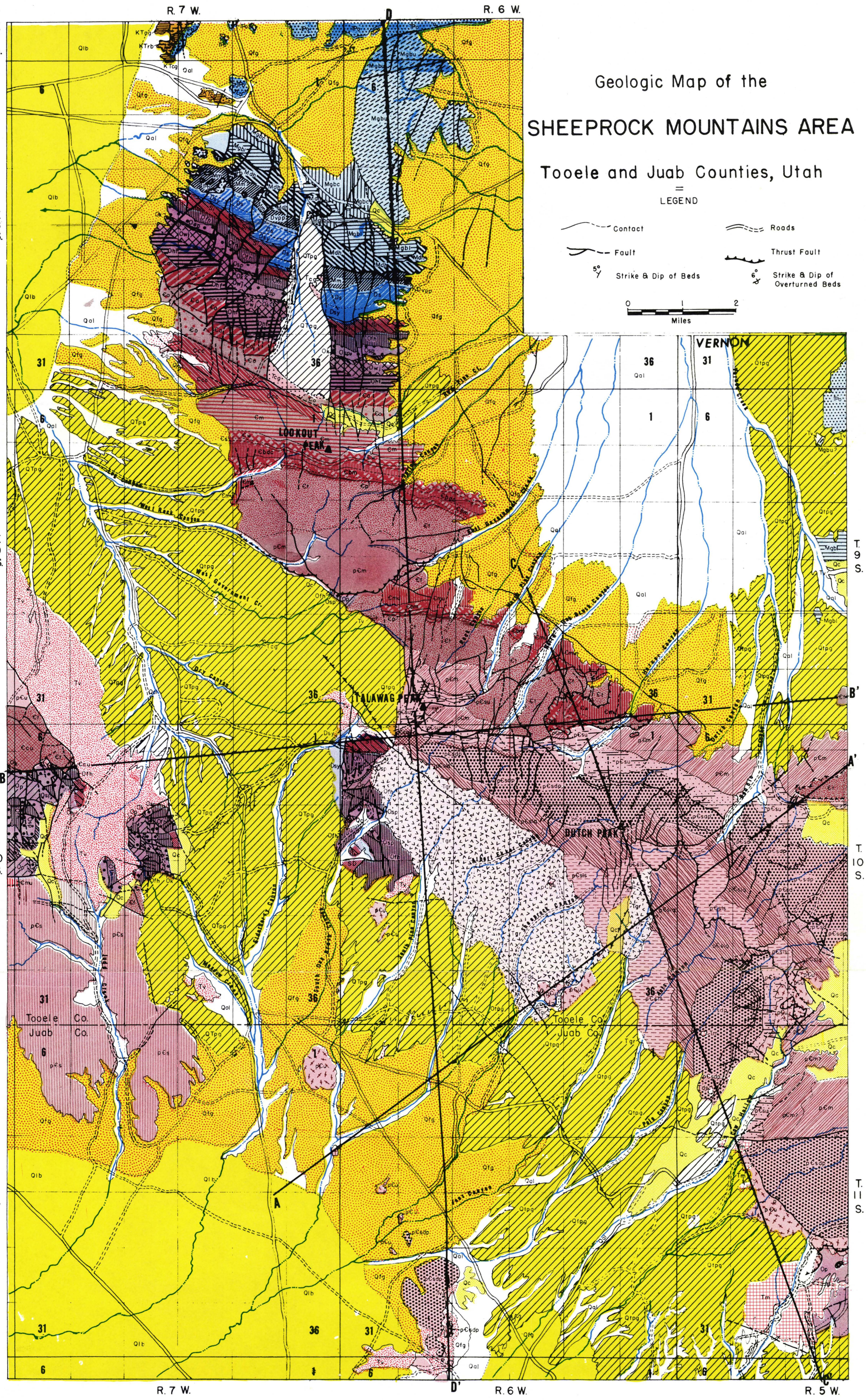
[1]Revised from a Ph.D. dissertation, University of Utah, Salt Lake City, Utah.

[2]Geological Engineer, Atomic Energy Commission, Salt Lake City, Utah.

TABLE 1 - SEDIMENTARY ROCKS OF THE SHEEPROCK MOUNTAINS AREA

System	Series	Formation	Thickness feet
	Recent to Pliocene? -	Gravel and clay -------------	
	Unconformity		
Quaternary and Tertiary.	Pliocene? ----------	Gravel and conglomerate -----	+150
	Unconformity		
Tertiary(?) or Cretaceous(?)---------	--------------------	Conglomerate and red beds----	+200
	Unconformity		
Permian and Pennsylvanian--------	--------------------	Oquirrh formation -----------	Limited exposure (not measured)
		Upper mbr.---	1400
	Chester ------------	Great Blue fm. Chiulos mbr. -	1818
Mississippian --------		Lower mbr.---	911
	Meramec ----------	Deseret-Humbug formations --	1142 - 1165
	Osage-Kinderhook---	Madison limestone-----------	399
		Total, Mississippian -------	5664±
	Unconformity		
	Upper Devonian -----	Victoria-Pinon Peak fms.-----	570+ - 775
Devonian ------------	Middle Devonian ?---	Simonson dolomite-----------	450 - 563
		Sevy dolomite ---------------	356 -1044
		Total, Devonian ------------	1851±
	Unconformity		
Silurian -------------	Niagran ------------	Laketown dolomite-----------	810 - 1001
		Total, Silurian-------------	905±
	Upper -------------	Fish Haven dolomite ---------	701 - 706
	Middle -------------	Swan Peak qtzt.(restricted)---	348 - 465
		Pogonip Group Kanosh shale ------	206 - 250
Ordovician ----------		Pogonip Group Juab limestone-----	161 - 204
	Lower -------------	Pogonip Group Wah Wah ls. -------	456 - 475
		Pogonip Group House-Fillmore ls -	1088 - 1111
		Total, Ordovician ---------	3086±
		Ajax dolomite ---------------	1016
	Upper--------------	Opex formation--------------	938
		Cole Canyon formation -------	899
		Marjum formation ----------	1171
		Wheeler formation-----------	405 - 430
Cambrian------------	Middle -------------	Swasey limestone------------	131 - 169
		Ophir Group Condor fm. --------	106 - 135
		Ophir Group Dome limestone----	37 - 81
		Ophir Group Burnt Canyon fm. --	178 - 221
		Ophir Group Millard formation --	246 - 355
		Ophir Group Busby formation ---	65 - 167
		Ophir Group Pioche shale-------	293 - 342
	Lower ------------		
		Tintic quartzite -------------	2572
		Total, Cambrian -----------	8269±
		Total, Paleozoic -----------	19775±
	? Unconformity?		
Precambrian---------	Post Beltian --------	Mutual(?) formation----------	924
	Unconformity		
	Post Beltian? -------	Sheeprock series-------------	10000+
		Total, Precambrian --------	10924+



EXPLANATION

SEDIMENTARY ROCKS

Quaternary
- Qal — Alluvium
- Qc — Colluvium
- Qm — Moraine?
- Qlb — Lake Bonneville Seds.
- Qfg — Fan Gravel

Tertiary Quaternary
- Qtpg — Pediment Gravel

Tertiary
- Tcg — Conglomerate

Tertiary Cretaceous
- KTcg — Conglomerate
- KTrb — Red Beds

Pennsylvanian
- Po — Oquirrh Fm.

Mississippian
- Great Blue Formation: Mgbu — Upper Limestone Member; Mgbc — Chulios Shale Member; Mgbl — Lower Limestone
- Md — Deseret - Humbug Formation
- Mm — Madison Limestone

Devonian
- Dvpp — Victoria-Pinyon Peak
- Ds — Simonson Dolomite
- Dsy — Sevy Dolomite
- SD — Silurian-Devonian Undifferentiated

Silurian
- Sl — Laketown Dolomite

Ordovician
- Ofh — Fish Haven Dolomite
- Osp — Swan Peak Quartzite
- Ok — Kanosh Shale
- Ow — Wah Wah-Juab Limestone
- Op — Pogonip Group
- Ohf — House-Fillmore Limestone

Cambrian
- Ca — Ajax Dolomite
- Co — Opex Formation
- Cc — Cole Canyon Formation
- Cm — Marjum Formation
- Cw — Wheeler Formation
- Cmu — Cambrian Middle Undifferentiated
- Ccu — Cambrian Carbonates Undifferentiated
- Cs — Swasey Limestone
- Ophir Group: Cbdc — Burnt Can-Dome-Condor Fms.; Cbm — Busby-Millard Fms.; Cp — Pioche Shale
- Cmu — Cambrian Middle Undifferentiated
- Ccu — Cambrian Carbonates Undifferentiated
- Ct — Tintic Quartzite

Precambrian
- pCm — Mutual Formation
- Sheeprock Series, Upper: pCsu — Upper Slates; pCsug — Upper Quartzite
- Middle: pCsdt — Dutch Peak Tillite
- Lower: pCsd — Diabase (?); pCslq — Lower Quartzite; pCsls — Lower Slates
- pCs — Sheeprock Series
- pCu — Pre Cambrian Undifferentiated

IGNEOUS ROCKS
TERTIARY

- Tv — Volcanics
- Tds — Dikes & Sills
- Tg — Sheeprock Granite
- Tm — West Tintic Monzonite

PLATE I

INTRODUCTION

PURPOSE AND SCOPE

This investigation is one of a series of geologic studies in the Sheeprock-West Tintic Mountains being conducted by graduate students of the Department of Geology of the University of Utah. The purpose is to decipher the geology of the area. Considerable attention has been paid the stratigraphy, igneous rocks, and structure. Regional correlations are proposed, and the local structures are related to the regional. A detailed geologic map is presented at the scale of 1:31,680 (pl. I).

LOCATION AND ACCESSIBILITY

The region of study includes the major part of the Sheeprock Mountains, the Allison Knolls, the eastern part of the Simpson Mountains, and the south end of the Onaqui Mountains (figs. 1 and 6 and pl. I). Three quarters of the area is in southeastern Tooele County; the remainder is in northeastern Juab County. The area comprises approximately 300 square miles and includes all of Tps. 8, 9, 10, and 11 S., Rs. 6 and 7 W., and the western half of R. 5 W., Salt Lake Base and Meridian.

Many roads, few of which are all-weather roads, surround the area and connect with branch wagon roads which lead various distances up nearly every major canyon in the area. Wood and stock roads link the main arteries and provide ready access to much of the intervening area. The western part of the area is reached via county roads leading west from State Highway 36 at Vernon and Faust. These converge to cross Lookout Pass which separates the Onaqui from the Sheeprock Mountains. This graveled road proceeds to Simpson Springs and points west, but a few miles west of Lookout Pass a secondary county road leads south across the east-west divide known as Erickson's Pass, between the Sheeprock and Simpson Mountains. This road eventually joins a county road leading from the northwest edge of the Desert Mountains to Jericho. The southern part of the Sheeprock area is accessible via either the Erickson Pass road or by a graveled road which leads westerly from U. S. Highway 6 at Jericho and which eventually joins the Erickson Pass road before continuing westward to Callao and the state line. A road from Sugarville, a settlement a few miles north of Delta, also provides access to the Desert Mountains and intersects the Jericho road at its junction with the Erickson Pass road. The northern part of the area can be entered by means of a series of roads from Vernon and from the Forest Service installations at Benmore.

GEOGRAPHY

Topography and drainage _ The Sheeprock Mountains are an L-shaped range and present a very rugged profile. The base of the L is an east-to-west element, and it is out of harmony with the general north-south trends which characterize most of the ranges of the Basin and Range province. Three of the highest peaks in the Sheeprock Range are in the Coast and Geodetic triangulation network, and stations are designated Bennion, Dutch, and Lookout Peaks. Bennion is the highest at 9,273 feet above sea level; Dutch and Lookout are a few hundred feet lower at about 9,000 feet elevation. Talawag Peak, about a quarter of a mile northwest of Bennion and, when viewed from the north, gives the impression of being the highest point in the range. Lookout Peak is referred to as Red Pine Mountain and Bennion Peak is designated as Black Crook Peak by residents on the south flank of the Range. The Sheeprock divide stands between 2,500 and 4,000 feet above the surrounding valley floor, which in places slopes to the Bonneville level at an elevation of about 5,135 feet. The north and east sides of the range are dip slopes and present the steepest topography.

Sharp V-shaped valleys mark the main drainages in the mountains. All perennial streams are nourished by springs originating at elevations of 6,000 feet or higher. Vernon and Cherry Creeks are the largest streams and their courses mark the geographic boundary between the southern part of the Sheeprock Mountains and the more subdued east-lying west Tintic Range. On the south side of the Sheeprock Mountains, Cow Hollow, Pole, Auts, Joes, Sheeprock, and Hard-to-Beat Canyons contain small perennial streams. Albert Ekker's (formerly Cottonwood) and South Pine Canyons are fairly well watered in spring and early summer, but the flow ceases in late summer. Elderberry Canyon contains the most persistent water on the western flank, whereas North Pine, North Oak Brush, Harkers, and Bennion Canyons supply the north flank with year around water. Except for Cherry and Vernon Creeks, all streams disappear into the alluvium and do not reach the valley bottoms.

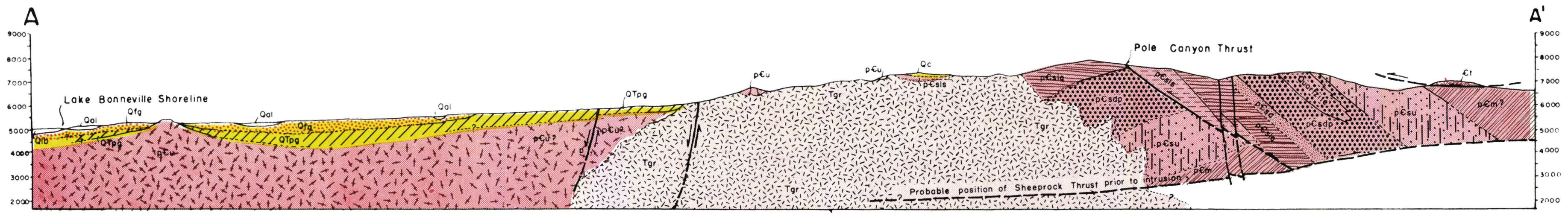
Climate and vegetation - Weather data is available from two stations in the area, one at Benmore on the north flank, the other at Government Creek (James Ranch) on the west side of the Sheeprock Range. Average annual precipitation is approximately 13.50 inches for these stations which are between 5,250 and 5,500 feet above sea level. The wettest months are from September through April when precipitation normally exceeds one inch per month. The higher portions receive over 30 inches (estimated) of precipitation mainly as snow which persists until late May in protected areas on the north-facing slopes. The south flank of the range is not well watered, and its climate is milder, being tempered by frequent southerly winds during most of the year. Temperature falls to below zero occasionally during December and January. Hottest weather can be expected in July and August when temperatures in excess of 100° F. have been recorded. Frost-free days usually extend from May 1 to October 30 in the valley areas.

Vegetation is that typical of a modified desert environment and contains characteristic stratification of botanical assemblages in zones commensurate with altitude and precipitation. Various species of sagebrush, *Artemisia*, are the most prominent plants of the valley floors and lower slopes. Grasses and small shrubs are abundant in the sage areas, and squat cacti become more abundant on the lower slopes. Intergrowing with sage on the higher slopes are junipers, locally known as cedars, of several species among which *Juniperus Utahnensis* is the most common. The junipers persist to considerable elevations and descend into the valley floors along dry washes and on pediments. At intermediate elevations oak brush replaces the junipers in the more protected and better watered zones. Mahogany, *Cercocarpus ledifolius*, though relatively sparse thins at high elevations principally on south-facing slopes where precipitation is low. Pinon and yellow pines are present principally on the north slopes of the highest elevations. Aspen, *Populus tremuloides*, and chokecherry, *Prunus virginiana*, are present near high altitude springs and along water courses at intermediate elevations. Cottonwoods and oak brush are present in a few localities where an abundance of water persists and are usually found near the junction of mountain slopes with the desert floor.

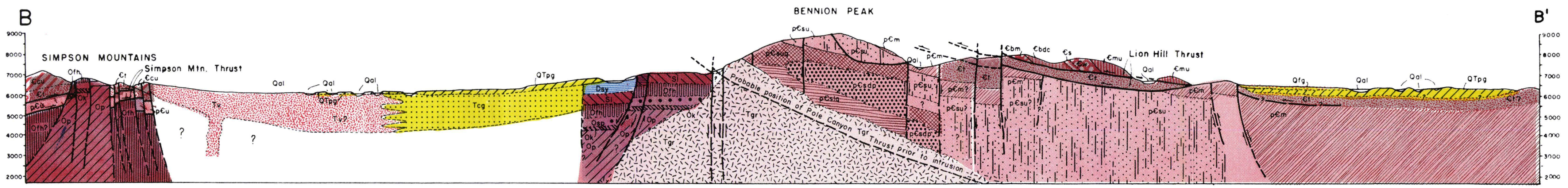
Previous geologic investigations - In 1858-1859 Captain J. H. Simpson of the Corps of Topographic Engineers headed an expedition commissioned to survey a wagon road from Camp Floyd in Rush Valley near the present town of Stockton, Utah, to California. Henry Englemann, expedition geologist, cites nothing pertaining to the rocks of the Sheeprock-Onaqui area except for a brief description of extrusive rocks at Simpson's Springs. On Simpson's map of Wagon Route in Utah Territory, the Stansbury, Onaqui, and Sheeprock Ranges were not differentiated, and the three are collective, included as Guyot's Range.

Gilbert (1890) in his study of the shoreline features of Pleistocene, Lake Bonneville, describes shorelines and a river channel west of the Simpson Mountains and along the Desert Mountains.

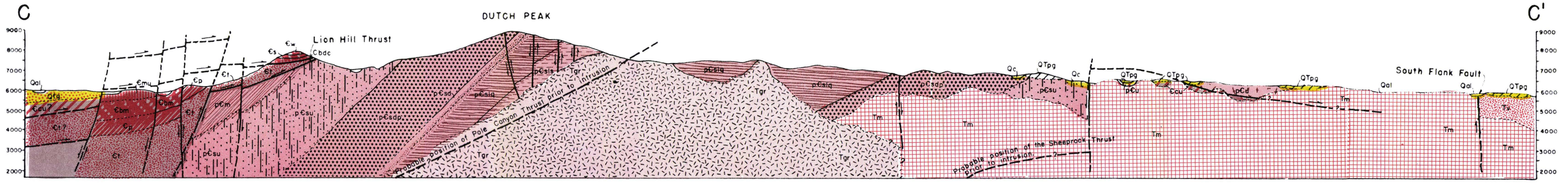
Loughlin (1920) in Professional Paper 111, Ore Deposits of Utah, very



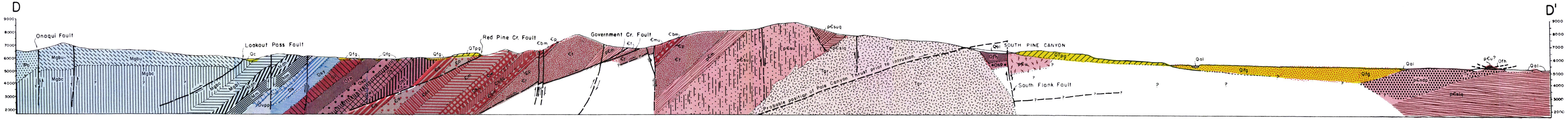
Section Along Line A-A'



Section Along Line B-B'



Section Along Line C-C'



Section Along Line D-D'

generally discusses the geology of the Sheeprock Mountains, and contributions by Heikes specifically deal with the Sheeprock, Simpson, and Desert Mountains. Although the ore deposits are emphasized, some general stratigraphic and structural relations in the ranges are included.

Eardley and Hatch (1940) in their discussion of the Proterozoic rocks in Utah measured a section of Precambrian metasediments in the Sheeprock Mountains and relate the structural features of the range to the regional pattern.

Part of the West Tintic mining district was mapped by Stringham (1940), who was concerned primarily with the mineralization in the vicinity of the Old Scotia mine.

Weston Gardner (1954) remapped the area previously studied by Stringham and extended the mapping to include the Sheeprock-West Tintic junction. Gardner deals with structure and stratigraphy of a small area.

Robert Hillier (1956) reported on the uranium occurrence in the South Oak Brush area on the southwestern flank of the Sheeprock Mountains.

FIELD WORK

Field work upon which the present report is based was begun in May, 1953 while the writer was assisting in a diamond drill program being conducted by the Brush Beryllium Company. Work was continued intermittently during 1954, 1955, and 1956, and completed, to the extent set forth in this report, in November 1956. Mapping was done on U. S. Forest Service aerial photographs at a scale of 1:20,000; and Fairchild aerial photographs of a scale of approximately 1:62,500. Except for the extreme northern and southern parts, the map was compiled from a Forest Service planemetric base and aerial photographs.

The geologic map (pl. I) is at a scale of 1:31,680 having been plotted on and reduced from a base map of a scale of 1:21,120. The map showing positions of stratigraphic sections and fossil localities (pl. III) is at a scale of 1:42,240 having been reduced from the 1:21,120 base map. On this map the positions of the stratigraphic sections referred to in the text are plotted and additional sections are noted. All measured sections, both those referred to in the text and the additional sections, are reported in Appendix A and shown on the map. Fossil localities of Appendix B similarly are recorded on the map.

A C K N O W L E D G E M E N T S

Valuable assistance has been received from many people during this study. I am particularly indebted to Dr. Norman C. Williams of the University of Utah for his interest and suggestions, to Dean A. J. Eardley, Professors W. L. Stokes, F. W. Christiansen, B. Stringham, and M. P. Erickson for suggestions and critical reading of the manuscript. The preparation of this report was influenced by discussions with M. D. Crittenden and H. T. Morris of the U. S. Geological Survey, Grant Steele and Dwight Arnold of the Gulf Oil Corporation, R. H. Olsen and R. C. Bright, colleagues at the University of Utah, and B. J. Sharp and A. E. Granger of the U. S. Atomic Energy Commission.

Especial thanks is due to the late M. A. Stainbrook, Christina Lochman Balk, A. R. Palmer, Walter Sadlick, Chester Arnold, and R. R. Brown for aid in identifying fossils.

Mr. R. C. Bright tendered invaluable assistance in identifying the Cambrian and Ordovician faunas.

The writer is indebted to William Salisbury for assistance and suggestions in the preparation of the illustrations.

Especial thanks are due my wife, Genevra, for her patience and understanding, and for typing at all stages of this work.

S T R A T I G R A P H Y

GENERAL STATEMENT

Sedimentary formations exposed in the Sheeprock Mountains have a total thickness of approximately 31,000 feet. Besides Precambrian rocks strata of the Cambrian, Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian, Cretaceous(?), Tertiary, and Quaternary periods are present.

The Precambrian system is represented by approximately 11,000 feet of low-grade metamorphosed sediments principally of continental origin.

Over 80 percent of the Paleozoic rocks are of marine origin, and the remainder are continental, interior shelf, or shoreline deposits. Continuous sedimentation seems to have prevailed from Precambrian through nearly the entire section of Paleozoic rocks exposed within the area.

The succeeding discussion and Appendix A present in detail the formations listed in Table 1. Plate III shows location of stratigraphic sections together with localities where fossils were collected. In Appendix B the material from these fossil localities is classified.

PLATE III

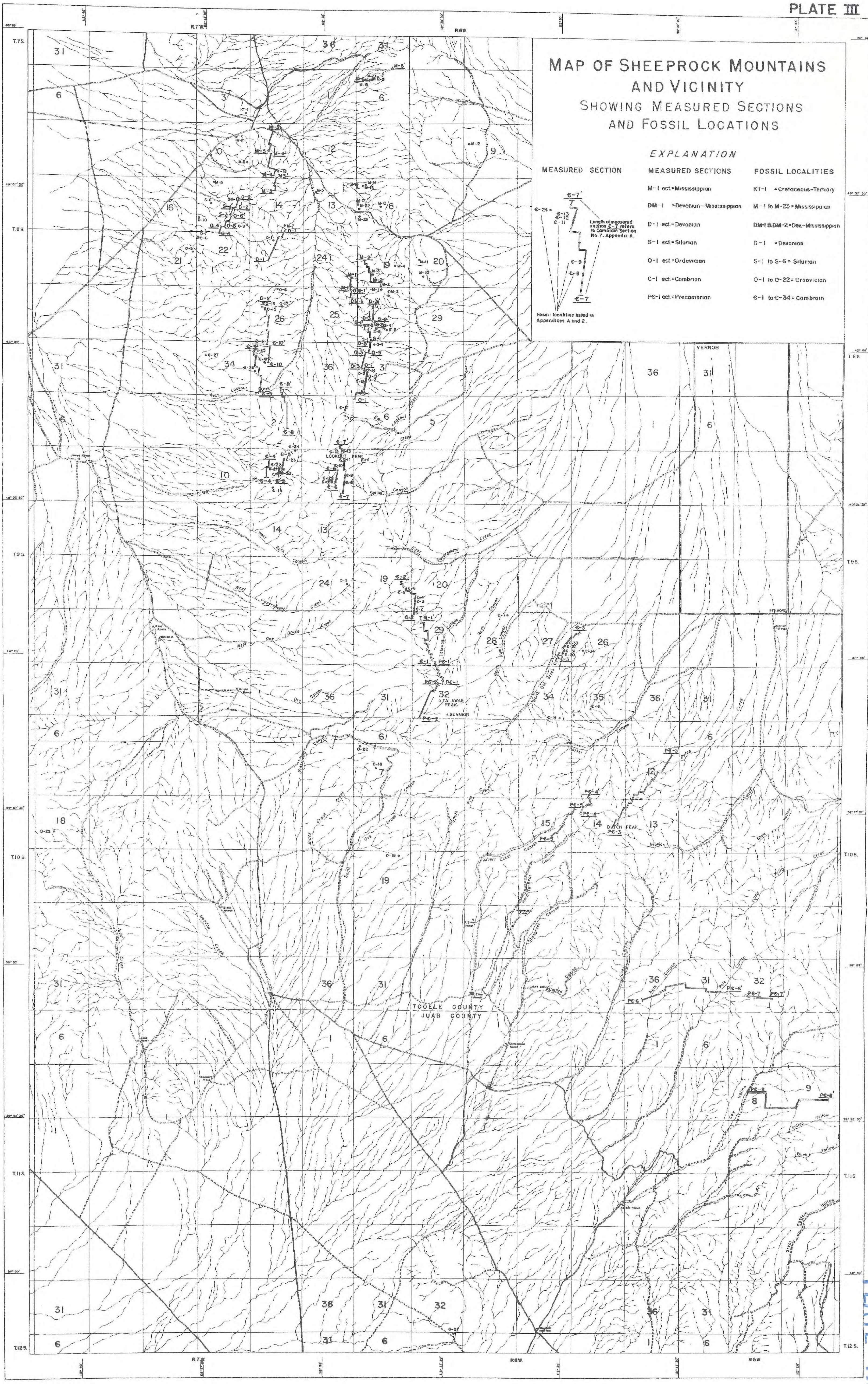


PLATE III

PRECAMBRIAN ROCKS

GENERAL STATEMENT

Rock strata assigned to the Precambrian system aggregate about 11,000 feet in thickness and are divisible into two major sequences. The upper sequence is composed of argillites, quartzites, and conglomerates and is correlated with the Mutual formation. The lower sequence is divisible into three units based upon lithologic features and stratigraphic position. The oldest unit is principally black slate and tan quartzite; the middle unit is a distinctive tillite; and the upper unit is mainly green and tan slates with subordinate quartzites.

Precambrian rocks, including the tillite, were recognized in the Desert Mountains and in the Simpson Mountains. The Simpson Mountain section is one of the most complete Precambrian sections of the region. The Precambrian rocks of the Simpson Mountains, however, were not thoroughly investigated and can only tentatively be correlated with those of the Sheeprock Range.

SHEEPROCK SERIES (NEW NAME)

General statement - A 9,000- to 10,000-foot sequence of metasediments composed of slate, tillite, phyllite, quartzite, and conglomerate constitutes the oldest rocks exposed in the Sheeprock Mountains. Owing to the difficulty and uncertainty of correlating this sequence with named formations in other areas, the term "Sheeprock series" is proposed for it. The Sheeprock series can, in several places, be further subdivided into three component units--the lower Sheeprock series, the Dutch Peak tillite, and the upper Sheeprock series.

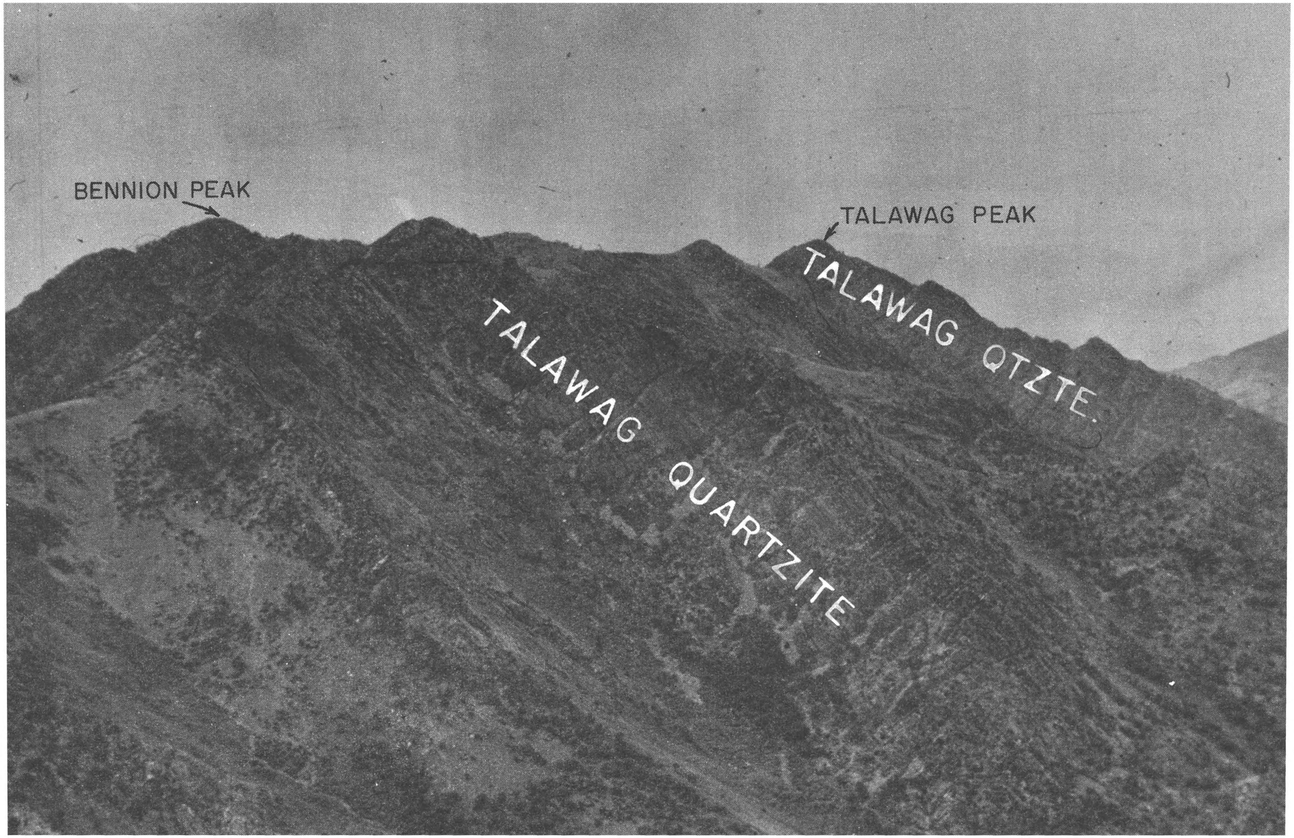
Distribution and thickness - The Sheeprock series comprises all of the strata south of the crest of the range from the divide to the desert floor. The only exceptions are the West Tintic and South Oak Brush areas, at which localities Paleozoic rocks crop out. The Simpson Mountains south of the vicinity of Black's Ranch are also composed largely of the Sheeprock series. North of the Sheeprock divide, from Little Valley to the desert floor near the mouth of Harker Canyon, the strata are entirely of the Sheeprock series. To the west, the rocks of the Sheeprock series extend south of a line from the mouth of Harker Canyon to Bennion Peak. The isolated knolls protruding through the desert floor south of the Sheeprock Range are likewise strata of the Sheeprock series.

The Sheeprock series is approximately 9,800 feet thick in the Auts-Pole-Cow Hollow area. At no place in the Sheeprock area is the base of the series exposed.

Topographic expression - The several lithologies of the Sheeprock series give it a variety of topographic expressions over its large area of outcrop. The more metamorphosed slates and argillites close to the intrusions weather to form steep slopes whereas in areas of less intense metamorphism the same rocks form gentle slopes. Quartzites form cliffs and steep slopes as do the conglomerates and more sandy facies of the tillite (pl. IV).

Lithology - The Sheeprock series is composed of many rock types, all of which are varieties of metasediments. Rocks close to the Sheeprock granite are the most severely metamorphosed.

The oldest exposed strata of the lower series are designated for mapping purposes as the "black-banded phyllite." Only one measured section (Appendix A, Section PC-6) in the Auts Canyon area, includes the phyllite. Units 24 through 30 represent the phyllite unit and measure 2,690 feet thick. The base of the phyllite is covered and believed to be intruded by the Sheeprock granite. Other exposures of the phyllite are on the



Upper slates and quartzites of the Sheeprock series with overlying Talawag quartzite member of the Mutual (?) formation showing repetition by faulting.

south flank of Dutch Peak and in the heads of Joes and Bennion Canyons. The rocks are thinly banded to varved, fine-grained, black to silver-black, and in most localities have been altered because of their proximity to the Sheeprock granite.

Conformably overlying the "black-banded phyllite" is a series of quartzites, conglomerates, and a few slates. This unit ranges between 1,350 and 1,470 feet in thickness. The quartzites are the dominant rock type and are characteristically tan with a very light green tint. Near the top of the sequence is a dark green diabasic textured unit which ranges from 20 to 60 feet in thickness. It serves as an excellent marker bed for determining the proximity of the top of the unit. Above the diabasic textured rock is a 40-foot thick unit of thin-bedded, flaggy black quartzite containing few streaks of dark green argillite. Overlying the black quartzite is a 20- to 40-foot unit of gray-tan to blue-gray tinted quartzite which conformably underlies the Dutch Peak tillite. The gray quartzite, black slaty quartzite, and diabasic textured units can be traced throughout the area where the base of the tillite is exposed.

The next higher unit in the Sheeprock series is a tillite member which ranges from a thin edge to over 4,000 feet in thickness. This unit is of special significance and a more complete discussion follows under a separate heading; and the term "Dutch Peak" tillite member is proposed.

Conformably overlying the tillite with gradational contact is the upper Sheeprock series. The gradational and lensing character of the upper series and attendant lithofacies changes make the accuracy of measurements of this sequence very doubtful. Between 2,000 and 3,000 feet of strata were measured or estimated to compose the unit. The upper Sheeprock series is composed mainly of tan and light green shale. In the easternmost exposure of the strata in Cow Hollow a large unit of white quartzite lies at the top of the sequence, but this is the only large exposure of quartzite in this series. At Talawag Peak in the western part of the range the Sheeprock series comprises drab shale and quartzite in the upper zone. There are no tillites on Talawag Peak (Appendix A, Section PC-2).

Field identification - The Sheeprock series includes the most altered and metamorphosed strata in the Sheeprock area. Some fissile rocks in the upper Sheeprock series are but slightly metamorphosed and may pass easily for unctious (greasy), thin-bedded shale. The cleavage cuts the bedding at a low angle. Some of the quartzites are very similar to the Tintic quartzite. Other than quartzites all other sedimentary rocks are easily recognized from younger rocks because of their greater induration. A few of the lowermost conglomerates are characterized by stretched pebbles.

DUTCH PEAK TILLITE (NEW NAME)

Need of new name - The name Dutch Peak tillite member is proposed for the tillite unit in the Sheeprock series. It is probable that the Dutch Peak tillite is in part equivalent in age to the Mineral Fork tillite of the Wasatch Mountains. The name Mineral Fork tillite was not used for designating lithologically similar strata in the Sheeprock Mountains for the following reasons:

1. The Mineral Fork tillite lies unconformably on rocks of the Big Cottonwood series or the older Farmington Complex. In the Sheeprock Mountains no basal tillite unconformity could be positively identified.

   The Mineral Fork tillite is unconformably overlain by the Mutual formation in the Cottonwood area. In the Sheeprock area rocks assigned to the Mutual(?) formation overlie with

PLATE V

Overturned strata of the Dutch Peak tillite on west side of Pole Canyon.

questionable unconformity shales and metasediments of the upper Sheeprock series. The contact between the tillite and the conformably overlying Sheeprock series is gradational.

3. In one direction the tillite of the Sheeprock area grades laterally into shales and quartzites of the Sheeprock series.

4. Similarity between the Mineral Fork tillite and the tillite of the Sheeprock Mountains and vicinity is only lithologic whereas upper and lower contacts of the two tillites are distinctly different.

5. The tillite of the Sheeprock area possibly is more representative of deposition farther from glacial centers whereas the Wasatch and Antelope Island deposits may represent areas of active abrasion by a continental ice sheet.

Distribution and thickness - The Dutch Peak tillite crops out from the head of South Oak Brush Canyon along the crest of the range to Dutch Peak where it leaves the divide and forms a dip slope along the north-facing slopes to Little Valley Creek. The tillite is absent in South Oak Brush Canyon but attains a thickness of 4,044 feet on the north slope of Dutch Peak. In Pole Canyon the overturned tillite occupies both sides of the canyon, extending from a reverse fault near the crest of the range to the foothills on the south. Tillite is present north of the principal mining area in the West Tintic mining district. Smaller exposures of tillites are in the Desert Mountains and in the Allison's Knolls. An isolated exposure is at Coyote Springs on the south slopes of the Simpson Mountains.

The tillite thickens eastward from Bennion Peak. The section measured on the north slope of Dutch Peak aggregates a total of 4,044 feet of strata. In Pole Canyon, 2,555 feet of tillite was measured in the overturned Precambrian section.

Topographic expression - The Dutch Peak tillite weathers to form slopes. Gently dipping strata are locally strewn with the resistant boulders common in the tillite.

Lithology - The tillite is a dark green conglomeratic rock having a slate of quartzite matrix. Unlike a conglomerate, the boulders, cobbles, and pebbles are widely dispersed in a slaty matrix (pl. V). The larger fragments of the tillite are subangular and subrounded with cobble and pebble sizes predominating (pls. VI and VII). Quartzite fragments predominate but schist, slate, limestone, pegmatitic quartz, and igneous particles are also represented in the coarser material. The larger boulders are generally more angular than the cobbles. Included in the tillite are afew lenses of well-rounded cobbles and in places some relatively pure lenses of quartzite. The quartzites are light gray to ivory colored but some have a purple cast. Bedding within the tillite is very poorly shown, although in several places cross-bedding is present.

The typical tillite possesses a cleavage which causes the rock to weather as irregular slabs. This fracture is well marked and in places may be mistaken for bedding. The tillite weathers greenish-brown to brown. Carbonate clastics usually weather out leaving holes which may be coated with an unidentified radiating, fibrous mineral, especially near the intrusion.

The largest boulder observed in the tillite measured 6' x 5' x 4'. It was tentatively identified as a quartz monzonite. A prospector in the West Tintic area mined such a boulder thinking it was an intrusion. Large blocks of limestone are also present in the tillite, and the largest noted was less than three feet across. Quartzite boulders seldom exceed two

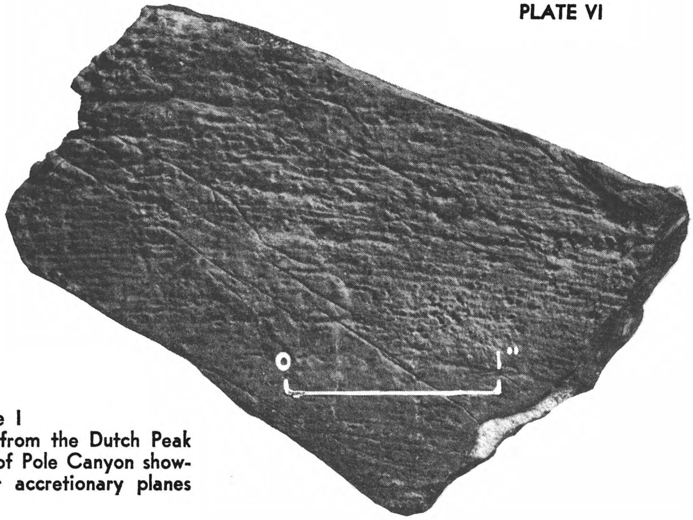


Figure I
Fragment of limestone from the Dutch Peak tillite on the west side of Pole Canyon showing curved bedding or accretionary planes . . . possibly algal origin.

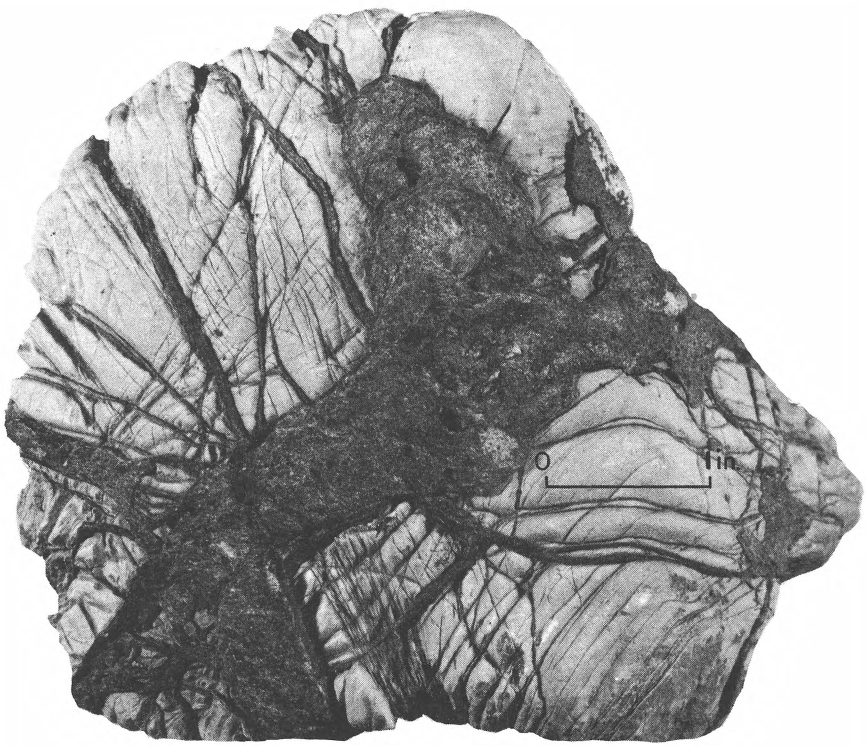
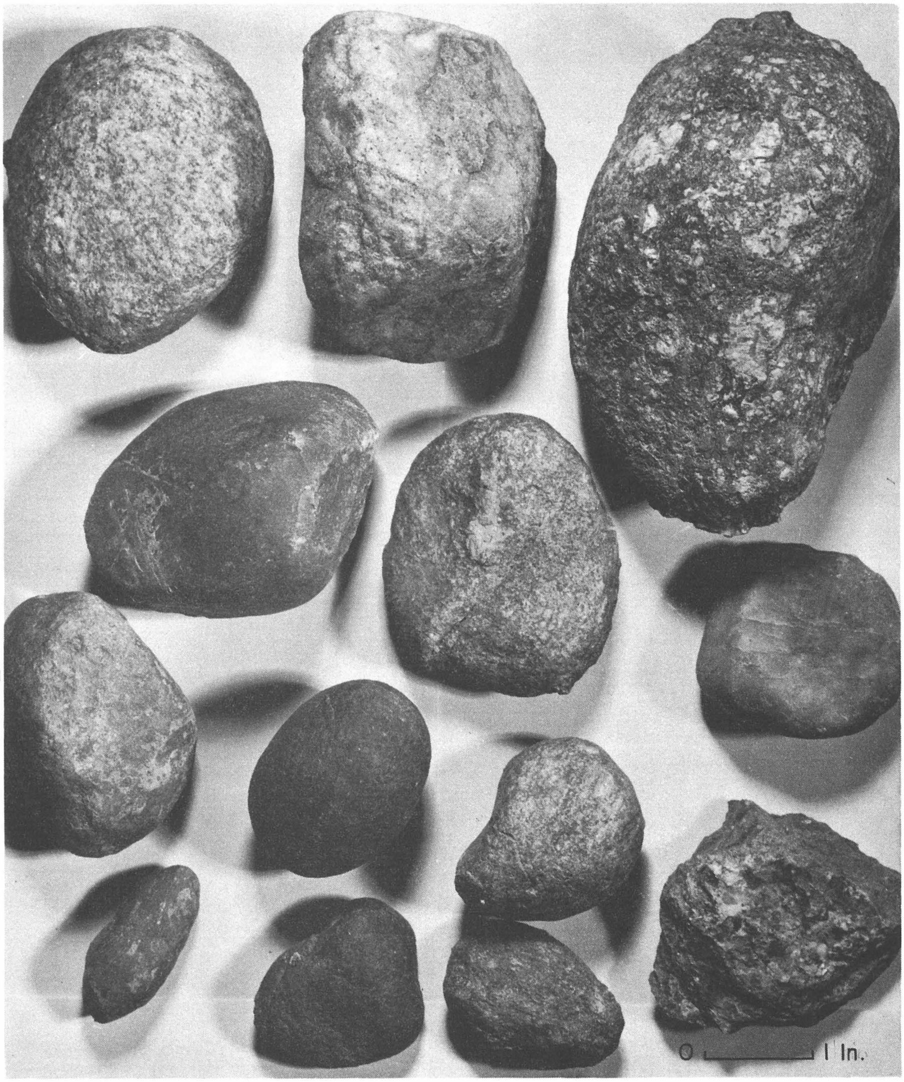
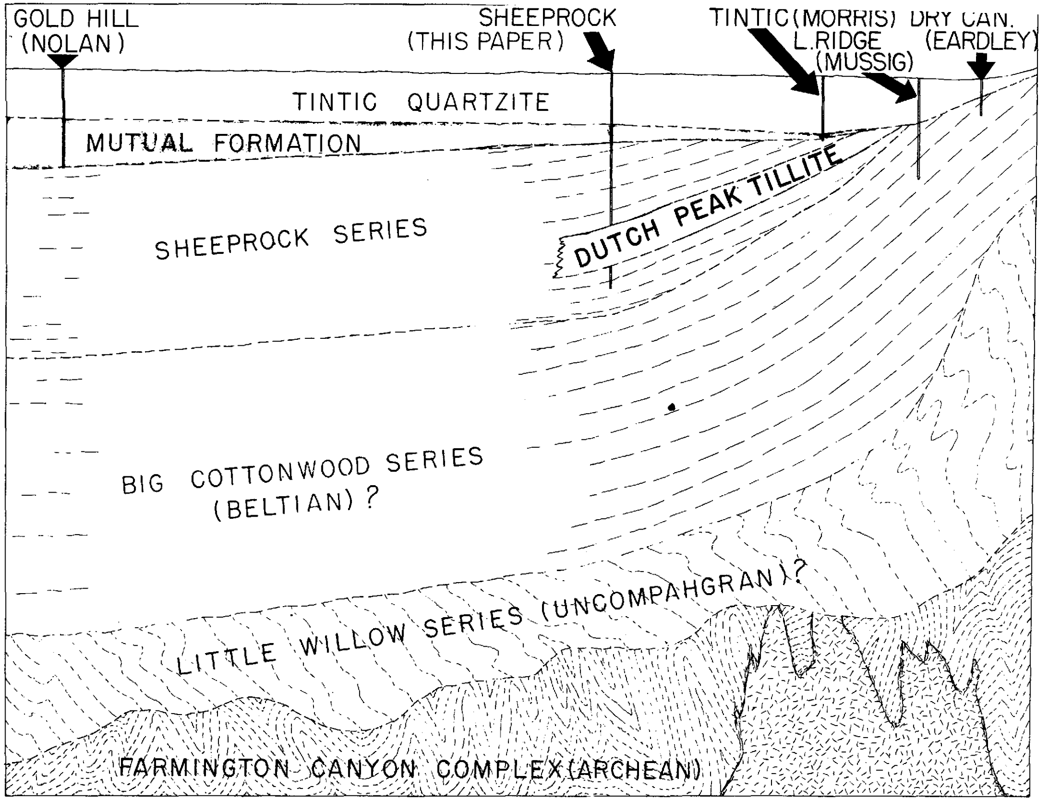


Figure 2
Cobble of limestone from the Dutch Peak tillite, from the west side of Pole Canyon showing fractures filled with a chloritic matrix.

PLATE VII



Cobbles from the Dutch Peak tillite, composed of igneous rock, quartzite and schist. Rounding indicates fluvial or partially fluvial origin. Matrix material at lower right.



PROPOSED STRATIGRAPHIC RELATIONSHIPS
OF THE PRECAMBRIAN
IN WEST CENTRAL UTAH

FIGURE 2

feet in diameter. Typical in the more bouldery facies are boulders of bright green quartzite. The coloration of the quartzites is probably caused by minute granules of chrome mica (fuchite) dispersed in the interstices.

Near the top of the tillite the matrix becomes more sandy and quartzitic and contains a few shale and sandy lenses. West of the Dutch Peak section the tillite is more sandy and conglomeratic. It intertongues with dark slates and quartzites of the Sheeprock series. As the unit pinches out it becomes more quartzitic and gradually changes to a brownish-purple conglomeratic quartzite. The upper and lower contacts of the tillite are conformable with adjacent rocks.

Field identification - The tillite is the most distinctive of all the Precambrian rocks in the Sheeprock area. The dark brownish-green color is particularly distinctive. The spotted gravelly and cobbly beds exhibiting prominent cleavage and flaggy weathering characteristics are also aids in recognition. Limestones and bright green quartzite cobbles and boulders of Precambrian age are found only in the tillite.

Correlation - The most obvious correlation of Precambrian units is that of the Dutch Peak tillite of the Sheeprock Range and the Mineral Fork tillite of the Wasatch Range (Eardley and Hatch, 1940, p. 827). The unusual lithology is not likely to be repeated and a minor unusual character such as the concentric laminae in the limestone boulders occurs in the tillite of both localities.

As to the lower and upper Sheeprock series, the following relations seem significant. In the Sheeprock Range the tillite rests on the lower Sheeprock series apparently conformably. On Antelope Island the tillite occupies depressions in the Farmington Canyon complex (Willard Larson, personal communication). It also rests on the old complex in the City Creek-Bountiful sector of the Wasatch Range (Byron Sharp, personal communication). In the Cottonwood dome of the Wasatch Range it rests on the eroded Big Cottonwood series (Granger, 1943, p. 2, and Crittenden, 1952, p. 5). Since the phyllites are in places varved and generally associated with the tillites, it is assumed that they are tied to the tillite sequence and are not part of the Big Cottonwood series. Hence, it is tentatively concluded that both the lower Sheeprock series and the tillite progressively overlap a terrane of older rocks, such as indicated in Figure 2.

The upper Sheeprock series is conformable with the underlying tillite. In being composed chiefly of tan and light green shale, it is unlike the Mutual formation of the Wasatch Range, which is made up of argillite and quartzite (Crittenden, 1952, p. 6). The Mutual also rests with pronounced angular unconformity on the Mineral Fork tillite, cutting it out entirely and resting in places on the Big Cottonwood series. It is therefore assumed that the upper Sheeprock series is older than the Mutual. The postulated relations are shown in Figure 2.

The best evidence of the unity of the upper Sheeprock series, the Dutch Peak tillite, and the lower Sheeprock series, is the facies relationship; the tillite fingers and grades into the Sheeprock phyllites and quartzites.

MUTUAL(?) FORMATION

General statement - The younger sequence of Precambrian rocks consists of two distinctive lithologic members, here correlated with the Mutual formation of the Wasatch Mountains. The Mutual(?) formation rests with questionable unconformity upon beds of the Sheeprock series. The evidence available suggests an unconformity, but limited exposures of the contact leaves much uncertainty about the relationships. However, the Mutual(?)

PLATE VIII

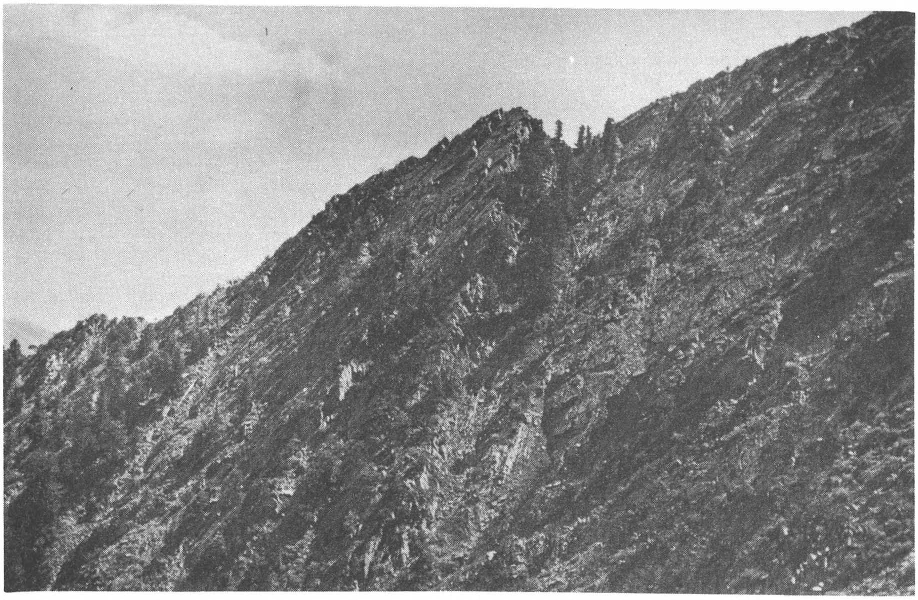


Figure 1
View of the Talawag quartzite member of the Mutual (?) formation on the dip slope north of Talawag Peak.

Figure 2
Basal unit of the Talawag quartzite on the west side of Talawag Canyon showing thin gritty bands and argillite bed (in shadow).

formation rests upon various rock types of the upper Sheeprock series. For example, in the Talawag area the Mutual(?) formation appears to rest upon the truncated edges of the tan quartzite member of the upper Sheeprock series; at Vernon Creek, in the central part of the West Tintic Mountains, the Mutual(?) formation rests upon a tan and drab shale sequence; in the Cow Hollow area, the Mutual(?) formation rests upon a thick, white quartzite. These relationships strongly suggest an unconformity, although the various rock types upon which the Mutual(?) formation rests may be facies of a single sedimentary unit, and not a composite surface.

Distribution and thickness - The Mutual(?) formation crops out in three small areas. The largest outcrop is on the north dip slope of Talawag Peak (pl. VIII).

At the head of Cow Hollow near the southeastern edge of the mapped area an overturned member of the Mutual(?) formation covers an area of approximately two-thirds of a square mile. South of Black's Ranch in the eastern part of the Simpson Mountains is a small exposure of the Mutual(?) formation, and other small exposures are on Vernon Creek.

The thickness of the Mutual(?) formation is 924 feet on Talawag Peak where both the top and the bottom of the formation could be fairly accurately located. The Cow Hollow section (overturned) is involved in thrust faulting and cannot be reliably measured.

Topographic expression - The Mutual(?) formation weathers to form cliffs and dip slopes under conditions prevailing in the Sheeprock area. The basal shale unit, together with the shales of the upper Sheeprock series, weathers to form saddles.

Lithology - The Mutual(?) formation is divided into two units: a basal slate or argillite and an upper conglomeratic quartzite. The upper unit is referred to herein as the Talawag member (new name).

The basal unit can best be described as an argillite or thin-bedded argillaceous quartzite. The unit is between 150 and 217 feet thick. The general color of the outcrop is dark purple although a few thin beds are tan. Muscovite mica is prominent on the bedding planes. Much of the material contains fine sand. The thin, flaggy beds together with the color make it distinguishable from the overlying conglomeratic quartzite. On Talawag Peak, ripple marks were observed; strata restored to a horizontal position indicate that the aqueous currents flowed from southwest to northeast. This current direction is shown by ripple marks seen in the Talawag area. The base of the shale contacts rock of varied lithology and color in different areas, but at any single locality the contact appears conformable. The argillite (shale) grades into the overlying conglomeratic quartzite. A few intercalated gray quartzites occur in this zone. The top of the unit is taken as the highest purple argillaceous bed.

The Talawag quartzite member on the north slope of Talawag Peak is 706 feet thick. It is composed of quartzite, conglomeratic quartzite, and conglomerate. The quartzite is principally coarse-grained, and cross-bedding is present, but not prominent in the lower 500 feet. The Talawag member contains conglomerate lenses composed of white and purple quartzite cobbles and pebbles. Quartz and jasper pebbles were noted about 300 feet above the base. The weathered rock is only slightly darker in hue than the fresh rock. Purple coloration, except for the constituent arenaceous material, is secondary. Near some faults the rock is more pink or reddish. The color of the unit is imparted by purple and red intergranular minerals. In many localities the soaking effect of solutions has locally produced a false cross-bedding.

Field identification - The coarseness of the constituent grains of the Talawag quartzite together with a few jasper pebbles and generally a deep purple tint serve to distinguish it from the overlying Tintic quartzite. Except for several thin purple units within the Tintic quartzite, there are no other quartzites that can be mistaken for Talawag in the area.

Correlation - At the type section, the Mutual quartzite unconformably overlies the Big Cottonwood series and the Mineral Fork tillite and is in turn unconformably overlain by the Tintic quartzite. No strata as old as the Big Cottonwood series can positively be identified in the Sheeprock Range. Questionable unconformities occur above and below the Mutual(?) facies in the Sheeprock area. The strata underlying the Mutual(?) formation conformably overlie and are gradational with the Dutch Peak tillite.

Similar stratigraphic position and lithologies, such as the purple coloration, grain size, and the presence of purple argillites, suggest that the Mutual(?) strata of the Sheeprock Range correlate with the type Mutual. In the Sheeprock Range, however, the strata both above and below are probably conformable whereas at the type section an unconformity exists at the base of the Mutual and, being the youngest of the preserved Precambrian strata, it is unconformably overlain by the basal Cambrian quartzite (Tintic). N.C. Williams (1953, p. 2783), however, has correlated the type Mutual with similar strata in the Uinta Mountains and has noted that the Red Pine shale, youngest Precambrian unit preserved in the western Uinta Mountains, conformably overlies the Mutual quartzite. The Tintic quartzite, in turn, truncates both the Mutual formation and the Red Pine shale. No shale overlies the Mutual(?) strata in the Sheeprock area and the type area of the Mutual; however, such a shale may have been present but eroded prior to Cambrian deposition. The Mutual formation at its type locality is lithologically distinctive, but because it is bounded by unconformities, its original thickness cannot be measured.

PRECAMBRIAN CORRELATION

Many problems exist in the correlation of Precambrian rocks.

Hinds (1935-1936) reviews the Precambrian geology of western North America and in summary divides the Precambrian into (1) Archean, (2) Uncompahgran, and (3) Algonkian (Beltian) systems.

Archean rocks (Hinds, 1936, p. 12) of the Big and Little Cottonwood Canyon areas of the Wasatch Mountains have been designated by Crittenden, Sharp, and Calkins (1952, p. 3) as the Little Willow series and correlation with the Farmington Canyon complex (Eardley and Hatch, 1940, p. 61) is strongly suggested.

Tillite and varved slate units formerly were included in the Cottonwood series and designated by Hinds (1936, p. 134) as Uncompahgran. Crittenden et al. (1952, pp. 3-5) demonstrated that the tillite unconformably overlies the Cottonwood series and have designated the lower beds as the Big Cottonwood series and the upper as the Mineral Fork tillite.

Hinds (1936, p. 135) in discussing Beltian rocks states, "So-called algal structures are common in the limestones." Crittenden (personal communication, 1955) found large circular and oval-shaped markings in the limestone boulders in the Mineral Fork tillite. Portions of similar markings were observed in limestone boulders in the Dutch Peak tillite of the Sheeprock area. Both occurrences suggest organic origin--possibly algal--and the markings found in the limestone boulders strongly suggest a Beltian age for the limestones. If the limestones are Beltian, the tillites are later Beltian.

Unconformably overlying the Mineral Fork tillite (Crittenden et al., 1952, p. 6) is the Mutual formation. Similarly, in the Sheeprock Mountains, the formation tentatively correlated with the Mutual, unconformably overlies the upper Sheeprock series.

Assuming the limestone boulders are Beltian, then at least two late-Beltian, Precambrian series may be present: (1) The strata represented by the entire Sheeprock series and the Mineral Fork tillite; and (2) The strata represented by the Mutual formation. The uplift causing the unconformity between the Mutual formation and the overlying Tintic (Cambrian) quartzite afforded an environment which provided the advancing Cambrian sea with material for the basal Cambrian quartzites.

PRECAMBRIAN-CAMBRIAN CONTACT

In the western United States the base of the Cambrian system is locally indefinite, especially since the basal Cambrian rocks are non-fossiliferous quartzites. Generally, the base of the Cambrian is taken at the first unconformity below the basal quartzite conformably underlying fossiliferous Cambrian strata. However, in parts of southwestern Nevada great thicknesses of strata are assigned to the Cambrian system (Hazzard, 1937). The conformability of the strata together with their great thickness suggest the possibility that the Precambrian-Cambrian boundary may occur within a conformable sequence in places. Nolan (1935, p. 6) in discussing the basal Cambrian quartzites in the Deep Creek Mountains of western Utah, assigns a thick basal sequence of quartzites and shales to the Prospect Mountain quartzite. The Prospect Mountain quartzite was first described by Hague (1883, pp. 253, 254) in the Eureka district (Nevada). As the base of the Prospect Mountain is not exposed at Eureka, Nevada, Nolan (1935, pp. 4-6) at Gold Hill extended the formation to include the entire conformable sequence--2,750+ feet of shales and quartzites conformably underlying the uppermost 2,500 feet of quartzite.

The writer suggests that the uppermost 2,500 feet of light colored quartzite may be tintic and the shale and quartzite strata below Mutual. The following observations support the proposal. Fossils collected from the overlying Cabin shale were identified as Lower Cambrian types. Other collections from the Busby formation in the Sheeprock Mountains indicate an age near the Middle-Lower Cambrian boundary. Conformably underlying approximately 300 feet of Pioche shale in the Sheeprock Mountains is 2,572 feet of strata assigned to the Tintic quartzite. Assuming the Pioche facies of the Sheeprock area is Lower Cambrian as is the Cabin facies at Gold Hill, one may then assume that the upper quartzite unit of the Prospect Mountain quartzite at Gold Hill and the Tintic quartzite in the Sheeprock Mountains are the same, and that the lower shale and quartzite units at Gold Hill are Mutual(?) facies of Precambrian age.

The basal Cambrian strata apparently overlap progressively from west to east older Precambrian rocks, and it therefore seems possible or even probable that in the central and western part of the Great Basin gradational contacts exist. Without meaningful lithologic breaks, the contact will be difficult to recognize, however.

CAMBRIAN SYSTEM

GENERAL STATEMENT

The Cambrian system of the Sheeprock Mountains is represented by 13 formations aggregating between 8,000 and 8,500 feet of strata. Formational terminology is taken from sections in the House Range and the East Tintic Mountains. The basis for the terminology and correlations is discussed in detail in later paragraphs.

The Precambrian-Cambrian boundary is vague and uncertain in the Sheeprocks as in many other Great Basin sections. The Tintic is nonfossiliferous and its base may be well within the Precambrian.

TINTIC QUARTZITE

General statement - The Tintic quartzite is separated from the underlying Mutual(?) formation by a questionable unconformity. The top of the Talawag quartzite member of the Mutual(?) formation is transitional with the overlying Tintic quartzite. The basal units of the Tintic quartzite are white and ivory with a slight but noticeable amount of green color due to a micaceous, interstitial mineral believed to be glauconite. The color change from purple hues to white and the presence of glauconite were taken as the contact between the Mutual(?) formation and the Tintic quartzite.

Distribution and thickness - The Tintic quartzite crops out in a band over a mile in width on the lower spurs along the north front of the Sheeprock Mountains. The formation trends northwesterly from its narrow eastern outcrop above a thrust fault in the mouth of Harker Canyon, and gradually widens westerly and crosses the main, north-south divide as a dip slope unit north of Talawag Peak. The Tintic quartzite is repeated north of an east-west reverse fault between Talawag and Lookout Peaks and here maintains a nearly east-west strike and a 45-degree northerly dip. A sizeable segment of Tintic quartzite strikes westerly in a 3,000-foot band across the divide between Meadow and Judd Creeks southwest of Black's Ranch in the eastern Simpson Mountains. Several outcrops of quartzite which lie above and in fault contact with the Sheeprock series in the eastern part of the area have tentatively been identified as the Tintic quartzite.

As no pronounced basal unit was observed in the Tintic quartzite and because paleontological evidence is lacking, the base of the Tintic quartzite may be arbitrarily placed at a point where conglomerate lenses, containing bright red jasper pebbles, become significant, the jaspers being arbitrarily considered as basal Cambrian. Conglomerate lenses are more pronounced in the conformably underlying Talawag quartzite, but since this unit averages about 850 feet in thickness and is usually purple, it would probably be best to consider this a separate unit rather than basal Tintic. On the basis of this reasoning the upper lighter quartzite facies have been assigned to the Tintic to give a total of 2,572 feet of strata.

Topographic expression - The Tintic quartzite weathers to form well-exposed ledges but at considerably lower elevations than either the underlying Talawag quartzite or the overlying Middle Cambrian limestones. The ridges and saddles formed by the Tintic are due to fracturing and mechanical erosion. The inability of the Tintic to provide a suitable parent material for soil formation is more than any other factor responsible for the excellent exposures.

Lithology - The Tintic quartzite is a typical medium-grained quartzite which is usually highly jointed and fractured. Its color, which has generally been referred to as buff, is varied, ranging from white through purples with pink and green tints not uncommon. Yellows and browns are typical of the coloration for 80 to 90 percent of the strata in the Tintic quartzite in the Sheeprock Mountains. Strata in or near fault zones contain abundant limonite as stains and fracture filling.

Bedding is not everywhere distinct but in places either micaceous partings or cross-bedding is present and affords opportunity for measurement.

Conglomerate lenses are present in the lower 400 feet of the Tintic quartzite. The highest purple beds are about 700 feet above the base. The purplish strata are generally coarse-grained and lower portions contain pebbles of pegmatitic quartz and gray and purple quartzite. Jasperoid pebbles are present up to 200 feet above the base. Well-rounded pebbles up to 1 1/2 inches are present in the conglomerate fractions.

Green micaceous shale partings up to one inch in thickness occur in the upper 450 feet of the Tintic. These partings indicate proximity to the overlying Pioche shale.

Dark purple argillites, having a micaceous sheen, were found near the center of the Tintic but proved to be of local extent only.

Basal Tintic strata include a greenish tinted quartzite with very thin micaceous partings. The coloration of the quartzite is due to the dispersal of a green micaceous mineral in the interstitial cement. This unit is 75 feet thick.

The top of the Tintic is very distinct and is taken at the base of the tan and olive weathering quartzites and shales of the overlying Pioche shale.

Field identification - The Tintic quartzite is at places difficult to distinguish from the various Precambrian quartzites. The presence of the fucoidal section of the Ophir formation at the top of the Tintic quartzite is the best criteria for identification. The base of the Tintic quartzite is of very inconstant and erratic lithology. Dark red jasperoid pebbles in conglomeratic zones were used as a means for determining the base. These pebbles were found to extend for a considerable interval into the underlying purple quartzites of the Talawag as well as into the greenish tinted white to tan quartzites assigned to the Tintic. The color change from purple to tan was found to be very erratic even in short distances and purple beds were found a few hundred feet above the red pebbles as were occasional six-inch beds of micaceous purple slates of the type common to the basal Talawag. Cross-bedding is common in both the Talawag member of the Mutual(?) formation and the Tintic quartzite and cannot serve as differentiating criterion. Near the top of the Tintic quartzite, thin beds of light green, very micaceous shales serve as a guide to the proximity of the Ophir shale.

Correlation - The Tintic quartzite of the Sheeprock Mountains is correlated with surrounding sections on the basis of lithology and stratigraphic position. In the East Tintic Range the type Tintic has been redefined by Morris (personal communication) and restricted to those quartzites above the jasperoid conglomerates and below the Ophir shale. The Tintic (redefined) aggregates approximately 3,000 feet of strata.

The Prospect Mountain quartzite of the Gold Hill district is in part the lithologic equivalent of the Tintic quartzite in the Sheeprock Mountains. The uppermost unit of the Prospect Mountain defined by Nolan (1935,

p. 6) is a "massive, dominantly light colored quartzite" and is 2,500 feet thick. The writer believes that this unit is equivalent to the Tintic quartzite of the Sheeprock Mountains. The slates or shale members as described by Nolan may be present in the Sheeprock sequence, but their inclusion in the Tintic quartzite would increase its thickness of 2,572 feet by 3,500 to 4,300 feet giving an aggregate total of approximately 6,900 feet.

Although the Tintic-Precambrian contact was established on the basis of jasperoid pebbles, it may be well to include the 800 feet of purple tinted conglomeratic quartzite which lies between the jasper pebble zone and the underlying purple argillite in the Tintic quartzite. This zone of quartzite contains many lenses of conglomerate and rests with apparent conformity on the argillite. The purple argillite thins and thickens and is locally absent. Other quartzites lens with the argillite and may represent an unconformity. If this is a valid unconformity, it is so slight as to be mistaken for continuous sedimentation. However, there are no quartzites or quartzitic conglomerates below the argillites that are typical of either the purple or brown varieties of the overlying strata. The argillites may be representative of the top of the Mutual formation; if so, drastic facies changes have occurred in the Mutual formation between the type local in the Wasatch Mountains and the Sheeprock area.

OPHIR GROUP

<u>General statement</u> - Correlation of the Ophir formation of the Sheeprock Mountains with previously described sections nearly poses certain problems of lithologic and faunal equivalency and contact positions which must be reconciled.

Loughlin (1919, p. 23) in discussing the top of the Tintic quartzite of the East Tintic Mountains states:

> In the easternmost railroad cut in the lower part of Eureka Gulch there are a few significant slate bands from two inches to one foot thick.
> . . . the rock as a whole gradually becomes slightly argillaceous and thin-bedded with finely micaceous partings, one-fourth of an inch apart.
> . . . This variety passes conformably but abruptly into the brown-weathering, highly micaceous and calcareous sandstone shale at the base of the Ophir.

The Ophir shale was measured "from the top of the Tintic quartzite to the top of the uppermost slate bed" (1919, p. 23) and for six localities in the district the Ophir shale averaged 400 feet in thickness. There are two choices in the Sheeprock sequence for the top of the Ophir shale is the foregoing, together with Figure 4 of Loughlin's work (1919, p. 25) are considered: (1) The strata lying between the top of the Tintic quartzite and the base of the upper limestone member of the Millard formation would aggregate a total of approximately 613 feet of rock assignable to the Ophir formation, or (2) between the top of the Tintic quartzite and the base of the limestone member of the Swasey limestone approximately 1,134 feet of strata could be assigned to the Ophir formation.

Regarding the Stockton-Fairfield area, Gilluly (1932, p. 9) states that the Tintic-Ophir contact is transitional and that:

> The boundary selected in mapping was the base of the lowest "shale" bed whose thickness exceeds one foot. This "shale"

bed, which is really a schist, is easily traceable and identifiable above the quartzite outcrops and was selected for this reason although it is possible that the top of the transitional beds would be an easier horizon to identify underground.

Also, in the Stockton-Fairfield area, the upper boundary of the Ophir formation like the lower is arbitrary but with less transitional material. Gilluly (1932, p. 11) states that, "The boundary between this formation and the Hartmann limestone is drawn at the top of the highest shale bed in this part of the section." The Sheeprock section can be divided similarly between the top of the Tintic quartzite and the base of the limestone member of the Swasey limestone (see fig. 3) and is represented by approximately 1,134 feet of Ophir strata compared to 320 feet of strata for the Stockton-Fairfield area.

In the Canyon Range (Christiansen, 1952, p. 723) considers the basal Ophir formation as the bottom of a fucoidal 55-foot unit of interbedded sandstone and shale, whereas the upper contact is the top of a shale sequence about 200 feet thick which lies above 225 feet of limestones. This choice of contacts gives a total of 975 feet of strata for the Ophir formation. If a similar choice of boundaries were made in the Sheeprock area, the Ophir formation would be represented by the interval between the top of the Tintic quartzite and the base of the limestone member of the Swasey limestone and would be 1,134 feet thick.

No problem of lithologic correlation exists between the Pioche and Ophir shales, but paleontologically a great gap is readily apparent. Even though it is proper to disregard time when correlating lithologic units, the writer believes the "disregard" should have some limits. Without limits, it is conceivable that far out on the Cambrian shelf areas the Pioche shale may conformably underlie the Lynch or the Ajax dolomite or other Upper Cambrian formations. A basal quartzite may have greater significance than the overlying shale because the quartzite cannot otherwise be adequately dated; whereas, the overlying shales can usually be dated by fossils. The basal shales of the deeper basins have been named "Pioche"; whereas, those in more shelving areas, relative to the Cambrian geosyncline, are called Ophir. Pioche shale has a Lower Cambrian connotation while Ophir shale implies Middle Cambrian. To correlate Pioche with Ophir without specific mention that the correlation is only lithologic is probably confusing to most geologists; to the students of Cambrian stratigraphy possibly no problem exists.

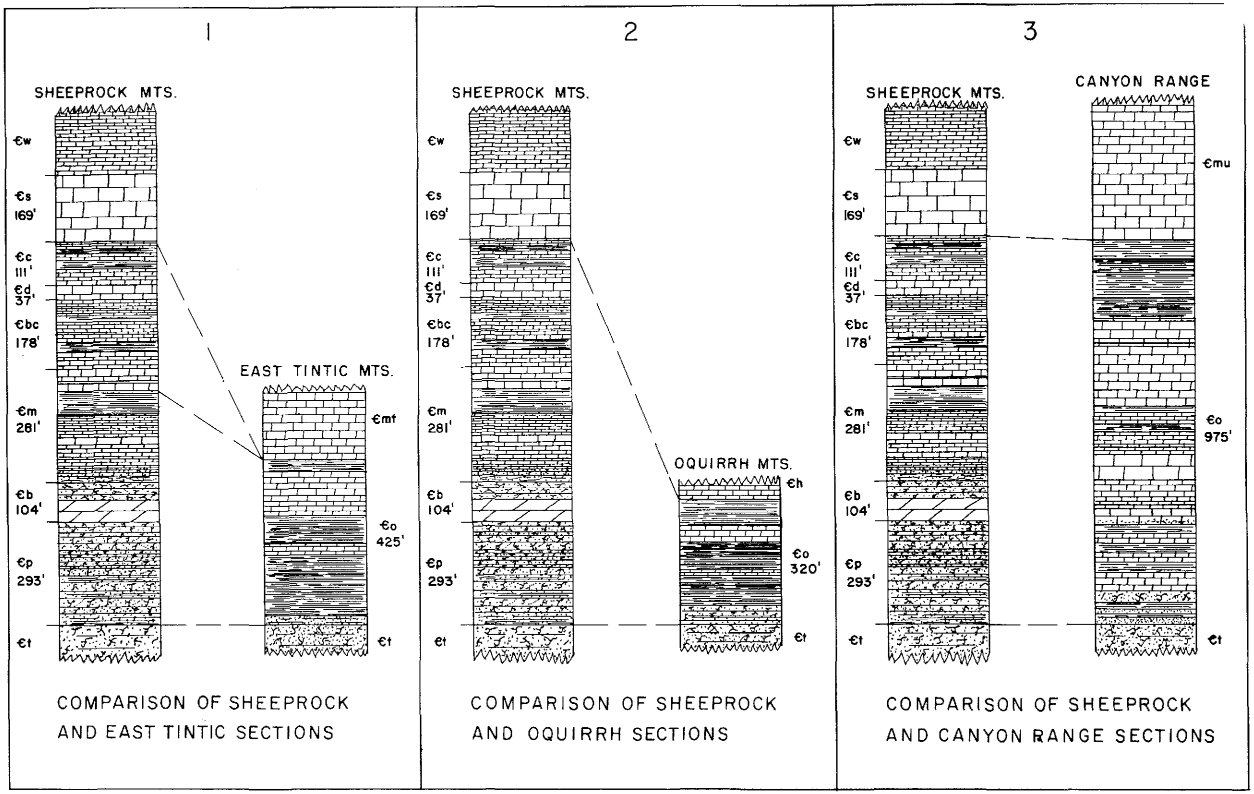
Wheeler (1948, p. 25) states:

> The "Ophir" and "Cabin" shales of western Utah are among the synonyms of the Pioche.

The writer believes that for the House Range section (pl. XI) the Ophir shale is not only a synonym of the Pioche but also the Busby, the Millard (Lyndon-Chisholm-Peasley), the Burrows, Burnt Canyon, Dome, and the Condor member of the Swasey. In the Deep Creek Mountains "Ophir" time is represented by the Cabin shale, the Busby quartzite and much of the lower portion of the Abercrombie formation.

Correlations with sections west of the Sheeprock Mountains is both paleontologic and lithologic; whereas the tie with "type" Ophir to the east is based mainly upon lithology.

The writer proposes that the terms "Ophir shale" and "Ophir formation" be restricted to the areas in which they have been applied. Various authors do not seem to be in agreement concerning the boundaries of the Ophir formation; however, the boundaries described mark sharp



REGIONAL STRATIGRAPHIC RELATIONSHIPS OF BASAL CAMBRIAN CARBONATES

€w = WHEELER FM., €h = HARTMANN LS., €mt = TEUTONIC LS., €mu = CAMBRIAN UNDIFF.

(€s = SWASEY LS., €c = CONDOR FM., €d = DOME LS., €bc = BURNT CAN. FM., €m = MILLARD FM., €b = BUSBY FM., €p = PIOCHE SH., €o = OPHIR FM., €t = TINTIC QTZT.)

FIGURE 3

lithologic changes and possess a high degree of utility within the limits of the area of each report. The different criteria used to depict a transitional contact as discussed in the foregoing paragraphs, together with the presence of three distinct faunal horizons within the Ophir of the Sheeprock area and a recognition of many House Range lithologies, has presented a problem which is best resolved by elevating the Ophir formation to group status. In this way future investigators may use Ophir group as a collective term or may subdivide it if time, lithology, and fauna permit.

Limits - The Ophir group as described here comprises all strata from the top of the Prospect Mountain quartzite through the Condor member of the Swasey limestone (pls. X, XI, and XVII). According to the Committee on Stratigraphic Nomenclature (Ashley et al., p. 437, 1933), a group is a local or provincial subdivision of a system based on lithology. It comprises two or more formations. Inasmuch as the top contact of the proposed Ophir group is placed at the top of the Condor member of the Swasey limestone, it is necessary to redefine the Condor as a formation to avoid placing a group contact within a formation.

The Ophir group comprises the following formations or their equivalents: Pioche shale, Busby quartzite, Millard limestone, Burrows limestone, Burnt Canyon limestone, Dome limestone, and the Condor formation (new name). Although many of the formations may have priority in published works, the term Ophir is applied because of its usage and widespread recognition on or near the "Wasatch line." Basically, the problem is one concerning the merging of the "basin or trough" Cambrian strata with the "shelf" Cambrian beds. To avoid presenting a series of new formations, an attempt has been made to simplify the situation. Strict adherents of either "basin" or "trough" terminology most likely cannot be satisfied; but, it is hoped that this presentation may resolve many uncertainties.

Conclusions - No reasonable paleontologic comparison between the type area of the Ophir shale and those areas directly correlated with the "type" section can reliably be made. To avoid further confusion, the writer has chosen to elevate the Ophir to group status for purposes of discussion of the Sheeprock section. Several distinct faunules fall within the boundaries of the Ophir group as do several lithologies.

A proposal such as the foregoing is bound to be challenged by members of the geological profession especially concerned with stratigraphic nomenclature. If others disagree they must automatically support a subdivision of Ophir in the Sheeprock Mountains either by members or by new formations with new names. This may be the proper approach but probably only an intermediate step to what has been proposed. It is intended by use of the "group" concept to simplify the discussion of the Cambrian system within the Sheeprock Mountains.

PIOCHE SHALE

Distribution and thickness - The Pioche shale is best exposed in an east-west band along the south side of Lookout (Red Pine) Mountain. The best exposures are on the north sides of west-trending Log Canyon and a low tributary of the east draining East Government Creek. Other exposures are in a belt trending westerly from the west side of North Oak Brush Canyon to the head of West Oak Brush drainage, across the divide.

PLATE IX

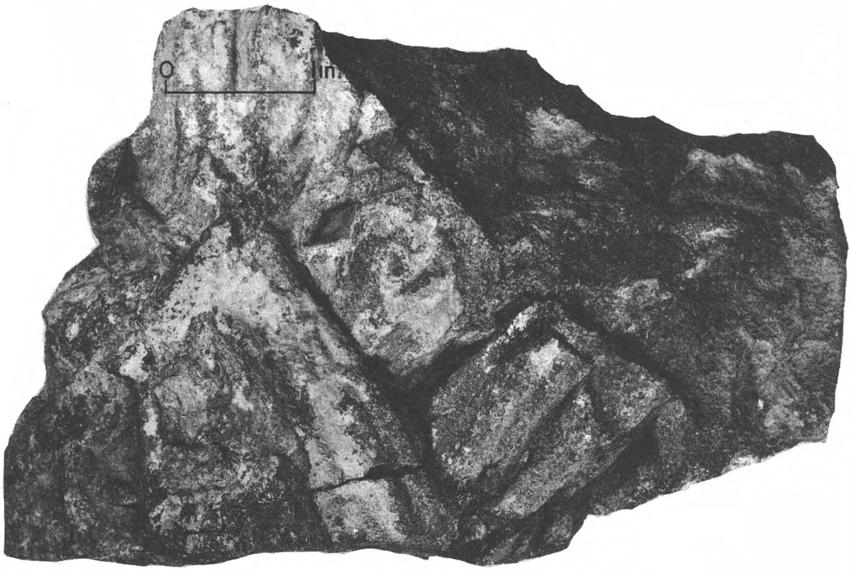


Figure 1
Fucoids from the Swan Peak quartzite (regressive conditions).

Figure 2
Fucoids from the Pioche shale (transgressive conditions).

The Pioche shale was measured in three places and found to be 175, 299, and 342 feet thick. The 175-foot measurement was in a covered area where contacts are questionable. It is south and east of the other sections. The westernmost measurement was 342 feet in Log Canyon whereas the 299-foot section is on the divide along the same outcrop about two miles east of the Log Canyon section. Assuming contacts were tolerably close, the Pioche shale thins to the southeast at about 200 feet per mile.

Topographic expression - The Pioche shale is well marked by the resistant dark maroon quartzites of the Pioche-Busby contact zone. These form a distinctive ledge or ridge unit which is easy to recognize. The lower half of the formation weathers to form ledges.

Lithology - The base of the Pioche shale is arbitrarily placed where shales comprise more than one-third of the strata. Strata assigned to the Pioche shale are best described as shaly quartzites. The quartzite comprises between one half and two thirds of the formation. The quartzites of the lower half of the formation range from two inches to six feet in thickness, are medium-grained, and are generally darker shades of ivory and dirty green. Cross-bedding is evident in many of the greenish beds. The interbedded shales comprise approximately one third of the strata. Shales are micaceous and fucoidal (pl. IX), and about 40 feet above the base, trilobite(?) tracks were found crossing fucoidal expressions.

A 90-foot stratum of dark purplish-green, thick-bedded, cross-bedded quartzite overlies the interbedded quartzite and shale zone 175 feet above the base of the formation. The top 75 feet of the formation is thin- to medium-bedded quartzite containing many shale partings. Scolithes are prominent in this zone.

Outcrops near the base of the formation are dominantly darker browns and green tints.

The top of the formation was tentatively placed at the base of a dolomite which ranges from 30 to 60 feet in thickness. This dolomite weathers to a sandpapery texture and is easily mistaken for sandstone on casual examination.

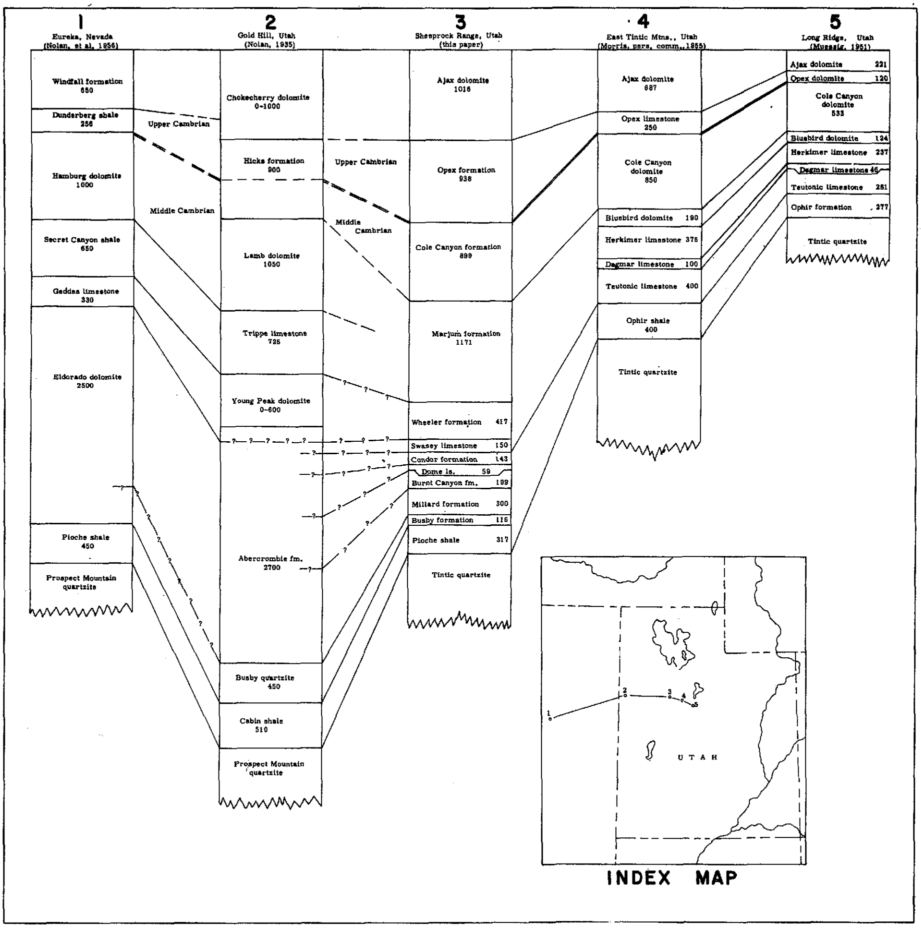
Field identification - The Pioche shale is easily recognized by the presence of fucoids. The Swan Peak quartzite, with which it might be confused, is fucoidal near the base but does not contain as much of the micaceous material that is typical of the Pioche. The quartzites of the Swan Peak are purer and whiter than those of the Pioche. Strata similar in color and with texture and bedding features identical to the Pioche are present in the Precambrian, but are not fucoidal.

Age and correlation - The Pioche shale in eastern Nevada and western Utah is the transitional unit between the basal Cambrian quartzites and the overlying carbonates (pls. X and XI).

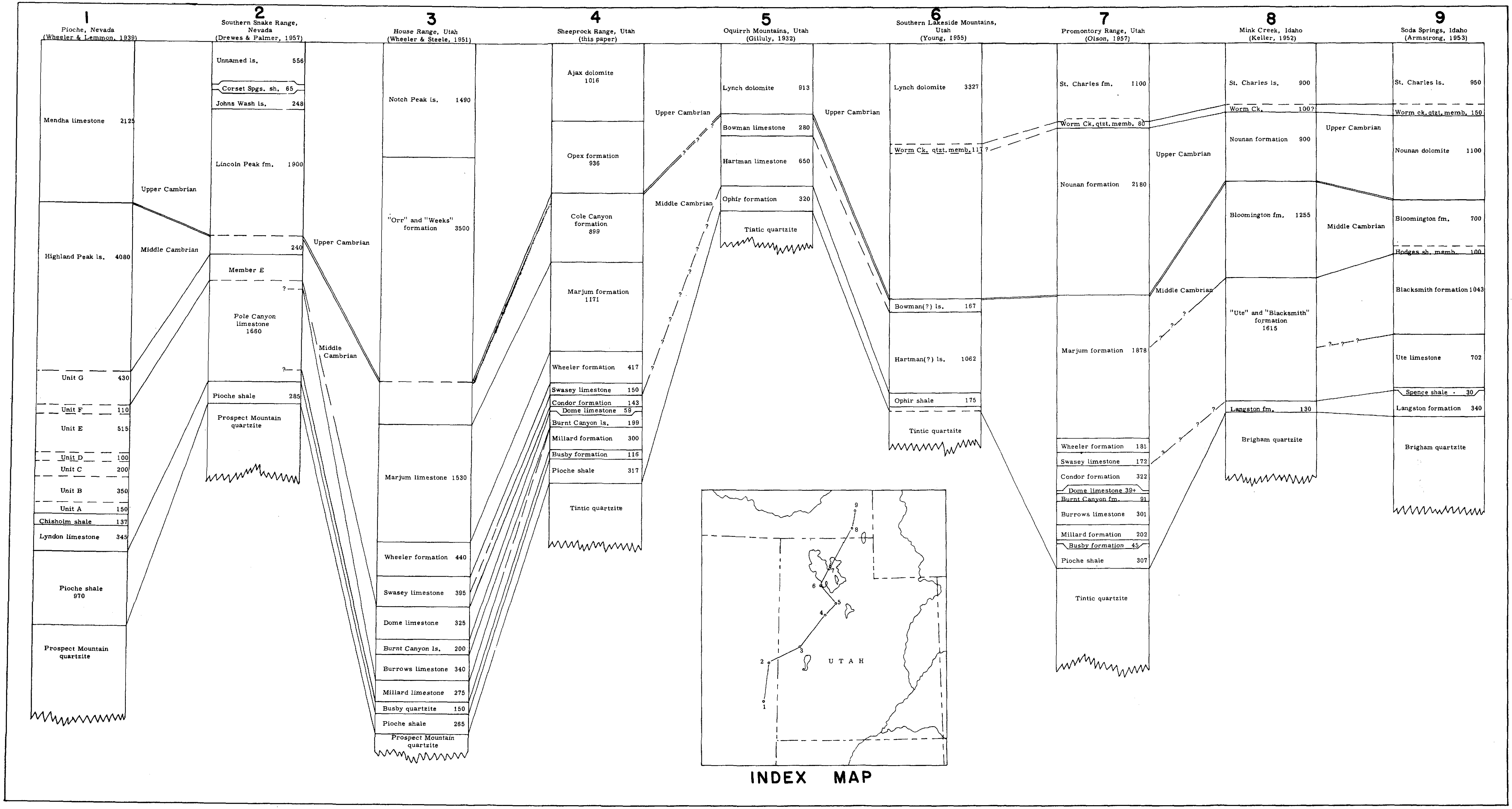
Fossils found in the Pioche facies include fucoidal marks and a single trilobite tract. The tract was found 40 feet above the base of the Pioche and is identical with those found by McKee (pl. 7, 1935) near the top of the Tapeats sandstone in the Grand Canyon region.

The Pioche is the lithogenic equivalent of the basal units of the Ophir shale formation in the Oquirrh (Gilluly, 1932), Wasatch (Calkins, 1943), and the East Tintic Mountains (Loughlin, 1919), and the Canyon Range (Christiansen, 1952). The Pioche shale is the lithogenic equivalent of, but is probably younger than, the Pioche in the House Range (Walcott, 1908), the Deep Creek Mountains (Nolan, 1935), and the basal

PLATE X



CORRELATION OF CAMBRIAN SYSTEM IN EASTERN NEVADA AND WESTERN UTAH



CORRELATION OF CAMBRIAN SYSTEM IN EASTERN NEVADA, WESTERN UTAH AND SOUTHEASTERN IDAHO shale of the Pioche district (Walcott, 1908a). The Pioche is the approximate age and lithogenic equivalent to the Pioche shale in the Promontory Range (Olson, 1956), the basal Ophir in the Lakeside Mountains (Young, 1955), and the Scolithus zone in the top of the Brigham quartzite in the Logan quadrangle, Utah (Williams, 1948).

BUSBY QUARTZITE

Distribution and thickness - The Busby quartzite has a distribution similar to that of the Pioche shale and likewise is present, but poorly exposed, along the northern flank of the range from North Oak Brush to West Oak Brush Canyons. The best exposures are in the Log Canyon drainage south of Lookout Peak.

The Busby was measured in several places and ranges from 65 to 146 feet thick where contacts are best exposed.

Topographic expression - The Busby is coincident in relief with the underlying Pioche and similarly weathers as ledges and ridge formers. The softer rocks of the overlying Millard formation are more easily eroded, allowing the topmost beds of the Busby quartzite to stand as ridge crests or prominent ledges (pl. XII).

Lithology - The Busby quartzite is about one-half quartzite and one-half carbonate. The lower 60 feet is carbonate and the basal 30 to 45 feet of this zone is a brown-weathering, gray sandy dolomite. The remainder of the unit is calcareous sandstone and sandy limestone.

The fauna of the Albertella zone (Howell et al., 1944) was found 40 feet above the base of the Busby quartzite in a relatively pure limestone. The fauna was found only by breaking a large quantity of rock from a ledge ten feet above the underlying dolomite.

The upper half of the Busby is typically a quartzite very similar to the purple quartzite of the uppermost units of the underlying Pioche. However, these quartzites are not consistent in thickness along strike. They thin slightly to the east allowing a thickening of the underlying basal carbonates. The youngest stratum of the Busby is a calcareous sandstone which in places becomes a sandy limestone. This unit weathers tan, is massive, and mica is present in some portions.

The base of the Busby is the base of the sandy, brown-weathering dolomite or, more specifically, the base of the first carbonate above the Tintic quartzite.

The top of the Busby is the top of a sandy limestone or calcareous quartzite below a pisolitic blue-gray limestone (pl. XII).

Field identification - The brown weathering dolomite is the lowest carbonate in the section and the only dolomite near the base of the Cambrian system. The next dolomitic strata in the section are 1,600 feet above.

Age and correlation - Fossils were collected from two localities in the Busby formation (Appendix B and pl. III). Locality C-21 is near the mouth of Log Canyon. Here the fauna is in a sandy limestone approximately 40 feet above the base of the formation. Locality C-30 is 6 1/4 miles east of C-21 and is near the mouth of North Oak Brush Canyon. Fauna of locality C-30 was collected 75 feet above the base in a sandy limestone.

PLATE XII

Figure 1
View to north from head of Spring Canyon section exposed from the Tintic quartzite to the Swasey limestone on the skyline.

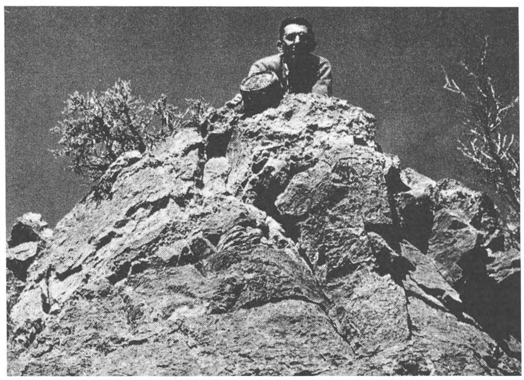


Figure 2
Outcrop of Busby formation near mouth of Log Canyon that contains the oldest fauna found in Sheeprock area.

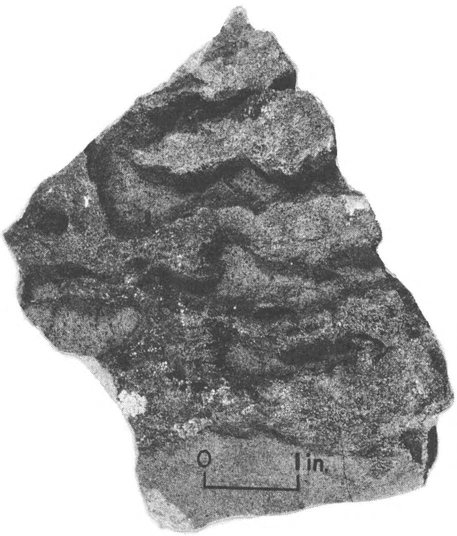


Figure 3
Hand specimen of sandy limestone from Busby formation. Sandy and quartzitic layers weathers in relief.

Mr. R. C. Bright reports the following:

C-21
<u>Caborcella</u> cf. <u>Arrojosensis</u> Lochman
<u>Kootenia</u> spp.
<u>Onchocephalus</u>? sp.
<u>Ptarmigania</u> or <u>Ptarmiganoides</u> sp.
Brachiopod fragments
<u>Helcionella</u> sp.
<u>Pelagiella</u>-like gastropod
<u>Scenella</u> sp.

C-30
<u>Dolichomitopsis</u> sp.
<u>Kochaspis</u> sp.
<u>Olenoides</u> sp.
<u>Oryctocephalites</u> cf. <u>O. resseri</u> Rasetti

Locality C-21 is assigned a lower <u>Albertella</u> age on the basis of the <u>Onchocephalus</u>? sp. Locality C-30 is <u>Albertella</u> age.

The type section for the Busby quartzite is in the Gold Hill mining district at the north end of the Deep Creek Mountains. Nolan (1935, p.7) applied the name to the strata between the underlying Pilot (Pioche) shale and the overlying Abercrombie formation. Type Busby is 450 feet thick and consists mainly of massive quartzites and a few shales.

In the House Range, south of the Deep Creek Mountains, Wheeler (1948, p. 28) assigned the term "Busby quartzite" to 150 feet of beds named Tatow limestone by Deiss (1938). Deiss had supplanted the Langston of Walcott (1908) calling it the Tatow limestone. The Busby of the House Range is a calcareous, coarse-grained, reddish-brown sandstone containing lenses of arenaceous shales. In the Sheeprock Mountains, the Busby quartzite comprises 146 feet of beds, mainly quartzites, sandstones, and sandy limestones.

Wheeler (1943, p. 1612 and 1948, p. 29) recognized the Busby quartzite at Cherry Creek, Nevada, and in the Wah Wah Range of southwestern Utah.

The age of the Busby formation in the Sheeprock area is lower Middle Cambrian with strong indications that it was deposited only very slightly after Early Cambrian time.

The Busby formation is the approximate age equivalent of the Busby quartzite of Nolan (1935) in the Deep Creek Mountains, Utah; the Busby quartzite of Wheeler (1948) in the House Range, Utah; the lower part of the Eldorado dolomite of Nolan, Merriam, and Williams (1956) in the vicinity of Eureka, Nevada; the lower part of member A of the Pole Canyon limestone of Drewes and Palmer (1957) of the southern Snake Range, Nevada; the upper part of the Pioche shale in the Virgin Mountains, Nevada; the lower portions of the Ophir shale of Gilluly (1932) in the Oquirrh Mountains, Utah; and the lower half of Langston formation of Walcott (1908) in the Blacksmith Fork area of northwestern Utah. The Busby lithology has been recognized by the writer in the Simpson Mountains and the Keg Mountains (McDowell Mountains) of west-central Utah. These sections are correlated with the Busby of the Sheeprock Range.

MILLARD FORMATION

<u>General statement</u> - The name Millard formation is substituted for Millard limestone of the House Range section. The Millard formation in the

PLATE XIII

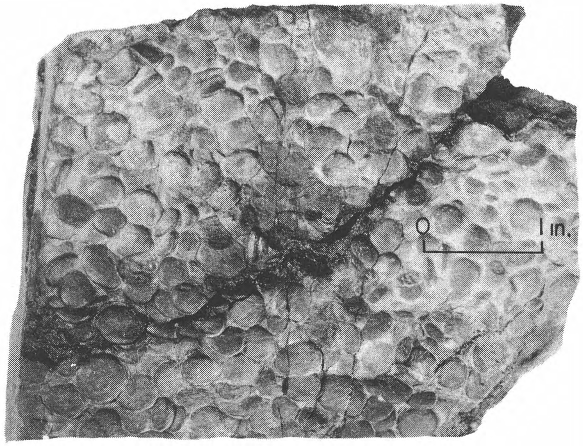


Figure 1
Flat pill-like pebbles from basal unit of the upper member of the Millard formation in Log Canyon.

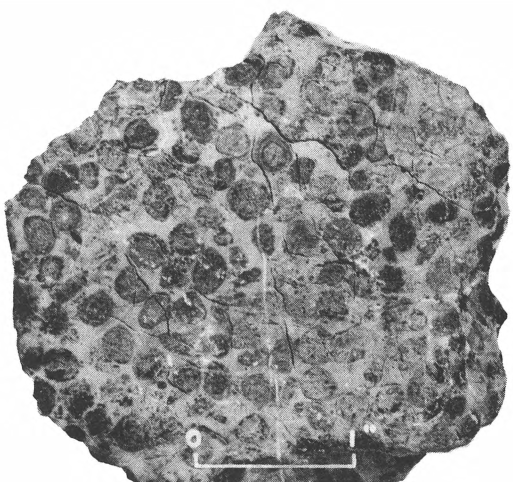


Figure 2
Pisolites or algal balls from the upper member of the Millard formation on Lion Hill.

Sheeprock Mountains is a three-fold unit composed of limestone-shale-limestone. These subdivisions are similar to the Millard equivalents of western Grand Canyon, the Wah Wah Range, Utah, and the Pioche district, Nevada; namely, the Lyndon limestone, Chisholm shale, and the Peasley limestone. Lithogenically the Millard formation is included among other formations within the confines of the Ophir formation of the "type" Ophir at Stockton, Tintic, and in the Canyon Range. It was decided that since a "basin" terminology was to be applied to the Sheeprock section it would be risky to bring a name such as Ophir into a relatively clear cut House Range section. The term "Ophir" should be restricted to the more easterly facies where correlation is mainly on lithology.

Distribution and thickness - The Millard formation crops out on the spurs along the north flank of the range from Harker Canyon to the head of West Oak Brush Canyon on the west flank. Lion Hill, a prominent northeast trending displaced mass separating the head of Harker drainage from North Oak Brush Canyon, contains the Millard formation along the base of its south margin from near the head of the Harker Canyon eastward to the spur east of the mouth of the Canyon. The best exposed sections are in a band along the south side of Lookout Peak from the mouth of Log Canyon to the divide.

The Millard formation is from 245 to 355 feet thick where measured. The shale unit varies considerably in thickness but always at the expense of the underlying limestone.

Topographic expression - The shale unit of the Millard weathers to form saddles and slopes and is generally masked by debris from the overlying limestones.

Lithology - The Millard is divisible into three distinct members. The basal member ranges from 150 to 207 feet in thickness. The lowermost unit is consistently a pisolitic, blue-gray, medium-bedded limestone. Pisoles are dark gray to black and range from one-fourth to nearly one inch in diameter. This unit is 15 or more feet thick and is overlain by a blue-gray, fine-grained, thin-bedded limestone with silty streaks between one- to two-inch limestone beds. The banded unit varies from 80 to 174 feet in thickness.

The middle unit is a green shale which measures from 50 to 120 feet thick. This is the Glossopleura zone of the Sheeprock Cambrian. The shale is platy and somewhat fissile, but this fissility is not parallel with the bedding and the rock is essentially a slate. This unit is only locally fossiliferous. It possesses a characteristic light green color at each observed locality. Fossils and other foreign matter are dark green as are minute network fractures which are present in the shale.

The upper unit is a pisolitic limestone of variable thickness which averages about 40 feet (pl. XIII).

The base of the Millard is at the top of the calcareous sandstone of the conformably underlying Busby quartzite. Pisolites are characteristic of the base of the Millard.

The top of the Millard formation, though more arbitrarily placed, is the top of the pisolitic limestone overlying the shale unit.

Field identification - The shale unit of the Millard is the most distinctive of any shale in the entire Sheeprock Range. It can readily be recognized by the presence of dark green patches of a network of fractures and spots on a light bleached green background of the unaltered shale. The close-packed pisolites of the upper and lower units also serve to distinguish the formation.

Age and correlation - Fossils were collected from ten localities in the Millard formation (Appendix B and pl. III); all except two collections were from the shale member. The two collections, C-28, near the head of Log Canyon, and C-31, near the mouth of North Oak Brush Canyon, are from the lower limestone member of the Millard formation. Mr. R. C. Bright studied the collections and reports the following:

C-28
Kootenia sp.
Helcionella sp.

C-31
Helcionella sp.

Christina Lochman Balk examined several specimens from C-28 and reported:

Pachyaspis(?) sp.

The remaining eight collections were examined by R. C. Bright, A. R. Palmer, and the writer. All contained Glossopleura sp. Locality C-1, studied by A. R. Palmer, yielded the following:

C-1
Ehmaniella sp.
Glossopleura sp.
Polypleuraspis sp.

One specimen from C-32, identified by R. C. Bright, was Glossopleura sp.

No fossils were collected from the upper limestone member of the Millard formation. The fauna indicates that the Millard formation is medial Middle Cambrian in age.

The Millard formation is the approximate age equivalent to the Millard limestone of Wheeler (1948) in the House Range, Utah, to the lower portion of the Abercrombie formation of Nolan (1935) in the Deep Creek Mountains, to members A, B, and C of the Pole Canyon limestone of Drewes and Palmer (1957) in the southern Snake Range, Nevada, to part of the Eldorado dolomite of Nolan, Merriam, and Williams (1956) in the vicinity of Eureka, Nevada, to the Lyndon limestone, Chisholm shale, and part of the Peasley limestone of McNair (1951) in the Virgin Mountains, Nevada, to the Lyndon limestone, Chisholm shale and the Peasley limestone of Wheeler (1939 and 1948) of the Pioche district, Nevada, to part of the Langston formation, the Spence shale, and the lower portion of the Ute limestone of Walcott (1908) and Deiss (1938) in the Blacksmith Fork area of northeastern Utah, to part of the Ophir formation of Gilluly (1932) in the Oquirrh Mountains, Utah, of part of the Ophir shale of Loughlin (1919) of the Tintic district, Utah, of part of the Ophir shale of Calkins (1943) of the Cottonwood American Fork district, Utah, and of part of the Ophir formation of Christiansen (1942) in the Canyon Range, Utah.

BURROWS LIMESTONE

General statement - The Burrows limestone is not clearly recognized in the Sheeprock area. However, on basis of grain size, the basal 21 feet of the Burnt Canyon limestone may represent the Burrows. Burrows lithology is considered absent, but Burrows time is probably represented in the basal Burnt Canyon lithology. Wheeler (1940 and 1943) noted unconformities above and below the Burrows limestone in the Pioche district, Nevada, but later (1948, p. 36) stated, ". . . these breaks now appear to be diastems of little stratigraphic significance." No unconformity was found at or near the base of Burnt Canyon lithology in the Sheeprock. However, it is possible that one may be present which could account for the absence of Burrows lithology.

BURNT CANYON FORMATION

Distribution and thickness - The Burnt Canyon formation crops out as the lowermost limestone cliffs on the south side of Lookout Mountain. The formation defends the spur ends along the north flank of the mountains from North Oak Brush Canyon to the divide.

The formation aggregates 178 feet of strata where measured on the north-south divide at the heads of Spring and Log Canyons. Near the mouth of North Oak Brush Canyon, 221 feet of strata is assigned to the Burnt Canyon formation.

Topographic expression - The Burnt Canyon formation crops out as a cliff-forming and steep slope unit.

Lithology - The strata comprising the Burnt Canyon formation are dominantly thin-bedded, fine- to medium-grained, blue-gray limestones. Throughout the whole formation are green shales which range in thickness from 1 to 25 feet. The greater part of the formation is made up of limestone beds about two inches thick. These are separated by tan and pinkish silty undulatory bands which range up to one or two inches in thickness. The formation changes physical character along strike with shales lensing and thickening. None of the shales are reliable as map units. The shales range from greenish-tan to green and in many localities are dense and blocky. The limestones above and below are gradational with the shale and are very thinly bedded in the transition zone.

Field identification - The Burnt Canyon formation is recognized by the banded appearance caused by the more silty interbeds. It may be confused with some of the limestones higher in the section such as many found in the Marjum formation. The presence of green blocky shale float is a good indicator that one is stratigraphically below the Dome limestone. The shale is not marked by the dark green fracture fillings and fossil fragments which characterize the lower *Glossopleura*-bearing shales of the Millard formation.

Age and correlation - Fossils collected from two localities include only fragments of linguloid brachiopods (Appendix B and pl. III). However, the position between the underlying *Glossopleura*-bearing Millard formation and the *Elrathina* fauna of the Condor formation leaves little doubt that the Burnt Canyon is medial Middle Cambrian in age.

The Burnt Canyon formation is the approximate age equivalent of part of the Abercrombie formation in the Deep Creek Mountains, Utah, of a unit C of the Highland Peak limestone of Wheeler and Lemmon (1939) of the Pioche district, Nevada, of the Ophir formation in the Oquirrh Mountains, Utah, and of part of the Ophir formation in the Canyon Range, Utah. The basal Burnt Canyon formation units are probably equivalent in age to the Burrows dolomite of Wheeler (1940) in the House Range, Utah.

DOME LIMESTONE

Distribution and thickness - The Dome limestone crops out along the south side of Lookout Mountain as a capping on the cliffs formed by the Burrows-Burnt Canyon strata.

The dome ranges from 37 to 81 feet in thickness on the divide south of Lookout Peak.

Topographic expression - The strata of the Dome limestone are more resistant to erosion than the shaly beds of the overlying Condor formation and invariably stand out as cliffs and dip slopes.

Lithology - The Dome limestone is a thick, massively weathering, thin-bedded, fine-grained, blue-gray limestone. The strata are homogeneous and dense and abundant secondary calcite occurs as fracture fillings. Thin, wavy, gray limestone of the same texture as the blue-gray beds serves to impart the vague but persistent thin-bedded character to the rock.

The base of the Dome limestone is gradational with the Burnt Canyon formation. It is placed at a point where the basal units of the Dome limestone weather massive and the bedding becomes thicker.

Field identification - The easiest method of recognition of the Dome limestone is by its position relative to the Glossopleura-bearing shale of the Millard formation and the overlying Condor formation. The dome limestone is the uppermost limestone unit above the Glossopleura zone usually forming cliff-like prominences. Immediately overlying the Dome are the more micaceous shales and thin-bedded silty limestones of the Condor formation.

Age and correlation - No fossils were found in the Dome limestone, but, like the Burnt Canyon formation, it is between faunal zones of the Millard formation and of the Condor formation and is therefore of medial Middle Cambrian age.

The Dome limestone is the approximate age equivalent to part of the Abercrombie formation in the Deep Creek Mountains, Utah, of units D and E of the Highland Peak limestone at Pioche, Nevada, of part of the Ophir formation in the Canyon Range, Utah, and probably part of the Ophir formation in the Oquirrh Mountains, Stockton-Fairfield area, Utah.

CONDOR FORMATION

General statement - The Swasey limestone of the House Range section consists of 395 feet of strata divisible into two parts: the basal 117 feet is a tan to gray, thin-bedded, argillaceous limestone and finely arenaceous fossiliferous shale (Condor member); the upper 278 feet is a dark to medium gray, fine- to medium-grained, thick-bedded, argillaceous limestone (Wheeler, 1948, p. 39). A similar division occurs within rocks referred to as Swasey limestone in the Sheeprock Mountains. Here the basal units of the Condor range from 107 to 135 feet in thickness. The Condor beds are arenaceous shales and thin-bedded limestones. Conformably overlying the shaly sequence is a cliff-forming upper unit about 169 feet thick composed entirely of thick-bedded, dark blue-gray, medium-grained limestone. The Condor member is recognized throughout the Cambrian sections of western Utah and eastern Nevada. Recognition of the Condor lithology in the Sheeprocks and Canyon Range sections indicates that it is sufficiently widespread and distinct to qualify as a formation. Steele (personal communication, 1956) has found it to be very distinctive in the Utah-Nevada territory and states that it may possibly be elevated to formational status. In discussing the stratigraphy of the East Tintic, Oquirrh, and Canyon Ranges, Loughlin, Gilluly, and Christiansen, respectively, cite that the top of the Ophir shale is the top of the uppermost shale in the sequence (See Ophir group, pp. 32-35, this paper).

In the Sheeprock Mountains the top of the uppermost shales in the sequence are 950 feet above the top of the Tintic and 169 feet below the Wheeler shale with its diagnostic fauna. On the basis of the foregoing it is obvious that the Condor member of the Swasey has either been included in the Ophir or should, by description of the upper contact, be included within the Ophir formation. In this report the Condor member of the Swasey limestone is treated as the uppermost unit of the "Ophir" group and is elevated to formational status.

Distribution and thickness - The Condor formation conformably overlies the Dome limestone and is exposed along the south side of Lookout Mountain and on the divide west of the mouth of Talawag Canyon.

The formation ranges from 107 to 135 feet in thickness. The thicker section is near the mouth of Log Canyon whereas the thinner unit is several miles south of Lookout Peak on the main divide. The section described is well exposed on the south slope of Lookout Mountain on the divide.

Topographic expression - The Condor formation consists of shales and thin-bedded silty limestones which aggregate a total of 111 feet of beds. In places much of the formation is obscured by debris of the overlying strata. The Condor changes appearance and composition along strike; the southernmost section is of fine gradational units each about 20 feet thick; the lower, middle, and upper units being thin-bedded (one to two inches), blue-gray, fine-grained limestones with tan silty partings. These limestones weather to form irregular thin slabs. Shaly units occur between the limestones. The shale units consist of more thinly bedded limestones and arenaceous greenish shales with much mica on bedding surfaces.

The base of the formation lies on top of the massive weathering underlying Dome limestone. The top is at the base of the blue-gray, thick-bedded, massive weathering limestone cliff comprising the Swasey.

Field identification - The Condor formation is easy to recognize because of its position below the cliff-forming Swasey limestone. The shales and thinly bedded limestones weather to form talus slopes. The shales are drab green and very silty and micaceous. The mica and gritty feel serves to distinguish the Condor shales from other shales in the Cambrian sequence.

Age and correlation - Fossils were collected from four localities in the Condor formation (Appendix B and pl. III). Two of the localities yielded only fragments of linguloid brachiopods. Localities C-23 and C-34 yielded specimens identified by R. C. Bright as:

C-23
Ehmaniella sp.
Acrothele sp.

C-34
Ehmaniella cf. *E. Burgessensis* Rasetti
Elrathina? sp.
Hyolithes cf. *H. cercops* Walcott
Micromitra? sp.
Iphidella sp.

The fauna indicates a medial Middle Cambrian age for the Condor formation.

The Condor formation is the approximate age equivalent of the lower part of the Swasey formation described by Walcott (1908) in the House Range, Utah, of the upper part of the Abercrombie formation in the Deep Creek Mountains, Utah, of Unit F of the Highland Peak limestone of Pioche, of member E of the Pole Canyon formation of Drewes and Palmer (1957) in the southern Snake Range, Nevada, of the upper parts of the Ophir in the Tintic district, and in the Canyon Range, Utah.

SWASEY LIMESTONE

General statement - Rocks assigned to the Swasey limestone are restricted to the upper part of the Swasey limestone of previous writers (see Condor formation).

Distribution and thickness - The Swasey limestone conformably overlies the flaggy, thin-bedded limestones of the Condor formation and form the first prominent cliffs south of the highest cliffs on Lookout Mountain.

The formation forms a homogeneous unit 169 feet thick.

Topographic expression - The Swasey limestone is a cliff-forming unit which forms the top of hogback spurs which extend from the divide to points low on the east and west flanks of Lookout Mountains.

Lithology - The dark blue-gray Swasey limestone is indistinctly thin- to thick-bedded. It forms massive appearing, nearly vertical cliffs. The rock is principally fine-grained, and fractures within the formation filled with white secondary calcite apparently impart a strength to the unit which enables it to stand nearly vertical.

Field identification - The overlying Wheeler and the underlying Condor formation form slopes and accentuate the steeper profile of the Swasey limestone. If underlying and overlying shaly units are not exposed, the Swasey may be mistaken for either the Marjum or the Dome.

Age and correlation - No fossils were found in the Swasey limestone, but its position between the fossiliferous Condor and Wheeler formations necessitates an age assignment somewhat above medial Middle Cambrian.

The Swasey limestone is the approximate age equivalent of the upper beds of the Abercrombie formation in the Deep Creek Mountains, Utah, of the upper limestone units of the Swasey formation of Deiss (1938) in the House Range, Utah, and of unit G of the Highland Peak limestone of the Pioche district.

WHEELER FORMATION

Distribution and thickness - The Wheeler formation is exposed along the south side of Lookout Peak, near the crest. It extends from the valley floors on both sides of the mountain. Small exposures are present on the divide west of Talawag Canyon and near the center of Lion Hill, north of Harker Canyon.

The Wheeler aggregates a total of 429 feet of thin-bedded strata on the divide south of Lookout Peak.

Topographic expression - The Wheeler formation forms the base of the notch of Lookout Peak which is evident at a distance from Rush and Skull valleys. The more easily eroded limestones comprising the formation form high level saddles between the uppermost limes of the Swasey and the basal units of the overlying Marjum formation. Characteristically, the Wheeler is a slope-forming unit beneath the Marjum cliffs. Marked strike valleys have developed along its outcrop on both sides of the mountain.

Lithology - The Wheeler consists of dark blue-gray, fine-grained, thin-bedded, flaggy limestone characterized by the smoothness and flatness of the bedding planes. The strata weather in slabs and blocks, usually with square edges. Silty partings afford breakage planes for the beds. Trilobites such as *Elrathia* sp. and *Peronopsis* (agnostid) are present on bedding planes in the upper one-third of the formation. The silty partings are tan to reddish-tan and like the limestone beds are remarkably smooth. Pyrite cubes (altered to limonite) are present along some of the bedding planes.

Field identification - The flat, flaggy character of the weathered Wheeler strata is very distinctive, so much so as to be unique and diagnostic of the formation in the Sheeprock area. Trilobites, though not abundant, and sufficiently plentiful to provide a sure means for identification and in all places where the Wheeler was observed, *Elrathia* was found.

Age and correlation - Fossils were collected from five localities (Appendix B and pl. III). Mr. A. R. Palmer reports:

C-3
Elrathia? sp.

C-4
Elrathina? sp.

C-10
Zacanthoides sp.

C-15
Elrathia sp.

Mr. R. C. Bright reports:

C-24
Elrathia sp.
Peronopsis interstrictus (White)
Protospongia sp.

The fauna indicates that the Wheeler formation is of upper Middle Cambrian age.

The Wheeler formation is the approximate age equivalent of the upper units of the Abercrombie formation in the Deep Creek Mountains, Utah, and of units H and I (?) of the Highland Peak limestone of Wheeler and Lemmon (1938) at Pioche. The Wheeler formation has been observed by Mr. R. H. Olson in company with the writer in the Promontory Range of northern Utah.

MARJUM FORMATION

General statement - The Marjum formation includes the strata lying between the Wheeler formation and Cole Canyon dolomite. Terminology of the Tintic mining district is applied to the Upper Cambrian strata above the Marjum formation.

Distribution and thickness - The Marjum formation is the most prominently displayed of all the Cambrian formations in the Sheeprock Mountains. It makes up the highest strata of Lookout Peak and comprises all of the rocks of the north dip slopes from Lookout Peak northward to the southern limit of the Lookout Hills at the drainages of East and West Red Pine Creeks.

The Marjum formation is 1,193 feet thick between the top of the Wheeler formation, about a quarter of a mile south of Lookout Peak, and a point on the south side of the West Red Pine Creek.

Topographic expression - The more resistant rocks of the Marjum formation form hogbacks and flatirons along the north-facing dip slopes of Lookout Mountains. The whole north slope slightly south of Lookout Peak to the Lookout Hills is composed of strata of the Marjum formation.

PLATE XIV

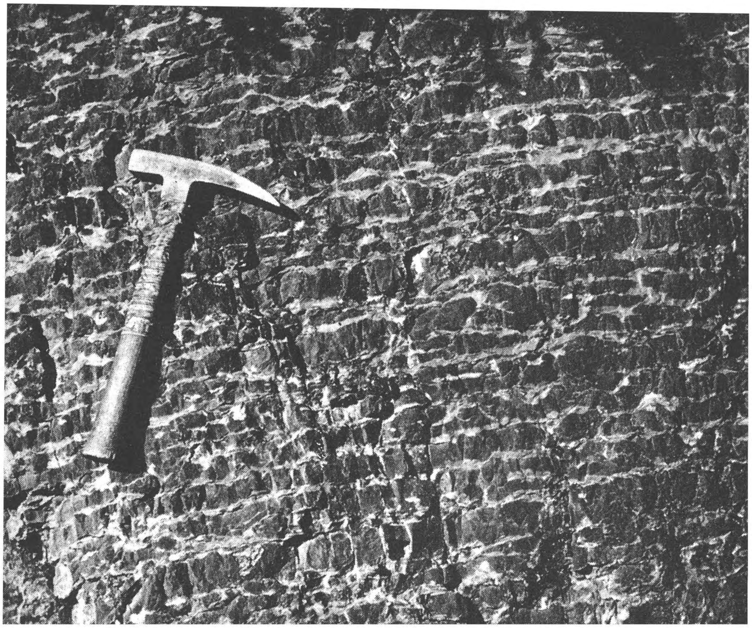


Figure 1
Marjum limestone near Lookout Peak showing undulatory bedding and tan silty laminations.

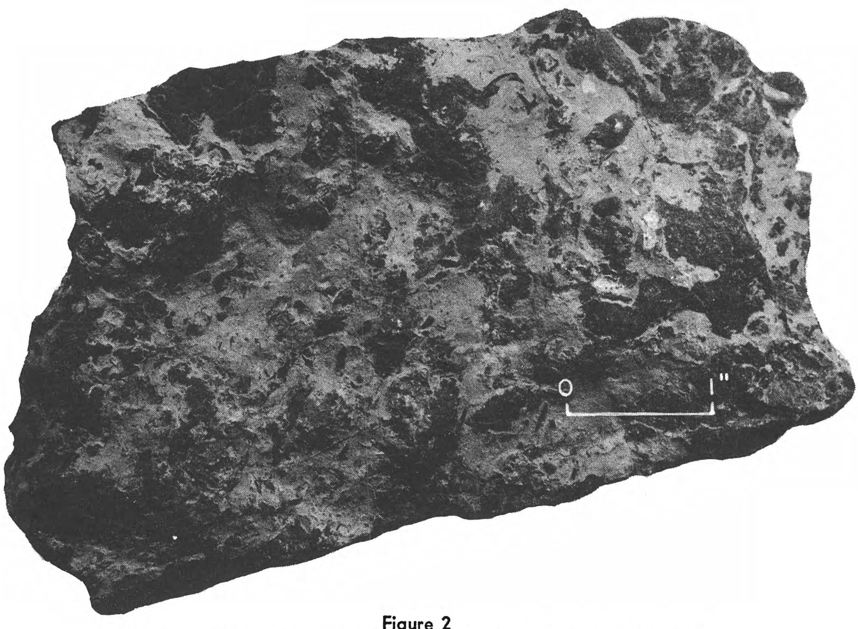


Figure 2
Hand specimen of Marjum limestone showing an irregular bedding surface.

Lithology - The Marjum formation is composed of carbonates and some shales. The lower 350 feet is a blue-gray, thin-bedded, fine- to medium-grained limestone. Most of the units of this interval contain tan, silty laminations which are very undulatory (pl. XIV). Above the basal units are approximately 50 feet of tan, fissile shale and shaly limestones which yielded fragments of inarticulate brachiopods. A few limestone beds above the shales are intraformational and are overlain by 210 feet of blue-gray, fine- to medium-grained, thin-bedded limestone which, like the basal strata, possesses tan, silty undulatory partings. A few beds in this interval contain black oolites up to one-sixteenth of an inch in diameter. The next 340 feet is mostly dolomite with some dolomitic limestone. The dolomite is dark blue-gray to gray, medium-grained, and is thick-bedded to massive. The darker blue varieties contain short, white, curved rods of dolomite. A 206-foot unit near the top of this sequence becomes a more neutral gray in its upper half and the topmost 26 feet is zebra-banded with white coarsely crystalline dolomite comprising the bands which in a few inches feather out and are absorbed in the gray of the country rock. The dolomites showing zebra-banding appear to be secondary since they have irregular areal distribution within short distances. This feature is most likely the result of solutions operating in and near the fault zone and penetrating into the more permeable strata. The topmost unit is a 122-foot dark blue-gray limestone similar to the basal strata of the formation.

The top of the Marjum formation is a chert zone from 8 to 12 inches thick at the top of a 7-foot, white weathering, pinkish-gray, aphanitic, laminated dolomite. This dolomite and others higher in the Cole Canyon dolomite resemble the "type" Dagmar of the Tintic district.

The base of the Marjum formation is at the base of the cliff-forming limestones overlying the platy Wheeler formation.

Field identification - The Marjum lithologies are easily mistaken for those of many formations; however, the thickness of the thin-bedded units is most diagnostic. The tan, very fissile shales bearing scraps of inarticulate brachiopods serve to confirm the identity of the formation.

Age and correlation - Fossils collected from three localities (Appendix B and pl. III) in the Marjum formation were mainly scraps of linguloid brachiopods and trilobites. Mr. A. R. Palmer examined the material and reported:

C-12
Indeterminate trilobite cf. Meteoraspis or Modocia

The one identifiable fossil is not sufficiently diagnostic to accurately determine the age of the formation. However, the stratigraphic position of the Marjum formation, together with the suggestion that it contains Middle Cambrian forms, leaves little doubt that it is upper Middle Cambrian in age. No fossils were found in the upper half of the formation, and it is possible that part of the Marjum may straddle the Middle-Upper Cambrian boundary.

The Marjum formation is the approximate age equivalent of the Trippe limestone in the Deep Creek Mountains, Utah, and of units J and K of the Highland Peak limestone at Pioche. The recognition of Cole Canyon dolomite facies in the Sheeprock section immediately overlying the Marjum limestone suggests that the Marjum correlates with the Bluebird dolomite and the Herkimer limestone of Loughlin (1919) of the Tintic mining district, Utah.

COLE CANYON DOLOMITE

Distribution and thickness - The Cole Canyon dolomite crops out low on the north flank of Lookout Mountain south of West Red Pine Canyon and extends over a half a mile northward in the West Lookout Hills. Reverse and normal faults restrict its extent to only a few feet in the East Lookout Hills. An east-west thrust fault along the north base of Lookout Mountain has eliminated an unknown thickness of the Cole Canyon strata. Tertiary conglomerates overlie a down-faulted, graben-like block which separates the Lookout Hills into eastern and western elements. The conglomerate obscures a considerable portion of the area between Lookout Mountain and Lookout Pass, several miles to the north.

Cole Canyon lithology was tentatively identified in the northern part of the Simpson Mountains.

Strata of the Cole Canyon formation total 899 feet where measured at the south end of the West Lookout Hills.

Topographic expression - The Cole Canyon, like all the formations north of Lookout Peak, occupies an area of low relief due to faulting and a shallow northerly dip. The Cole Canyon weathers to form low ridges with rounded crests. The outcrops are fewer than the underlying formations and much more colluvium masks the terrane.

Lithology - The Cole Canyon dolomite consists of nearly equal parts of dolomite and limestone. Limestone is most common in the lower half whereas the upper half consists principally of dolomites. Units range from 5 to over 200 feet in thickness. The dolomites tend toward grays while the limestones are mainly blue-gray. The limestones are characteristically thin-bedded with gray, tan, or pinkish silty partings which are undulatory but have a longer "wave length" than the partings of the underlying Middle Cambrian formations. Some of the limestones contain nodules of silt and in all cases the silty bands are of a lighter color than the limestones (pl. XV). Most of the dolomites in the lower part of the formation are gray, fine-grained, and laminated.

The base of the formation is arbitrarily placed at the top of a thin black chert zone in a laminated dolomite of conformably underlying Marjum formation.

Field identification - The Cole Canyon dolomite is composed of thin and thick units of dolomite and limestone which are laminated on a large scale. The finely laminated, light gray weathering dolomites are typical of this formation as well as of strata in the Silurian and Devonian systems. However, the units in the Cole Canyon are usually less than ten feet thick, whereas those of other systems are 30 or more feet thick. The banded limestones of the Cole Canyon weather to smoother outlines and the bedding planes are not as wavy as those of the limestones of the Middle Cambrian formations.

Age and correlation - No fossils were found in the Cold Canyon dolomite. Forms found in the basal units of the overlying Opex formation are of lower Upper Cambrian age. The top of the Cole Canyon dolomite is tentatively considered to be the top of the Middle Cambrian.

The Cole Canyon dolomite is the approximate age equivalent of the Lamb dolomite and the lower part of the Hicks formation described by Nolan (1935) in the Deep Creek Mountains, Utah, of most of the Hamburg dolomite of Nolan, Merriam and Williams (1956) of the Eureka district, Nevada, of the upper part of the Marjum limestone in the House Range, Utah, of the upper part of the Bloomington formation of Walcott (1908) in the Blacksmith Fork area, Utah, of the upper part of the Highland Peak limestone and the lower part of the Mendha formation of the Pioche district, and to part of the Lynch dolomite of Gilluly (1932) in the Oquirrh Mountains, Utah.

OPEX FORMATION

Distribution and thickness - The Opex formation is principally limestone. It crops out in a belt nearly 2,600 feet wide in the southern end of the East and West Lookout Hills. North-trending normal faults slightly offset the strata on the western end.

The Opex was measured in the West Lookout Hills as a continuation of the line of the Cole Canyon section. At this locality it is 938 feet thick.

Topographic expression - The Opex weathers like the underlying Cole Canyon strata as rounded hills capped with considerable alluvial cover.

Lithology - The Opex formation is mainly limestone and dolomite with fissile shale comprising the remainder. The limestones are medium- to fine-grained, thin-bedded with pinkish, silty partings, and weather as rough flags. Intraformational conglomerates are common.

The lowest shale is a 10-foot unit 120 feet above the base. It is light green in color and is extremely fissile; its presence is detected only by float. Overlying the shale are additional limestones aggregating nearly 200 feet in thickness, which in turn are capped by 32 feet of shale containing a 5-foot bed of light gray, laminated dolomite near the center. Above the uppermost shale is 79 feet of limestones of which the lower 20 feet are oolitic and pebbly. Trilobite fragments were found in this zone. The next overlying unit is a 10-foot bed of blue-gray limestone which contains dispersed irregular chert masses. Brachiopods were collected from this unit. The topmost unit of the Opex formation is a banded, silty limestone which weathers blocky. The bands are very flat and display some lamination, and trilobites characteristic of the *Conaspis* zone are found on the silty partings.

A fault at the top of the Cole Canyon formation has cut out an unknown thickness of basal Opex. The missing units possibly represent between 100 and 300 feet.

Field identification - The Opex formation is distinguished by the banded limestones of its topmost unit. The presence of a great thickness of Ajax dolomite above, and the thick dolomites at the top of the Cole Canyon below, are the best means for identification. The top of the Opex was found to be consistently.

Age and correlation - Fossils were recovered from six localities in the Opex formation (Appendix B and pl. III). A. R. Palmer identified the specimens from localities C-17 and C-19 and reported:

C-17
Conaspid trilobite fragments
Billingsella sp.
Conodonts
Acrotretids of Upper Cambrian type
Problematicum I - described by Westergard
(Geologiska Foreningens I Stockholm Forhandlinger, Band 75, Heft 4, pp. 464-468, 1953) from Upper Cambrian beds in Sweden.

C-19
Acrotretid brachiopods of Upper Cambrian type
Conodonts

PLATE XV

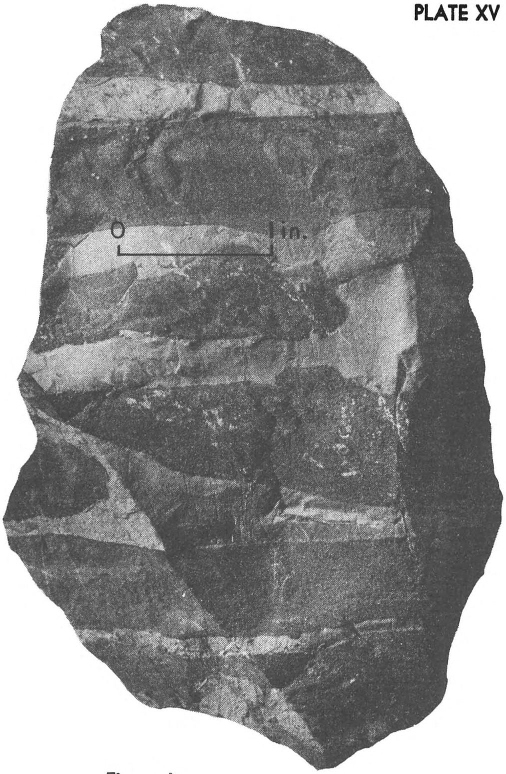


Figure 1
Specimen of banded dolomite from Cole Canyon formation.

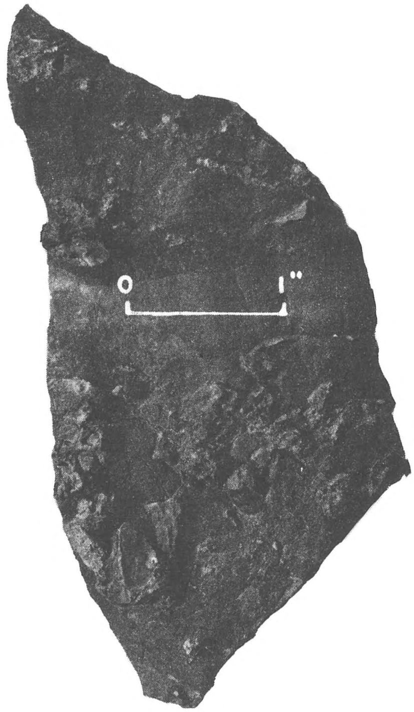


Figure 2
Specimen of limestone from the Opex formation containing silt and chert.

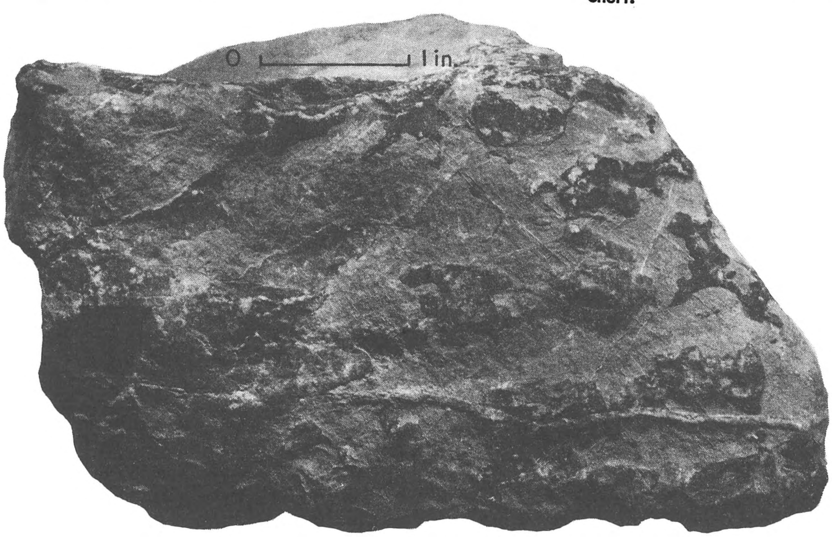


Figure 3
Specimen of silty limestone from Cole Canyon formation.

Palmer states:

> Collections C-17 and C-19 are Upper Cambrian in age. Although they may come from a unit that lithically resembles the Opex, they contain fossils that indicate an age equivalence to the Ajax dolomite. Collection C-17 is of particular interest because, in addition to the presence of silicified specimens of *Billingsella*, a characteristic middle Upper Cambrian brachiopod, it contains examples of Cambrian conodonts, and a specimen of a peculiar three-pronged problematicum that has been described only from Upper Cambrian beds in Sweden. Cambrian conodonts have been recognized in collections from the Dugway range in rocks that seem to resemble those from which collection C-17 was obtained. They are also known from Wyoming and Central Texas. At all known localities they have been obtained only from horizons equivalent to the *Conaspis* zone of middle Franconian age in the standard Upper Cambrian section.

R. C. Bright examined collections from localities C-25, C-26, C-27, and C-35. The identifications are as follows:

C-26, near the base of the Opex.
Coosella spp.
Kormagnostus cf. *K. simplex* (Resser)
Pseudagnostus prolongus (Hall and Whitfield)
Syspacheilus ? sp.
Tricrepicephalus walcotti (Lochman)
Lingulella sp.
Hyolithes primordialsis (Hall)

C-27, near base.
Trilobite pygidium affinity Upper Cambrian

C-35, near top of Opex.
Elvinia montis Resser
Elvina sp.

C-25
Maustonia sp.
Parabolinoides contractus Fredrickson
Taenicephalus cf. *T. hyrumensis* Resser
Taenicephalus shumardi Hall
Taenicephalus cf. *T. striatus* Resser
Taenicephalus n. sp.
Acrotreta cf. *A. microscopia* Walcott
Acrotreta ophirensis Walcott
Billingsella cf. *B. coloradoensis* Walcott
Eoorthis desmopleura Walcott
Lingulella sp.
Linguloid brachiopods
Pelagiella-like gastropod

The Opex formation is lower and middle Upper Cambrian in age. The basal Opex is represented by fauna from C-26 which is of the upper *Cedaria* zone or the basal *Crepicephalus* zone of the Dresbachian stage. Fauna from C-35 represents the *Elvinia* zone. Specimens from localities C-17, C-19, and C-25 near the top of the Opex represent the *Conaspis* zone of the Franconian stage.

The Opex formation is the approximate age equivalent of the Dunderberg shale of Walcott (1908) of the Eureka district, Nevada, of the Nopah formation of Wheeler and Steele (1951) in the House Range, Utah, of most of the lower half of the Mendha formation at Pioche, of the Nounan and the lower half of the St. Charles of Walcott (1908) in the

PLATE XVI

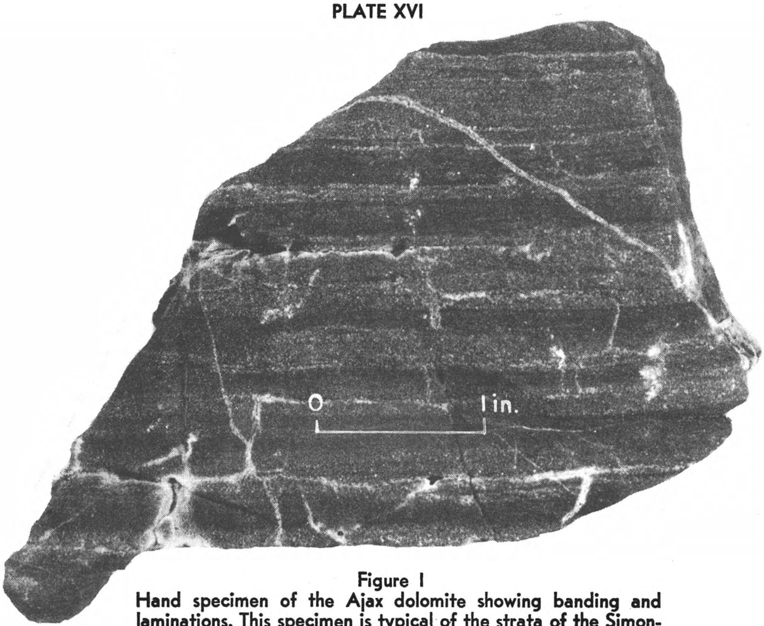


Figure 1
Hand specimen of the Ajax dolomite showing banding and laminations. This specimen is typical of the strata of the Simonson dolomite.

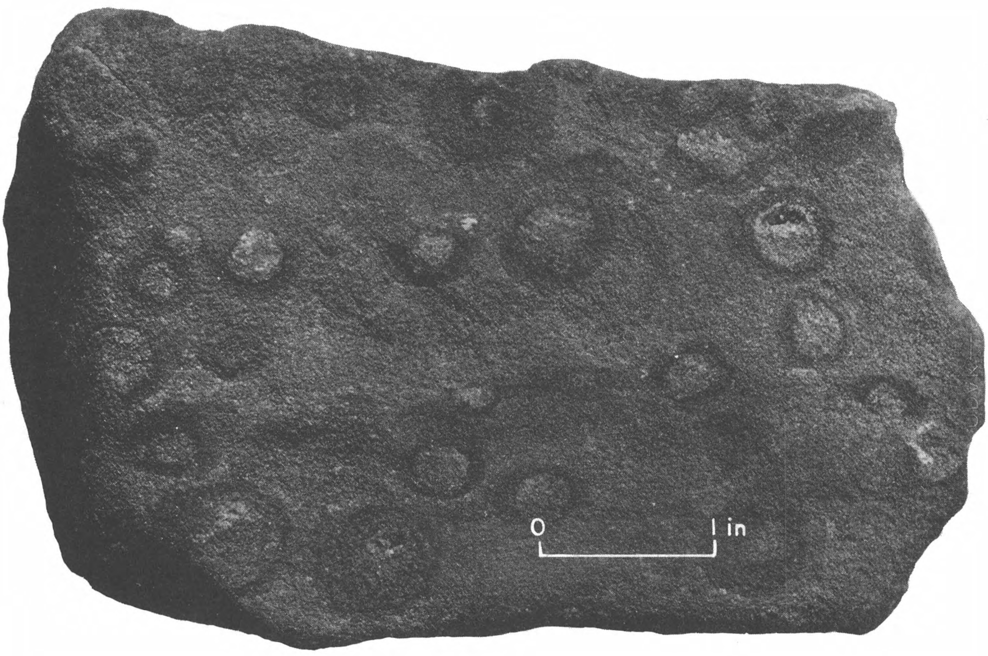
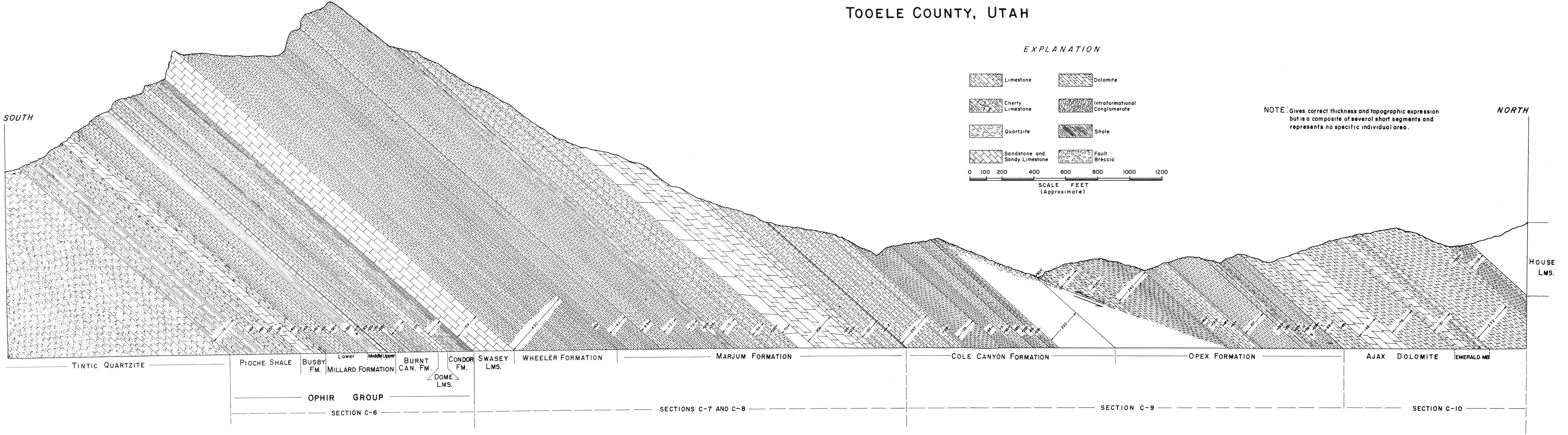


Figure 2
Specimen of the Ajax dolomite with pisolitic structures dispersed in the medium-grained dolomite.

Composite Diagrammatic Cross Section of Cambrian Formations in Northern Sheeprock Mountains and Lookout Hills Tooele County, Utah

PLATE XVII



Blacksmith Fork area, Utah, of the Johns Wash limestone and the Corset Spring shale of Drewes and Palmer (1957) in the Snake Range, Nevada, and of the upper part of the Hicks formation in the Deep Creek Mountains, Utah.

AJAX FORMATION

Distribution and thickness - The Ajax formation crops out in a belt about 1,000 feet wide at the south end of the East Lookout Hills and strikes north of west to the West Lookout Hills where it is displaced northward. Minor thrusting has decreased the dip in the western part of the outcrop and the strike is more westerly. No other dolomites recognizable as Ajax were noted on the rest of the range or in the eastern part of the Simpson Mountains.

The Ajax formation was measured in the West Lookout Hills and found to be 1,012 feet thick. No apparent thinning was noted, but much cover in the eastern part of the outcrop area renders measurement there practically impossible.

Topographic expression - The Ajax formation crops out in ridges and steep slopes, being resistant enough to afford good exposures in most of the outcrop area.

Lithology - The Ajax formation is composed entirely of dolomite in the Sheeprock area. The lower 450 feet of strata are dark gray, medium-grained dolomites. Light and dark mottles are common. Black chert nodules up to eight inches in length are present in the basal unit as are wormy, gray chert inclusions. The next 150 feet is a light gray and sugary textured dolomite which has been called the Emerald member after its correlative in the Tintic mining district. The upper units aggregate over 400 feet of strata, being mainly a dark-gray to blue-gray, sugar- to medium-grained dolomite. At several localities pisolites were noted in the upper part of the Ajax (pl. XVI). They are distributed in random positions and are not in close contact with each other.

The contact between Cambrian and Ordovician is conformable and gradational. The top of the Ajax formation is a gray, flaggy dolomite, whereas the basal strata of the overlying House limestone are nearly 100 percent intraformational and have silty partings.

Field identification - In the Sheeprock Mountains the Ajax formation is entirely dolomite. The dark gray to black color of the upper and lower units is very characteristic as is the crystallinity. A few beds of scattered pisolites are present in the upper part of the formation. Near the middle of the Ajax is 150 feet of white to light gray, crystalline dolomite known as the Emerald member of the Ajax formation. Many vermicular and slightly curved, rod-like bodies occur in the upper part of the lower unit.

Age and correlation - The Ajax dolomite is devoid of fossils. A middle Upper Cambrian age is inferred for the formation because of its striking lithic similarity to the Ajax dolomite of the Tintic mining district.

The Ajax dolomite is the age equivalent of the upper half of the St. Charles formation of the Blacksmith Fork area, Utah, of the Notch Peak formation of Walcott (1908) in the House Range, Utah, of part of the Chokecherry dolomite(?) in the Deep Creek Mountains, Utah, of the upper part of the Mendha formation at Pioche, and of part of an unnamed limestone in the Snake Range, Nevada.

CAMBRIAN CORRELATION

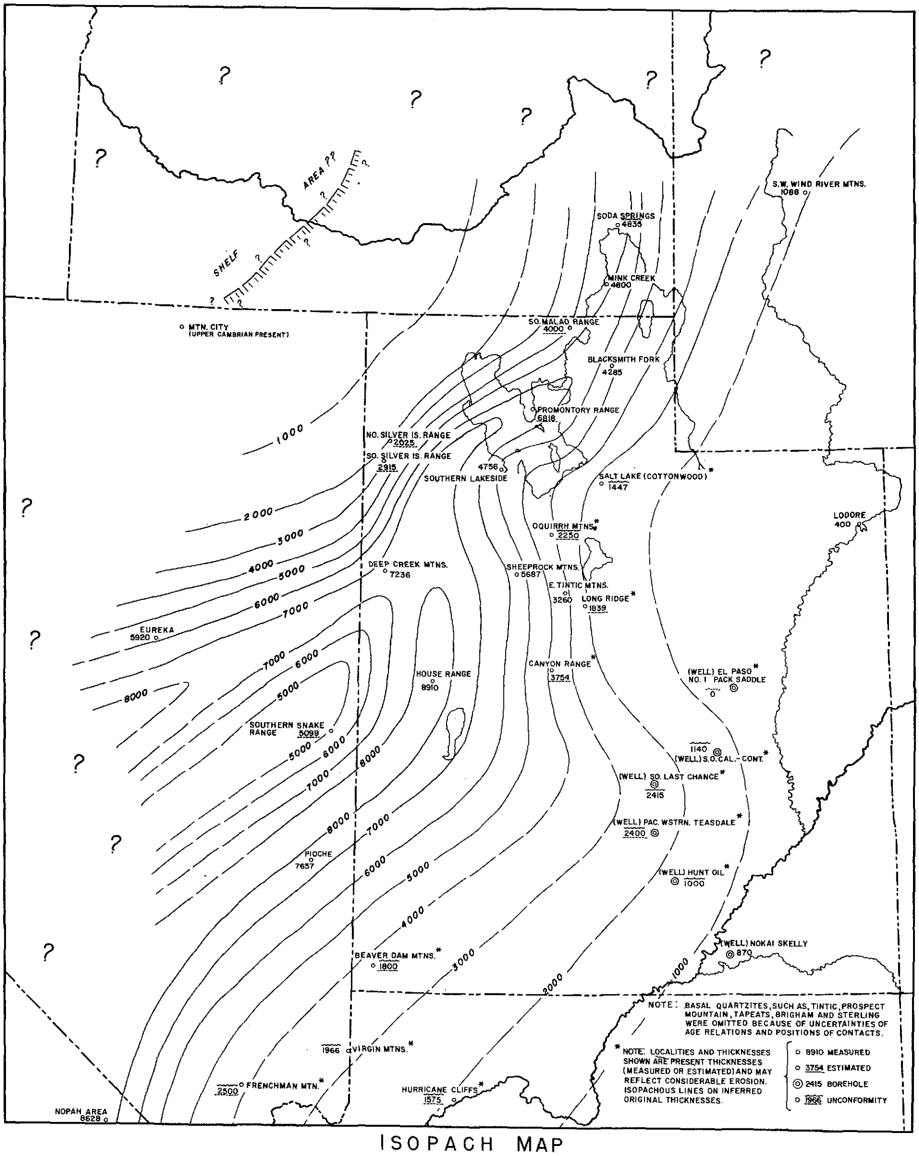
Cambrian strata of the Sheeprock Mountains present many problems in correlation. Though not singularly restricted to the Sheeprock area, the problems are especially significant because of the geographic position of the Sheeprock Range relative to other measured sections of Cambrian strata in the Oquirrh, East Tintic, House, and Deep Creek Mountain regions.

Many localities of measured Cambrian strata were plotted on Figure 4, and the known or estimated thicknesses of Cambrian strata above the basal quartzite were isopached. The isopachous lines aid in deciding to which previously studied sections one may most properly and accurately correlate newly recognized Cambrian strata. The writer does not infer that all sections lying with a certain isopach are correlative. Factors such as distance of transport and source of a detrital fraction tend to disrupt a lithologic correlation.

Carbonate or chemical fractions are most likely to be correlative both in time and lithology. Intra-carbonate arenaceous sediments such as Worm Creek and the Swan Peak quartzites likewise are correlated with ease both lithogenically and faunally. Detrital fractions, particularly the basal Cambrian quartzites and shales, are lithogenically correlative. Basal quartzites not underlain by accurately dated carbonates will most likely cross time lines and, if accurately examined, will be found to change lithologically from one locality to another, though in many instances the differences may be small. The change in lithology, however significant, is due to the character of the source material and of the transporting media. The littoral processes along the edges of a transgressing sea are not always capable of leaving a basal detritus of like lithology over the floor of an entire geosyncline. As mentioned previously, a limestone or other chemical deposit precipitated directly from sea water may be more ideally correlative lithologically and faunally. However, the writer does not imply that a marine environment would necessarily be so uniform chemically as to cause deposition of lithologically similar limestones over the entire geosyncline, but at the same time he wishes to infer that deposition of a lithologically similar limestone over a very large area is possible. Weather, ventilation of the seaways, organisms, and detrital fractions all tend to modify or restrict a chemical environment.

It seems logical to assume that if water currents were sufficiently competent to carry silt far into the deeper basin or basins and thus form shales, that these competent currents would tend to follow designated courses and that along the courses nearer the source, there should be more shale. Herein lies the danger of projecting "basin" shale units too far from the type localities. A basin shale may be mainly the manifestation of a part of a more extensive shale unit farther removed from the basin. The writer does not adhere to the idea that a basin shale may be an isolated unit without a connection with a source, but at the same time recognizes that it may possibly be thicker by process of stagnation and ponding. Further temporary failure in "competency" may allow carbonate deposition to built a considerable thickness of strata in an interim between episodes of shale deposition. Such weakening in competency may be due either to fluctuation at the source or differential sinking of the terrain, or to both.

Salients or shoaling areas, as shown on the isopachous map, likewise cannot be completely correlated with close-lying sections situated in the deeper portions of the geosyncline. Only the strata which were deposited at nearly equal rates during a specific time interval will be correlative. An example is the Upper Cambrian strata of the Sheeprock-East Tintic area. The Middle Cambrian strata of the Sheeprock region cannot be accurately correlated with strata of similar age in the East Tintic Mountains because the East Tintic area, though negative in Middle



ISOPACH MAP
OF CAMBRIAN SYSTEM
EXCLUSIVE OF BASAL QUARTZITES
FIGURE 4

TABLE 2 - SOURCES OF INFORMATION FOR CAMBRIAN SYSTEM ISOPACH MAP

Locality	Author	Publication	Date
WYOMING			
S.W. Wind River Mtns.	Love, J. D.	Wyoming Geol. Assoc. 5th Ann. Field Conf.	1950
IDAHO			
Soda Springs	Armstrong, F. C.	(Chart), Intermountain Assoc. Pet. Geol., 4th Ann. Field Conf.	1953
Mink Creek	Keller	Thesis, Univ. of Utah	1952
UTAH			
Southern Malad Range	Coulter, H. W.	Idaho Bureau of Mines and Geol., Pamphlet 107	1956
Blacksmith Fork	Williams, J. Stewart	G.S.A. Bull. v. 59	1948
Promontory Range	Olson, R. H.	Guidebook to Geol. of Utah, No. 11	1956
Promontory Range	Olson, R. H.	Private communication	1957
No. Silver Island Range	Anderson, W. L.	Thesis, Univ. of Utah	1957
So. Silver Island Range	Schaeffer, F. E., Jr.	Private communication	1957
Southern Lake-side Mtns.	Young, J. C.	Utah Geol. and Mineral. Survey, Bull. 56	1955
Salt Lake (Cottonwood)	Granger, A. E.	U. S. Geol. Survey, Circ. 296	1953
Lodore	Untermann, G. E. and B. R.	Utah Geol. and Mineral. Survey, Bull. 42	1954
Oquirrh Mtns.	Gilluly, James	U. S. Geol. Survey, Prof. Paper 173	1932
Deep Creek Mountains	Nolan, T. B.	U. S. Geol. Survey, Prof. Paper 177	1935
Sheeprock Mountains	Cohenour, R. E.	This paper	1957
East Tintic Mountains	Lindgren, W., and Loughlin, G. F.	U. S. Geol. Survey, Prof. Paper 107	1919

TABLE 2 - SOURCES OF INFORMATION FOR CAMBRIAN SYSTEM ISOPACH MAP

Locality	Author	Publication	Date
UTAH (cont'd.)			
Long Ridge	Muessig, Siegfried, J.	Thesis, Ohio State Univ.	1951
Canyon Range	Christiansen, F. W.	Geol. Soc. America Bull. v. 63	1952
House Range	Wheeler, H. E. and Steele, Grant	Guidebook to the Geology of Utah, No. 6	1951
(Well) El Paso Nat. Gas #1 Packsaddle; (Well) Stan. Oil of Calif. and Continental Oil; (Well) South Last Chance; (Well) Pac. Western #1 Teasdale; (Well) Hunt Oil; (Well) Nokai-Skelly	Wells, Lewis F.	Intermountain Assoc. Pet. Geol., 5th Ann. Field Conf.	1954
Beaver Dam Mountains	McNair, A. H.	Guidebook to the Geology of Utah, No. 7	1952
NEVADA			
Mountain City area	Cohenour, R. E.	U. S. Atomic Energy Comm.	Unpublished
Eureka	Nolan, T. B., Merriam, C. W., and Williams, J. S.	U. S. Geol. Survey Prof. Paper 276	1956
Southern Snake Range	Drewes, H., and Palmer, A. R.	Amer. Assoc. Pet. Geol., Bull. v. 41	1957
Pioche	Wheeler, H. E.	Univ. of Nevada Bull., v. 34, no. 8	1940
Virgin Mtns.	McNair, A. H.	Amer. Assoc. Pet. Geol, Bull. v. 35	1951
Frenchman Mountain	McNair, A. H.	Guidebook to the Geol. of Utah, No. 7	1952
CALIFORNIA			
Nopah Area	Hazzard, J. C.	Calif. Jour. of Mines & Geol., v. 33	1937

Cambrian times, was not so negative as the Sheeprock area during the same time interval. This could possibly erase any semblance of lithogenic correlations, but would not necessarily destroy faunal correlations.

The isopach map of Cambrian strata above the basal quartzite (fig. 4) was prepared to show the features of the Cambrian geosyncline and as an aid to correlation. The Sheeprock section occupies a position within the deeper portions of the trough and, for this reason, the writer correlated the Sheeprock strata with the House Range section. As is apparent, a more logical correlation would have been with the Deep Creek section; however, the Cambrian of the Deep Creek Mountains has not been sufficiently subdivided and dated, and therefore, terminology from that area was not used. The East Tintic Mountains and the Oquirrh Mountains sections both appear to be in areas marginal to the deeper troughs. The section in the southern Snake Range (Drewes and Palmer, 1957) indicates that a southwest- to northwest-trending element may parallel and divide the deeper trough between the Pioche and the House Range sections. Further, there appears to be an east-west element forming as a salient from the Wasatch Mountains as an extension of the east-to-west trend of the Uinta Mountains. The writer proposes that this prominence be named the "Stansbury Salient" because of its direction through Stansbury Island. The isopachous map of the Ordovician quartzites (fig. 5) substantiates the presence of the aforementioned elements. The Ordovician quartzites are deepest in areas where the Cambrian trough was best developed and are considered to be a manifestation of differential compaction of the Cambrian strata in a region of slight epirogenic uplift.

The carbonate-shale sequence of the Sheeprock Range totals 5,700 feet and should contain strata similar to the strata of the deeper parts of the Cambrian trough, namely the House and Deep Creek (Gold Hill) Mountains sections. The Cambrian carbonates of the southern Oquirrh Mountains (Stockton) total 2,250± feet in thickness, whereas those represented in the East Tintic Mountains (Tintic district) aggregate approximately 3,260 feet. Both the Stockton and Tintic sections are more representative of that part of a basin nearer the shelf area, especially during Early and Middle Cambrian time.

Gilluly (1932, p.11) writes the following regarding age and correlation of the Ophir formation:

> . . . Fossils from the Ophir formation, collected from schistose beds less than 50 feet above the base, were submitted to Dr. C. E. Resser of the Smithsonian Institution, who reports as follows:
>
> > Localities 4 and 6 contain a Middle Cambrian fauna which is characterized by _Dolichometopus productus_. Collection 5 seems to have a specimen of Neolenus. All of this Ophir shale group is represented in the nearby Wasatch and elsewhere, occupying a position below the middle of the Middle Cambrian.
>
> Walcott (1912, pp. 164, 165) lists the following fossils from the Ophir formation at Ophir. About 75 feet above the quartzitic sandstones of the Cambrian:
>
> > _Obolus (Westonia) ella_
> > Concretionary limestone about 100 feet above the quartzitic sandstones of the Cambrian:
> > _Micromitra_ sp.
> > _Micromitra (Paterina) labradorica utahnensis_
> > _Obolus (Westonia) ella_
> > _Olenoides_ (?)
>
> These are all assigned to the Middle Cambrian. However, in discussing the Cambrian of Utah, Walcott (1891, pp. 319-320) stated:

> The section in the Oquirrh Range above Ophir City has a quartzite at the base with shale above it carrying *Lingulella ella*, *Olenellus gilberti*, and *Bathyuriscus producta* as determined by the collection brought in by the Wheeler Survey. It is possible, however, that as in the case of the Big Cottonwood section, *Olenellus gilberti* occurs at the base of the shale, and the other two species at a higher horizon.
>
> . . . On this basis, the Ophir formation is in part Lower Cambrian and in part Middle Cambrian in age. Diligent search during this survey failed to reveal any specimens of *Olenellus*, so that it is impossible to say how much is Lower and how much is Middle Cambrian. The fossils ascribed to the Middle Cambrian by Dr. Resser were collected within 50 feet of the base of the formation so that if Lower Cambrian is present, it includes less than this thickness of Ophir beds. Careful search failed to reveal any sharp lithologic change or any unconformity within this interval. The schistose material discussed above extends higher than this, so that the absence of schistosity in the topmost part of the formation and its presence toward the base cannot be considered evidence of a significant difference in the age of these beds. Accordingly, either sedimentation was here continuous between Lower and Middle Cambrian time, or *Olenellus* survived into the Middle Cambrian, as was stated by Ulrich (1911, pp. 619-620) to be true in the Appalachian region. The only other possible interpretation is that an unconformity really is present but escaped observation. If so, it is not marked by notable erosion, angular discordance, or sharp lithologic differences, and the writer believes it is exceedingly improbable that one exists.

In the Sheeprock Mountains a trilobite(?) track was found 40 feet above the base of the Pioche shale in material similar to that of the Ophir formation in the Oquirrh Mountains, with the exception that at the Sheeprock section the material is abundantly fucoidal. The next faunule in the Sheeprock Mountains was collected 351 feet above the top of the Tintic quartzite, in a limestone unit within the strata assigned to the Busby formation. The fauna is most characteristic of the *Albertella* zone of the standard section. All Cambrian faunal correlations were made in accordance with the standard correlation chart (Howell, et al., 1944). The standard correlation chart was used because of the present disagreement in the zonation of the Cambrian in the western United States.

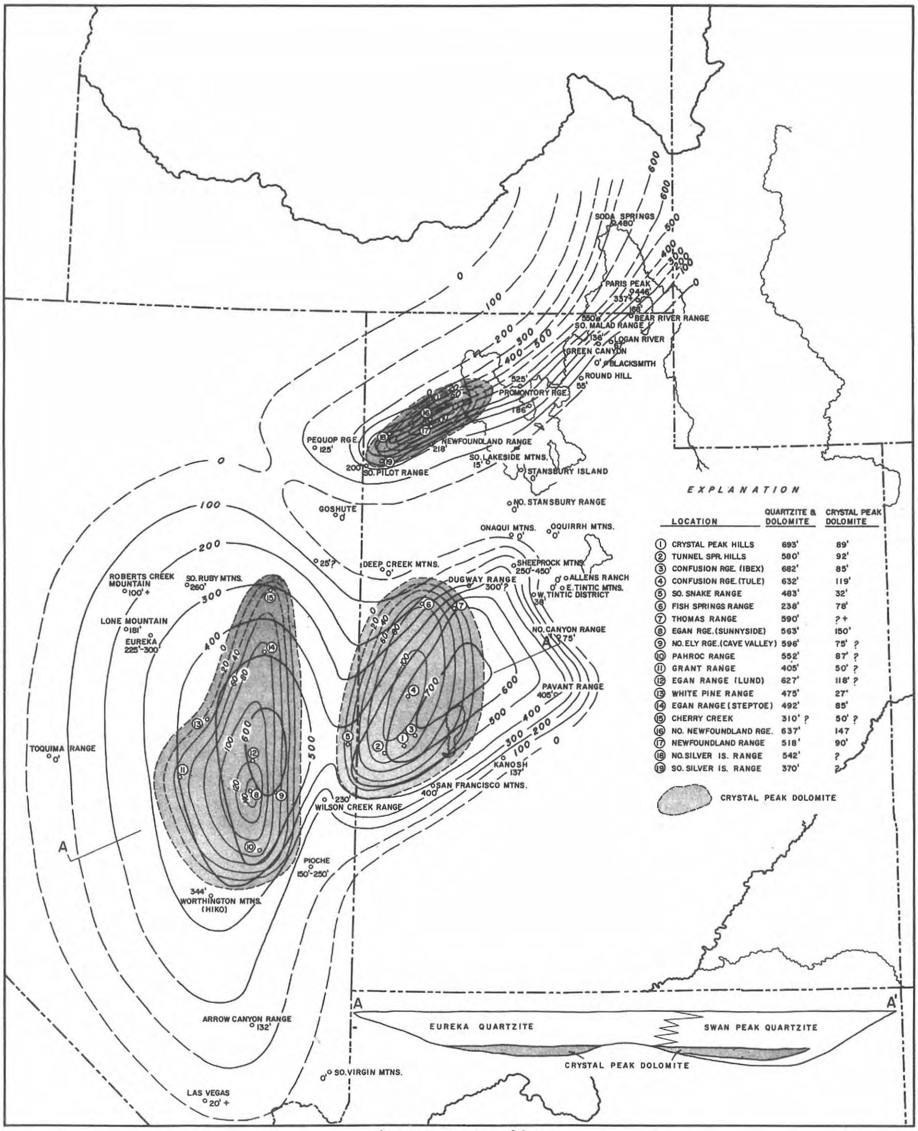
No unconformity could be demonstrated within the shale sequence below the *Albertella* zone nor in the carbonates above.

The fossils are present in limestones of the Busby formation overlying about 30 feet of grayish-tan dolomite, also of the Busby formation. However, both east and west of the fossil locality a 30- to 50-foot dark reddish-brown quartzite overlies the dolomite. Whether or not the quartzites represent an unconformity could not be demonstrated. They do indicate that a source was nearby and that the source was positive in earliest medial Cambrian. The writer believes that this positive area was either to the north or east but recognizes that it may have been local, since only 60 to 90 feet of relief need be available to provide an exposure of Tintic. McKee (1945) has demonstrated that temporary regression is in the main responsible for the formation of stray quartzites. The fossils recovered by Gilluly form the Ophir shales are most likely representative of the *Albertella* or a younger zone. If this is true for material collected 50 feet above the base of the Ophir in the Oquirrh Mountains, and if the assignment of the older *Albertella* zone for material procured 351 feet above its stratigraphic equivalent in the Sheeprocks is valid, then it would be most logical to assume that a highland or promontory existed northeast of the Sheeprock Mountains in early Middle Cambrian time. A highland is necessary because the fauna found by Gilluly not only represents a younger faunal zone, but also one which is 50 feet above the Tintic quartzite, whereas the Sheeprock fauna is older and is 350 feet above the Tintic. The writer guesses that the highland immediately affecting the Sheeprock sedimentary environments was most likely a peninsula-like prominence which extended from the Wasatch shelf area westward toward Gold Hill. This proposed headland or relatively positive area most likely partially separated the eastern part of the Cordillero-Cambrian trough into northern and southern embayments with relatively deep (isostatically negative) connections through the Gold Hill region. If this is valid, then it would seem that the Blacksmith Fork and northern Utah early Middle Cambrian strata would be lithologically and faunally more like the House Range section than either the Cambrian strata of the Oquirrh Mountains or the Central Wasatch Mountains. This condition of similarity would exist until the salient was erased which probably occurred in late Middle Cambrian time. By late Middle Cambrian time similar environmental conditions prevailed over the entire area. The writer believes that such an environment, which persisted during Wheeler time, must have been effective over a wide area. The Wheeler, to possess its bedding parallelism (varves), either had to be deposited below wave base or else conditions were extremely quiet (no wind). Total thickness of the Upper Cambrian strata indicates that all of the sections were receiving sediments at nearly the same rate excepting those thicker sections which possessed a "momentum-of-sinking" probably because of an earlier start and a greater weight of sediments (the weight of the sediments acting isostatically and promoting differential compaction). In light of present day weather phenomena, it would seem unreasonable to assume that a condition of violent weather could persist locally without affecting the sedimentary environment of vast portions of the surrounding area. This is especially significant since laminae usually indicate inundation and quiescence. The oolites present in the Dagmar limestone and the Hartmann limestone would merely indicate shallower water with sufficient current and wave activity to allow the CO_2 to escape and to disturb, by rolling, the nuclei of carbonate deposition.

During Late Cambrian time the physical and chemical factors effecting sedimentation were similar for most of the geosynclinal area; consequently, correlation of strata by lithology and paleontology should be more accurate.

CAMBRIAN-ORDOVICIAN CONTACT

The Cambrian-Ordovician boundary in the Sheeprock Mountains appears to be conformable and marked by continuous sedimentation across the time line. The chosen contact is sharp and is placed at the top of the darker, more massive, crystalline dolomite of the Ajax. The Ordovician, House limestone, is a blue-gray, medium-bedded, intraformational limestone. Sufficient contrast in both texture and color exists to enable one to differentiate the two wherever they are found. The House limestone contains silt and a little chert in its basal units, whereas the uppermost strata of the Ajax are massive, chertless, and indistinctly laminated. The Cambrian-Ordovician contact was chosen on the basis of differing lithologies which seems to correlate with those observed in the East Tintic Mountains between the Ajax and the Opohonga limestone of Early Ordovician age. In the miogeosynclinal facies of the Lower Ordovician formations of Utah, the Pogonip group and the more northerly Garden City limestone both contain a great thickness of intraformational conglomerates (relative to any rock systems before or since Lower Ordovician in the eastern Basin and Range province). Therefore, on the basis of similar lithology between proven Ordovician (Canadian) sections in both the Confusion Basin and northern Utah, the basal Ordovician strata were recognized.



ISOPACH MAP
OF MIDDLE ORDOVICIAN QUARTZITES

FIGURE 5

TABLE 3 - SOURCES OF INFORMATION FOR MIDDLE ORDOVICIAN ISOPACH MAP

Locality	Author	Publication	Date
IDAHO			
Soda Springs	Armstrong, F. C.	Intermountain Assoc. Petrol. Geol., 4th Ann. Field Conf.	1953
Paris Peak	Coulter, H. W.	Idaho Bureau of Mines and Geology, Pamphlet 107	1956
Locality 337'+	Bright, R. C.	Private communication	1957
NEVADA			
Pequop	Stokes, W. L.	Private communication	1956
Goshute	Stokes, W. L.	Private communication	1956
Locality 25'?	Stokes, W. L.	Private communication	1956
Roberts Creek Mountain	Merriam, C. W.	Geol. Soc. Amer. Spec. Paper 25	1940
Southern Ruby Mountains	Webb, G. W.	Utah Geol. & Mineral. Survey, Bull. 57	1956
Cherry Creek	Stokes, W. L.	Private communication	1956
White Pine Range	Webb, G. W.	Utah Geol. & Mineral. Survey, Bull. 57	1956
Southern Snake Range	Webb, G. W.	Utah Geol. & Mineral. Survey, Bull. 57	1956
Egan Range (Lund)	Webb, G. W.	Utah Geol. & Mineral. Survey, Bull. 57	1956
Grant Range	Webb, G. W.	Utah Geol. & Mineral. Survey, Bull. 57	1956
Egan Range (Sunnyside)	Webb, G. W.	Utah Geol. & Mineral. Survey, Bull. 57	1956
North Ely Range (Cave Valley)	Webb, G. W.	Utah Geol. & Mineral. Survey, Bull. 57	1956
Wilson Creek	Sharp, B. J. and Myerson, B. L.	U. S. Atomic Energy Commission, RME-2048 (Rev.)	1956
Pahroc Range	Webb, G. W.	Utah Geol. & Mineral. Survey, Bull. 57	1956
Pioche	Westgate, L. G. and Knopf, Adolph	U. S. Geol. Survey, Prof. Paper 171	1932

TABLE 3 - SOURCES OF INFORMATION FOR MIDDLE ORDOVICIAN ISOPACH MAP

Locality	Author	Publication	Date
NEVADA (cont'd.)			
Worthington Mtns. (Hiko)	Webb, G. W.	Utah Geol. & Mineral. Survey, Bull. 57	1956
Arrow Canyon Range	Webb, G. W.	Utah Geol. & Mineral. Survey, Bull. 57	1956
Las Vegas Quad.	Kirk, Edwin via Longwell, C. R.	Amer. Jour. Sci.	1933
South Virgin Mountains	Bowyer, B.	Private communication	1957
South edge of map	Longwell, C. R.	Guidebook to the Geol. of Utah, No. 7	1952
UTAH			
Bear River Range	Richardson, G. S.	U. S. Geol. Survey, Bull. 923	1941
Southern Malad Range	Hanson, A. M.	Thesis, Univ. of Wisconsin	1949
Logan River	Ross, R. J., Jr.	Peabody Mus. of Nat. History, Bull. 6	1951
Green Canyon	Ross, R. J., Jr.	Peabody Mus. of Nat. History, Bull. 6	1951
Blacksmith Fork	Ross, R. J., Jr.	"	1951
Round Hill	Ross, R. J., Jr.	Peabody Mus. of Nat. History, Bull. 6	1951
Promontory Range, 525'	Olson, R. H.	Guidebook to the Geol. of Utah, No. 11	1956
Promontory Range, 186'	Olson, R. H.	Private communication	1957
Newfoundland Range	Paddock, R. E.	Thesis, Univ. of Utah	1956
Silver Island Range	Schaeffer, F. E., Jr.	Private communication	1957
Southern Pilot Range	Stokes, W. L.	Private communication	1956
Southern Lakeside Mountains	Young, J. C.	Utah Geol. & Mineral. Survey, Bull. 56	1956

TABLE 3 - SOURCES OF INFORMATION FOR MIDDLE ORDOVICIAN ISOPACH MAP

Locality	Author	Publication	Date
UTAH (cont'd)			
Stansbury Island	Webb, G. W.	Utah Geol. and Mineral. Survey, Bull. 57	1956
Northern Stansbury Range	Webb, G. W.	Utah Geol. and Mineral. Survey, Bull. 57	1956
Oquirrh Mountains	Gilluly, James	U. S. Geol. Survey Prof. Paper 173	1932
Onaqui Mountains	Croft, M. G.	Brigham Young Univ. Research Studies, Geol. Ser. v. 3, no. 1	1956
Sheeprock Mountains	Cohenour, R. E.	This paper	1957
Allen's Ranch	Proctor, P. D. et al.	U. S. Geol. Survey, Map MF-45	1956
East Tintic Mountains	Lindgren, W., and Loughlin, G. F.	U. S. Geol. Survey, Prof. Paper 107	1919
West Tintic	Gardner, W.	Thesis, Univ. of Utah	1954
Dugway Range	Kirk, Edwin	Am. Jour. Sci.	1933
Deep Creek Mountains	Nolan, T. B.	U. S. Geol. Survey, Prof. Paper 177	1935
Fish Springs Range	Webb, G. W.	Utah Geol. and Mineral. Survey, Bull. 57	1956
Thomas Range	Webb, G. W.	Utah Geol. and Mineral. Survey, Bull. 57	1956
Northern Canyon Range	Stokes, W. L.	Private communication	1956
Confusion Range	Webb, G. W.	Utah Geol. & Mineral. Survey, Bull. 57	1956
Confusion Range	Webb, G. W.	Utah Geol. and Mineral. Survey, Bull. 57	1956
Crystal Peak Hills	Webb, G. W.	Utah Geol. and Mineral. Survey, Bull. 57	1956
Tunnel Spring Hills	Webb, G. W.	Utah Geol. and Mineral. Survey, Bull. 57	1956
Kanosh	Webb, G. W.	Utah Geol. and Mineral. Survey, Bull. 57	1956
San Francisco Mountains	Stokes, W. L.	Private communication	1956

O R D O V I C I A N   S Y S T E M

GENERAL STATEMENT

The Ordovician system is represented by over 3,086 feet of strata. Limestone, dolomite, quartzite, and shale represent the system and are in the same order of abundance. The lower part of the system is nearly all limestone and represents the thickest portion of Ordovician rocks in the area. Five formations are recognized as mappable units and were correlated with the Tintic and Ibex Hills sections. Capping the limes is a shale which, together with the upper portion of the underlying limestone, is the most fossiliferous stratum in the Ordovician. Between 200 and 400 feet of quartzite overlies the shale and is in turn conformably overlain by the dark, cherty Upper Ordovician dolomites, which grade into the lighter magnesium rocks tentatively assigned to the Silurian.

Ordovician terminology is confusing. The Pogonip, Chokecherry, Garden City, Opohonga, and four newly named formations from the Ibex area all appear to correlate with the Sheeprock section. The Sheeprock Mountain region represents the hub into which these names are converging--all may be recognized. Several courses may be followed: (1) abandon all previous names and propose new ones, (2) accept one or more of the previously used names, or (3) consider the strata as undifferentiated. A new name would only add more confusion to the problem.

Pogonip, the oldest name, was used because it included Upper Cambrian in its lower part; however, Pogonip "restricted" would apply if the Sheeprock sequence could not be clearly subdivided.

Chokecherry dolomite cannot correlate because it represents only a part of the Lower Ordovician in question, having an unconformity at the top. Furthermore, lack of adequate paleontology leaves dating of the Chokecherry very questionable. The formation may be in part Upper Cambrian.

The term Opohonga limestone is also undesirable because of an unconformity at the top of the unit in the area of the type section (East Tintic Mountains). The Garden City represents a longer span but is not subdivided, except paleontologically, and is excluded.

The Ibex section, which includes the House, Fillmore, Wah Wah, and Juab limestones, is probably the best group with which to correlate since the section is lithologically subdivided and adequately zoned by trilobites. Except for the presence of chert, the House and Fillmore limestones are difficult to differentiate in the Sheeprock area. Distinctive recognizable fossils were not found in this interval, but the writer believes the interval can be zoned by careful collection and study. The upper two formations are easily recognized lithologically and the contacts can be easily traced.

The Swan Peak-Eureka quartzite was isopached (fig. 5) for various localities in Utah, Nevada, and Idaho. Included with the thickness of quartzite is the Crystal Peak dolomite. The isopachous lines appear to follow troughs of the Cambrian and Lower Ordovician intervals. The writer believes that this thickness is more of a reflection of the differential compaction of the thicker pre-existing rocks of Cambrian and Ordovician times than it is of a negative tendency of the geosyncline.

Fish Haven lithology was easily recognized and can be traced with ease. However, the Fish Haven-Laketown contact is placed only by arbitrary decision.

PLATE XVIII

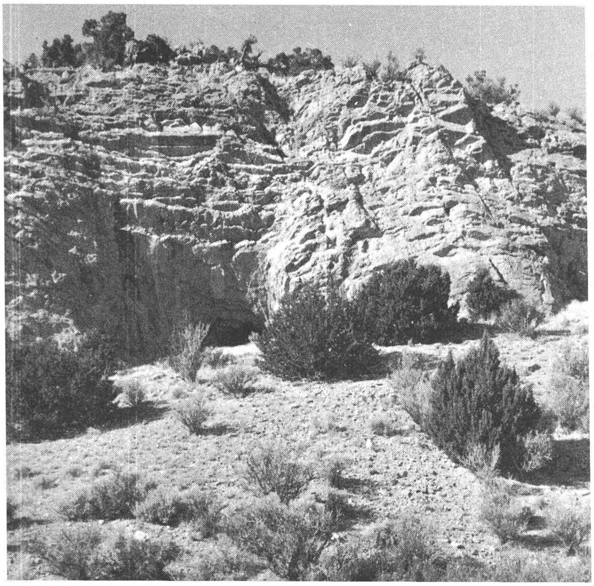


Figure 1
View of the House limestone in the West Lookout Hills conformably overlying the covered Upper Cambrian, Ajax dolomite in the foreground.

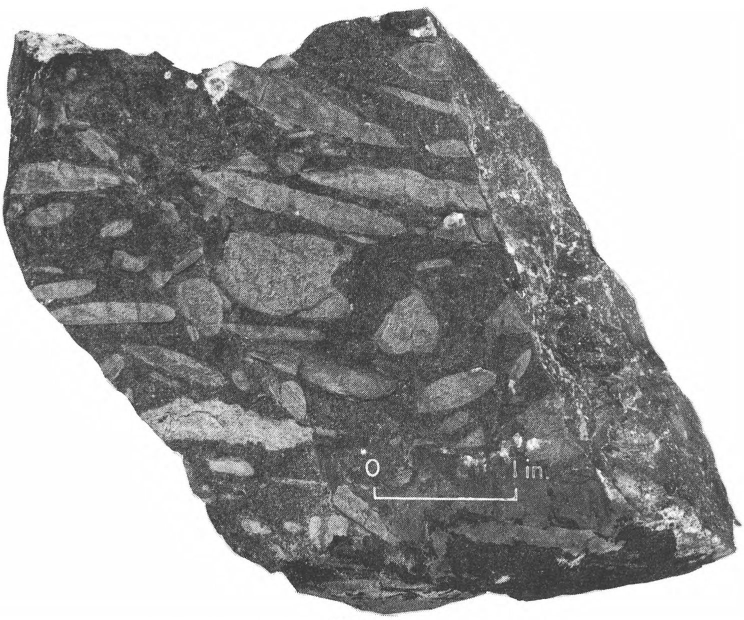


Figure 2
Hand specimen of the intraformational limestone conglomerate from the House and Fillmore formations.

HOUSE AND FILLMORE FORMATIONS UNDIFFERENTIATED

Distribution and thickness - The House and Fillmore formations crop out in both the East and West Lookout Hills about one mile north of the south end of the hills. The strata traverse the country in a northwesterly direction and are cut in the West Lookout Hills by several faults. Small outcrops of the upper part of the Fillmore are present in the eastern portion of the Simpson Mountains northwest and west of Black's Ranch.

The House and Fillmore formations were measured in both the East and West Lookout Hills, being 1,111 and 1,088 feet thick, respectively (Appendix A and pls. III and XX).

Topographic expression - The House and Fillmore formations generally are moderately resistant to erosion; the more slabby beds weather to form saddles while more massive beds form ridges and cliffs.

Lithology - The base of the House-Fillmore formation is arbitrarily placed at a point where the thin-bedded, flaggy, blue-gray dolomites of the conformably underlying Ajax formation became calcareous. The basal beds of the House limestone are characteristically slabby with tan silty mottling and slightly undulatory partings and resemble much of the strata in the upper part of the Opex formation. Some intraformational conglomerate beds are present. Though the House and Fillmore limestones were not differentiated and mapped as separate units, the writer believes that the House limestone probably represents the lower 160 feet of the 1,088 feet of strata assigned to the House-Fillmore sequence. The top (?) of the House limestone is represented by 23 feet of medium-bedded, blue-gray, cherty limestones. The cherts are smooth and rounded; they are gray when fresh, tan when weathered.

Intraformational conglomerates comprise over 80 percent of the remaining 928 feet of the House-Fillmore sequence (pl. XVIII). Generally these conglomerates are medium-bedded with some thin beds. Close inspection is necessary to detect the intraformational character of many of the beds. Near the top, poorly preserved trilobite parts and unidentifiable gastropod and brachiopod fragments are present, especially in a calcareous, silty, pink, fine-grained matrix. Nearly all the pebbles in these conglomerates are tabular with rounded edges both in section and plan views, and many of the pebbles are thin and their bedding can be matched with the bedding in adjacent pebbles.

Field identification - Intraformational limestone conglomerates are more prominent and numerous in the House and Fillmore formations than in any other strata in the Sheeprock region. Characteristically the pebble constituents are tabular with rounded edges and are either a lighter or darker gray than the enclosing matrix which is usually finer grained. The upper part of the House strata contains a little pinkish chert which occurs as small longitudinal masses seldom over one inch thick. Fragments of fossils can be observed within the matrix of many of the conglomerates. The Ajax formation conformably underlies the House formation and is blue-gray to gray, flaggy, medium-grained dolomite having generally wavy bedding planes. The Fillmore formation grades into the conformably overlying Wah Wah formation which is recognized by its generally darker coloration, being more tan and sandy with an abundance of reddish silts.

Age and correlation - Fossils were recovered at four localities from the House-Fillmore strata (Appendix B and pl. III). Unidentifiable crinoid stems with brachiopod, gastropod, and trilobite fragments were recovered.

R. C. Bright identified the following:

O-2, near the top of the formation
Pseudocybele sp.
Orthis sp.
Ophileta-like gastropod
Cystoid columnals - plates

The presence of *Pseudocybele* sp. indicates that this zone is equivalent to the H, I, or J zones of Hintze (1952). Hintze's zones B through K range in age from Lower to Upper Canadian. The House-Fillmore formation is equivalent in age to most of the Garden City formation of Richardson (1913) in northeastern Utah and to most of the lower half of the Pogonip group, namely the Goodwin limestone and part of the Nine Mile formation of Nolan, Merriam, and Williams (1956) of the Eureka, Nevada area. The Opohonga limestone of Loughlin (1919) of the Tintic district, Utah, is probably equivalent to part of the House and Fillmore formations in the Sheeprock Mountains.

WAH WAH FORMATION

Distribution and thickness - The Wah Wah formation crops out north of the Fillmore formation in a band about 300 feet wide in the East and West Lookout Hills. Regional dip is north and northeast, and faulting has displaced the unit to the north in the West Lookout Hills. Small areas of the formation are exposed in the Simpson Mountains west and northeast of Black's Ranch.

Measurements of the Wah Wah formation indicated 456 feet in the East Lookout Hills and 475 feet in the West Lookout Hills (Appendix A and pl. III). No thinning was noted in the Sheeprock-Simpson area.

Topographic expression - Sands within the Wah Wah formation, together with some secondary chert, enable the formation to resist erosion. Except on slopes defended by the Swan Peak quartzites, the Wah Wah beds are always ridge-makers and because of their brown color may be mistaken for quartzite from a distance.

Lithology - The base of the Wah Wah limestone conformably overlies and is gradational with the top of the Fillmore limestone. The contact was selected where the intraformational conglomerate of the Fillmore changes to a series of dark gray to gray, medium-grained, medium-bedded, sandy limestones.

The entire sequence is sandy with the proportion of sand increasing toward the top. Steps and small cliffs are a characteristic expression of this lithology, which, from a distance, resembles sandstone. The sand and calcarenite granules increase to over 50 percent of the total material in the upper 50 to 60 feet, the exposures weather to form shallow holes in a brown outcrop and can be easily mistaken for a relatively pure sandstone on superficial examination. Many of the arenite granules are aligned essentially parallel with the bedding while others display a very low-angle, cross-bedded relationship. Few intraformational conglomerate beds are present in the formation.

Field identification - The Wah Wah formation is readily recognized by its brown weathering sandy surfaces. Many small brachiopods and unidentifiable trilobites are present in the more silty beds. Near the base are a few intraformational conglomerates, but the larger part of the strata consists of medium-bedded, silty and sandy blue-gray limestones. The conformably overlying platy limestones of the Juab formation always form dip slopes with the uppermost beds of the Wah Wah in highest relief. Some of the more sandy beds weather to form longitudinal holes, and the rock appears to be a limy sandstone.

Age and correlation - Fauna was collected from two localities (Appendix B, pl. III) in the Wah Wah formation. R. C. Bright identified the following:

0-6
Hesperonomia cf. *H. fontinalis*
Maclurites sp.

The Wah Wah is of Canadian age.

The Wah Wah formation is the approximate age equivalent of the upper part of the Garden City formation in northern Utah and of the upper half of the Nine Mile formation of Eureka, Nevada.

JUAB FORMATION

Distribution and thickness - The Juab formation conformably overlies the Wah Wah formation. The Juab strikes northwest and west in a band about 200 feet wide through the central portions of the East and West Lookout Hills. As with the House, Fillmore, and Wah Wah formations, faulting also displaces the Juab formation northward. In the area northwest, west, and southwest of Black's Ranch in the Simpson Mountains, an occasional exposure is seen on the slopes protected by the overlying Swan Peak quartzite. Though covered, a small area northwest of Clinger's mine, in the head of South Oak Brush Creek, is present but terminated to the west by normal faulting which places it in contact with Devonian beds.

The Juab formation was measured in the East and West Lookout Hills and was 161 feet and 204 feet, respectively.

Topographic expression - The Juab formation weathers readily to form saddles and covered slopes; the overlying Kanosh shale debris nearly everywhere conceals the Juab. In the Lookout Hills area, the Juab strata form gently inclined, north-facing dip slopes south of saddles marking the overlying shales.

Lithology - The basal contact of the Juab formation is gradational and is placed where the medium- to thick-bedded, conformably underlying beds of the Wah Wah limestone became thin and slabby and contain a greater abundance of silt and shaly material between the one half to one inch thick beds of blue-gray limestone. The top of the Wah Wah is sandy, more massive, and weathers to form ledges.

About 100 feet above the base is a 5-foot bed of calcareous sandstone. The beds of the main bulk of the formation are thin-bedded, slabby, medium-grained, sandy, blue-gray limestones. Bedding is undulatory and lensing is prominent.

The Juab grades into the conformably overlying Kanosh shale, but at all places this zone is more or less covered. The top was arbitrarily placed between definite Juab and distinct Kanosh shale or at the break of the saddle occupied by the Kanosh shale. Near the top many silicified brachiopods were collected.

Field identification - The Juab formation is poorly exposed, being covered by its own debris and that of the Kanosh shale. Weathering is generally deep, and only a few exposures are available for study. For the most part the Juab can be recognized by the abundance of small white brachiopods in a silty and slabby limestone. The low slope between the Kanosh saddles and the Wah Wah ridge servesto delineate the formation.

Age and correlation - Three localities (Appendix B, pl. III) from the Juab formation yielded fossils which were examined by R. C. Bright, who reports as follows:

0-3
Orthambonites subalata
Orthambonites sp.
Anomalorthis sp.
Lingula sp.
Ostracods - *Macronotella*-like
Receptaculites ellipticus

0-7
Orthambonites subalata

0-15
Orthambonites subalata
Gastropods

The presence of *orthambonites subalata* indicates that the Juab formation is Chazyan in age.

The Juab formation is the approximate age equivalent of the uppermost units of the Garden City formation in northern Utah and to the lower portions of the Antelope Valley limestone of Nolan, Merriam, and Williams (1956) in the vicinity of Eureka, Nevada.

KANOSH SHALE

Distribution and thickness - The Kanosh shale is very poorly exposed being hidden beneath either soil or float from the overlying Swan Peak quartzite. No complete exposure was found in the Sheeprock or Simpson Mountains. This shale is present in its entirety in the East and West Lookout Hills as a narrow band dipping beneath the cliff-forming Swan Peak quartzite.

A total of 205 feet of the shale was measured in the East Lookout Hills area, but this may be in considerable error because neither the top nor bottom is exposed. The Kanosh shale may be up to 400 feet thick in the Simpson Mountains, but, being obscured, it was not measured.

Topographic expression - The Kanosh shale weathers readily to form saddles and slopes and is never found in positive relief.

Lithology - The base of the Kanosh shale appears to be gradational with and conformably above the Juab limestone. The platy limes of the Juab gradually become more and more shaly, but the base of the Kanosh is everywhere covered. The dip slope or break of the saddle between the Juab and Swan Peak quartzites affords a means for determining the contact.

Except near igneous intrusions or extrusions, the Kanosh is a very fissile shale and is usually covered by a thick blanket of soil. Olive drab, maroon, grayish-green, and black are the characteristic colors of the shale. One color predominates at any one locality and the unit cannot be considered as variegated. Trilobites, brachiopods, and graptolites are present.

The top of the shale is characterized by undulatory, thin, platy, lensing limestones which are extremely fossiliferous, bearing brachiopods, trilobites, and *Receptaculites*. The thin, shale-lime sequence gives way to the shale-quartzite strata which mark the top of the Kanosh and the bottom of the Swan Peak quartzite.

Field identification - The Kanosh shale is very fissile and may be black, maroon, or green in color. It can be mistaken lithologically for other shales ranging from Mississippian to Precambrian, but the graptolites which are found in all exposures are diagnostic.

Age and correlation - R. C. Bright examined collections from three localities (Appendix B, pl. III) in the Kanosh shale and reports:

0-14
Didymograptus cf. *D. Artus*

0-16
Trilobite fragments
Anomalorthis sp.
Orthocone cephalopod
Receptaculites sp.

0-22
Eleutherocentrus petersoni
Goniotelus sp.
Lingulella sp.
Lingula sp.
Gastropods
Ostracods
Didymograptus artus
Protocycloceras sp.
Orthocone cephalopods
Modiolopsis sp.

The fauna corresponds to the M zone of Hintze (1951, pp. 18-19) of the lower Kanosh shale.

The Kanosh shale is the approximate age equivalent of the lower part of the Swan Peak formation of Ross (1949) in northeastern Utah, of the upper half of the Antelope Valley limestone of Eureka, Nevada, and of the Orient shale member of the Orient formation in the West Tintic mining district on the eastern edge of the Sheeprock Range (Stringham, 1942, p. 271). It is proposed that the names Orient formation and its subdivision Orient shale and Orient quartzite be supplanted by the Kanosh shale and the Swan Peak quartzite. The beds above the Orient quartzite have been recognized by Gardner (1952) to be units of the Fish Haven dolomite.

SWAN PEAK QUARTZITE

Distribution and thickness - The Swan Peak quartzite is considered to be the best marker bed in the Sheeprock Mountains. It crosses the East and West Lookout Hills in a 300-foot band in a northwesterly direction and is offset to the north in the western foothills. The quartzite is well exposed as a series of jumbled blocks extending from the northwesternmost exposure of the Sheeprock granite westward across Erickson's Pass to the high north-south divide of the central part of the Simpson Mountains.

The Swan Peak measures 462 feet in the East Lookout Hills but is slightly thinner in the Simpson Mountains. No detectable thinning was noted in the Lookout Hills area.

Topographic expression - The Swan Peak always weathers to form prominent ridges and cliffs. The soft, underlying Kanosh shale serves to emphasize the Swan Peak.

PLATE XIX

View of the Swan Peak quartzite in the East Lookout Hills. Note holes which represent poorly cemented parts of rock.

Field identification - The Swan Peak quartzite is medium-grained, ranges from white to tan with a few gray beds near the base, and in places shows cross-bedding. The talus blocks from many of the beds weather easily to form rounded corners; some of the strata are more nearly sandstone than quartzite. Near the base of the unit is a very thin series of gray and buff quartzites containing an abundance of phosphatic shards and debris. Close examination reveals many curved, sliver-like plates of a black material as thin, generally parallel streaks. These fragments weather to light bluish-gray. Included in the same series are many fucoidal quartzites and a few tan, micaceous shales. Everywhere the top of the quartzites is in sharp contact with the dark, cherty Fish Haven dolomites. About 40 feet from the bottom is a 6-foot bed of quartzite that weathers with a swiss cheese texture. Though not universally present, this lithology serves as an aid to identification. The Swan Peak can be mistaken for the Tintic or a Precambrian quartzite if only a limited exposure is seen.

Lithology - The base of the quartzite is covered in most of the outcrop area. However, in the eastward-trending gulch, southwest from the easternmost exposure of the Swan Peak quartzite in the West Lookout Hills, portions of the base with its fucoidal conodont-bearing beds are exposed in the drainage bottom. The basal 60 to 80 feet of the formation are fucoidal and consist mainly of reddish and greenish tinted quartzites with a few beds between two and eight inches of green micaceous shales.

The "phosphatic key bed" weathers to resemble bleached bone. Perhaps a better name would be "conodont bed," but this would imply that conodonts are present only in this horizon which may not be the case, as future paleontologic investigations may prove. The "phosphatic key bed" is very evident wherever the basal Swan Peak was found. Although seldom seen in outcrop, the talus overlying the Kanosh shale has yielded float of the phosphatic bed. The "phosphatic key bed" is a dark brown to red quartzite which some geologists may call a graywacke-like rock. Bedding planes are usually fucoidal containing light pastel green, minutely micaceous shales between the fucoids. Fragments of phosphatic shell material are present in thin layers and as randomly scattered particles in the quartzites. These fragments are small, slightly curved in section, and are usually angular, showing no great amount of wearing and probably indicate limited transportation. They are probably trilobite and brachiopod remains. Occasionally a conodont will be found in this material. The shards weather to a gray-white surface and give portions of the rock a light gray cast, like bleached bone.

The main mass of the Swan Peak quartzite is a well-sorted, well-rounded, pure quartzite. Cross-bedding was noted but is generally absent. Most exposures of the Swan Peak are white to "old ivory" colored orthoquartzites; however, in some places pockets of uncemented sands weather to form holes giving the outcrops a swiss cheese appearance (pl. XIX). Also some of the poorly cemented rocks become rounded, like exfoliated granite.

Age and correlation - One locality in the thin transitional zone between the Kanosh shale and the Swan Peak quartzite yielded the following fossils which were identified by R. C. Bright:

O-17
Conodonts
Oistodus sp. (undescribed fauna)
Stereoconus sp. (undescribed fauna)
Plate-like structures
Fucoids

The Swan Peak Quartzite is Middle Ordovician in age.

The Swan Peak quartzite is the approximate age equivalent to parts of the Swan Peak quartzite and the Eureka quartzite of Webb (1956) in the Ibex Hills area, Utah, to the massive quartzite units of the Swan Peak formations of Richardson (1913) in northeastern Utah, and to the Orient quartzite of the West Tintic district, Utah.

FISH HAVEN DOLOMITE

General statement - Nearly everywhere in the Great Basin province, where the Swan Peak or Eureka quartzite is found, the Fish Haven or a similar dark colored dolomite is present overlying the quartzite. Generally the quartzite-dolomite contact will be locally conformable, but in a few places a slight discordance has been noted. Various investigations have demonstrated the existence of a hiatus at the top of Middle Ordovician which extends to beyond the middle of Late Ordovician time. This interval would seem to indicate a period of little or no erosion or deposition, because it is apparently everywhere present in the western states.

It is possible that erosion was affecting a surface of extremely low relief as evidenced by the presence of the almost continuous blanket of quartzite, which to have survived this extended period of time, must have been relatively untouched. This quiescent period must have been affecting a terrane which not only was positive but must have been of extremely low relief.

The advance of the Fish Haven sea must have been rapid, at least fast enough to inhibit the formation of a normal shale sequence below the carbonate beds.

Distribution and thickness - The Fish Haven dolomite is the most widespread of the Paleozoic formations in the Sheeprock area; small patches are found in the Desert Mountains and many blocks are present in a trend west from the Sheeprock granite across Erickson's Pass and into the high ridges of the Simpson Mountains. The East and West Lookout Hills provide the best exposures. The dark, blue-gray dolomites characteristic of the unit crop out in an 800-foot band extending from the southeast to the northwest at a location slightly north of the center of the hills. Brown's Ridge, in the West Tintic Mountains, consists mainly of Fish Haven dolomite.

In the central part of the East Lookout Hills the Fish Haven is 706 feet thick. The Fish Haven dolomite, as measured by Gardner (1954, pp. 17-18), is 1,280 feet thick in the West Tintic mining district. The thickness does not appear to change in the Simpson Mountains and is between 500 and 700 feet thick, as in East Lookout Hills.

Topographic expression - The Fish Haven dolomite weathers to form ridges and cliffs. In steeply dipping rock sequences a sharp saddle is usually found between the Fish Haven and the underlying quartzites; the top of the Fish Haven forms dip slopes. Many cliffs contain shallow caves at the base which generally mark the top of the more slabby basal beds.

Lithology - The base of the formation appears to be conformable on the Swan Peak quartzite. A disconformity is probably present at this point as the regressive Swan Peak quartzite would seem to indicate. Parallelism between the beds of the Swan Peak quartzite and the Fish Haven dolomite is everywhere present; the basal unit is 128 feet thick and is composed primarily of dark gray, cherty, medium-grained, crystalline dolomite, in beds 4 to 8 inches thick. Many of the tan and black cherts are in bands from 1 to 3 inches thick; others are as elongate nodules. These cherts weather reddish-brown. The basal unit weathers more easily and forms saddles between the more resistant underlying Swan

Peak quartzite and the overlying massive dolomites comprising the bulk of the Fish Haven dolomite.

The greater portion of the Fish Haven consists of dark gray, medium-grain, medium-bedded to massive dolomites. This part is a cliff-forming sequence and comprises about 484 feet of strata. The chert boxwork zones change along strike, in places becoming entirely massive chert; these zones probably do not persist as a reliable mappable unit, except in a general way. Most of the dolomite beds of the Fish Haven weather with a surface texture similar to medium to coarse sandpaper.

Field identification - The Fish Haven is easy to recognize if a fairly large exposure is examined. The chain coral (*Halysites*) was found in every outcrop, but in most instances a diligent search was required, especially in the more cherty zones. The first appearance of crinoid columnals with a five-pointed central canal is in the lower beds of the Fish Haven dolomite. Near the top of the sequence much dark gray to black chert, as beds, nodules, and as boxwork fracture filling, is present; some of the chert occurs as pale pinkish-gray, onion-like masses. Except for the basal beds the Fish Haven weathers very rough and tends to form shallow caves. The light gray, fine-grained Laketown(?) dolomite conformably overlies the dark dolomites of the Fish Haven. The color change and the presence of the bedded cherts serve to establish the contact.

Age and correlation - Fossils were collected from nine localities in the Fish Haven dolomite (Appendix B, pl. III), but all were very poorly preserved. The following forms were identified by the writer:

Halysites cf. *H. catenularia*
Syringopora sp.
Streptelasma sp.
Crinoid columnals
Brachiopod fragments

The Fish Haven dolomite correlates lithologically with dolomites overlying the Middle Ordovician quartzites at numerous localities in the Great Basin. The fauna found in the Sheeprock section is not sufficiently diagnostic to give an exact age. However, the lithology and stratigraphic position of the dolomite leave little doubt that it is the Fish Haven and is of Richmond (Late Ordovician) age.

The Fish Haven correlates with the Hanson Creek formation of Merriam (1940) in Roberts Creek Mountains, Nevada, with the Ely Springs formation of Westgate and Knopf (1932) of the Pioche district, Nevada, and with the lower part of the Blue Bell dolomite of Loughlin (1919) in the Tintic district, Utah. The Blue Bell has been subdivided by Lovering and others (1949) and the Fish Haven portion designated the Eagle dolomite. Mr. H. T. Morris of the U. S. Geological Survey, by oral communication with the writer, verifies the existence of the Fish Haven dolomite at Tintic.

ORDOVICIAN-SILURIAN BOUNDARY

The Ordovician-Silurian boundary within the Cordilleran region is very problematical and indefinite. Most workers separate the Fish Haven dolomite from the Laketown dolomite on the basis of fauna and/or lithology. If fossils are present, the *Pentamerus* brachiopod serves as a guide for the Silurian. Investigators usually choose the next lower lithic unit below the pentameroid-bearing strata as the top of the Ordovician. If diagnostic fossils are absent, a color or textural change may serve as the demarkation. In some areas a color or textural change, though present, may amount to only a few feet of strata. Generally, workers who differentiate the Ordovician from the Silurian entirely by lithology will have thicker Silurian sections than those of nearby areas, where a diagnostic fauna is found.

Richardson (1941, pp. 17-18) in describing the type Fish Haven distinguishes the Ordovician from the Silurian on the basis of color; the Laketown being a light gray to white dolomite, while the Fish Haven is dark gray to blue-black dolomite.

In the Gold Hill area, Nolan (1935, pp. 16-17) separates the Fish Haven dolomite from the Laketown on the basis of Silurian fauna and the presence of dolomite conglomerates and dolomite sands in the basal Laketown, and states:

> . . . the dolomite conglomerate and wavy contact found at the base of the Laketown are no better defined than similar features within many of the lower Paleozoic formations.

A color change is not present in the Gold Hill area, and except for the aforementioned features, the formations blend with each other. The writer spent one day in the Ibapah area near the mouth of Sevy Canyon and noted that the Laketown was dark blue-gray and contained scattered chert about 35 to 400 feet below the top. This cherty zone yielded abundant fossils, including _Favosites_, _Halysites_, pentameroid, and other brachiopods, cup corals, and other coral debris.

In central Utah, Bauer (1952), mapping in the Thomas Range, separates the Fish Haven from the Laketown on the basis of pentameroid brachiopods. At this locality the Fish Haven is light to medium gray, whereas the overlying Laketown is a white crystalline dolomite.

Morris (personal communication, 1956), in a detailed study of the East Tintic area, places the Ordovician-Silurian boundary in a cherty zone, fauna of each period being procured within 20 feet of the chert. The chert is distributed in such a way as to give the unit a "leopard skin" appearance.

In the West Tintic mining district at the southeast end of the Sheeprock Mountains, Gardner (1954, p. 13) arbitrarily distinguished Fish Haven from Laketown by means of a chert zone. He further states, "The usually large thickness of 1,280 feet is undoubtedly due to inclusion of part of the overlying Laketown dolomite in the unit."

Hanson (1949), working in the southern Malad Range in northern Utah, states: The Fish Haven dolomite ". . . is distinguishable from the overlying Laketown dolomite only on the basis of its darker color."

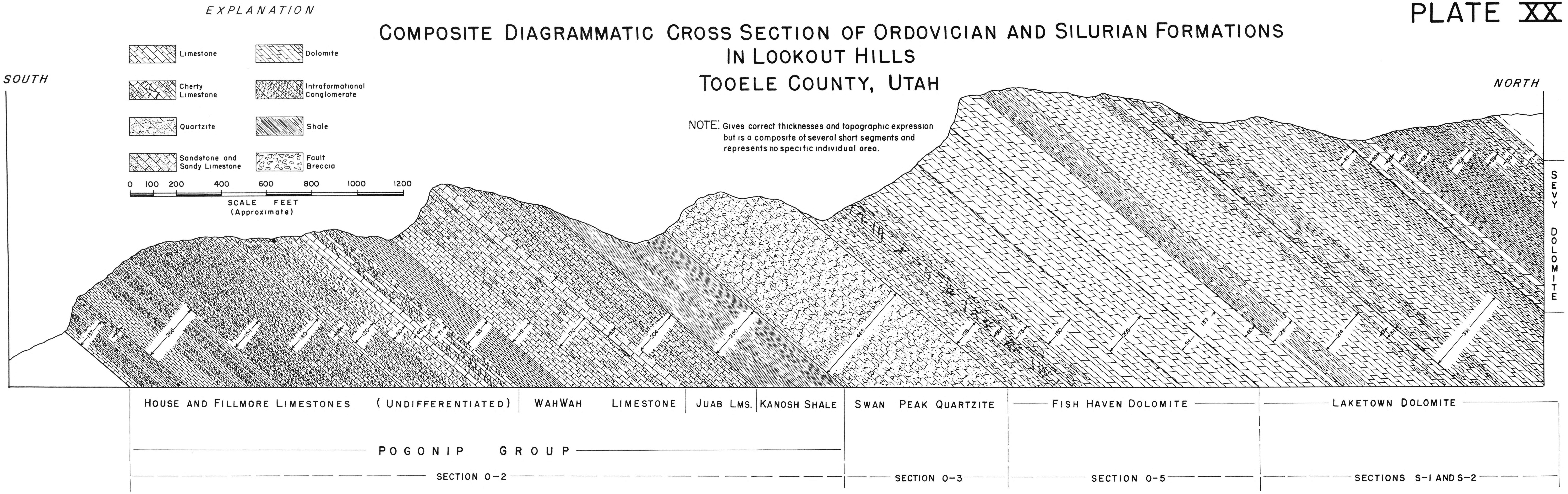
Young (1955, p. 23) admits that the Laketown is difficult to separate from the underlying Fish Haven dolomite and subdivides the two on the presence of pentameroid brachiopods and vugs lined with quartz crystals.

Williams (1948, p. 1137) clearly distinguishes the Ordovician from the Silurian by lithology and fauna in the Logan quadrangle. The Fish Haven is dark neutral gray in contrast with the light gray basal Laketown strata.

The Laketown dolomite varies in lithology from place to place but can generally be divided into two facies. One with light gray lithology predominating is at and around the type section in northern Utah, and the other more southern sections, where dark gray and black strata comprise nearly the entire Silurian system. In the northern Sheeprock area the Silurian is difficult to separate from the Ordovician and as in most other places was distinguished by the presence of the pentameroid brachiopods above a "leopard skin" chert zone, similar to that at Tintic. No marked color change was noted, and the lower part of the Laketown is as dark a gray as the underlying Fish Haven dolomite. Stokes (personal communication, 1956) uses the quartz crystal-lined vugs as a criteria for Laketown lithology in northern Utah.

PLATE XX

Composite Diagrammatic Cross Section of Ordovician and Silurian Formations In Lookout Hills Tooele County, Utah



S I L U R I A N   S Y S T E M

GENERAL STATEMENT

The Silurian system is poorly represented in the Sheeprock-Simpson Mountain region. Beds assigned to the Silurian have few fossils and cannot be positively correlated. Strata totalling 1,001 feet have tentatively been assigned to the Silurian. The Laketown dolomite is the only Silurian formation recognized in the area.

LAKETOWN DOLOMITE

Distribution and thickness - The Silurian rocks crop out in numerous places in the Sheeprock-Simpson region. The most extensive exposure is a nearly continuous band about 1,200 feet wide in the East and the West Lookout Hills area. Silurian strata are present near the granite contact in Elderberry Canyon, north of Clinger's mine, and also approximately three quarters of a mile west of the mine dump. Another exposure in the Simpson Mountains is approximately one mile west of the summit of Erickson's Pass.

Since the upper and lower contacts of the Silurian are indefinite, the thickness of 1,001 feet is only an approximation and is based mostly on a slight lithologic change at the base, and the presence of scattered quartz sand grains in the light gray dolomites at the top. No thinning was detected in the Laketown dolomite; however, Gardner (1954, p. 18) measured 945 feet of the formation in the southern part of the Sheeprock Mountains.

Topographic expression - The Silurian beds weather more easily than the underlying dark, cherty, more crystalline dolomites of the Fish Haven and form slight saddle-like depressions. The apparently conformable overlying Devonian rocks are slightly more resistant than the Silurian and nearly always rise gently from the saddles formed by the Laketown dolomite.

Lithology - The Laketown dolomite is not a distinct unit; the lower half can be easily mistaken for the Fish Haven, whereas the upper half resembles Devonian strata. The lower portion consists mainly of dark gray, medium-grained, crystalline, cherty dolomite. Dolomitization has, except for vague outlines, destroyed the fossils which in some zones are rather prolific. Bedding is from 3 to 8 inches apart with some zones being poorly laminated. Chert is common to abundant, and some strata contain up to 80 percent silica. *Halysites*, *Syringopora*, *Calopaecia*, and small cup corals, along with stromotoporids and pentameroid brachiopods, are found in the lower half of the formation. The upper half is dominantly gray, aphanitic to fine-grained, and contains little chert. This unit is faintly laminated, but on casual examination appears massive. *Favosites* and stromotoporids are present in some of the lowermost of the more dense dolomites. The upper part of the Laketown weathers smooth with a light gray color in contrast with the lower which weathers with "sandpaper" surface and is nearly black. Dolomitized fossils are lighter gray in the black strata and, where silicified, are shades of gray and brown.

The base of the Silurian is taken as the top of a "leopard skin" bed which contains small nodules of rounded chert which weather in relief and resemble leopard hide. This marker bed is not everywhere present as a distinctive unit in the Sheeprock Mountain area.

Field identification - Silurian strata are not sufficiently distinctive to be identified with certainty, if only single outcrops are examined. However, light gray, fine-grained, thin-bedded (many times indistinct) dolomites in thicknesses of more than 25 feet can, in most instances, be considered as Silurian or Devonian. The nature of the formations above and below the Laketown are the surest means of identifying the formation. Both contacts are apparently gradational. The bottom grades into the dark gray, generally granular, cherty (black), Halysites-bearing dolomites of the Fish Haven; the top grades into gray dolomites of nearly identical lithology. However, small rounded sand grains and occasional low-angle, cross-bedded sand streaks distinguish the Devonian.

Age and correlation - Fossils were collected from six localities in the Laketown dolomite (Appendix B, pl. III). R. H. Waite examined four of the collections and reported:

S-3
Camarotoechia sp.

S-4
Halysites sp.
Howellella sp.
Stromotopora sp.
Streptelasma sp.

S-5
Eospirifer? fragments
Douvillian cf. *D. genicalata*

S-6
Halysites sp.
Pentamerus? sp.
Favosites sp.
Stromotopora sp.

The *Douvillina*, according to Waite, is characteristic of the Upper Silurian (Niagara).

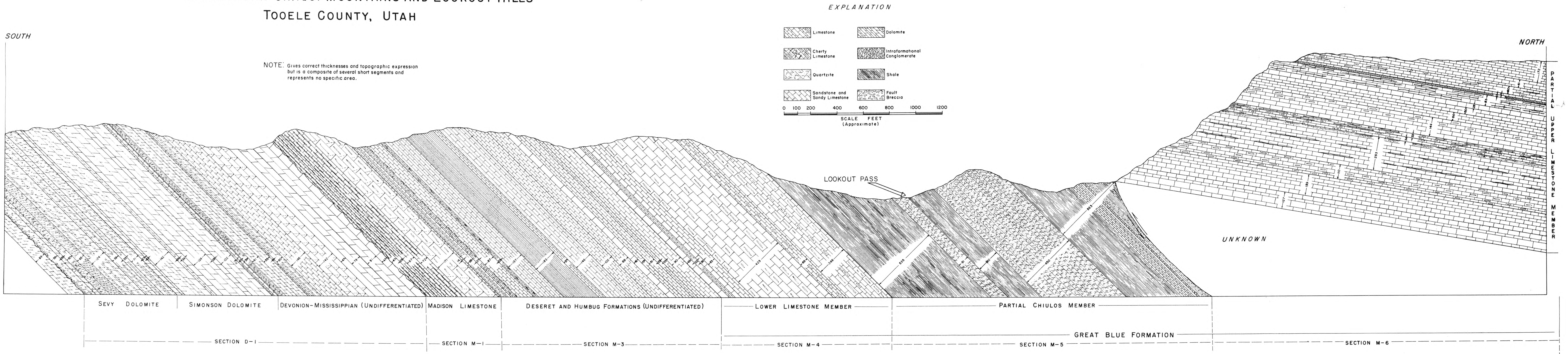
The Laketown dolomite is the approximate age equivalent of part of the Blue Bell dolomite of the Tintic district. The interval later named Beecher dolomite by Lovering (1949) has been recognized by Morris (personal communication) as equivalent to the Laketown dolomite. The Laketown dolomite is the approximate age equivalent to the Roberts Mountain formation and probably part of the Lone Mountain formation (restricted) of Merriam (1940) in the Eureka, Nevada, area; and the Roberts Mountain and Jack Valley formations and the Decathon dolomite of Rush (1956) of western Millard County, Utah.

SILURIAN-DEVONIAN CONTACT

The contact between the Silurian, Laketown dolomite, and the overlying Devonian, Sevy dolomite, is placed at the horizon of the first appearances of minute, round quartz sand grains dispersed in mouse-gray, aphanitic dolomite. The dense dolomite is characteristic of the top of the Laketown and of the entire Sevy. However, sand grains are absent in the upper Laketown beds.

Sections measured in two places across the Silurian-Devonian contact from the Halysites-bearing chert zone in the Laketown to the sand-speckled light gray dolomite of the Sevy vary 197 feet in thickness in a distance of one mile. The eastern section is 480 feet thick. The top of the Laketown in the eastern section is represented by 89 feet of dark gray aphanitic dolomite which weathers light gray with a pinkish tint. No unconformity was detected at the top of the dark gray unit. The eastern section is 283 feet thick, using the same contacts as in the eastern

Composite Diagrammatic Cross Section of Devonian and Mississippian Formations
In Southern Onaqui Mountains and Lookout Hills
Tooele County, Utah



section. The observed difference in thickness may not represent an extensive thinning, but in view of the constancy of the thicknesses of the underlying lower Ordovician limestones, quartzites, and dolomites, it would seem that a short interval across the boundary should not be thinned 40 percent in one mile unless an undetected unconformity is present between the Laketown and Sevy. Dip slope debris covers the upper beds of the Laketown in the western section.

D E V O N I A N   S Y S T E M

GENERAL STATEMENT

The Devonian system is represented by 1,732 feet of strata consisting primarily of dolomite with some limestone and quartzite in the upper portion. Formations representing the Devonian system in the Sheeprock Mountains are correlated with those recognized by Nolan (1935) in the Gold Hill mining district, approximately 66 miles west of the Sheeprock Mountains. Three lithologically distinct formations are present: Lower Devonian(?), Sevy dolomite; Middle Devonian, Simonson dolomite; Upper Devonian(?), Victoria and Pinon Peak formations. They are relatively well exposed in the Lookout Hills. The complexity and metamorphism prevailing in the West Tintic district in the southernmost part of the Sheeprock Mountains preclude correlating the Devonian of the northern Sheeprock Mountains with that area, although lithologies are similar.

SEVY DOLOMITE

Distribution and thickness - The Sevy dolomite is present in two places within the area described in this report. The most extensive outcrop of the formation is an east-west belt approximately 500 feet wide in the central part of the East and West Lookout Hills. A smaller portion of the Sevy crops out as a narrow north-south band about one mile northwest of Clinger's mine in South Oak Brush Canyon.

The Sevy was measured in two places approximately one mile apart in the West Lookout Hills; the eastern section being 491 feet thick, and the western 355 feet thick. The western section is probably in error since the base is covered in the depression between the Laketown and Sevy hogbacks.

Topographic expression - The dense character of the Sevy dolomite makes it especially resistant to weathering, and it forms white hogbacks in both the East and West Lookout Hills. The Sevy weathers to form step-like topography on moderate to steep slopes (pl. XXI).

Lithology - The base of the Sevy is similar in color and texture to the underlying Laketown dolomite but is distinguished by the presence of medium-grained quartz sand in a white weathering mouse-gray aphanitic dolomite. The rock breaks with subconchoidal and splintery fractures and generally weathers to form talus, consisting mainly of small rectangular blocks. Casual examination suggests that the unit is medium-bedded, whereas close observation shows the rock is finely laminated to thin-bedded. The sand grains consisting mainly of gray quartz, range from .3 mm to 1 mm, and are well rounded and frosted. The grains are randomly dispersed in the dense dolomitic groundmass and in most rocks do not show any lineation. In places, however, low-angle cross-bedding is apparent because of the alignment of the sand grains. Throughout the total thickness of the Sevy, the sand grains are very persistent and in places near the top are estimated to comprise as much as 2 percent of the total rock.

Field identification - The Sevy dolomite may be confused with the uppermost beds of the Laketown dolomite if color only is considered. The absence of sand grains in the upper Laketown serves to distinguish it from the overlying equally aphanitic white weathering Sevy. The Sevy generally supports less vegetation and is very white in contrast to the underlying and overlying formations; it is therefore one of the easiest formations to distinguish in the area.

Age and correlation - No fossils were found in the Sevy dolomite. The Sevy ranges from 356 to 1,044 feet in thickness in less than three miles along its strike, whereas the Simonson ranges from 450 to 563 feet in thickness. The greater range in thickness of the Sevy relative to that of the Simonson is taken to indicate a very pronounced unconformity at the base of the Sevy, but the recognition of Upper Silurian fossils near the Fish Haven-Laketown contact, together with the unconformity between the Laketown and the Sevy dolomites, indicates that the Sevy is most likely of Early Devonian age.

The Sevy dolomite is the approximate age and/or lithic equivalent of the Beacon Peak dolomite of the Nevada formation and the Ox Yoke Canyon sandstone member of the Nevada formation (Nolan, Merriam, and Williams, 1956, pp. 42 and 48) near Eureka, Nevada, of the King Canyon dolomite of Rush (1956) in the Confusion Range, Utah, and of the middle of the Blue Bell dolomite or the Dora dolomite of Lovering (1949) in the Tintic district. The Sevy is lithologically equivalent to the Water Canyon formation of Williams (1948) in the Logan quadrangle, Utah.

SIMONSON DOLOMITE

Distribution and thickness - The Simonson dolomite is in conformable contact with the underlying Sevy dolomite. Their outcrop patterns are similar in the Lookout Hills area, being nearly centrally located with an east-west trend. The Simonson weathers darker and generally its basal units occupy dip slopes of the Sevy hogbacks. Like all formations in the northern Sheeprocks, the Simonson is displaced by a series of north-trending faults. The Simonson is 505 feet thick; the lower contact is well marked, being drawn where white weathering Sevy dolomite gives way to a more gray-buff weathering and saccharoidal textured, medium-grained dolomite.

Topographic expression - The Simonson dolomite is the least well exposed of the Devonian formations in the area. The north-south ridge crests in the East and West Lookout Hills afford the most favorable exposures. The formation is fairly easily eroded, most likely because the coarseness of grains comprising the dolomites is favorable to chemical weathering. Generally the Simonson occurs in drainage depressions.

Lithology - The Simonson dolomite, where measured, is almost entirely dolomite. The top of the Sevy dolomite was placed at the base of a tan, saccharoidal, massive dolomite. Beds of the conformably overlying Simonson dolomite are gray to dark gray and afford a very distinctive color change from the white weathering Sevy dolomite. The main mass of the formation is medium- to coarse-grained, crystalline, medium to dark gray dolomite. Bedding ranges from laminated through massive; the more massive dark gray to black weathering beds contain faint slightly undulatory laminae which disappear within a few feet. The Simonson changes along strike westerly and within a mile contains a bed of blue-gray limestone which is approximately 47 feet thick. This limestone unit is extremely fossiliferous, granular to friable, and emits a fetid odor when struck with a hammer, and is probably representative of the black fossiliferous dolomites near the top of the measured section to the east. The units of this formation all seem to thin or thicken along strike, and, taken singly, are not reliable as mappable units.

Field identification - The Simonson dolomite is mainly a medium- to coarse-granular, laminated, dark gray to black dolomite. The laminations aid in distinguishing it from most of the other dolomites in the area, but laminae are also present in the Fish Haven dolomite and the Guilmette formation. The Fish Haven is readily distinguished by the presence of brown and black chert as boxwork and nodules; little or no chert is present in the Simonson. The overlying Guilmette contains similar laminated black dolomites, but if a sizeable outcrop is examined, white quartzite float will usually be found. The 30- to 50-foot bed of quartzite near the base of the Guilmette serves as a good marker for the top of the Simonson in the Sheeprock Mountains section. A black dolomite, which at one locality is found near the middle of the formation, contains many brachiopods and coral fragments. This dolomite is medium crystalline, whereas the fossils are cream colored and composed of very coarse dolomite. Dolomitization has destroyed the identifying features of the fossils, but this bed at the one locality is one of the most fossiliferous of the Paleozoic formations in the area.

Age and correlation - Only one locality in the Simonson dolomite contained fossils, but dolomitization of the formation has largely destroyed the identifying features of the fauna. The writer recognized brachiopod cross-sections and *Cladopora?* sp. in a dark gray to black dolomite, approximately 300 feet above the base of the formation. The questionable *Cladopora* sp. and stratigraphic position of the formation strongly suggest a Middle Devonian age and a correlation with the type Simonson at Gold Hill, Utah (Nolan, 1935, p. 19).

Section D-2 (Appendix A, pl. III), measured in the West Lookout Hills, contains a fauna from locality DM-1 in the Simonson dolomite. This locality is in a cherty and fractured limestone the dip of which coincides with the underlying and overlying dolomite units. Soil and blocks of quartzite obscure the contacts with the limestone and dolomite. M. A. Stainbrook examined the collection and reported:

Proetus? sp.
Athyroid? brachiopod
cf. *Brachythyris*? sp.
Camarotoechia? sp.
Chonetes sp.
Cyctina?
Leptostrophia?
Productid
Spirifer sp.
cf. *Syringothyris*
Tylothyris?
Straporolloid gastropod

Regarding the collection Stainbrook states:

> The specimens are somewhat scrappy and not too well preserved, so that I could not do very much with them. I identified some of the genera but even here some of the identifications are questionable. I am sorry that I could not give more reliable identifications, but the nature of the material left considerable to be desired. To some extent they seem to be possibly younger than Devonian, but again, I cannot be more definite.

The presence of the thrusted quartzite blocks overlying this area suggests that the limestone containing the fauna may have been dragged into its coincident position and would thus substantiate Stainbrook's suspicions of a younger age.

The Simonson dolomite is the approximate age and/or lithic equivalent of the Sentinal Mountain dolomite, Woodpecker limestone, and probably part of the Bay State dolomite members of the Nevada formation at Eureka, Nevada. The Simonson probably correlates with the Noah dolomite (Lovering, 1949) in the Tintic mining district, Utah. The Simonson is the approximate age equivalent to the lower portion of the Jefferson dolomite (Young, 1955) in the southern Lakeside Mountains, Utah.

VICTORIA AND PINON PEAK FORMATIONS UNDIFFERENTIATED

Distribution and thickness - The Victoria and Pinon Peak formations crop out in a 700-foot belt on the south slope of the Madison hogbacks. No other Victoria-Pinon Peak facies were recognized in the remainder of the Sheeprock Mountains.

The Victoria-Pinon Peak formations were measured near the center of the West Lookout Hills, but faulting near the top necessitated the inclusion of the top units as measured in the East Lookout Hills. The section is 736 feet thick, but this may be in error because of rapid facies changes which are apparent in one mile distance.

Topographic expression - The formations weather like the Simonson dolomite and are present beneath the talus covered fore-slopes of the ridges formed by the cherty, more resistant Madison limestone. The light gray to white quartzite units of the formation are fractured and weather like the dolomites above and below.

Lithology - The Victoria-Pinon Peak formations are similar to the conformably underlying Simonson dolomite. The top of the Simonson dolomite is gradational with the basal members of the Victoria-Pinon Peak formations. The Victoria-Pinon Peak sequence contains appreciable amounts of quartzite near the base. The bottom of a 21-foot unit of dark gray dolomitic limestone, immediately below a 33-foot gray, cross-bedded quartzite, was designated as the contact between the Simonson dolomite and the Victoria-Pinon Peak strata. No quartzite is present in strata assigned to the Simonson dolomite. Although the finer laminations are not as prevalent as in the Simonson, the individual units of gray, dark gray, and black dolomites, with the thin quartzites, give the outcrops a lamination on a large scale. Some of the dolomites are calcareous; all the carbonates are crystalline and medium-granula. Quartzites range from white to grayish-tan and are very dense, indicating extensive cementation. All are fractures and some show low-angle cross-bedding. Gray and light gray dolomite lenses are intercalated in many of the quartzites. Most of the quartzite units are thin- to medium-bedded, and lenses up to 6 inches thick are present. Limestone and dolomitic limestone are erratic in occurrence and are blue-gray, crystalline to dense, and usually medium-bedded. None of the strata comprising the formations can be used as reliable map units.

Field identification - The Victoria-Pinon Peak is readily distinguished from the underlying Simonson, the Laketown and Ajax, by the presence of the quartzite units.

Age and correlation - The only collection from this formation was scrambled and lost in transit to the laboratory. The Victoria-Pinon Peak strata by its lithology and stratigraphic position is assigned to the Middle and Upper(?) Devonian.

The Victoria-Pinon Peak strata are the approximate age equivalent of the Guilmette formation of Nolan (1935) in the Deep Creek Mountains, of the Victoria quartzite and part of the Pinon Peak limestone of Loughlin (1919) at Tintic, Utah, and of part of the Jefferson (Williams, 1948) in northeastern Utah.

DEVONIAN-MISSISSIPPIAN CONTACT

The contact between the Devonian and Mississippian systems was arbitrarily placed at the top of the uppermost quartzite of the Victoria-Pinon Peak formations. The basal Madison is a medium- to coarse-grained limestone which, in places, is silty. There is no chert in the lower unit, and few beds resemble the flaggy limestones of the Deseret-Humbug formation. No unconformity between the Devonian and Mississippian rocks was recognized in the Sheeprock Mountains. Detailed paleontologic work is needed to establish the exact nature of the boundary between the Devonian and Mississippian systems in the Sheeprock Mountains area.

M I S S I S S I P P I A N S Y S T E M

GENERAL STATEMENT

The Mississippian period is represented by over 5,700 feet of strata consisting mostly of chemical sediments. Limestone is the most common rock followed in abundance by black shale, quartzite, and chert.

Four formations are present: the Madison, Deseret, Humbug, and Great Blue. However, the extreme variability of the Mississippian in this area, in comparison with nearby sections, warrants a different treatment of the units. The Madison limestone is essentially the same as surrounding districts. The Deseret is unidentified or missing in the area, and it is thought that this name should be dropped or combined with the Humbug. The Great Blue is extremely thick and includes a thick black shale in the center which is entitled to member status, and henceforth will be referred to as the Chiulos member (type locality is in East Tintic Mountains; named by U. S. Geological Survey). The Great Blue formation, as defined, consists of the Lower Great Blue limestone, the Chiulos shale member, and the Upper Great Blue limestone.

MADISON LIMESTONE

Distribution and thickness - The Madison limestone crops out in a belt approximately 800 feet wide in the northern end of the East and West Lookout Hills. The Lower Mississippian strata maintain a regional dip which is more northerly than the Early Paleozoic sediments lying to the south. In the vicinity of Lookout Pass, the more westerly strike of the rocks can be attributed to faulting. Madison limestone is absent in the remainder of the Sheeprock Mountains and in the eastern part of the Simpson Mountains.

The Madison limestone is 623 feet thick in the East Lookout Hills area. The westernmost exposures of the Madison limestone are generally unrecognizable, being covered by silicified brecciated rocks and alluvium.

Topographic expression - The cherty portion of the Madison limestone has considerable resistance to weathering, resulting in a relatively high east-west ridge traversing the hills in the northern part of the area. The underlying Devonian strata erode more easily, forming a long low ridge between the basal Madison and the Fish Haven dolomite. The top of the Madison limestone is marked by a dip slope formed by weathering of the weaker limy sandstones of the conformably overlying Deseret-Humbug formation.

Lithology - The base of the Madison is not a sharp lithologic contact and was arbitrarily taken as the top of the highest white quartzite in the underlying Victoria-Pinon Peak formation. The beds near the base of the Madison are not cherty and in places contain much silt, which causes the beds to weather in flaggy blocks. Chert occurs as bands 1 to 2 inches thick at intervals of 3 to 6 inches in the crystalline gray limestone. Near the top a few bands ranging up to 6 feet in thickness are composed almost entirely of crinoid remains.

Field identification - The Madison limestone is easy to recognize. The dark chert bands are very distinctive, being from 1 to 2 inches thick spaced at nearly regular 3- to 6-inch intervals in blue-gray limestone. Crinoid columnals are especially abundant in several beds near the top of the formation, but these beds do not seem to persist for any great length along the strike. The upper contact is a very pronounced dip slope formed by weathering back of the soft Deseret-Humbug formation.

Age and correlation - Madison limestone or Madison equivalents are present at Ophir and in the East Tintic Mountains, as well as in the northern Onaqui Mountains and at Gold Hill, Utah. The Madison limestone is among the most widespread and easily recognized formations of the Rocky Mountain miogeosyncline (Millard Belt) and the Utah-Wyoming Shelf. In the East Tintic Mountains Morris et al. have subdivided the Madison into the Fitchville and the Gardison formations, which, for that region, constitute the Madison group. Elsewhere in Utah the Madison is more of a uniform lithology. However, in the Sheeprock Mountains the basal 200 feet may be representative of the Fitchville formation of the East Tintic Mountains.

Fossils were collected from several localities. Dr. William Lee Stokes and the writer identified the material listed below:

M-1, approximately 250 feet above base
Chonetes loganensis
Ostracods
Crinoid fragments

M-7, near base
Exochops ? sp.
Composita humilis
Martinia rostrata
Productus gallatinensis
Schuchertella chemungensis
Straparellus ophirensis

M-9, near base
Spirifer centronatus

The fauna listed is typical of the Madison limestone in the Oquirrh and the Deep Creek Mountains, Utah.

The Madison limestone compares favorably in thickness with sections at Gold Hill, Oquirrh, East Tintic, the central Wasatch, and southern Lakeside Mountains.

The prevalent phosphatic shale which characterizes the Madison-Deseret contact at Ophir (Gilluly, p. 24) is absent or is concealed in the Sheeprock Mountains region. The presence of reddish weathering, silty, and somewhat shaly limestones in the section was taken to mark the base of the Deseret. This saddle-forming unit may conceal the phosphatic shales, which characterize the division between the Madison and the conformably overlying Deseret limestone of nearby sections.

The Madison limestone in the Sheeprocks is transitional with the apparent conformable underlying Devonian strata. Morris (personal communication, 1956) states that the Devonian-Pinon Peak formation cannot be logically separated from the Fitchville (Basal Madison) formation. A similar situation probably exists in the Sheeprock Mountains area and for convenience the top of the uppermost quartzite in the conformably underlying Victoria-Pinon Peak formation was taken as the base of the Madison limestone. Close paleontologic control is necessary for establishing the exact time boundary.

Correlation with other Utah sections is based primarily on the fauna and gross lithologic similarities and not the characteristics of the upper and lower contacts.

The Madison limestone is the approximate age equivalent of most of the Gardner formation of Loughlin (1919) in the Tintic district, of the Joana limestone of Spencer (1917) of central Nevada area, and of the Topache limestone of Butler (1913) of the San Francisco region, Utah. The Madison is present in the Oquirrh, Deep Creek, and Lakeside Mountains, and other ranges in Utah and the Great Basin region.

DESERET-HUMBUG FORMATION

General statement - The Deseret and Humbug formations cannot be differentiated in the Sheeprock Mountains, and their dominant lithologies are reverse to that of their type sections in the Oquirrh Mountains, approximately 20 miles to the north. The unit contains more sand in the lower half and a high percentage of limestone in the upper half, and for this reason the formations have not been differentiated and are discussed as a single unit. Evidently a facies change accounts for the reversal of lithology. Paleontologists and stratigraphers may at some future date be able to subdivide the Chester fauna in this zone and establish a suitable time boundary. The writer is of the opinion that to attempt a lithologic division would be unwarranted and perhaps misleading.

Distribution and thickness - The Deseret-Humbug formation crops out near the northern end of the East and West Lookout Hills in a nearby continuous band 900 feet wide in an east-west direction. The beds dip to the north at 40 degrees and conformably overlie the Madison limestone. No other Deseret-Humbug strata crop out in the Sheeprock Mountains region.

Two sections of the Deseret-Humbug formation (Appendix A and pl. III) were measured in the East and West Lookout Hills areas with thicknesses of 1,145 feet and 1,165 feet, respectively.

Topographic expression - The sandy limestones and sandstones of the Deseret-Humbug formation weather to form slopes. Flaggy debris conceals much of the strata. In all places the massive weathering overlying lower Great Blue limestone forms cliffs on the crest of the ridges. Debris from the Great Blue formation masks the contact at most localities.

Lithology - The Madison limestone grades into the conformably overlying Deseret-Humbug unit. The contact is sharp, being at a place where the typical, chert-banded, blue-gray, medium-grained limestones of the Madison limestone are overlain by sandy, flaggy, reddish-tan, weathering limestones of the Deseret-Humbug formations. The Deseret-Humbug is characteristically a series of relatively thick limestones and sandstones with limestone comprising about three quarters of the total. Many of the sandstones are quartzitic and all are gradational with adjacent limestones. A few of the limestones show cross-bedding accentuated by the presence of sand streaks. The basal units of the formation are silty and weather pinkish-tan. Flaggy weathering and poorly exposed beds characterize the basal 360 feet of the Deseret-Humbug formation. A few of the limestones near the center of the sequence contain small chert nodules.

The contact between the Deseret-Humbug and the Madison limestone is conformable, but is poorly exposed.

Field identification - The Deseret-Humbug formation is recognized by the abundance of reddish-yellow to purplish, flaggy, sandy limestone which contains an abundance of bryozoa. The top is rather vague and gradational into the conformably overlying Great Blue formation and is taken at a point where the limestones become more massive. Typical cherty Madison conformably underlies the flaggy limestones of the Deseret-Humbug.

Age and correlation - Fossils were collected from three localities (Appendix B and pl. III) in the Deseret-Humbug formation. Mr. Walter Sadlick identified the material from locality and reported:

M-5
Faberophyllum cf. *F. araneosum*
Blastoid fragments
Triplophyllities (*Triplophyllites*) cf. *clinatus*
Fenestella cf. *F. nodulosa* Phillips

Sadlick reports that W. H. Easton recently described *Triplophyllities* from the Salem and Warsaw limestone of the lower Meramecian series in the type Mississippian area.

The Deseret-Humbug formations (undifferentiated) are the approximate age equivalent of the type Deseret and Humbug formations of Gilluly (1932) in the Oquirrh Mountains, Utah, of the Woodman formation of Nolan (1935) at Gold Hill, Utah, of the lower part of the Brazer formation of Richardson (1913) in the northeastern Utah region, and of probably part of the Chainman shale of Spencer (1917) near Ely, Nevada.

GREAT BLUE FORMATION

Distribution and thickness - The Great Blue formation crops out on the northern extremity of the Lookout Hills and disappears beneath the alluvium north of the road to Simpson Springs. The formation is divided into three parts; a lower limestone, a shale, and an upper limestone. Lookout Pass, a saddle-like divide, on the road from Vernon to Simpson Springs, marks the position of the middle shale member and the terminus of northerly dip of the rocks. The upper limestone, lying north of the road, is nearly flat, dipping slightly to the east; a fault trending from NW to SE through Lookout Pass is responsible for the change in attitude of the rocks. The Great Blue formation is not completely exposed, and the overlying Manning Canyon shale and an unknown portion of the Great Blue have been removed by erosion. The upper member of the Great Blue is terminated by faulting on both the north and west sides.

The Great Blue formation has an aggregate thickness of 4,139+ feet, being divided as follows: the Lower limestone, 911 feet; the Chiulos shale member, 1,818+ feet; the Upper limestone, 1,410+ feet. Since the two upper units are incomplete, the Great Blue formation may total more than 4,500 feet. No thinning was detected, but the exposure is of limited extent along strike.

Topographic expression - The limestone portions of the Great Blue formation weather to form cliffs and ridges, whereas the intervening shale unit forms saddles. Except for the quartzite interbeds, the shale is seldom exposed and then only in gulches where only small portions are visible. The upper limestone is the most prominent and forms west-facing cliffs, many of which are nearly vertical.

Lithology - The upper Great Blue limestone is almost completely a medium-grained limestone. The lower half is blue-gray, whereas the upper half contains more gray strata. The base of the unit is not exposed and is in fault contact with the Chiulos member at Lookout Pass where erosion has provided the best exposure of some of the lowermost beds. Black chert is present as bands and nodules in many of the units. Chert is not abundant, except locally, and persists at intervals throughout the entire section. A tan, calcareous siltstone is present about 430 feet from the top of the measured section. Erosion has removed an estimated 200 to 300 feet of beds representing the transition zone of the conformably overlying Manning Canyon shale. Corals and brachiopods are abundant in various zones throughout the formation. Most obvious are the large cup corals in the lower one third of the unit.

The Chiulos member - This unit is primarily a black fissile shale with many interbedded ribs of quartzite near the center. Except for the quartzite the strata weather easily to form low covered areas in contrast to the cliff-forming massive upper and lower limestone members. At one place scattered irregular black chert was observed in the shale. It is of particular interest because of the fine granules of marcasite dispersed in the mass. Much of the shale is broken and the fractures are limonite-stained. It seems reasonable to assume that most of the iron oxide originated from decomposition of the iron sulphides within the shale. No fossils were found in the black shale where sulphides occur. The lack of a sandy fraction within most of the shale seems to indicate the absence of a vigorous transportation agent, which in turn would indicate a quiescent condition and poor ventilation of a restricted aqueous environment. This stability and toxicity would be a poor environment for any megascopic life dependent upon oxygen. The thickness of the unit does indicate that the shale had considerable areal dimensions, and it may be permissible to suspect that the less toxic marginal areas contained much plant and animal life; that on death these forms rotted and were buried relatively close to their life zones; and that the expanse of the toxic mass was sufficiently wide to discourage "carcass dispersal" over the entire expanse.

Tan, medium-grained, cross-bedded quartzites with abundant limonite stains as dispersed spots and blocks become prominent about 805 feet above the base and are present for the next 450 feet. Much black shale is interbedded with the quartzite, but the weathering differential of quartzite vs. shale promotes an exposure which is dominantly quartzite and quartzite blocks. Calamites species was found in the quartzite zones. The stalks are poorly preserved but are seldom mashed; this would indicate that the plants were growing near the places of burial. The cross-bedding indicates a rapid influx of sand, probably the result of vigorous torrential rainfall on a neighboring highland. Above the quartzite strata is more black shale and sandy reddish-tan weathering, fossiliferous, flaggy limestone. Limestone becomes the dominant lithology in the uppermost beds. A few gritty beds and some reddish quartzites are also present, as are a few beds of shell conglomerates. These beds are nearly vertical in areas of best exposure and are probably typical of the top of the shale member. The abundance of limestone indicates a transition, and it is estimated that typical upper Great Blue limestone would commence only a few hundred feet above.

The lower Great Blue limestone is conformable with the overlying Chiulos shale and the underlying Humbug formation. The top of the lower Great Blue is easily distinguished from the basal shales of the Chiulos member, and wherever relief is prominent the top of the lower Great Blue forms a dip slope. The limestones comprising the lower Great Blue are very similar to those of the upper limestones. Large cup corals, brachiopods, and gastropods occur in the lower Great Blue. The cup corals are especially abundant. Near the middle of the unit there are a few discontinuous bands of black chert which range from 4 to 6 inches in thickness, spaced at intervals of 1 to 3 feet. This sequence is about

425 feet thick and is crudely laminated by dispersal of 5- to 6-foot beds of dark gray, rough weathering limestones among cherty, blue-gray, massive limestones which comprise the greater part of this interval.

The base of the Great Blue formation is gradational with the underlying Humbug formation and is drawn at a point where quartzites and sands become a prominent, but not dominant, lithology. Very little sand is dispersed in the basal beds of the Great Blue formation.

Field identification - The massive character of the units of the Great Blue formation is very distinctive, as is the presence of large horn corals in the upper and lower members of the formation. Some black chert is in the basal beds of the lower and upper limestone members, and its presence may suggest the Madison formation, especially if the outcrop is small in area. Generally, the large horn corals serve to complete the identification. Thick colonial corals serve as an aid for identifying the upper part of the lower limestone member. The two limestone units are difficult to separate without the presence of the intervening Chiulos shale. The blue-gray color is rather uniform in the two limestones, and fresh surfaces are only slightly darker than the weathered rock. Black shale on both sides of a thick quartzite unit serves to identify the Chiulos as does the Calamites sp. near the center of the quartzite beds. Dark brown limonite-stained zones in the cross-bedded quartzite have yielded these plant fossils. The upper shale contains many brachiopods.

Age and correlation - Fossils were collected from sixteen localities (Appendix B, pl. III) in the Great Blue formation. Walter Sadlick examined the specimens and reported:

Lower limestone member:
M-4
Faberophyllum sp.

M-18
Faberophyllum sp.
Spirifer (large) Spirifer haydensis?
Gastropod
Spiriferoid n. sp. aff. Spirifer bifurcatus
(poorly preserved)

M-11
Small spyringoporid coral
Lithostrotion sp.
Linoproductus aff. Striatifera brazerianus
Faberophyllum ?

M-14
Diaphragmus ? very poor

M-15
Linoproductus n. sp. aff. Striatifera brazerianus
"Productus" aff. arkansanus
Antiquationa n. sp.
Diaphragmus ? sp.
Spirifer aff. S. increbencens

M-16
Linoproductus aff. L. Magnispinus

M-22
Linoproductus n. sp. aff. Striatifera brazerianus
Lithostrotion sp.
Eumophalid gastropod

M-23
Spiriferoid n. sp. aff. Spieifer bifurcatus
Linoproductus cf. pileiformis
Dictyoclostids aff. D. inflatus

Roland W. Brown identified Calamites sp. from plant remains in the quartzite zone of the Chiulos shale member.

Upper limestone member
M-12
Striatifera brazerianus
Echinocconchus aff. E. genevievensis
Dictyoclostus aff. D. Burlingtonensis
Composita trinuclea ss.
Cleithyridina n. sp.
Reticularina spinosa, small form

M-13
Rhipidomelba aff. R. carbonaria

M-19
Lithostrotionella sp.
Caninia ?

The fauna indicates that the Great Blue formation is basal Upper Mississippian (Chesterian) in age.

The Great Blue formation is the approximate age equivalent to the Ochre Mountains of Nolan (1935) at Gold Hill, Utah, to the upper part of the Chainman shale at Ely, Nevada, and to the greater central portion of the Brazer formation in northeastern Utah.

Sadlick indicates that he was considering elevating the Great Blue formation to group status and naming the lower limestone the Flux limestone (location in northern Stansbury Mountains, Utah). The Chiulos member is probably equivalent to the Long Trail shale of the type Great Blue limestone in the Oquirrh Mountains and the Herat shale member of the Ochre Mountain limestone in the Deep Creek Mountains.

P E N N S Y L V A N I A N   S Y S T E M

OQUIRRH FORMATION

The Oquirrh formation is in fault contact with the upper limestone member of the Great Blue formation. The Oquirrh is exposed only along the northern limits of the mapped area. No study was made of the Oquirrh, since neither the top nor the base of the formation is exposed. The rocks comprising the Oquirrh are silty gray limestone and tan to slightly purplish tinted quartzites. Bryozoan fragments were recovered from some of the tan silty limestone units.

In the north end of the West Lookout Hills allochthonous blocks of strata, tentatively assigned to the Oquirrh formation, are in thrust contact with strata of Ordovician to Mississippian age.

Cretaceous or Tertiary red beds and conglomerates unconformably overlie steeply dipping beds of the Oquirrh formation in the northwest corner of the area.

RESUMÉ OF PRECAMBRIAN AND PALEOZOIC HISTORY

PRECAMBRIAN

The advancing Cambrian seas moved from southwest to northeast along troughs probably formed during Late Precambrian time. As the troughs deepened, the basal Cambrian sediments became less and less conformable with underlying Precambrian strata.

Prior to deposition of basal Cambrian strata in the Sheeprock area, an area of considerable relief must have been present in or around the Sheeprock region. Tillites testify to the presence of a highland, though it may have been far removed from the Sheeprock vicinity, as are the ice centers of present day glaciation removed from the terminal edges of associated ice sheets. Slates and quartzites of the Sheeprock series, below the Dutch Peak tillite, indicate that those rocks are probably of continental and lacustrine origin. The Sheeprock series contain, as a gradational unit, the Dutch Peak tillite. The Sheeprock series is considered to be younger than the Big Cottonwood series. The Mineral Fork tillite, probably equivalent in age to the Dutch Peak tillite, unconformably overlies the Big Cottonwood series in the Wasatch region some 60 miles east of the Sheeprock area. The Big Cottonwood series may be Beltian in age and could conformably underlie the strata of the Sheeprock series with gradational contact. The Mutual formation is the youngest of the Precambrian rocks recognized in the Wasatch region. In the Sheeprock area the presence of strata with differing thicknesses and lithology above the Sheeprock series suggest an unconformity, and these strata are questionably designated the Mutual formation.

The Tintic quartzite is the basal Cambrian formation in the Sheeprock region and unconformably overlies rocks assigned to the Mutual(?) formation.

The sequence of events for the Precambrian are:

1. Folding, intrusion, and metamorphism of Archean (Farmington Canyon Complex) rocks.
2. Deposition of Little Willow series.
3. Deformation of Little Willow series.
4. Deposition of Big Cottonwood series in geosynclinal or shelving areas to the west.
5. Deposition of Sheeprock series on shelf in the geosyncline and on rising hinge area along Wasatch front.
6. Glaciation, probably of the Piedmont type, which eroded material from terrane composed mainly of strata of the Little Willow and Big Cottonwood series.
7. Slight uplift and rejuvenation of erosion which furnished sediments for the Mutual formation.
8. Advance of marine conditions into Sheeprock area over a sinking continental margin which produced a basal Cambrian quartzite over discordant strata of the younger Precambrian.

CAMBRIAN

Cambrian seas gradually transgressed the region from southwest to northeast. Continental sedimentation in the back valleys and depressions continued as the seas sorted the shoreline sediments to form the basal Cambrian quartzites and conglomerates. The highlands flanking the seaways were continually being deformed by isostatic adjustments, and it is possible that certain unidentified sequences of continental Cambrian sediments were continually being transgressed by the expanding Cambrian seas. The basal conglomerates were probably derived from the highlands to the east and from island areas within the region of invasion, such as in east-central Nevada, and northwestern and north-central Utah. Seas continued to occupy the region during the remainder of Cambrian time. During Middle and Late Cambrian times some areas shoaled sufficiently to allow formation of oolites and other primary shallow water features. There were times when the competency of the marine waters increased or when greater supply of silts was available for marine deposition. This type of chemical and mild clastic deposition persisted at intervals throughout the Cambrian and into the Ordovician.

ORDOVICIAN

Ordovician environmental conditions were mainly similar to the Cambrian until Middle Ordovician time. During Middle Ordovician time, the seas slowly withdrew and a shale-quartzite sequence was deposited in its wake. The period of this withdrawal was relatively slow, but was completed during Middle Ordovician time. A transgression of marine waters into the region occurred again in Late Ordovician. The Late Ordovician Fish Haven sea occupied the region rather rapidly. The absence of an overlying shale indicates a rapid transgression. The lack of fragments of the Eureka or Swan Peak quartzites in the basal unit of the Fish Haven dolomite indicates that an insufficient amount of time was available for even partial lithification of the sands. The source of the Ordovician sands was most likely the basal Cambrian quartzites of the highlands east of the "hinge line" or eastern border of the geosyncline. The thickest sands (see fig. 5) coincide with areas of greatest Cambrian (see fig. 4) and Lower Ordovician sedimentation. The thicker portions of the Ordovician sands may be considered to occupy the deepest portions of the Cambro-Ordovician geosyncline, where differential compaction was greatest. Conditions conducive to dolomitic sedimentation persisted to the end of Ordovician time.

SILURIAN

Lower and Middle Silurian rocks are missing or are represented by only a few feet of beds. Absence of strata representing most of this time may be either the result of non-deposition or deposition and removal by erosion. The variation of thickness of the overlying Sevy dolomite of Devonian age indicates considerable relief of the buried surface, which separates the Silurian from the Devonian. Lower and Middle Silurian time probably was one of non-deposition.

DEVONIAN

Early Devonian time was characterized by relatively shallow seas and tidal flats. Slight uplift must have been present along the eastern flanks of the geosyncline. Ordovician and Cambrian quartzites were being eroded and redeposited in the dolomite muds by wind action. Fish remains in the basal Devonian dolomite suggest as estuarine environment. The dispersal of frosted and rounded quartz grains in the Lower Devonian dolomite indicates winds sufficiently strong to have carried the sand from an area near the "hinge line" in central Utah to a point as far west as eastern Nevada. This required east-to-west winds, which may be questionable. A possible alternative source of the wind-frosted sands could be island areas developed in the region of the Manhattan Geanticline to the west.

Middle Devonian time was marked by deeper waters and oscillations which produced environmental changes sufficient to cause color alternations in coarser dolomitic sediments. Middle Devonian was probably a period of relative quiescence with highlands remaining static. Late Devonian was a period of general instability in the eastern margin of the geosyncline and along a salient extending from Salt Lake and Provo area westward to beyond the Nevada-Utah line. The rising lands furnished debris to the deeper portions of the geosyncline. The "Stansbury Salient," a peninsular-like prominence, received extensive conglomerates from the rising highlands. The sands intertongue with carbonates farther west. The sand tongues and lenses lack underlying or overlying shales, which seems to be characteristic of slower regressions and transgressions of sea waters. It is, therefore, assumed that the sands of the Upper Devonian period were principally of fluvial origin and, therefore, would be confined to areas nearer the "hinge line," the source area.

MISSISSIPPIAN

Mississippian time opened with extensive seaways which covered much more area than most of the previous Paleozoic seas. Following Madison time, with its extensive seaways, silts and sands become more prominent, indicating that rising highlands were again being formed. Following the chemical and mildly clastic deposition of Middle Mississippian were the periods of alternating carbonate and clastic deposition in late Middle and Upper Mississippian times. An extensive, nearly east-west, narrow trough developed in mid-Great Blue time and a black shale environment prevailed. Cherty, black shale containing marcasite indicates a toxic environment. Cross-bedded orthoquartzites, bearing *Calamites*, are intercalated with the black shale. Clastic limestone with abundant silt and fragments of water-worn brachiopods indicate shallow waters and proximity to land. Rocks representing the Upper Mississippian period have been removed by erosion or are buried beneath Pliocene-Pleistocene and Recent alluvium in the Sheeprock area.

PENNSYLVANIAN AND LATER PERIODS

Marine conditions prevailed for the greater part of Pennsylvanian time. Subsidence began in the Oquirrh Basin, allowing many thousands of feet of sediments to be deposited. Similar conditions persisted into Permian time.

No Upper Permian, Triassic, or Jurassic rocks have been noted in the Sheeprock area. Limestones containing Lower Triassic fauna have been found in the Wasatch Range near Salt Lake City, Utah, in the Ruby Range, in east-central Nevada, and at Gold Hill, Utah (Nolan, 1943, p. 159). Similarly, Meekoceras beds are present in the Confusion Range in west-central Utah (Zeller, 1951, p. 66). This suggests that at least a Lower Triassic sea occupied the area of west-central Utah and possibly covered the Sheeprock area. Upper Triassic and Jurassic rocks, though present near Salt Lake City, Utah, have not been found in western Utah.

C R E T A C E O U S (?) -- T E R T I A R Y (?) R O C K S

GENERAL STATEMENT

Rocks of an unknown but post-Pennsylvanian age are present in the northern portion of the mapped area. The strata include beds of massive red, marly, friable siltstone overlain by a highly silicified conglomerate (pl. XXII). These rocks are poorly exposed but probably exceed 200 feet in thickness. The red, marly unit laps on the steeply dipping Oquirrh formation, and the conglomerate in turn overlies the marl and overlaps the Oquirrh. The strata of the younger sequence dip from 5 to 15 degrees westerly. Plant remains are present in the conglomerate as are boulders and cobbles from the Oquirrh(?) formation (pl. XXII). Most of the cobbles are quartzite; very few are limestone. The limestone cobbles, which escaped silicification, weather out to form holes as do many of the twigs and stems of the entombed plants. Where the strata are weakly silicified, the material is a poorly sorted conglomeratic sandstone. The strata are post-tilting and must, therefore, be considered younger than Late Cretaceous.

T E R T I A R Y R O C K S

GENERAL STATEMENT

Several exposures of Tertiary conglomerates were noted along the west flank of the Sheeprock Mountains and in "Little Valley," which lies between the East and West Lookout Hills. The conglomerates are all younger than the normal faulting, which formed the graben structure occupied by "Little Valley," and the material comprising the conglomerate originated from the strata of the upthrown blocks. The position of the conglomerate relative to the faulting suggests a Pliocene(?) age. High-level terraces, though faint, are present in "Little Valley" and are considered to be Pliocene. Several of the terrace surfaces are developed on the conglomerates.

The pediment gravels along the flanks of the range are of Late Tertiary age.

Q U A T E R N A R Y

GENERAL STATEMENT

At the mouth of North Oak Brush Canyon there is a deposit of bouldery material which may possibly be a Pleistocene terminal moraine. Some of the large boulders are of the Sheeprock series and have been transported from the head of the canyon, a distance of over 3 miles. Although the deposit may be a mudflow, the absence of spurs and the reasonably well-developed U-shape of North Oak Brush Canyon lend support to the glacial origin of the deposit.

Bonneville lake beds covered with recent alluvial material are present along the southwest and northwest portions of the map.

Recent material comprises talus cones, fanglomerate material, and stream sands and gravel.

PLATE XXII

Figure 1
Looking north at the Tertiary conglomerate west of Lookout Pass.

Figure 2
Closeup of the Tertiary conglomerate showing silicified fragments of wood.

I G N E O U S   R O C K S

GENERAL DISTRIBUTION

Intrusive and extrusive igneous rocks occur in the Sheeprock Mountains area. Both crop out over nearly equal areas and are confined to the south half of the area. The intrusive rocks are, in the main, confined to the south flank of the Sheeprock Range. A monzonite and a granite stock dominate the intrusive bodies of quartz diorite and seem to be associated with the monzonite stocks. Rhyolitic and basic dikes are associated with the stocks. A basic sill, probably Precambrian in age, is associated with metasediments of the Sheeprock series. Extrusive rocks are chiefly of andesitic and rhyolitic composition but include a single minor occurrence of basalt. The extrusives are confined to areas south and west of the intrusive rocks.

INTRUSIVE ROCKS

Precambrian(?) sill - A diabasic textured rock crops out beneath the Dutch Peak tillite of the Sheeprock series in the vicinity of Dutch Peak and extends southeast to Sec. 28, T. 10 S., R. 5 W. Float from the same rock type was found on the west side of Pole Canyon, where the Precambrian section is overturned. The rock ranges from 60 to over 100 feet in thickness. In the main, its contacts with the metasediments are obscure, and the writer was not able to ascertain whether the metamorphism is contact or regional. The rock was examined in thin section by B. J. Sharp, who reports, "Andesine, grunerite, chlorite, magnetite present. Rock is highly altered and probably a basic sill."

The rock is definitely pre-folding and, therefore, pre-Tertiary.

West Tintic monzonite stock - The oldest extensive intrusive rock in the eastern part of the Sheeprock Mountains is the West Tintic stock. Loughlin (1920, p. 436) identified the rock as a monzonite and assigned it to the Tertiary. Stringham (1942) mapped the intrusive in the West Tintic mining district and verified Loughlin's identification. The monzonite crops out in Secs. 28, 29, 32 and 33, T. 11 S., R. 5 W., Salt Lake Base and Meridian, being approximately circular with a diameter of about 6,000 feet. It weathers to form rounded masses and subdued topography. Associated with the larger intrusive are a series of smaller satellitic bodies which trend north-northwest from the monzonitic parent intrusion to the drainage of Pole Canyon in Sec. 6, T. 11 S., R. 5 W.

Loughlin (1920, p. 435) and Stringham (1942, pp. 272-273) demonstrate that Precambrian rocks have been thrust over Paleozoic rocks in the West Tintic area. Further, they show that the monzonite intrusion is post-thrusting, since it intrudes both the upper and lower plates of the thrust. Gardner (1954) has detailed the intrusive relationships.

The northern and eastern edges of the monzonite, here intrusive into the Precambrian and Paleozoic rocks, are easily traced because of the contrasting lithologies, although the exact contact is generally concealed. The southwest and western limits of the stock are obscured by pediment gravels and alluvium. Volcanic rocks are in fault contact with the monzonite along its southern extremities.

Petrographically, the typical monzonite has a uniform, medium-grained, granitic texture. Stringham (1942, p. 274) states:

> White plagioclase, light-pink orthoclase, biotite, and small crystals of hornblende are discernible in hand specimen. In all of several specimens studies microscopically it was found that

> orthoclase predominates slightly over plagioclase, quartz varies from 8 to 17 percent of the whole rock, and hornblende remains constant at around 5 to 6 percent. Medium-sized plates of biotite constitute 10 to 12 percent. Sphene, augite, magnetite, and apatite are the accessories. Chlorite, magnetite, sericite, and epidote, present in specimens in minor amounts, indicate that alteration has been slight. The typical texture is seriate with the largest crystals 3 to 4 mm in greatest dimension . . . .

The monzonite intrudes Paleozoic carbonate strata, principally of Ordovician age, along its northern and eastern boundaries. A zone of contact metamorphism of considerable width extends along the eastern margin of the intrusion. Stringham (1942, pp. 277-278) reports:

> The contact zone of the monzonite attains its greatest width--2,500 feet--directly east of the Tintic Western mine (now Desert Tungsten) and narrows toward the north and west about 750 feet . . . .

also

> Near the Tintic Western mine, almost at the contact of the monzonite, a coarsely crystalline calcite marble has prominent laminations or streaks composed of bottle-green idocrase alternating with white fluorescent wollastonite . . . Under the microscope bands of quartz, orthoclase, and diopside parallel and alternate with these laminae. Scattered throughout the entire rock and included in all minerals are small epidote crystals."

A number of smaller intrusives are associated with the West Tintic stock. Each is roughly circular in area and intrudes the Precambrian metasediments. However, their contacts are obscured everywhere by colluvium and soil. The southernmost of the minor intrusive masses in Sec. 17, T. 11 S., R. 5 W. are a porphyritic quartz diorite. Thin section examination revealed the following: andesine, 60 percent; quartz, 20 percent; hornblende, 8 percent; biotite, 7 percent; orthoclase, 5 percent; magnetite, less than 1 percent. A dike associated with this intrusion is principally hornblende and biotite and is classified as spessartite. The next intrusive north of the quartz diorite was found to be a granite with a similar spessarite dike. The other intrusions farther to the north were not identified by thin section, but in hand specimen resemble the parent monzonite.

Sheeprock granite stock - The Sheeprock granite is exposed over an area of approximately 9 square miles along the south side of the range. It extends as a concordant mass southeasterly from the head of South Oak Brush Canyon to Burned Canyon, a distance of nearly 10 miles. Apophyses of the granite crop out in the bottom of Joes Canyon and in Auts Canyon. The main stock extends 2 miles from the valley floor to within a mile of the divide.

The granite clearly intrudes overturned and thrusted Precambrian rocks in Auts Canyon and Joes Canyon and is in intrusive contact with Ordovician rocks at its northwestern extremity. It has been dated as middle Miocene (15 and 17 MY) by the U. S. Geological Survey (personal communication, H. T. Morris).

Weathering has reduced the granite to rounded crumbly masses. However, on the divide between Hard-to-Beat and Albert Ekkers Canyons, the granite stands as spires and overhanging masses. Sheet jointing and the coarse interlocking nature of the constituent minerals apparently control the configuration of these peculiar landforms. Good hand specimens of fresh rock are rare.

The main granite is a limonite-stained, white to light gray rock with a medium to coarse granitoid texture. Much of the rock is porphyritic, especially near the contact with the Precambrian metasediments. Orthoclase phenocrysts ranging from one half to one and one half inches in diameter are distributed uniformly throughout the rock. The groundmass is principally gray quartz (45 percent) and microcline (50 percent) with a little biotite.

Two facies are recognized in the granite: the central core is whiter; whereas, the surrounding rock is more limonite-stained and called "red" facies in the field. The "white" facies is considered to be a late stage differentiate of the intrusive. The "white" facies contains beryl in pegmatitic fractions, in clusters of radiating crystals disseminated throughout the rock, (pl. XXIII) as dispersed granules, and in thin veinlets. The "white" facies is centered in Hard-to-Beat Canyon and crops out over an area of approximately 1 square mile.

The main mass of granite is cut by numerous sets of joints. The strongest set strikes northeast and dips nearly vertical. A minor set trends northwest and dips at a shallow angle. The joints contain limonite which locally gives the rock a red-brown tint.

Aplite dikes and greissenized fracture zones cut the granite in northeasterly directions. Tungsten minerals, principally wolframite and some hubnerite, are associated with some of the greissen zones. The pegmatitic pods occurring in the granite are generally devoid of valuable minerals; however, samarskite and beryl have been recovered from some.

A rhyolite dike, ranging in width from a few feet to nearly 50 feet, cuts the granite along its southwestern margin from the mouth of Burned Canyon northwesterly to the drainage of Albert Ekkers Canyon. The dike is traced by float and in places by the presence of more prolific vegetation. The rock is dense with phenocrysts of quartz, orthoclase, and oligoclase, ranging from 2 mm to 5 mm in diameter, in a fine groundmass of orthoclase and quartz with some magnetite. The dike and an associated copper-fluorite vein system are both approximately parallel to the south flank fault. The dike and the vein system may be closely associated in age since both are more radioactive than the intruded granite. Except for minor amounts of pyrite in thin fractures in the dike near Burned Canyon, no mineralization of the dike was observed.

A thick prominence of andesite is present near the perennial spring in Elderberry Canyon on the west flank of the range. The height and position of this mass indicate that it may be a remnant of a short chain of small volcanoes aligned along the west flank fault.

EXTRUSIVE ROCKS

<u>General statement</u> - The flows along the south and west flanks of the Sheeprock Mountains are mainly andesitic in composition and are probably closely associated with the flanking normal faults and are probably late Miocene or Pliocene. The igneous rocks around the Allison Knolls are part of an intrusive and volcanic center located in the Desert Mountains. The similarity between the Desert Mountains intrusive and the Sheeprock stock suggests that this assemblage is Miocene in age also. The only basalt flow is in the Simpson Mountains region, south of Black's Ranch. It is thought to be the youngest extrusive rock in the area mapped.

<u>Extrusives in the West Tintic area</u> - The West Tintic monzonite stock is in fault contact with volcanic rocks of andesitic composition along its southern border. The andesites and some associated tuffs appear to be relatively flat-lying and are probably late Miocene or

PLATE XXIII

'White facies' of Sheeprock granite containing rosettes of beryl.

Pliocene in age. The volcanics are of considerable thickness near the contact. Drilling in the area revealed between 400 and 800 feet of volcanics overlying the monzonite.

Extrusives flanking the Sheeprock stock - The rhyolitic extrusive on the west side of South Pine Canyon occupies the area of a small drainage basin. The position and flow banding of this rock indicate that it flowed southerly over a relatively mature dissected erosion surface. Since no faults are located north of the volcanic occurrence, it may be assumed that the Sheeprock granite in that area is most likely of late Miocene or Pliocene age. The andesitic occurrence in the Elderberry Canyon area likewise is associated with flanking faults, and parts of it have been beveled by the high level Miocene-Pliocene erosion surface which slopes westward toward Erickson's Pass.

Extrusives flanking the Simpson Mountains - Volcanic rocks of rhyolitic and andesitic composition and low easterly dip flank the Simpson Mountains. The volcanics are, in the main, not affected by the numerous gravity faults which cut the Paleozoic rocks in that area. The volcanism is probably late Miocene and Pliocene in age. The extrusives have been truncated by low-level Pliocene pediment surfaces in the vicinity of Erickson Pass.

Animal burrows in the Ordovician shales penetrate volcanic rock, indicating that feeders for the rhyolite are present along the west flank of the Simpson Mountains. A small basalt flow covering several acres is present in the area. It is only a few yards thick and dips with the erosion surface. This basalt may be as young as Pleistocene and may coincide in age with the basaltic fields to the south (northwest of Delta, Utah).

Volcanics in Allison Knolls - Volcanic breccias and rhyolitic and andesitic flows, together with a probable volcanic plug, are present in the Allison Knolls. The volcanics intrude and cover Precambrian and Ordovician rocks which were involved in thrusting in the area. The volcanics are approximately the same age as those flanking the Sheeprock Range (Miocene-Pliocene).

S T R U C T U R E

MAJOR FEATURES

The structural elements of the Sheeprock area consist of a north-dipping monocline, north-trending folds, north-trending low-angle thrusts, older high-angle faults, low-angle strike-slip faults, and east-trending thrusts. The structures in above sequence are the result of progressive stages of deformation during the Laramide orogeny. A number of less prominent, high-angle normal and strike-slip faults range from Laramide to Recent.

FOLDS

Sheeprock monocline - The Sheeprock monocline is the dominant structural element in the Sheeprock Mountains. It extends from the granite contact northward to Lookout Pass, and from Vernon Creek on the east to Skull Valley on the west. Rocks ranging in age from Precambrian through Mississippian are involved in the structure which dips from 35 degrees to 55 degrees to the north and northeast. The orientation of the Sheeprock monocline is east-west which is contrary to the north-south folding present in the north-lying Onaqui and Stansbury ranges.

Pole Canyon anticline - A major north-trending recumbent limb of an anticline is evident from the areal distribution of Precambrian rocks in the vicinity of Pole Canyon south of the divide. The fold, here referred to as the Pole Canyon anticline, extends from Joes Canyon eastward to the head of Cow Hollow. It is terminated on the north by the Pole Canyon fault, on the east by a Laramide fault complex (east of mapped area), on the south by a cover of pediment gravel and colluvium, and on the west by the Sheeprock granite. The exact position of the anticlinal axis is uncertain. The Sheeprock or related thrusts were probably contemporary structures. The Pole Canyon anticline was torn, thrust, and dragged to its present position by Laramide forces. The exposed rocks of the structure are mostly near vertical. They are slightly overturned near the granite contact, and the degree of overturning increases easterly to a maximum of 15 to 20 degrees and dips westward in the vicinity of Cow Hollow. The rocks east of Cow Hollow are poorly exposed, but a few exposures east of the map boundary indicate that the overturned limb has been thrust easterly and that the thrust surface may be the Sheeprock thrust or one which is closely related to the major thrusting in the area.

Death Canyon anticline - The major structure present in the southern portion of the Simpson Mountains is the north-plunging Death Canyon anticline. The anticline is symmetrical with an axis that trends approximately north and coincides with the drainage of Death Canyon. The eastern limb of the anticline is included in the mapped area. As far as is known, rocks ranging in age from Precambrian through basal Cambrian quartzites are present in this structure. Dips ranging from 40 to 60 degrees to the northeast are present along the eastern limb. The anticline is terminated on the north, in the vicinity of Black's Ranch, by a large east-west fault which extends through the Simpson Range. This fault is either a gravity or a strike-slip fault. The nose of the Death Canyon anticline is believed to be covered by allochthonous blocks of subsequent thrusts. Younger normal faulting further complicates the structural interpretation in the Simpson Mountains.

FAULTS

Sheeprock thrust - The Sheeprock thrust (Loughlin, 1920, p. 436) was first recognized in the West Tintic mining district near the southeast end of the Sheeprock Mountains. Subsequent workers (Stringham, 1942; Gardner, 1954) have confirmed the presence of the thrust and have added some detail to its outline. The Sheeprock thrust involves thrusting of Precambrian rocks (including tillite) over rocks ranging from Cambrian(?) to Devonian in age. Rocks of Upper Paleozoic age may have been overthrust farther to the east, and a subsequent work by Sidney Groff will probably delineate the relationships of the Sheeprock thrust in the east-lying West Tintic Mountains. The Sheeprock thrust can be traced only by the presence of windows of Paleozoic carbonate rocks in the upper plate. The largest exposure is near the West Tintic monzonite in Sec. 28, T. 11 S., R. 5 W. Another small exposure is in Indian Hollow approximately one and one half miles northwest of the main mass of the West Tintic monzonite. The thrust plane ranges in dip from near-horizontal to 15 degrees northward. The West Tintic monzonite has penetrated both the lower and upper plates of the thrust and the attendant metamorphism has obliterated primary structures of many of the carbonate rocks of the westernmost rocks of the windows. Rocks involved in thrusting, probably related to the Sheeprock thrust, crop out in the Allison Knolls near the center of the south edge of the mapped area. Dark blue gray dolomites exposed on the eastern side of Allison Knolls are in nearly horizontal contact with the underlying Precambrian tillites. The dolomites are assigned to the Ordovician on the basis of color and the presence of *Halysites* and are thought to be units of the Fish Haven dolomite. The carbonates dip 41 degrees northeast, whereas the underlying tillites dip from 35 to 48 degrees in the same direction.

In the northern part of the West Lookout Hills, allochthonous blocks of quartzite and silicified limestone, bearing crinoid columnals, have been thrust over rocks which range from Ordovician to Mississippian in age. These overthrust sediments are tentatively identified as Oquirrh formation of Pennsylvanian age. The dip of the strata of both the thrust plates is approximately 45 degrees northerly. The fault surface is somewhat undulatory, as suggested by the slight differences in elevation of the bases of the allochthonous blocks which occupy the crests of the hills in the area. This thrust is related to the movement which produced the Sheeprock thrusts and the north-south folds of the north-lying Onaqui and Stansbury Mountains. The thrusting in the Lookout Hills probably is an extension of the Los Ricos thrust of Croft (1956, p. 29) which is exposed along the west flank of the Onaqui Mountains.

The highest elevation in the west-lying Simpson Mountains are allochthonous blocks of Precambrian quartzite and are most likely related to the Sheeprock thrust. Although the area is highly disturbed by normal faulting, the presence of Precambrian strata in the higher elevations suggests that both the Precambrian and much of the Cambrian sediments have been thrust to their present position. Without thrusting, normal faults with relative displacements of about 10,000 feet would be necessary to account for the outcrop pattern, and some of these would be only a few hundred feet apart.

Older normal faults - The principal, older, high-angle faults are confined to the west flank of the Sheeprock Range. They are most pronounced at their southern extremities west of Bennion and Talawag Peaks; the faults strike north-south and dip from vertical to slightly west. Later movements along the west flank fault have accentuated its scarp. The presence of the monoclinal structure indicates that the initial movement along the fault may have been essentially a diagonal fault (strike-slip fault with relative movement of eastern block rising as it moved in a southerly direction). The covered area along the west side of the range obscures the basement rocks which are necessary to establish the exact relationship of the fault. Rocks ranging in age from Cambrian to Devonian are present on the downthrown side of the fault. The differences between dip of the strata in the Simpson Mountains and the Sheeprock monocline indicate that the west flank fault is closely related to the formation of the Sheeprock monocline.

Another high-angle fault, trending nearly east-west, transverse to the axis of the southern Onaqui Mountains is here called the Onaqui fault. This feature marks the junction of the north-south fold system on the Onaqui Mountains with the northward-dipping strata comprising the Sheeprock monocline. The Onaqui fault is concealed beneath alluvium both east and west of the range. Johnson (1956, fig. 2), interpreting gravity measurements at the south end of Skull Valley, indicates an anomalous condition east of Davis Mountain which may be caused by the presence of the buried Onaqui fault.

Pole Canyon thrust - A major, north-dipping, high-angle thrust exposed along the heads of Pole and Auts Canyons is here referred to as the Pole Canyon thrust (pl. XXIV, fig. 2). Displacement along it is to the south and southwest. The thrust trace can be followed from the divide near the head of Cow Hollow westward through the heads of Pole and Auts Canyons, thence northwest into Bennion Canyon, thence south to the Sheeprock granite. The Sheeprock granite is later than the thrust and probably intrudes the area containing the westward trace of the thrust. The Pole Canyon thrust is of unknown displacement, but has probably moved several miles. The drag and compressional folds observed along the thrust plane indicate movement from the north and northeast. Precambrian rocks of the overturned Pole Canyon anticline are truncated and overridden by the Precambrian rocks of the upper plate. The thrust involved all the strata of the highest portions of the range. The dip of the thrust plane ranges from 45 to 65 degrees northerly.

Lion Hill and related north flank thrusts - The Lion Hill and related thrusts are confined to the area north of the Sheeprock drainage divide.

PLATE XXIV

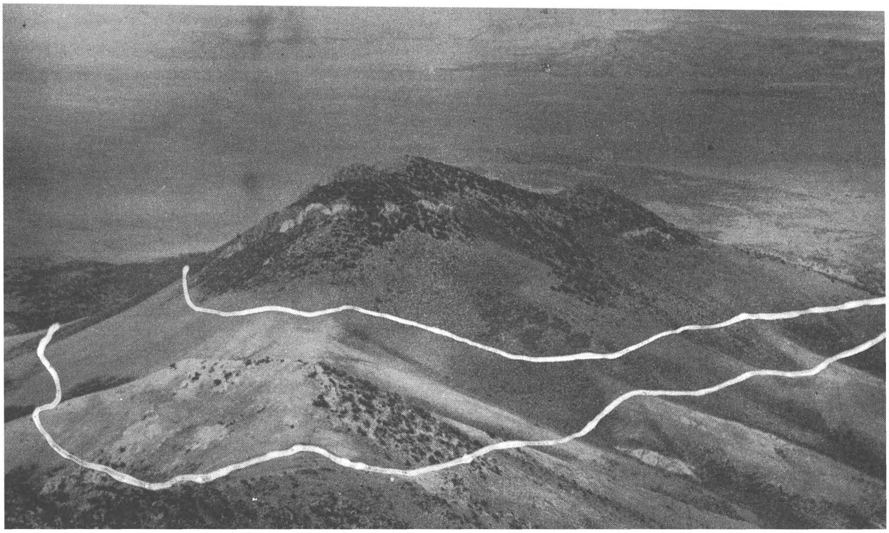


Figure I
View to the north of Lion Hill. Segments of the Lion Hill thrust are marked on the photograph. Lighter Tintic quartzite in center foreground is thrust over the Precambrian. Middle Cambrian carbonates comprising the upper part of the hill are thrust over the Tintic quartzite.

Figure 2
View to the northwest near Bennion Canyon showing limonite-stained thrust plate. The rocks in the lower right and the rocks in the ridge in the background are thrust to the south.

The outcrop of the thrust can be traced around Lion Hill and into the foothills east and west of the mouth of Harker Canyon (pl. XXIV, fig. 1). A smaller patch of white quartzite located north of Little Valley is in thrust contact with underlying Precambrian rocks. The thrusts are low-angle; they dip 10 to 15 degrees northerly. Rocks of the Cambrian system, ranging from the Tintic quartzite to the Marjum formation, have been thrust over Precambrian strata assigned to the Mutual(?) formation and part of the upper Sheeprock series. The stratigraphic displacement is approximately one mile. The dips of the strata of the upper plate of the thrust more or less coincide with the dip of the rocks of the lower plate which are disposed 45 degrees northeastward. The similarity of the Cambrian strata of the thrust segment with the surrounding Cambrian sections precludes the possibility that this, the Lion Hill, thrust comprises rocks far removed from the Cambrian sections in the vicinity; therefore, it is concluded that the strata recognized in the upper plate have not been displaced any great distance and that the outcrop pattern of the area indicates that the movement on the thrust is to the south and southwest. Further, the dip of the thrust plane indicates that the compression producing the thrust was post-tilting of the Sheeprock monocline.

Low-angle, strike-slip faults - An east-west, north-dipping, strike-slip fault is traceable across the range in the vicinity of East and West Government Canyons. This fault is referred to as the Government Creek fault. The fault plane dips north from 30 to 45 degrees. Strata of the upper Sheeprock series have been moved over strata of the Marjum formation, a stratigraphic distance of approximately 5,000 feet. The relative movement of the hanging wall block appears to be westward and south. The greater component is westerly and probably did not exceed 4 miles. This fault is probably associated with the forces which produced the Pole Canyon and Lion Hill thrusts.

Other strike-slip faults of lesser displacement than the Government Creek fault are the Red Pine Creek and the Lookout Pass faults. The Red Pine Creek fault located north of Lookout Peak (Red Pine Mountain) dips north 18 degrees. The fault is difficult to trace, but absence of normal stratigraphic units indicates that the north-lying hanging wall block cut out between 600 and 1,000 feet of strata. The relative movement on this fault is difficult to determine but is presumed to favor a westward movement for the hanging wall block. The high-angle, northeast-trending strike-slip faults in the West Lookout Hills lying between the Lookout Peak and Lookout Pass verify this interpretation.

The Lookout Pass fault is traced for only a short distance in a northwest direction north of the Lookout Pass road. Westward, the fault is obscured by fan gravels. The Chiulos shale member of the Great Blue formation is cut out by the faulting east of Lookout Pass. Relative movement of the hanging wall block to the west places the upper Great Blue limestone member in contact with the lower limestone member. The missing interval represents approximately 2,000 feet of strata, the entire Chiulos member. A small syncline is developed in the footwall block east of the pass which indicates an eastward movement for that segment.

Miocene normal faulting - The normal faulting associated with the intrusion of the Sheeprock granite is Miocene in age. The trend of the faults is generally at right angles to the intrusive contact and of small displacements. The major fault along the east side of the Simpson Mountains was either initiated or rejuvenated at this time as was the west flank fault along the Sheeprock Range. Similarly the faults along the south flank of the Sheeprock Mountains were rejuvenated. The network of faults north of Black's Ranch and on the southwest end of the Sheeprock Mountains affecting Ordovician rocks is probably of Miocene age and may represent collapse structures which attend the extrusion of rhyolites and andesites in those areas.

Pliocene fault movements - Faulting resumed in late(?) Pliocene and pediment surfaces formed during late(?) Miocene and early Pliocene time were re-elevated and a new period of erosion initiated. The displacements were mainly confined to the older north-south faults. The faults flanking the range on the north and east probably came into existence at this time. The east-west, south-facing, erosional scarp at Erickson Pass indicates that the south flank faults were again active and the early(?) Pliocene surface north of the pass was elevated several hundred feet.

Pleistocene and Recent fault movements - The most recent recognizable fault scarps are those of the north and east flanking faults. Displacements of recent alluvium may be traced from the mouth of Bennion Canyon northwestward to East Government Creek, thence north to the Lookout Pass Road. The presence of slump and graben structures in unconsolidated fan and terrace gravels suggests that the latest movement along these faults occurred within the last few hundred years.

OROGENIC PHASES

General statement - The only absolute dates in the orogenic history of the Sheeprock area are those afforded by the Pennsylvanian strata, the Miocene age of the Sheeprock granite, and the present. An intrusive in the nearby East Tintic Range is probably Eocene, and a monzonite in the West Tintic Range seems to be related. The succession of orogenic events which is established by structural and intrusive relations, is then fitted to these few guideposts as well as possible, and at the same time the chronologies of nearby areas are respected. The first three major deformational phases of the Sheeprock area thereby seem best assigned to the Cedar Hills, early Laramide and mid-Laramide orogenies (see Eardley's usage, 1951).

Cedar Hills orogeny(?) - mid-Cretaceous phase - The monocline that dominates the Sheeprock Mountains was formed in early deformational times and pre-dates the thrusting which seems to be early Laramide in age. This deformational phase may then be the Cedar Hills orogeny (Eardley, 1951, p. 273).

Early Laramide orogeny - Montana phase - The earliest phase of Laramide orogeny began by simple folding which developed into extensive thrusting at its culmination. Great masses were thrust eastward and in places overrode the upturned rocks of the previous episode of tilting. The Death Canyon and Pole Canyon anticlines were formed during the Montana phase. The Pole Canyon anticline was overturned and thrust in imbricate sheets eastward over tilted Precambrian rocks. The oldest structure resulting from this phase is the Sheeprock thrust, which is recognized by means of windows in the precambrian rocks of the upper plate. In the West Tintic area carbonate strata of the lower plate ranging in age from Cambrian through Devonian are vertical to overturned and are believed to indicate thrusting from the west. In the Allison Knolls, Ordovician rocks assigned to the Fish Haven dolomite have been thrust over Precambrian tillites. The tillites in this area dip identically with the rest of the Precambrian rocks of the northwest-trending line of small knolls which extend toward Erickson's Knoll. This dip is similar to those of the small Precambrian outcrops west of South Pine Canyon and the rest of the rocks of the Sheeprock monocline. In the Simpson Mountains the thrusting of Cambrian and Precambrian strata over Ordovician rocks is assigned to the main period of thrusting of this phase. The allochthonous blocks of the Oquirrh (Pennsylvanian) formation, which are in thrust contact with Ordovician through Mississippian rocks in the north end of the West Lookout Hills, are assigned to the Sheeprock thrusting phase of the orogeny. The similarity in dip of both the upper and lower plates proves the thrusting is post-tilting. This thrust is believed to be related to the thrusting in the (Los Ricos thrust) northern Onaqui Mountains which is considered by Croft (1956, p. 30) to be of the early

Laramide orogeny. During this phase, the monoclinal structure acting somewhat as a buttress was displaced to the east. The northern part of the monocline moved farther east than the southern segment. The initial movements on the north-dipping, strike-slip faults at Government Creek, Red Pine Creek, and Lookout Pass probably occurred at this time. The north dip of the faults is believed to be the result of a wrapping of forces around the main mass of the monocline. The resistance of the monoclinal block imparted a relatively strong southwesterly vector to the main easterly directed force. The Onaqui fault, a transverse fault separating the Sheeprock area from the Onaqui-Stansbury Ranges, formed at this time. The Onaqui fault is principally a strike-slip fault north of which the strata yielded to form folds and thrusts; to the south the presence of the tilted strata offered more resistance which resulted in strike-slip movements and thrusting of more competent masses.

Mid-Laramide orogeny(?) - Paleocene phase - Following the west-to-east compressive phase of Montana(?) time, possibly after a period of relative quiescence, orogenic activity once again affected the Sheeprock area. Forces directed in a southerly and southwesterly direction caused large masses of the monocline to be thrust a few miles to the southwest, overriding and truncating pre-existing folds and thrusts. The north-dipping Pole Canyon thrust overrode the overturned limb of the Pole Canyon anticline. The Lion Hill thrust and related north flank thrusts of smaller southerly displacements are also assigned to this phase. Movements along strike-slip faults of an earlier orogenic phase were probably renewed at this time.

Late Laramide orogeny - Following the period of compression the West Tintic monzonite was intruded into the strata near the eastern end of the Sheeprock Mountains. The intrusive cuts both the upper and lower plates of the Sheeprock thrust and the strata of the overturned limb of the Pole Canyon anticline. The West Tintic monzonite is older than the Sheeprock granite which is Miocene in age. An Eocene or Oligocene age for the monzonite is postulated because of its age relative to the granite and its similarity with the East Tintic intrusive which is probably Eocene in age (Morris, 1955, personal communication). The West Tintic intrusive probably marked the end of Laramide activity in the Sheeprock area.

Basin and Range phase - Following an extensive period of erosion during Oligocene and early Miocene, the Sheeprock area was again uplifted. Tensional faults along the south and west sides of the Sheeprock range were initiated or reactivated. The Sheeprock granite was intruded at this time and many of the small normal faults surrounding the intrusive were formed. The area lying between the higher portions of the Sheeprock and Simpson Mountains was complexly faulted at this time. Volcanic rocks located in the same area were erupted. Another period of erosion separated the Miocene faulting from the Pliocene. During late(?) Pliocene, renewed faulting established new base levels and lower pediments were formed. Very young scarps in unconsolidated material along the north side of the Sheeprock Range indicate renewed faulting in Recent time.

G E O M O R P H O L O G Y

GENERAL FEATURES

The north-trending segment of the Sheeprock Range joins the Lookout Hills on the north at Red Pine Canyon. The Lookout Hills form a link with the north-lying Onaqui Mountains. The east-west-trending segment of the Sheeprock Range on the south combines with the north-trending segment to produce a drainage system dominantly to the north-northeast and to the south. Drainage to the north-northeast is into Rush Valley and to the west into Skull Valley. The south flank drains into the sinks of

PLATE XXV

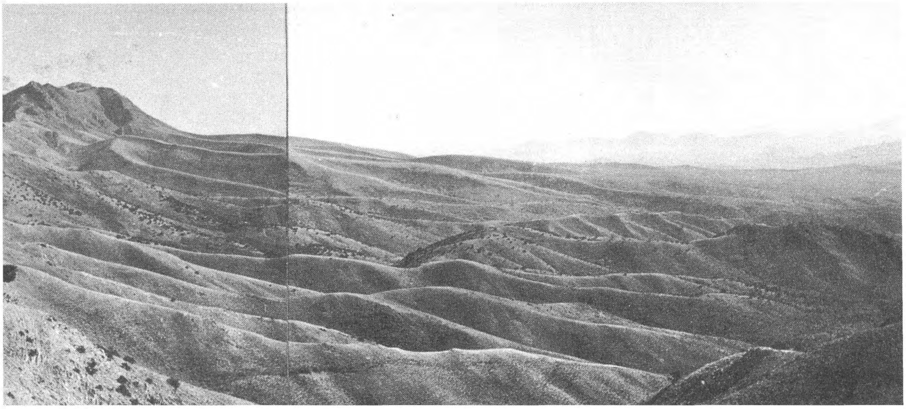


Figure 1
Looking south at Miocene-Pliocene surface. Bennion Peak on the left, Erickson Pass on the right at low point of surface.

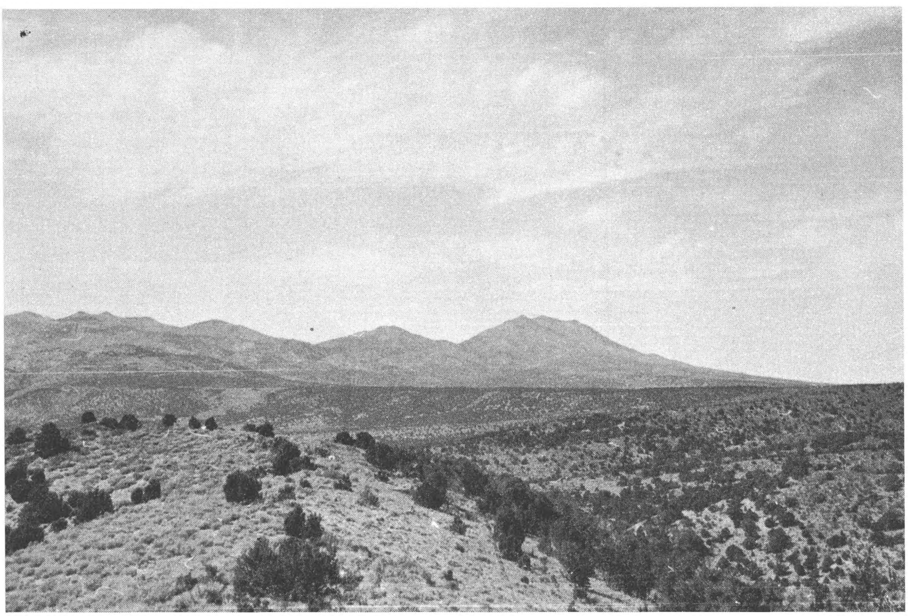


Figure 2
Looking west at Erickson Pass and Pliocene surface; Simpson Mountains in background. Erosional scarp in center of photograph.

the "Old River Bed," the prehistoric river connecting the Sevier embayment with the main body of water of Lake Bonneville.

Sedimentary rocks of the Sheeprock Range dip dominantly to the north, and the present topography reflects strongly the erosion of this structure. Dip slopes are prominent northeast of the divide where differential weathering has influenced the terrane. The south and west slopes are less steep than the northeast slopes, and the drainage is more sinuous. The granite crags, steep slopes, and V-shaped valleys indicate the area is in the "youthful" erosion stage. Five principal landforms are recognized: (1) fault scarps, (2) pediments, (3) alluvial fans, (4) lacustrine features, and (5) glacial landforms.

FAULT SCARPS

General statement - Fault scarps outline the main mass of the Sheeprock Range. The oldest faults are the west and south flanking faults, whereas the north and east flanking faults are more recent (see Geologic map, pl. I).

West Flank fault - The western escarpment, formed by the West Flank fault, rises abruptly 1,500 to 2,000 feet from the "high level" pediment at the head of West Oak Brush Creek. An associated fault one mile west of the main fracture cuts the high level pediment and further accentuates the topography. The West Flank fault is offset to the west by a reverse strike-slip fault near the head of West Government Creek. Springs and seeps mark the fault line as do small depressed saddles at the junction of the pediment surface with the mountain front. The dissection of the older and younger pediments of Government Valley indicates recurrent uplift and movement along the West Flank and associated faults which form the graben-like structure between the Sheeprock and the Simpson Mountains.

South Flank fault - The South Flank fault is poorly marked, being near the junction of the granite with the flanking pediment. Loughlin (1920, p. 424) noted the gradient change of the streams near the mouth of the canyons along the south side of the range. The change or grade or "nickpoint" does not represent the main South Flank fault. The "nickpoint" is in its present position because of erosion and pedimentation. The main vertical movement is along a zone of approximately parallel faults; the zone extends from the granite about one mile into the valley. The exact traces of the faults can only be estimated since pediment gravels mask most of the bedrock.

North and east flanking faults - Recent movement along the north and east flanking faults is indicated by low scarps cutting fan gravels close to the mountain front. These low scarps have not been dissected and are probably of very recent age. Grabens and landslides associated with the faulting are present near the mouths of North Oak Brush and Harker Canyons.

PEDIMENTS

General statement - Pediments of several periods of uplift are evident along the west and south sides of the Sheeprock Range. The pediments are classified as high-level and low-level (pl. XXV).

High-level pediments - The oldest pediment surface is noted near the heads of Elderberry, Dry and West Oak Brush Canyons. The spurs are rounded and appear as mature surfaces.

The highest parts of the Sheeprock stock also appear to be truncated by an ancient erosion surface and contain concave slopes and perched shallow mature valleys which have been dissected by later erosion. The Elderberry surface and the surface on the high points of the granite may be parts of a single erosion surface.

High, truncated, colluvial covered spurs are on the north side of East Government Canyon and on the east side of Lookout Valley.

Low-level pediments - Gently sloping surfaces, eroded in granite and volcanic rocks, are evident on the flanks of the range. They are veneered with alluvium which ranges from a few feet to over 100 feet thick. Several episodes of uplift are noted by the perched terrace-like surfaces above the present day gradient. The pediment gravel shown on the map includes the debris-built surface which extends the pediment surface into the valley. All the pediment surfaces are dissected by deep gullies, especially near their upper extremities.

ALLUVIAL FANS

Alluvial fans of more recent age than the pediment surfaces surround the range.

The south side of the Simpson Mountains is flanked by alluvial fans, many of which coalesce in their lower reaches forming a bajada which extends into the "Old River Bed." A study of aerial photographs of the Simpson Mountains reveals that much of the dissection of the pediments and alluvial fans coincides with the tenure of Lake Bonneville. The fans which were partially covered by Bonneville waters are more dissected above the old water level. The limited and sporadic nature of the precipitation of the present day climate is causing alluviation near the apices of the fans.

Fans on the north side of the Sheeprock Range and on the east side of the East Lookout Hills grade into soil-covered alluvium where the farm lands around Vernal, Utah, at the southern end of Rush Valley are located.

LACUSTRINE LANDFORMS

Topographic features associated with Lake Bonneville include wave-cut beaches, wave-built terraces, and offshore bars. Lacustrine deposits are present in Skull Valley and in the northern part of the Sevier Desert (Gilbert, 1890).

The most prominent wave-cut beach and wave-built terrace is that of the Bonneville shoreline at an elevation of 5,135 feet. Other shorelines of lower lake stages are indistinct.

In areas of gentle slopes, faint remnants of small offshore bars and berms (storm beached) occur. These are especially noticeable where the Meadow Creek drainage intersects the shoreline.

Poorly developed, rocky wave-cut beaches are present along the west side of Allison Knolls.

Associated lacustrine deposits are of sand, silt, and clay.

GLACIAL LANDFORMS

Possible evidence of glaciation in the Sheeprock Mountains was noted at only one locality--North Oak Brush Canyon. North Oak Brush Canyon is U-shaped in cross-section and at its mouth is a deposit of large boulders which may represent a terminal moraine. The head of the canyon is very steep and probably represents a poorly developed cirque basin. Precipitous north-facing slopes present along the divide from Talawag Canyon to Dutch Peak may represent erosional features of nivation centers which were present along the north flank of the divide during Pleistocene time.

ECONOMIC GEOLOGY

ORE DEPOSITS

The ore deposits of the Blue Bell, Columbia, Erickson, and West Tintic mining districts (fig. 6) are associated with the two main intrusive masses, the West Tintic monzonite and the Sheeprock granite, and since the two stocks are of different ages, two phases of mineralization are suggested. This seems probable also because the groups of minerals present in association with each are different. It has been concluded that the monzonite is probably early Tertiary and the granite is middle to late Miocene, and hence these ages are presumed to be those of the two phases of mineralization.

The early Tertiary(?) deposits have yielded most of the production in the West Tintic district. Silver, lead, gold, zinc, and tungsten comprise the metals that have been commercial in the district. Lead-silver-gold-zinc fissure-filling, replacement bodies and tungsten-bearing, contact metamorphic zones are the chief types of commercial deposits in the area.

Miocene and later deposits include the fissure-filling veins associated with faulting due to intrusion of the Sheeprock granite. Copper-fluorite, lead-zinc, manganese-fluorite-uranium veins represent most of the ore and protore deposits associated with the granite. Contact deposits and fissure deposits within the granite contain some values of tungsten. Syngenetic deposits include disseminated segregations of beryl near the center of the Sheeprock stock.

Most of the old mine workings in the Sheeprock area are inaccessible and consequently little can be added to earlier resumes of the deposits (Butler, et al., 1920). However, an attempt was made to relate the deposits to various phases of igneous activity and to report on more recent developments within the area.

The deposits of the West Tintic district will not be discussed in this paper, and for information concerning them, see U. S. Geological Survey, Professional Paper 111, Ore Deposits of Utah.

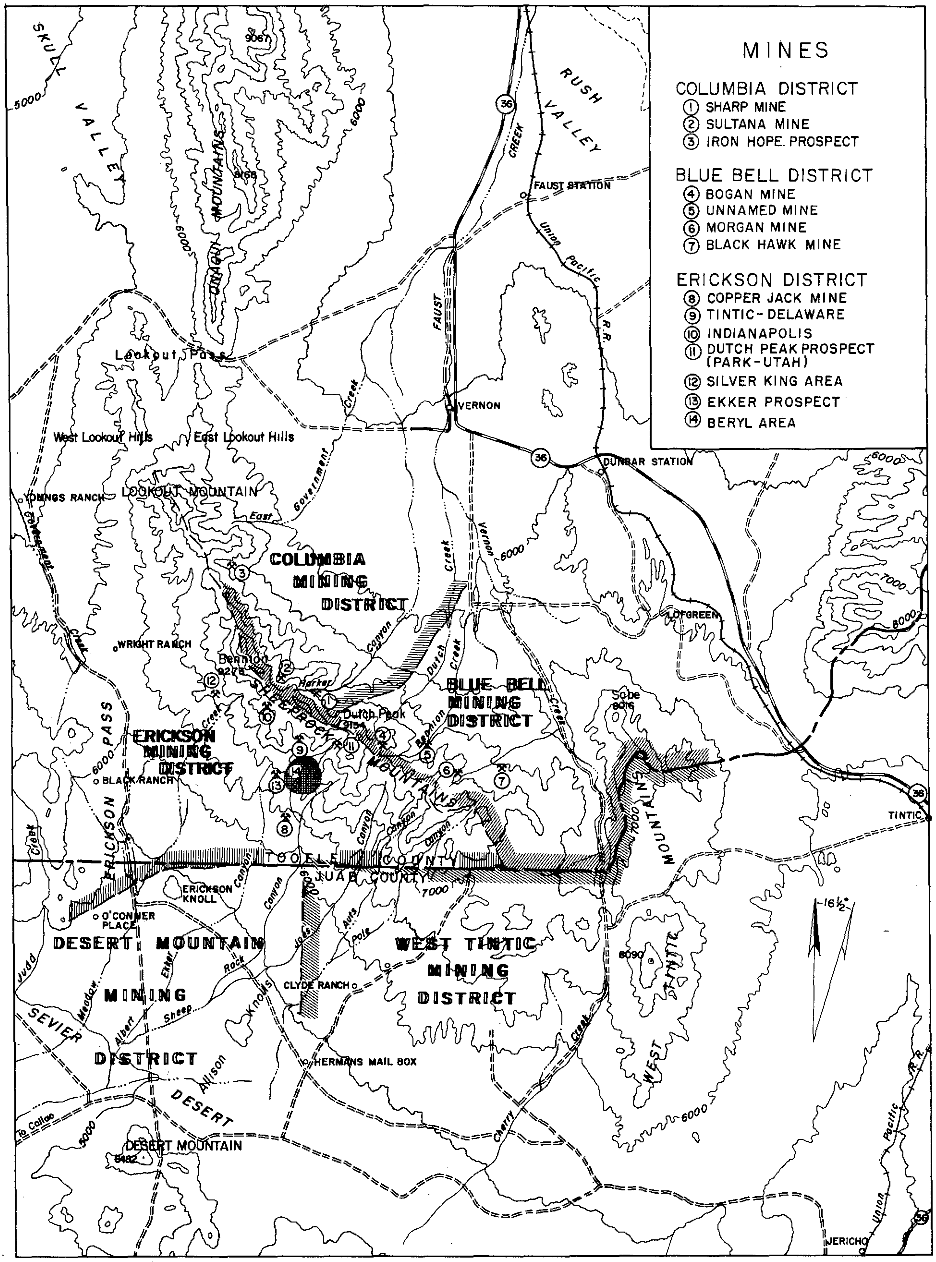
HISTORY AND PRODUCTION

Shortly after ore was discovered in the East Tintic area in 1869, prospectors claimed ground in the West Tintic area, and the district was organized in 1870. In 1871 the Columbia mining district was organized and was followed in 1894 by the organization of the Erickson or Black Crook district, and later in 1896 the Blue Bell district was organized.

Production from the four districts within the Sheeprock area has been meager. The West Tintic district produced a considerable quantity of lead, zinc, silver, and gold in earlier years and during World War II some tungsten was shipped from the mines near the eastern periphery of the monzonite. The Black Hawk mine has been the principal producer of the Blue Bell district. Lead ore valued at 40 to 50 thousand dollars has been produced from the Black Hawk property. The Columbia and East Erickson districts have produced only token amounts of ore, principally lead-zinc.

COLUMBIA DISTRICT

Location - The Columbia district lies on the east side of the Sheeprock Mountains in Tooele County, north of the Blue Bell district. The



INDEX MAP SHOWING LOCATION OF MINING DISTRICTS IN THE SHEEPROCK MOUNTAINS

0 10 20
SCALE MILES

FIGURE 6

deposits of the district are related to the Sheeprock stock of Miocene age.

Lead-zinc veins - The Sharp mine is near the head of Harker Canyon on the north side of the Sheeprock Range. The mine portal is in Cambrian slates and quartzites, which dip steeply northward.

V. C. Heikes reports (1920, p. 426):

> Since 1880 the Sharp mine, a lead-silver-zinc property has been the only notable producer. In the later part of 1908, a 50-ton concentrator, equipped with rolls, Huntington screen jigs, and Wilfley tables, was built. Some lead concentrate was shipped in 1908 and 1909, and shipments of lead-zinc sulphides have been reported. In 1914 the lessees were shipping a fair grade of crude ore.

Further, Loughlin reports (1920, p. 429):

> According to L. D. Gordon, a former operator of the mine, the lead carbonate ore contained about 40 percent lead and 20 ounces of silver to the ton, and the mixed sulphide ore about 30 percent lead and 25 percent zinc. The mine has been worked through tunnels aggregating 1,250 feet in length. The main tunnel when visited was caved in, and a small stream of water issued from it. The ore on the dump included both primary sulphide, lead carbonate, and limonite but nothing is known of their relative amounts. The wall rock includes a large amount of the chloritic beds that have been replaced and impregnated to some extent by ore.

The Sharp mine and the Benmore mine were visited by the writer in 1955-1956. Both were inaccessible; the Sharp mine was caved for a distance of over 100 feet from the portal, and the Benmore mine, a short distance west of the Sharp portal, was caved near its portal. Water issues from both mines and is sufficiently rich in iron to stain rocks near the portals. Specimens of rocks from the dump of the Sharp mine indicate, as Loughlin observed, that the ore, which is principally lead-zinc, fills fractures and fault zones. Drusy and comb quartz is mixed with galena and sphalerite. A few rocks contained only white quartz and pyrite. Some samples of chloritic wall rock were replaced by galena and quartz. Pyritization is prominent in some of the quartzites. Besides green, tillitic slates, the wall rocks penetrated consist of gray quartzite conglomerate and black micaceous slate.

The trend of the mineralized zones could not be traced by surface exposures; however, there is a strong shear zone which extends nearly due west, southeast of the property. Gossan from the shear zone yields manganese and limonite. Faults extending northward from the Sheeprock stock may have been traced to the north side of the range and may at the juncture of the east-west shearing have been favorable for concentration of the lead-zinc deposits in the area of the Sharp mine.

Manganese oxide ores, totaling 1,496 long tons and averaging 25 percent, have been shipped from the vicinity of the Sharp mine in the 1930's by C. W. Jenkins (Crittenden, 1951, p. 38).

The Sultana property is north of the divide at the head of North Oak Brush Canyon. The mine was not entered, but from material on the dump, slate, quartzite, and tillite were penetrated.

Loughlin (1920, p. 429) states:

> The New Sultana ore body had not been opened at the time of the writer's visit in 1912. It is reported to be a vein 4 feet

thick in quartzite, and the ore is said to contain 60 cents in gold and 5 ounces in silver to the ton, 48 percent lead, and 28 percent iron. The zinc content is not known. One hundred tons of ore are said to have been mined in 1914.

There are three adits on the property and the remains of a mill which apparently was never utilized. The westernmost adits bear approximately N. 90° W. into black varved slate containing pyrite and with limonite gossan. No ore was produced from this venture, and the black slate was the only rock penetrated. A quartz-filled breccia zone was interesected as shown by material on the dump.

An upper adit commences in gray quartzite and spongy limonite gossan. Less than 100 feet of tunnel was driven at this place.

The main Sultana workings aggregate approximately 300 feet of tunnel. The portal is in steeply dipping tan quartzite of Precambrian age immediately overlying purple, quartzitic tillite. Ore from the dump is rich in pyrite and galena. Quartz forms the bulk of the gangue minerals. One specimen consisted of fine-grained specular hematite with later inclusions of pyrite. The ore is very similar to that of the Sharp mine, which is less than a mile to the east. Pyritization of the quartzites near the fissures represents the extent of the alteration.

The Iron Hope prospect, near the head of East Government Canyon, consists of a short adit and a shaft in the Tintic quartzite along a fault associated with the Government Creek fault zone. The ore is specularite and quartz in a quartzite fault breccia which strikes N. 90° E. and dips 70° S. Some pods of ore are several feet in width; however, the structural setting precludes the possibility of a large-scale commercial venture.

BLUE BELL DISTRICT

Location - The Blue Bell district lies on the east side of the Sheeprock Mountains near the south boundary of Tooele County. The deposits of the district are generally considered to be related to the Sheeprock granite.

Lead-zinc veins - Four areas containing significant lead-zinc veins in the district are the Bogan and an unnamed mine at the mouth of Bennion Canyon, the Morgan mine, and the Black Hawk mine.

The Morgan mine is discussed by Loughlin (1920, p. 431) and since that time no detectable development work has been done. The Morgan property is in the lower quartzite sequence of the Sheeprock series. The workings follow fault zones which trend west and southwest. The ore is principally galena with some manganese and quartz.

The Black Hawk property is immediately removed from the area of the map, being approximately one and one quarter of a mile northeast of the Morgan mine. However, the mine is in a fault zone in the Dutch Peak tillite. Production from the Black Hawk represents the bulk of the ore shipped from the district. The ore favors fault zones and is principally galena and cerussite.

The Bogan mine is at the head of Bennion Canyon about a half mile east of Dutch Peak. The mine is in gray quartzite immediately underlying the Precambrian diabase. The ore is principally galena and iron and manganese oxides in quartz gangue. The mine was caved but shows extensive development work. The ore occurs in fractured zones associated with north-south faults. Production from the property is unknown. Bismuthinite was reported from the property. Reports from Richard Ekker indicate that the area of the Bogan mine was to have been the objective of the Park Utah venture located at the head of Hard-to-Beat Canyon.

The unnamed mine at the mouth of Bennion Canyon is in Precambrian tillite. The portal bears S. 45° W. following a mineralized fracture zone and crosses barren fractures which strike N. 70° E. and dip 45° N. The ore consists of light yellow sphalerite, galena, pyrite, and quartz. The pyrite is principally disseminated in the enclosing wall rock. Large boulders of quartz monzonite were observed in the tillite, some measuring over two feet in diameter.

ERICKSON DISTRICT

Location - The Erickson (Black Crook) district includes the Simpson Mountains and the western slopes of the Sheeprock Mountains northward to Government Creek. The area described in this report includes only the eastern part of the district. The deposits of the east Erickson district are considered to be related to the Sheeprock stock and are post- mid-Miocene in age.

Copper-fluorite veins - Copper-fluorite veins lie near the base of granite cliffs closely paralleling the south flank of the range. The veins follow N. 45° W. fissures which coincide with the trend of the South Flank fault. Four properties constitute the group which lies along the trend of the vein. The Silver Shield (Flying Dutchman) and the Copper Jack mines are most extensively developed. The high water table discourages shaft sinking as pumping is normally necessary only a few feet below the surface. The mineralization can be traced from near the mouth of Burned Canyon northwestward to Dutchman Hill, on the east side of Hard-to-Beat Canyon. Sheeting is evident in the veins which occur in porphyritic granite. The veins range from a few inches to several feet in width. Chalcopyrite, fluorite, manganese, and pyrite comprise the principal vein minerals in quartz gangue. Much of the fluorite is dark purple and several specimens of the ore contained radioactivity estimated to indicate in excess of 0.15 percent U_3O_8. The uranium mineral was not identified but may be similar to that occurring on the Silver King claims approximately 4 miles to the northwest where uraninite was identified (Hillier, 1956, p. 9).

Alteration is moderate in the granite flanking the mineralized fissures. Much of the biotite is altered to limonite and pyritization is evident. Secondary alteration within the veins is prominent. Pyrite and chalcopyrite are partially altered to limonite. Malachite, chrysocolla, and turquoise are locally developed. Ore on the dumps indicates that secondary alteration is limited as unaltered samples are abundant. The shallowness of the water table further indicates that enriched zones will be scarce.

Lead-zinc veins - Several lead-zinc deposits similar to those of the Sharp and Sultana mines occur on the Erickson side of the divide. They are the Tintic-Delaware (former Free Coinage) in Albert Ekker Canyon, the Indianapolis in South Pine Canyon, and the Dutch Peak prospects at the head of Hard-to-Beat Canyon.

The Tintic-Delaware mine is on the contact of the Sheeprock stock and Precambrian metasediments in the head of the middle fork of Albert Ekker Canyon. Workings totalling 750 feet of drift, roughly describe a D-shape on one level. The portal penetrates Precambrian quartzite approximately 300 feet north of the granite-metasediment contact. The ore, principally pyrite, galena, and sphalerite in quartz gangue, occurs as irregular masses along a fissure which more or less parallels the trend of the granite contact. A massive hematite gossan marks the surface trend of the vein. Specularite aids in tracing the mineral zone westward to the bottom of the left-hand fork of Albert Ekker Canyon, thence toward the old Porcupine prospect. One small pillar in the mine appeared to be of ore grade; it was made up of galena and pyrite in a matrix of sericite.

The Indianapolis mine is near the head of the left-hand fork of South Pine Canyon. The workings total 310 feet and are inclined along a vein which strikes S. 65° E. The ore is specularite, galena, and sphalerite with quartz gangue. The lowermost workings contain some pyrite reported to contain up to $30 in gold per ton. Precambrian quartzite and minor amounts of slate compose the wall rocks. In 1956 R. Ekker leased the property to Ran Rex Mining Company; roads were built to the property, but as of August, 1957, no further development has been undertaken.

The Dutch Peak prospect near the head of Hard-to-Beat Canyon is approximately 400 feet north of the granite-Precambrian contact. The operators drifted along stringers of pyrite and galena for about 600 feet at which time Park Utah Mining Company acquired an interest and continued the drifting another 4,000 feet due east. No significant ore was developed, and the venture was terminated. The mine yields a second-foot of very soft water which provides Hard-to-Beat Canyon with the most persistent perennial water of any of the canyons of the south flank of the range.

Manganese-fluorite-uranium veins --The Silver King claims in Sec. 7, T. 10 S., R. 6 W., Salt Lake Base and Meridian, are near the head of South Oak Brush Canyon on the granite-Paleozoic contact. Rocks of Middle and Upper Ordovician age intruded by the Sheeprock granite have been identified as the Kanosh shale, the Swan Peak quartzite, and the Fish Haven dolomite. The contact represents the westernmost exposure of granite in the Sheeprock area. The granite here is a light colored, coarse-grained porphyritic rock. Euhedral crystals of feldspar and few quartz provide the porphyritic texture to a groundmass of quartz, feldspar, and biotite. Many fractures in the granite, ranging in direction from N. 45° W. to nearly due east, are mineralized. Near the portal of the Silver King #1 tunnel a fault at the granite-quartzite contact was intersected. This fault is related to the West flank fault zone and strikes N. 25° W. and dips 50° SW. and is about 15 feet in width. All veins examined were very thin (1 to 6 inches) with the exception of a few fracture zones containing manganese. Specularite, manganese oxides, chalcopyrite, pyrite, fluorite, and quartz comprise the ore and gangue minerals. Manganese soaking from a network of fine fractures stains the granite black and provides false impressions of its abundance. Uranium occurs as uraninite in a few of the zones underground, but to date sufficient ore for commercial production has not been developed. Some stripping and diamond drilling was conducted by the U. S. Atomic Energy Commission in 1955 in a fruitless endeavor to provide ore-grade material (Hillier, 1956, p. 16).

Wolframite-quartz veins - Claims containing tungsten lie approximately 1 mile north of the Arnold Ekker homestead in Albert Ekker Canyon. The tungsten occurs as wolframite in a matrix of quartz with some biotite. The vein contains only pods of ore and has been exposed at intervals for a distance of approximately 400 feet. The vein is irregular and trends slightly north of east and has a nearly vertical dip. Both hanging and footwalls are of limonite-stained porphyritic granite. Eastward, the vein becomes progressively more greissenized and fine muscovite becomes prominent. The greissen zones are referred to as the "blue dummy" veins by the local prospectors. Several tons of ore were produced but to date none has been shipped.

Pegmatite deposits - Thorium was discovered in 1955 by Richard Ekker in the granite on the left side of South Pine Canyon. Roads were built and the deposit was partially opened by stripping. The ore occurs as short veinlets and pods in an aplitic groundmass. The ore consists of magnetite and an unidentified thoria-bearing mineral in a mass of large biotite crystals and smoky quartz. The biotite crystals range from a fraction of an inch to one and one quarter inches in diameter. Pods of ore measure up to 3 to 4 feet in width. Sheet-jointing dipping 30 to 40 degrees northwest has exercised considerable control on the shape of the pods; the long dimension of the pods very nearly parallels the sheeting. Much of the quartz is massive and is similar to the quartz associated with pegmatites two miles to the east. Radioactivity is strongest near concentrations of the biotite. Hubnerite was reported from a similar prospect several hundred feet north of the present development.

Two pegmatites, one between Sheeprock and Burned Canyons, the other about a half mile northeast of the Silver King portal, have yielded samarskite. These pegmatites are the "barren" type with quartz and orthoclase the predominant minerals. The pegmatites are pod-shaped, and in places, the contact with the coarse granite is very gradational. The largest more easterly occurrence is approximately 50 feet in length. The samarskite from the Silver King area was used in one of the age determinations of the Sheeprock granite.

The beryl-bearing area is centralized in Hard-to-Beat Canyon approximately a half mile north of the forest boundary. Beryl was discovered by Richard Ekker and the deposit was explored in 1953 by the Brush Beryllium Company. The beryl-bearing area spreads over most of Sec. 22, T. 10 S., R. 6 W., Salt Lake Base and Meridian. Beryllium mineralization occurs in thin veinlets, and as disseminated particles and nodular replacements in the granite. The granite ranges from fine- to coarse-grained in texture, and the beryl is found is all the textures. The granite of the area is less limonite-stained than the surrounding granite and is referred to as the "white facies" (N. C. Williams, 1954). The beryl, especially the nodular replacements, is unusual in that it occurs as pods with beryl crystals radiating from a common center. The crystals grow with little regard for the surrounding matrix and normally contain unreplaced granules of quartz and feldspar. Greissen and iron-bearing fissures cut the "white facies," thus establishing the age of the beryl as late magmatic, or more closely associated with the final stages of solidification of the granite. It is postulated that the beryllium was trapped in the intrusive chamber and that movement of the residual beryllium-bearing liquors was practically impossible. The residuum was denied escape to deposit elsewhere as pegmatites and its components were deposited in their entrapped area. The beryllium migrated to the nearest centers of beryl nucleation and was deposited in the several previously noted forms. The growing beryl crystals were in a matrix of already solidified granite and being unable to displace the foreign crystals incorporated them in the pod. Williams reports in abstract (1954, p. 1388) on "Nonpegmatite Beryl" in the Sheeprock Mountains as follows:

> A white granite facies centrally located within a large red granite intrusive in the Sheeprock Mountains, Utah, contains an abnormal amount of nonpegmatite beryl. The beryl occurs as (1) small disseminated particles, (2) rosettes of myriads of crystals whose c axes radiate from a common center to produce spherical and nodular masses up to 2 feet in diameter, (3) in massive form in tiny seams and veinlets, and (4) distinct individual crystals in small aplite pods and in quartz veinlets.
>
> Few typical pegmatites are present within the granite, and these contain little or no beryl. No pegmatites are found satellite to the intrusive. Other minerals found in nonpegmatite occurrences include fluorite, topaz, and samarskite.
>
> Mapping and thin-section study leads to the following interpretation: (1) the granite intrusion was relatively rich in

pegmatitic components, (2) the white granite facies represents a portion that solidified late and was enriched in the pegmatitic fluids which had been expelled from the solidified granite, (3) the pegmatitic residuum was not expelled or allowed to escape from the enriched white granite to form satellite pegmatite bodies as is normally the case late in cooling history of a granite, (4) the pegmatitic residuum thus entrapped crystallized contemporaneously with and shortly after the host granite facies, (5) the beryl crystallized during this cooling period (a) as an accessory mineral in the granite, (b) as replacements of granite, (c) as fracture filling with partial replacement, and (d) as free crystals in aplitic segregates.

Further investigation of the beryllium content of the Sheeprock granite is being conducted by Williams, and his final report will no doubt be more explanatory of the processes and geologic development of this beryllium occurrence.

WATER SUPPLY

General statement - The existing water supply is principally from springs originating from high-level sources.

A greater water supply, as yet unexploited, is believed to exist as subsurface water in undeveloped areas at lower elevations. The broad pediments and alluvial fans absorb the flow of all the perennial streams, and this water no doubt could be recovered at the lower elevations by use of wells and pumps. The broad valleys adjacent to the Sheeprock Mountains, especially south of the range, are believed to constitute areas of large subsurface water resources.

The springs and seeps developed to date produce water commensurate with the amount of precipitation which principally occurs during the winter months. The supply of water reflects directly the precipitation.

North slope springs - Springs on the north slope of the range issue from Precambrian metasediments at elevations in excess of 6,500 feet. All these springs are at localities where the steeper mountain slopes become more gentle. The more persistent waters of North Oak Brush and Bennion Canyons are augmented by waters from the mines near the heads of the canyons. The largest flow of water is in Bennion Canyon. This flow reaches the valley but disappears into the alluvium within a few miles. The flow of Bennion Canyon water is slightly in excess of one second-foot. All waters dwindle in August, but even in drouth years there is usually enough for stock raising. The waters of the north flank are regulated by bedding planes and cross fractures. The 45-degree northward dip stems to direct most of the groundwater recharge of the summit areas to the north slope drainage.

South slope springs - The south flank of the range is less well watered than the north flank, and the springs are normally at slightly lower elevations than those of the north slope. All of the south flank springs are in granite. The springs from Sheeprock, Hard-to-Beat, Albert Ekker, and South Pine Canyons issue from drainage bottoms immediately upstream from the canyon mouths. This peculiar control is due to the intersection of the water table and Late Tertiary normal faulting along the south flank and to the presence of a rhyolite dike which is exposed from near the mouth of Burned Canyon northwesterly to Albert Ekker Canyon where it disappears beneath alluvium and pediment gravels. The dike probably exercises control of the lower springs of the Ekker brothers' homesteads in Joes and Auts Canyons. In covered areas the position of the dike is ascertained by the more luxuriant growth of oak in the drainage bottoms.

Higher perennial springs occur at the granite-metasediment contacts in South Oak Brush, South Pine, Sheeprock, and Joes Canyons. Additional waters in Joes Canyon and the upper springs in Auts and Pole Canyons and in Cow Hollow are similar to those on the north flank, being controlled by west-dipping overturned Precambrian metasediments and cross fractures. Recharge areas of all the canyon streams are mainly the divides between the headward drainages.

West slope springs - Perennial water from Elderberry Canyon issues at high elevation from a fault zone on the west flank of the range. This water is lead by ditch several miles westerly to the Wright Ranch 2 miles north of Erickson Pass.

Water is scarce northward from Elderberry Canyon and that which is present was developed from seeps near the canyon mouths by residents and the U. S. Forest Service. Seeps along the west side of the range are due to the intersection of water table and the West Flank fault.

Lookout Hills area - Almost no water has been developed in the Lookout Hills with the exception of a small spring in the Chiulos shale near Lookout Pass.

East slope springs - East slope water is present in Spring Canyon and in East Government Canyon. Faults apparently determine the position of the springs there. The water in East Government Canyon contains sulphur, but not of sufficient quantity to prevent its use by cattle.

Meadow Creek spring - Near the head of the broad drainage of Meadow Creek near the Black's Ranch (formerly Erickson place) a persistent spring issues from the alluvium. The spring flows several second-feet most of the year, being slightly warm but not noticeably mineralized. The Erickson spring is approximately a mile from the summit of Erickson Pass. The origin of this water and its thermal qualities can only be guessed. Its association with volcanics and proximity to the Simpson Mountains suggest that the recharge is in high ground to the west in the Simpson Mountains and that the water moves through fault conduits in which the heat is imparted either by added hot water or by warm wall rock contact.

Government Creek area - Government Creek, which is the principal drainage northward into Skull Valley from the area between the Sheeprock and Simpson Mountains, is watered by seepage from the high ground of the mountainous areas and by percolation of water stored in porous pediment gravels and rhyolite flows, especially in its upper extremities.

Copper Jack area - The shallow groundwater conditions between Burned and Hard-to-Beat Canyons in the neighborhood of the Copper Jack mine is difficult to explain. The rhyolite dike being the first obstruction to the groundwater brings the water to the surface. The persistence of a down gradient may be explained by either deep weathering with clay products of decomposing feldspar affecting the permeability of the rock or by the presence of an impervious contact (fault or igneous) hidden beneath the alluvium a few hundred yards south of the mine. Dump material from the Dutchman Hill mine indicates that black slate was cut in the workings. It is reported by Richard Ekker that during exploratory drifting in the Dutchman Hill, miners drilling through the rhyolite dike encountered a flow of water which prevented them from loading the holes. The drift was abandoned and subsequently the water was ditched to flow to the Albert Ekker homestead, one half mile southwest from the Silver Shield portal. This water flows until late August. Seeps near the original homestead, located near the top of a small spur between Hard-to-Beat and Albert Ekker Canyons, have been developed by wells from 6 to 12 feet in depth. The water rises to within approximately 3 feet of the surface and is piped to the buildings. The recharge area of this loaf-like spur does not appear to be sufficient for the continual flow available at the wells and, like the Silver Shield water, it tends to lessen in flow in August. Control of water probably from the dike area is postulated to be similar to that of the Copper Jack area.

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A P P E N D I X   A

MEASURED SECTIONS

SECTION PC-1 OF MUTUAL? FORMATION ALONG RIDGE NORTH FROM TALAWAG PEAK, SECS. 29, 32, T. 9 S., R. 6 W., TOOELE COUNTY, UTAH

Cambrian		Feet
Tintic quartzite:		
	Quartzite. White to brown; medium- to coarse-grained; cross-bedded; few conglomerate lenses in lower half.	
Precambrian?		
<u>Mutual</u>? <u>formation</u>:		
<u>Talawag quartzite member</u>:		
1.	Quartzite. Purple-tinted; medium- to coarse-grained; medium- to thick-bedded; transitional with overlying milky white Tintic quartzite; few pebble conglomerate lenses.	34.4
2.	Quartzite. Purple, much cover.	68.4
3.	Quartzite. Pink to purple; medium- to coarse-grained; low-angle cross-bedding prominent; irregular distribution of pebble conglomerate lenses; few white beds. This unit is more markedly purple than underlying strata.	137.6
4.	Quartzite. Pink to purple-tinted; coarse-grained; medium-bedded; has a few conglomerate lenses ranging from 5 to 12 inches in thickness with abundant white quartz pebbles.	34.4
5.	Quartzite. Pink; coarse-grained; medium-bedded to thick-bedded.	74.5
6.	Quartzite. Pink; coarse-grained; thin-bedded; locally is sandstone; heavily hematite-stained lenses.	24.1
7.	Conglomerate. Thick lens; cobbles range from 1 1/2 to 2 inches and are composed of well-rounded gray, white, and purple quartzite with a few jaspers.	4.0
8.	Quartzite. Pink; coarse-grained; medium- to thick-bedded; some cross-bedding; few pebbles of white quartzite.	328.8
	Total Talawag quartzite member	706.2
<u>Shale member</u>:		
1.	Quartzite and shale, interbedded. Purple and gray; transitional unit; shales are micaceous.	27.7
2.	Shale. Purple; quartzitic; micaceous; forms platy debris; some minor cross-bedding; ripple marks indicate aqueous current from the southwest.	79.0
3.	Shale. Purple; similar to above but more blocky.	98.8

4.	Quartzite. Tan; medium-grained; medium-bedded; thickens eastward to over 90 feet.	7.0
5.	Shale. Purple; micaceous; sandy; laminated.	10.0
	Total shale member	217.5
	Total Mutual? formation	923.9

Sheeprock series:

Slate, shale, and quartzite. Green to olive green interbedded large and small scale.

SECTION PC-2 OF THE SHEEPROCK SERIES AT THE HEAD OF ELDERBERRY CANYON ON THE SOUTH SLOPE OF TALAWAG PEAK, SEC. 32, T. 9 S., R. 6 W., TOOELE COUNTY, UTAH

Precambrian? Feet

Mutual? formation:

Talawag quartzite at top:
Coarse-grained; cross-bedded; thick-bedded to massive; purplish and conglomeratic; grades into purple slates at contact.

Unconformity(?): Very questionable.

Precambrian

Sheeprock series:

1.	Slate. Green; coarse-grained; weathers bleached pea green; forms slopes.	332.6
2.	Slate and quartzite, interbedded. Slate: olive drab; thinly laminated in places. Quartzite: olive drab; medium-grained; in beds from 1/2 inch to 2 feet thick; weathers to form saddles; the more quartzitic units weather to form ledges.	352.8
3.	Slate. Olive drab; weathers to form slopes.	117.6
4.	Quartzite. Olive drab; medium-grained; thin- to medium-bedded.	47.0
5.	Intraformational conglomerate, green slate, and pea gravel. Slate occurs as randomly oriented fragments; slate contains pea-size pebbles of quartzite; pea gravel is the matrix fraction for the unit.	43.7
6.	Quartzite and slate, interbedded. Slate: tan; thin-bedded. Quartzite: dark green; in 6-inch to 3-foot beds.	218.4
7.	Slate. Tan; gritty; upper half is fine-grained, and more greenish.	73.9
8.	Quartzite and slate, interbedded. Thin- to medium-bedded. Quartzite: tan; medium-grained.	111.1

	Slate: green and tan; lower 1/3 is 50-50 slate and quartzite; top 2/3 is 20-80 slate and quartzite.	
9.	Quartzite. Tan; medium-grained; medium-bedded, forms ledges.	30.0
10.	Quartzite. Light brown; medium-grained; thick-bedded to massive, two- to ten-foot beds with a few interbeds (one to three inches) of green slate.	200.6
11.	Quartzite. Greenish-brown; medium-grained; gritty; medium-bedded.	101.0
12.	Slate and conglomerate. Quartzite: white and gray; rounded cobbles; pebbles and grit. Slate: almost fissile; may be shaly; is thinly laminated and is medium-green; some slates are interbedded with pebble conglomerate; some beds are mixtures of slate fragments and quartzite pebbles; top 1/2 of unit is less conglomeratic and contains dark green quartzite interbedded with shale.	131.1
13.	Slate. Green; undulatory bedding.	10.1
14.	Quartzite. Light reddish-tan; medium-grained; medium- to thick-bedded; contains scattered white quartz pebbles in lower half of the unit.	161.3
15.	Quartzite, conglomeratic. Purplish-gray to tan; medium-grained; medium- to thick-bedded; contains scattered white quartz pebbles in lower half of the unit.	161.3
16.	Quartzite. White; medium-grained; medium-bedded; "low-angle" cross-bedding; 6-inch micaceous; green quartzite and slate parting 25 feet from bottom of the unit.	90.7
17.	Quartzite. Light gray-green; medium-grained; massive.	3.4
18.	Quartzite. Light tan; medium-grained; massive; "low-angle"cross-bedding.	80.6
19.	Slate. Purple; laminated; micaceous; some 8-inch purple quartzite beds in lower half.	13.4
20.	Quartzite. Light tan; medium-grained; massive.	6.7
21.	Quartzite. Purple; medium-grained; with 3-inch purple slate parting at top.	3.4
22.	Quartzite. White; medium-grained; massive.	13.4
23.	Slate and quartzite, interbedded. Purplish; thin-bedded; irregular (undulatory) bedding.	3.4
24.	Quartzite. White; medium-grained; thin-bedded; massive weathering.	26.9

25.	Slate. Light and dark gray; laminated to thinly bedded; a little mica developed on cleavage surfaces which parallels the bedding; a few short, thin lenses of deep purple; medium-grained quartzites are present.	13.4
26.	Quartzite. White to pinkish-white; medium-grained; thick-bedded to massive.	117.6
27.	Quartzite. Green; fine-grained; thin-bedded.	6.7
28.	Quartzite. White; medium-grained; massive.	6.7
29.	Quartzite. Green; fine-grained; thin-bedded, flaggy.	3.4
30.	Quartzite. White; medium-grained; thick-bedded.	84.0
31.	Quartzite. Pink-tinted; medium-grained; thin-bedded; cross-bedded.	16.1
32.	Quartzite. Similar to unit #30.	108.2
33.	Slate and quartzite, interbedded. Quartzite: dark green; medium-grained; beds are from 3 inches to 10 feet thick. Slate: dark olive green; pebbly; resembles till; cleavage parallel with strike of beds but 10 degrees steeper; unit weathers to a saddle and slopes; much is covered.	813.1
34.	Quartzite. Reddish-tan; medium-grained; medium- to thick-bedded; dip steepens and is in fault contact with a limestone conglomerate; fractures in quartzite are stained with brown limonite.	150.0
	Total exposed Sheeprock series	3653.6

Covered near Tertiary granite.

SECTION PC-3 OF PRECAMBRIAN FROM DUTCH PEAK NORTH TO RIGHT HAND FORK, DUTCH CREEK, SECS. 12, 13, 14, T. 10 S., R. 6 W., TOOELE COUNTY, UTAH

Precambrian — Feet

Colluvium:

Purple argillites at top, thence reddish-brown quartzites.

Sheeprock series:

1.	Shale. Tan to olive drab; fissile; some of basal beds are more sandy with occasional pebbles of quartzite, schist, and igneous rocks.	1095.0
2.	Quartzite. Gray; medium-grained; massive; subglassy.	14.4
3.	Quartzite. Light green; medium-grained; medium-bedded; a few cobbles (like in tillite); weathers slabby.	258.5

4.	Tillite(?). Green; sandy; blocky; a few thin beds.	10.8
5.	Shale and sandstone, interbedded. Sandstone: greenish-brown; fine-grained; thin-bedded. Shale: dark greenish-brown; no pebbles.	107.7
6.	Quartzite. Dark greenish-brown; fine-grained; medium-bedded; contains pebbles and cobbles of quartz, quartzite schist, and igneous rocks.	197.5
7.	Quartzite. Grayish-tan; medium-grained; thick-bedded to massive; vitreous.	96.9
8.	Shale. Dark olive drab; sandy.	172.3
9.	Quartzite. Gray; medium-grained; massive.	10.8
	Total exposed Sheeprock series above Dutch Peak tillite	1963.9

Dutch Peak tillite (type section):

1.	Tillite. Dark brown; pebbly; weathers slabby.	86.2
2.	Tillite. Green to dark green; slabby but some blocky beds also.	1080.6
3.	Conglomerate. Green; fine sandy matrix; cobbly.	32.3
4.	Tillite. Dark brownish-gray to dark green; spotted with cobbles and pebbles; matrix sandy shale; weathers slabby.	547.1
5.	Tillite. Light green; sandy; weathers blocky.	829.3
6.	Tillite. Green; slabby; cobbly; pebbly; pebbles are of limestone, gneiss, quartzite, and igneous rocks.	700.1
7.	Tillite. Dark tan; sandy; a few cobbles and boulders of quartzite.	71.8
8.	Tillite. Dark green; very conglomeratic; very large boulders with pebbles and cobbles.	696.5
	Total Dutch Peak tillite	4043.9

Sheeprock series:

1.	Quartzite. Gray-tan; medium-grained; thin- to medium-bedded.	35.9
2.	Quartzite. Black; fine-grained; very thin-bedded; nearly fissile, silvery.	89.5
3.	Diabasic rock. Dark green; medium- to coarse-grained; medium- to thin-bedded; may be altered shale or tuff.	61.0
4.	Quartzite and slate, interbedded. Quartzite: greenish-gray; fine-grained; medium-bedded. Slate: greenish-black; slate beds are 3 to 7 feet thick.	86.2

5.	Quartzite. Light greenish-gray; medium-grained; thick-bedded to massive.	107.7
6.	Slate. Very dark greenish-brown; slight silver sheen.	35.9
7.	Graywacke. Gray; medium-grained; thick-bedded.	15.0
8.	Quartzite. Tan to gray; medium-grained; thick-bedded.	469.7
9.	Conglomerate. Bluish-green matrix with light gray and white cobbles; contains schist and igneous cobbles and pebbles.	89.5
10.	Quartzite. Dark brown to black; fine-grained; thin-bedded; some beds are pebbly; much cover; conglomeratic near top.	179.5
11.	Graywacke and quartzite, interbedded. Graywacke: greenish-gray; coarse-grained. Quartzite: greenish-brown; fine-grained; thin-bedded.	301.6
	Total measured Sheeprock series below Dutch Peak tillite	1471.5

Quartzite and black schist to contact with Tertiary granite.

COMPOSITE SECTIONS PC-4 AND PC-5 AT HEAD OF HARD-TO-BEAT CANYON, SECS. 14, 15, T. 10 S., R. 6 W., TOOELE COUNTY, UTAH

Precambrian

Dutch Peak tillite

1.	Quartzite. Green-tinted; fine-grained; massive; glassy.	95.0
2.	Quartzite. Dark brown; slaty; fine-grained.	8.0
3.	Quartzite. Tan; fine-grained; massive; contains small dark specks giving rock a peppery appearance.	17.5
4.	Tillite and quartzite, interbedded. Tillite: olive drab with white quartz pebbles and grit dispersed in matrix; weathers blocky. Quartzite: white and gray; medium-grained; massive; units 2 to 15 feet thick.	134.5
5.	Tillite. Dark greenish-brown; gritty; slaty.	62.5
6.	Quartzite. Grayish-tan; medium-grained; medium-bedded.	112.5
7.	Quartzite and slate, interbedded. Slate: sub-fissile; olive drab; quartzitic. Quartzite: light gray; medium-grained; massive; vitreous.	62.5
8.	Tillite. Olive drab; gritty; blocky.	52.5

9.	Conglomeratic quartzite (quartzitic tillite). Brownish-green; massive.	540.0
10.	Tillite. Green; blocky; more sandy in lower third.	294.0
11.	Quartzite. Gray; coarse-grained; much cover.	62.5
12.	Quartzite. Gray; fine-grained; shaly.	65.0
13.	Tillite. Green; cobbly.	112.5
	Total partial Dutch Peak tillite	1619.0

<u>Sheeprock series</u>:

1.	Covered; in saddle; shaly?	90.0
2.	Quartzite. Tan; medium-grained; thick-bedded.	335.0
3.	Conglomerate. Light greenish-gray; green chloritic matrix; weathers brown; cobbles of gneiss, schist, quartzite, monzonite, and quartz.	190.0
4.	Quartzite. Dark brown; fine-grained, thin-bedded; slaty; much cover.	127.5
5.	Conglomerate. Greenish-gray; like unit #3 with thin interbeds of greenish, cross-bedded quartzite.	1044.0

Section PC-5

6.	Quartzite. Light gray; medium-grained, massive.	28.0
7.	Quartzite. Gray; fine- to medium-grained; thin-bedded; bluish-gray, thin bands of fine-grained quartzite intercalated with unit.	257.6
8.	Quartzite. Purple; fine- to medium-grained; thin-bedded.	47.6
9.	Conglomerate. Similar to unit #5.	42.0
10.	Quartzite. Brown; medium-grained, thin-bedded; darker brown bands.	6.0
11.	Quartzite. Bluish-gray; fine-grained; low-angle cross-beds.	15.0
12.	Quartzite. Tan; medium-grained; massive.	29.0
13.	Conglomerate. Similar to unit #5.	252.4
14.	Covered.	28.0
15.	Quartzite. Tan; medium-grained; thick-bedded.	260.4
16.	Conglomerate. Light gray, green chloritic matrix; pebbles of tan and gray quartzite.	240.8

17.	Conglomeratic quartzite. Purple, blocky.	70.8
18.	Quartzite. Reddish-tan; coarse-grained; massive.	78.4
19.	Sill. Dark green; contains fragment of wall-rock, probably associated with intrusion.	11.2
20.	Granite. Sill-like lenses along bedding.	28.0
21.	Quartzite. White, sugary (hydrothermal effect).	148.4
22.	Quartzite. White to ivory; medium-grained; medium- to thick-bedded; approximately every 100 feet are thin units of olive quartzite and a little conglomerate.	565.6
23.	Quartzite. Dark brown; medium-grained; thinly banded; distorted bedding and sugary texture 0-3 feet from base which is at granite contact.	50.0
	Total exposed Sheeprock series below Dutch Peak tillite	3945.7

Tertiary granite. Porphyritic granite; large phenocrysts of orthoclase; matrix lightly stained with iron oxide.

COMPOSITE SECTIONS PC-6, PC-7, AND PC-8 OF PRECAMBRIAN STRATA IN COW HOLLOW, POLE, AND AUTS CANYONS AREA, SECS. 8 AND 9, T. 11 S., R. 5 W., JUAB COUNTY, UTAH: SECS. 31 AND 32, T. 10 S., R. 5 W., TOOELE COUNTY, UTAH: AND SEC. 36, T. 10 S., R. 6 W., TOOELE COUNTY, UTAH

Precambrian - entire section overturned thrust fault contact at top of stratigraphic column. — Feet

PC-8

Mutual? formation

Talawag member:

1.	Quartzite. Purple; conglomeratic; cross-bedded; diffusion bands of dark purple incomplete.	300.0 (est.)

Shale member:

1.	Slate. Purple; micaceous.	150.0-322.0
	Total exposed Mutual? formation	600.0±

Sheeprock series:

1.	Slate. Green; micaceous.	150.0-200.0
2.	Quartzite. White; medium-grained; massive.	1500.0-1675.0
3.	Slate. Dark greenish-gray; micaceous.	733.0

PC-7

4.	Quartzite. Tan; medium-grained, thick-bedded to massive; contains pebble conglomerate near top which ranges from 10 to 20 feet thick.	75.0
5.	Shale. Green; fissile; micaceous.	278.0
6.	Shale. Yellow to yellow-brown; fissile; finely micaceous.	353.0
	Total Sheeprock series above Dutch Peak tillite	3201.0

Dutch Peak tillite:

1.	Tillite. Green; cobbly; shaly matrix; igneous; quartzite, schist, and quartz cobbles.	568.0
2.	Quartzite. Tan; medium-grained; thick-bedded; to massive.	90.0

PC-6

3.	Tillite. Green; bouldery; micaceous; boulders of gray and blue-gray limestone, granite, white to green quartzite, monzonite, and some fuchite quartzite in slaty matrix.	1391.0
4.	Tillite. Light green; silver sheen; micaceous; much grit and few pebbles; no cobbles.	38.6
5.	Tillite. Green; micaceous; predominantly shale with quartzite grit.	202.7
6.	Quartzite. Purplish-tan; medium-grained; massive; lensing along bedding.	72.5
7.	Tillite. Light green; micaceous; angular blue-gray limestone boulders up to 5 feet present in matrix; also quartzite and monzonite cobbles and boulders.	163.2
8.	Tillite. Light green; micaceous; slaty; only a few pebbles of quartzite and limestone.	39.0
	Total Dutch Peak tillite	2555.0

Sheeprock series:

1.	Slate. Micaceous; varved(?); very minute quantity of dispersed quartz grit.	33.8
2.	Covered. Tan quartzite float.	115.9
3.	Quartzite. Greenish-gray; medium-grained; medium-bedded with slaty partings. Slate: silver-gray; micaceous; book-like lamina; bedding grades into greenish-gray quartzites.	91.8
4.	Quartzite. Greenish-gray; medium-grained; massive; changes gradually to tan near top; weathers brown.	37.5

5.	Quartzite. Tan; medium-grained; massive; white secondary quartzite in gash fractures.	9.4
6.	Covered. Abundant tan quartzite float.	32.8
7.	Quartzite. Greenish-gray with white kernels of quartzite; coarse-grained; gritty; somewhat like graywacke.	2.8
8.	Quartzite. Green-tinted; fine-grained; thin-bedded.	4.7
9.	Argillite. Medium green; spotted; cleavage parallels bedding; brown spots; weathers dark gray-green with brown currant-sized spots.	2.5
10.	Quartzite. Green-tinted to tan; fine- to medium-grained; medium-bedded; sub-flaggy.	7.9
11.	Quartzite and argillite, interbedded. Both gray-green. Quartzite: fine-grained; thin-bedded.	2.4
12.	Slate. Gray-green; sandy; micaceous; splits as book mica.	2.5
13.	Quartzite. Gray-green; fine-grained; medium-bedded; weathers dark gray-green or light olive.	2.6
14.	Quartzite. Gray-green; medium-grained; thin-bedded.	4.7
15.	Quartzite. Gray-green; medium-grained; massive; weathers brown.	5.0
16.	Quartzite. Tan; medium-grained; thick-bedded.	99.6
17.	Quartzite. Gray-tan; medium-grained; massive; sub-glassy.	199.2
18.	Quartzite. Tan; medium- to fine-grained; massive; weathers light reddish-brown.	373.5
19.	Slate. Yellow-tan; micaceous; laminated.	44.0
20.	Quartzite. Green-tinted; medium-grained; massive; several 6-inch zones more shaly tan quartzite; this unit is not complete and gradually changes to tan color.	155.7
21.	Quartzite or graywacke. Green-tinted; medium- to coarse-grained; thick-bedded; contains slate and quartz inclusions; weathers light brown, with scattered holes.	98.4
22.	Quartzite, conglomeratic. Light blue-gray; medium-grained; thin-bedded; contains few quartzite pebbles appearing as small eyes.	12.8
23.	Conglomerate, quartzitic. Blue; medium-grained matrix; white pebbles.	4.3
24.	Shale (slate). Black; some is fissile; slightly micaceous; contains few limonite pseudomorphs after pyrite; weathers dark brown; forms saddles.	51.4

25.	Graywacke. Dark gray to black; quartzitic matrix; white quartz pebbles.	38.5
26.	Quartzite. Light gray and olive interbedded; thick beds; olive quartzite, contains dispersed grit.	34.2
27.	Shale (slate). Dark greenish-gray; fissile; micaceous; weathers with silvery cast; forms saddles.	627.8
28.	Shale (slate) and quartzite, interbedded. Quartzite: dark olive; medium-grained; sub-glassy; thin-bedded in 6- to 10-foot units. Shale: silver-blue-black; fissile; micaceous; gray bands; 1 to 6 feet.	305.2
29.	Shale (slate). Silvery green-gray; micaceous; some is metamorphosed and possesses a spotted texture.	1022.3
30.	Covered. Much slate float as unit #10.	611.2
	Cover (?)	
	Total exposed Sheeprock series	4034.4

Miocene

Sheeprock granite

SECTION C-1 OF THE TINTIC QUARTZITE ALONG RIDGE ON NORTH SLOPE OF TALAWAG PEAK, SEC. 29, T. 9 S., R. 6 W., TOOELE COUNTY, UTAH

Middle Cambrian (?) — Feet

Pioche shale:
Quartzite and micaceous green shales interbedded.

Middle Cambrian and/or Lower Cambrian

Tintic quartzite:

1.	Quartzite. Black, brown, and gray; medium-grained; medium-bedded; glassy.	45.0
2.	Quartzite. Tan; medium- to coarse-grained; medium-bedded; moderately brecciated.	316.0
3.	Quartzite. Tan; medium-grained; medium- to fine-bedded; thin micaceous greenish shale partings (1 inch).	87.0
4.	Quartzite. Light tan to white; medium-grained; massive; limonite stains irregular distribution; brecciated.	412.0
5.	Quartzite. Milky white upper half, lower half is varicolored, gray, light gray, green, and tan; medium-grained; brecciated.	174.0
6.	Quartzite. White; medium-grained; massive; brecciated; limonite staining along fractures.	621.0

7.	Quartzite. Very light orange, brown, and white; fine-grained; medium-bedded, some brecciation; sub-vitreous.	86.0
8.	Quartzite. White to gray-brown; medium- to coarse-grained; medium-bedded; glassy.	86.0
9.	Quartzite. Light purple, color grades to white and light tan near top; medium- to coarse-grained; cross-bedding prominent.	85.0
10.	Quartzite. Deep purple, color fades to light purple tint toward top; medium-grained; cross-bedded; very thin bedding in places.	86.0
11.	Quartzite. Pink; medium-grained containing some coarse grains of purple quartz; thick-bedded; vitreous.	155.0
12.	Quartzite. Pink-tinted; medium-grained; medium-bedded.	18.0
13.	Quartzite. Light brown; medium-grained; medium-bedded; brecciated, silicified.	10.0
14.	Quartzite. White and purple with greenish tint; medium-grained; medium-bedded; pebble conglomerate lenses containing jasper and quartzite pebbles in lower third.	212.0
15.	Quartzite. White and green; medium- to fine-grained; medium-bedded; green quartzite micaceous along bedding planes.	75.0
16.	Quartzite. White and brown quartzite; medium- to coarse-grained; medium-bedded; pebble conglomerate lenses in upper portion containing jasper and glauconite pebbles.	69.0
17.	Quartzite. Pink, tan, medium-grained; thick-bedded; grades into coarse-grained quartzite.	35.0
	Total Tintic quartzite	2572.0

Precambrian(?)

Mutual formation:
Quartzite. Pink, purple; cross-bedded; sub-vitreous.

SECTION C-2 OF CAMBRIAN FORMATIONS ALONG RIDGE FROM NORTH BASE OF TALAWAG PEAK TO THE DIVIDE NEAR THE HEADS OF EAST AND WEST GOVERNMENT CANYONS, SECS. 19, 20, AND 29, T. 9 S., R. 6 W., TOOELE COUNTY, UTAH

Precambrian — Feet

Sheeprock series:
Tan and green shale and quartzite; some conglomerates and light colored quartzite.

Fault: Government Creek fault

Middle Cambrian

Marium formation(?):

1.	Limestone and shale, interbedded. Limestone: blue-gray; fine-grained; thin-bedded (average 1 inch). Shale: light green; fissile; laminated; this unit is approximately 95 percent limestone and 5 percent shale. Fossil locality C-6: 1 foot above the base; scrap of linguloid brachiopod.	38.4
2.	Limestone. Dark blue-gray; medium-grained; thin-bedded; weathers smooth; some silty tan partings.	83.2
3.	Limestone and shale, interbedded. Similar to unit #1. Fossil locality C-5: 20 feet above base; scraps of linguloid brachiopods.	76.0
4.	Limestone. Blue-gray; fine-grained; thin-bedded (average 2 inches); brecciated; healed with white crystalline calcite; faulting suspected.	38.0
	Total Marium formation	235.6

Wheeler formation:

1.	Limestone. Dark blue-gray; fine-grained to dense; thin-bedded (average 1 inch); remarkably persistent in color and bedding; weathers smooth to rough; some grayish-tan silty mottles, in slope former weathering in bedding thick blocks and flags; trilobite fragments. Fossil locality C-3: 30-40 feet above base - *Elrathia* ? sp., locality C-4: 215 feet above base - *Elrathina* ? sp.	405.1

Swasey limestone:

1.	Limestone. Dark blue-gray; fine-grained; thick-bedded to massive; contains reddish-tan silts (small amount); weathers fine "sandpapery" to rough.	130.8

Condor formation:

1.	Limestone. Dark blue-gray; fine-grained; thin-bedded (1 to 2 inches); weathers with slightly undulatory tan-gray bedding surfaces and in section appears as brown and blue-gray interbeds; breaks in flags and forms steep slopes, some elongate cherty (silty) nodules parallel with bedding.	20.0
2.	Shale. Light bleached green; fissile; laminated; non-micaceous; weathers to greenish-tan.	20.1
3.	Limestone. Similar to unit #1.	24.2
4.	Shale. Similar to unit #2. Fossil locality C-2: scraps of linguloid brachiopods.	23.0
5.	Limestone. Similar to units #1 and #3.	18.2
	Total Condor formation	105.5

Dome limestone, Burnt Canyon formation, Millard formation, Busby formation, and Pioche shale, undifferentiated, complicated by faulting.

1.	Limestone. Light blue-gray to light gray; fine-grained; massive.	25.3
2.	Limestone. Dark blue-gray to blue-gray; fine-grained; medium-bedded; unit contains tan silty mottles and silt-filled worm(?) holes; weathers rough.	126.6
3.	Shale. Light greenish-gray; fissile; laminated; breaks with flat surfaces; slightly micaceous; grades upward into limestone; scraps of linguloid brachiopods.	8.4
4.	Limestone. Blue-gray; fine-grained; medium-bedded; abundant fractures filled with white calcite; pisolitic (to 3/8 inch in diameter); weathers gray and rough; faulting(?).	25.3
5.	Shale. Green; very thin-bedded; fissile; extremely fossiliferous; trilobite remains common; much hash on bedding surfaces; some flat brachiopods (inarticulate); specimens are all black. Fossil locality C-1: *Ehmaniella* sp., *Glossopleura* sp., *Polypleuraspis* sp.	42.2
6.	Limestone and dolomitic limestone, interbedded. Limestone: blue-gray; fine-grained; micaceous; sandy. Dolomitic limestone: light brown; fine- to medium-grained, micaceous; sandy; unit is medium-bedded (6 to 14 inches); much cover.	88.6
7.	Quartzite and slate, interbedded. Quartzite: brown and reddish-brown; medium-grained; some cross-bedded strata, 6 inches to 2 feet. Slate: light brown to light green; micaceous; fine sandy; much cover.	130.0
8.	Quartzite. Black, gray, and brown; in beds 6 inches to several feet thick; vitreous.	45.0
	Total Dome limestone through Pioche shale	491.4

Tintic quartzite:

Quartzite. Tan; medium- to coarse-grained; moderately brecciated; much cover.

SECTION C-3 OF CAMBRIAN FORMATIONS AT THE MOUTH OF NORTH OAK BRUSH CANYON, SECS. 26, 27, T. 9 S., R. 6 W., TOOELE COUNTY, UTAH

Middle Cambrian — Feet

Swasey limestone:

Limestone. Blue-gray; fine-grained; thin-bedded; measured 78 feet, upper half covered.

Condor formation:

1.	Limestone and shale, interbedded. Limestone: blue-gray; fine-grained; thin-bedded. Shale: dark olive green; blocky; weathers to form slopes; much of unit is covered. Fossil locality C-34: approximately 60 feet above base; linguloid brachiopod fragments, *Hyolithes* cf. *H. cercops* Walcott, *Ehmaniella* cf. *E. burgessensis* Rasetti, *Elrathina*? sp., *Micromitra*? sp., *Iphidella* sp.	129.6
2.	Shale and limestone, interbedded. Limestone: gray. Shale: green; shale comprises 80 percent of unit; much cover.	50.9
	Total Condor formation	180.5

Dome limestone:

1.	Limestone. Light gray; medium-grained; thick-bedded to massive.	55.6

Burnt Canyon formation:

1.	Limestone. Blue-gray; fine-grained; thin-bedded (1 to 2 inches); tan and grayish-tan slightly undulatory partings; weathers smooth; forms slopes.	129.3
2.	Shale: dark green; platy. Fossil locality C-33: at 31 feet above base; linguloid brachiopod fragments.	44.6
3.	Limestone. Blue-gray; fine-grained; thin-bedded; contains worm-like inclusion on bedding surfaces; pink silty partings characterize a few of the beds; weathers smooth; forms slopes.	46.8
	Total Burnt Canyon formation	220.7

Millard formation:

Upper limestone member:

1.	Limestone. Blue-gray; medium-grained; medium-bedded; pisolitic (up to 3/4 inch diameter).	66.9

Middle shale member:

1.	Shale. Light green; slightly micaceous. Fossil locality C-32: *Glossopleura* sp.	80.3

Lower limestone member:

1.	Limestone. Blue-gray; fine-grained; thin-bedded; flaggy; slightly undulatory bedding.	24.2
2.	Limestone, shaly. Fine-grained; thin undulatory beds. Shale: light olive; micaceous.	14.5
3.	Limestone. Dark blue-gray; fine-grained; thin-bedded; few mottles and pisolites; weathers flaggy; few prominent thin sandstone lenses in upper half of unit.	82.1

4.	Limestone. Blue-gray; fine-grained; thin- to medium-bedded; dispersed mottles in lower half; upper half more regularly spaced undulatory tan silty partings (1/2 to 1 inch).	53.1
5.	Limestone. Dark blue-gray; medium-grained; medium-bedded; pisolitic.	12.1
6.	Quartzite. Tan to light brown; medium-grained; medium-bedded, blocky.	4.8
7.	Limestone. Blue-gray; medium-grained; medium-bedded; pisolitic; silty tan mottles and undulatory bedding. Fossil locality C-31: *Helcionella* sp.	7.2
8.	Sandstone, calcareous. Tan; medium-grained; thin-bedded; contains approximately 10 percent blue-gray limestone as lenses; unit weathers dark brown.	9.7
	Total lower limestone member of Millard formation	207.7
	Total Millard formation	354.9

Busby formation:

1.	Quartzite. Purple with black lenses; medium-grained; cross-bedded; lower 19 feet shaly.	52.3
2.	Quartzite. Tan; medium-grained; medium-bedded; flaggy; weathers brown.	26.8
3.	Dolomite. Light blue-gray; medium-grained; medium-bedded; weathers brown; forms ledges.	8.9
4.	Limestone. Blue-gray; medium-grained; thin- to medium-bedded; interbeds of thin brown calcareous sandstone ranging from 1/2 to 1 1/2 inches; limestone weathers light blue-gray; sandstone lenses weather dark brown; unit thins from 21.7 to 6.5 feet. Fossil locality C-30: approximately 10 feet above base, *Olenoides* sp., *Kochaspis* sp., *Dolichomitopsis* sp., *Oryctocephalites* cf. *O. resseri* Rasetti.	14.0 (approx)
5.	Dolomite. Light gray; medium-grained; medium-bedded; sandy; calcareous; weathers brown.	39.2
6.	Quartzite. Brown; medium-grained; medium-bedded.	8.7
7.	Dolomite. Light blue-gray; medium-grained; medium-bedded; upper half grades into calcareous sandstone; weathers dark brown.	17.4
	Total Busby formation	167.3

Pioche shale:

1.	Quartzite and shale, interbedded. Beds range from three inches to two feet in thickness; all beds are green; shales are fucoidal and micaceous.	30.5

2.	Quartzite. Dark green to purple; interbedded with dark green fucoidal shales; units 2 to 6 feet thick; much cover.	154.6
3.	Quartzite. Brown; medium-grained; cross-bedded.	9.7
4.	Shale. Green; micaceous; blocky.	9.7
5.	Covered. Few exposures, green quartzite; base obscured by talus.	96.6
	Total exposed Pioche shale	301.1

Tintic quartzite:
Quartzite. Tan; medium-grained; cross-bedded.

SECTION C-4 ACROSS CONTACT OF TINTIC QUARTZITE AND LOWEST CARBONATE OF THE CAMBRIAN AT THE MOUTH OF LOG CANYON, SEC. 11, T. 9 S., R. 7 W., TOOELE COUNTY, UTAH

Feet

Middle Cambrian

Upper limestone member of the Millard formation:
Limestone, pisolitic. Blue-gray; medium-grained; thin-bedded; weathers massive to form ledges and cliffs; pisolites are black or dark gray but weather light brown or reddish brown.

<u>Millard formation</u>:

<u>Middle shale member</u>:

1.	Shale. Green and olive drab; fissile; trilobite parts and hash on bedding planes; near top is thin-bedded (shaly) limestone; gray-tan with silt (tan) partings; at very top is blue-gray medium-grained limestone with disk-like pebbles; intraformational. <u>Glossopleura</u> sp. and linguloid brachiopods.	70.6

<u>Lower limestone member</u>:

1.	Shale(?). Green shale float; covered on slope.	53.2
2.	Limestone, sandy. Blue-gray; medium-grained; thin-bedded; sand, medium- to fine-grained; tan; weathers flaggy.	22.2
3.	Limestone, pisolitic. Blue-gray; medium-grained; medium- to thick-bedded; dark gray, black pisolites.	15.0
4.	Limestone, sandy. Blue-gray; medium-grained; thin-bedded; weathers massive; sand is fine and tan.	25.1
	Total lower member of the Millard formation	186.1

<u>Busby formation</u>:

Quartzite. Purple with thin black bands; medium-grained; thin-bedded; massive; weathering; many	30.1

dark purple and black bands are in 2- to 3-inch lenses.

2.	Quartzite. Greenish-gray; medium- to fine-grained; thin-bedded; micaceous; weathers flaggy.	30.1
3.	Limestone. White; medium-grained; almost crystalline; massive; contains reddish-brown, silty inclusions that interfinger with many of the crystals.	5.0
4.	Sandstone. Gray-tan; calcareous; medium-grained; gradational with upper and lower unit.	5.0
5.	Limestone. Blue-gray; medium-grained; thin- to medium-bedded; some interbeds of tan, reddish weathering; medium-grained calcareous sandstone.	5.0
6.	Dolomite. Gray to blue-gray; medium-grained; sandy; weathers to form reddish "sandpapery" ledges.	45.2
	Total Busby formation	120.2

Pioche shale:

1.	Quartzite. Purple; medium-grained; medium-bedded; cross-bedded.	35.1
2.	Quartzite, shaly. Greenish-tan; medium-grained; thin-bedded; few 8- to 14-inch interbeds of light brown, medium-grained, cross-bedded quartzite; some of quartzite beds are greenish-gray; dark green micaceous mineral fills vertical holes in quartzite, fucoidal near base.	40.2
3.	Quartzite. Dark purple to dark purplish-green; medium-grained; medium- to thick-bedded; some cross-bedding.	90.4
4.	Shales and quartzites, interbedded. Shale: tan to olive drab; platy; micaceous. Quartzite: light greenish-brown; medium-grained; thin-bedded; unit contains a few 3- to 6-foot beds of thick-bedded, medium-grained brown quartzites in upper part of the middle half; shale is fucoidal; fucoids are of tan, fine-grained sandstone (quartzite) in greenish micaceous matrix; weathers to form slopes.	145.6
5.	Quartzite. Brown; medium-grained; medium-bedded; cross-bedded.	20.8
6.	Quartzite. Olive-drab; medium-grained; thin-bedded; shaly; micaceous; fucoidal.	10.0
	Total Pioche shale	342.1

Tintic quartzite:

Quartzite. Cream colored; medium-grained to coarse-grained; cross-bedded; lower part covered.

SECTION C-5 APPROXIMATELY 1300 FEET EAST OF C-4 ACROSS CONTACT OF TINTIC QUARTZITE AND THE LOWEST CARBONATES OF THE CAMBRIAN AT THE MOUTH OF LOG CANYON, SEC. 11, T. 9 S., R. 7 W., TOOELE COUNTY, UTAH

Middle Cambrian	Feet
<u>Marium formation</u>:	
Limestone. Blue-gray; thin- to medium-bedded; undulatory bedding; shaly in places.	
<u>Wheeler formation</u>:	
1. Limestone. Dark blue-gray; fine-grained; thin-bedded (1 to 2 inches); persistent in color and bedding; bedding partings are very flat and smooth; distinguished by tan color; unit weathers to form flat flags; some beds are laminated; fossils collected approximately 250 feet above the base. Locality C-24: *Protospongia* sp., *Peronopsis interstrictus* (White), *Elrathia* sp.	410.0
<u>Swasey limestone</u>:	
1. Limestone. Blue-gray to dark blue-gray; fine-grained; thin-bedded to massive; fractures healed with while calcite; weathers to form cliffs.	160.0
<u>Condor formation</u>:	
1. Limestone and shale, interbedded. Limestone: blue-gray; silty and shaly; fine- to medium-grained; thin-bedded. Shale: greenish-gray; micaceous; roughly fissile; units range from few feet to 15 feet in thickness; weathers to form slopes. Fossil locality C-23: 15 feet from top; *Ehmaniella* sp., *Acrothele* sp.	135.5
<u>Dome limestone, Burnt Canyon formation, and Upper Member of Millard formation, undifferentiated</u>:	
1. Limestone. Blue-gray to dark blue-gray; fine- to medium-grained; thin- to medium-bedded; shales and pisolites in lower half.	250.0 (approx.)
<u>Middle shale member of the Millard formation</u>:	
1. Shale. Pale olive green; laminated; slightly micaceous; fossiliferous. Fossil locality C-22: *Glossopleura* sp.	35.5
<u>Lower limestone member of the Millard formation</u>:	
1. Limestone, shaly. Greenish-gray; thin-bedded; fine-grained; weathers to thin flags; forms slopes.	25.0
2. Limestone. Blue-gray; pisolitic; medium- to coarse-grained; medium-bedded to massive; pisolites 1/4 to 1/2 inch diameter; unit sandy in lower portions.	125.0 (approx.)
Total lower member of Millard formation	150.0

Busby formation:

1.	Limestone. White; medium-grained; massive; contains limonite inclusions dispersed as irregular spots (1/2-inch thick) among calcite crystals.	10.0
2.	Limestone, sandy. Blue-gray; medium-grained; medium-bedded; unit very sandy near top; weathers reddish-tan; lime in upper zone weathers to form shallow holes and pits. Fossil locality C-21: at 10 feet above the base; *Kootenia* sp., *Ptarmigania* or *Ptarmiganoides* sp. *Pelagiella*-like gastropod, *Helcionella* sp., *Onchocephalus*? sp., *Caborcella* cf. *C. Arrojosensis* Lochman, brachiopod fragments.	25.0
3.	Dolomite. Tan to gray; medium-grained; medium-bedded to massive; weathers brown; forms ledges.	30.0
	Total Busby formation	65.0

Pioche shale:

1.	Quartzite and shale, interbedded. Quartzite: green and greenish-brown; cross-bedded; medium-grained; medium-bedded; contains scolithus and fucoids; occurs at 5- to 30-foot interbeds. Shale: tan to green; micaceous; fucoidal in 5- to 10-foot interbeds; few thin quartzite lenses in shales. Fossil locality C-20: at 40 feet above the base - "trilobite tracks" (McKee, 1945, Part I).	300.0 (approx.)

Tintic quartzite:

Quartzite. Cream to buff colored; medium-grained; medium-bedded; cross-bedded.

SECTION C-6 OF CAMBRIAN FORMATIONS AT HEAD OF LOG CANYON, APPROXIMATELY ONE MILE EAST OF C-5 SEC. 12, T. 9 S., R. 7 W., TOOELE COUNTY, UTAH

Middle Cambrian — Feet

Swasey limestone:

Limestone. Dark blue-gray; fine-grained; thin-bedded; massive weathering; forms cliffs.

Condor formation:

1.	Limestone and shale, interbedded. Limestone: gray to blue-gray; fine-grained; thin-bedded; slightly micaceous partings. Shale: gray-green; micaceous; units 5 to 20 feet thick; weathers to form slopes.	111.1

Dome limestone:

1.	Limestone. Blue-gray; fine- to medium-grained; thin-bedded; weathers massive.	37.4

Burnt Canyon formation:

1.	Limestone. Blue-gray; fine-grained; thin-bedded; (1 to 3 inches); reddish-tan silty undulatory partings, two 10- to 15-foot green blocky shales near middle of unit.	111.1
2.	Shale. Green; platy.	24.9
3.	Limestone. Blue-gray; medium-grained; medium-bedded; contains gray mottles along bedding.	20.8
4.	Limestone. Blue-gray; fine-grained; thin-bedded; "worm trail" markings; reddish silty undulatory partings.	20.8
	Total Burnt Canyon limestone	177.6

Millard formation:

Upper limestone member:

1.	Limestone. Blue-gray; dense to medium-grained; thin-bedded to massive; pisolitic.	29.1
2.	Shale. Light green.	4.2
3.	Limestone. Dark blue-gray; medium-grained; medium-bedded; pisolitic.	16.6
	Total upper member of Millard formation	49.9

Middle shale member:

1.	Shale. Green. Fossil locality C-29: *Glossopleura* sp.	58.1

Lower limestone member:

1.	Limestone. Blue-gray; fine-grained; thin-bedded; silty tan undulatory partings; weathers to form slopes.	58.1
2.	Limestone. Blue-gray; medium-grained; medium-bedded; pisolitic (1/2 to 1 inch diameter); forms ledges.	16.6
3.	Limestone. Blue-gray; medium-grained; thin- to medium-bedded; tan silty undulatory partings; forms slopes.	41.5
4.	Limestone, sandy and quartzitic. Blue-gray; dense; fine- to medium-grained; medium-bedded; silty; tan mottles parallel with bedding; quartzitic in lower 15 feet; quartzite occurs as grayish-pink lenses. Fossil locality C-28: at base, *Helcionella* sp., *Kootenia* sp., *Pachyaspis*? sp.	41.5
5.	Sandstone and shale. Yellow and buff; fine-grained; thin-bedded. Shale: coarsely micaceous.	12.5
	Total lower member of Millard formation	170.0
	Total Millard formation	278.0

Busby formation:

1.	Quartzite. Dark green; sandy; flaggy; micaceous quartzite interbedded with purple; cross-bedded, medium-grained quartzite in 6- to 10-foot units.	45.7
2.	Dolomite. Tan to gray; medium- to coarse-grained; medium-bedded; faintly pisolitic; weathers gray to brown; massive; forms ledges.	58.1
	Total Busby formation	103.8

Pioche shale:

1.	Quartzite. Tan; medium-grained; medium-bedded.	8.3
2.	Quartzite. Purple; medium-grained; medium-bedded.	16.6
3.	Quartzite. Shaly; medium-grained; thin- to medium-bedded; fucoidal.	45.7
4.	Quartzite. Purple; medium-grained; medium-bedded.	23.2
5.	Quartzite. Purple and green interbeds; medium-grained; medium-bedded; some cross-bedding.	23.1
6.	Quartzite and shale, interbedded. Quartzite: tan; brown and green; medium-grained; medium- to thick-bedded; cross-bedded. Shale: tan to green; very micaceous interbeds of quartzite and shales range from 4 inches to 8 feet; quartzite comprises 60 percent of the unit; shales are fucoidal; some quartzites contain *Scolithus*.	175.9
	Total Pioche shale	292.8

Tintic quartzite:
Quartzite. Tan; medium-grained; cross-bedded.

COMPOSITE SECTIONS C-7 AND C-8 OF CAMBRIAN FORMATIONS ON LOOKOUT MOUNTAIN, SECS. 1, 2, AND 12, T. 9 S., R. 7 W., TOOELE COUNTY, UTAH

Fault:	extensive breccia zone; gray and blue-gray dolomite silica cementing breccia.	Feet

Cole Canyon formation:

1.	Covered. Alluvial.	318.2
2.	Limestone. Dark blue-gray; fine- to medium-grained; thin- to medium-bedded; undulatory with gray mottles and "worm tracks" on bedding.	51.5
3.	Limestone. Blue-gray; medium-grained; medium-bedded; contains scattered ivory colored crystalline dolomite rocks.	4.7
4.	Dolomite. White weathering; light pinkish-gray; dense; thin-bedded to laminated; a few very thin beds of blue-gray dolomite.	4.7

5.	Dolomite. Blue-gray; medium-grained; thin-bedded.	14.0
6.	Limestone. Similar to unit #2.	237.7
	Total exposed Cole Canyon formation	630.8

Marium formation:

1.	Dolomite. Light pinkish-gray; dense; laminated to thin-bedded; weathers white; with 1-foot mixed dolomite and black chert at top.	7.0
2.	Limestone. Dark blue-gray; fine- to medium-grained; thin- to medium-bedded; undulatory with gray mottles and "worm tracks" on bedding.	121.7
3.	Dolomite. Gray; medium-grained; massive; weathers rough sandpapery.	23.4
4.	Limestone. Blue-gray; medium-grained; medium-bedded.	14.0
5.	Dolomite. Dark blue-gray and gray; medium-grained; thick-bedded to massive; contains short white curved rods; lower half mostly blue-gray, upper half 50-50; zebra banding in upper 26 feet.	205.9
6.	Dolomite. Gray to pinkish-gray; medium-grained; massive.	70.2
7.	Limestone, dolomitic. Blue-gray; thin black bands; medium-grained; thin-bedded; weathers massive; sandpapery.	4.7
8.	Dolomite. Similar to unit #7.	14.0
9.	Dolomite. Blue-gray; medium-grained; thin- to medium-bedded; weathers sandpapery.	4.7
10.	Limestone. Blue-gray; medium-grained; thin- to medium-bedded; weathers sandpapery.	4.7
11.	Limestone. Blue-gray; fine-grained; thin- to medium-bedded (1/2- to 3-inch beds); contains gray-tan silty bedding mottles and undulatory partings; also many medium interbeds of oolitic limestone (1/16-inch oolites) and "worm tracks."	94.1
12.	Limestone. Blue-gray; fine-grained; silty tan and pinkish-tan mottles and partings; also some "worm tracks" on bedding surface; a few beds of 1/16-inch oolites. Fossil locality C-12: 20 feet above the base; undetermined trilobite cf. *Meteoraspis* or *Modocia*. Fossil locality C-13: 70 feet above the base; indeterminate trilobite.	118.8
13.	Intraformational conglomerate, limestone. Blue-gray; medium-grained; matrix; medium-bedded; pebbles are gray, fine-grained, tabular, thin-bedded; silty up to 3 inches long; some weather pink.	9.1

14.	Limestone. Blue-gray; very silty; weathers tan; fine-grained; thin-bedded (1/2 inch).	4.1
15.	Shale. Dark olive drab; extremely fissile. Fossil locality C-11: scraps of linguloid brachiopods.	11.3
16.	Intraformational conglomerate, limestone. Similar to unit #14.	2.3

Offset: 1 1/4 miles east to C-7

17.	Limestone. Blue-gray; fine-grained; thin-bedded; few feet of brown silty bands in lower 40 feet of unit; weathers very pale blue-gray on dip slope.	78.7
18.	Limestone. Dark gray to black; fine-grained; thin-bedded (average 2 inches); abundant white calcite-filled fractures; weathers to form cliffs; weathers to blue-gray; very irregular (knobby on a small scale) surfaces.	338.5
19.	Limestone. Blue-gray; fine-grained; thin-bedded; (average 2 inches); brown, silty bands (to 1 inch) between beds.	43.4
	Total Marjum formation	1170.6

Wheeler formation:

1.	Limestone. Dark blue-gray; fine-grained; thin-bedded (almost all beds 1-inch thick); in basal 25 feet beds are very thin (almost shaly); partings in smooth tables 1/16-inch thick; many partings are thin light brown, silty and fine sandy trilobites collected 215 feet above the base (fossils only in thin silty coatings). Fossil locality C-10: *Zacanthoides* sp.	429.6

Swasey limestone:

1.	Limestone. Dark blue-gray; fine-grained; thick-bedded to extremely massive; fractures healed with white calcite; weathers to form cliffs.	169.0

Condor formation:

1.	Limestone and shale, interbedded. Limestone: blue-gray; fine-grained; thin-bedded; tan silty streaks of limestone weathers very light gray. Shale: light bleached green; fissile; laminated; limestone about 2/3 of total; shale 1/3 of unit. Fossil locality C-9: scraps of linguloid brachiopods and indeterminate trilobite.	107.0

Dome limestone:

1.	Limestone. Blue-gray; fine-grained; thick-bedded to massive; abundant white calcite veinlets; cliff former.	81.3

Burnt Canyon formation:

1.	Limestone. Light blue-gray; fine-grained; thin-bedded (approximately 2 inches); some green shale in basal five feet; light tan silty bands parallel the bedding and some are as thick as the limestone beds.	111.3
2.	Limestone. Blue-gray; fine-grained; thin-bedded; undulatory tan and pink silty partings and "worm trails"; weathers to form slopes.	68.2
	Total Burnt Canyon formation	179.5

Millard formation:

Upper limestone member:

1.	Limestone. Blue-gray; medium-grained; medium-bedded; shaly near base; pisolitic but pisolites are nearly same color as the matrix and are difficult to distinguish; weathers to form steep slopes.	34.5

Middle shale member:

1.	Shale. Pale olive green; fissile; few units break to form irregular slabs; very fossiliferous. Fossil locality C-8: Glossopleura sp.	59.9

Lower shale member:

1.	Limestone. Blue-gray; fine-grained; thin- to medium-bedded; banded; light brown streaks parallel with the bedding; few pisolites; weathers light blue-gray.	151.7
	Total Millard formation	246.1

Busby formation:

1.	Sandstone. Olive green; fine-grained; thin-bedded; shaly; micaceous; slightly calcareous.	13.2
2.	Sandstone, quartzitic. Purplish-black; medium- to coarse-grained; medium-bedded; slightly calcareous.	39.6
3.	Dolomite. Light tan to light gray; medium-grained; medium-bedded; sandy.	70.4
	Total Busby formation	123.2

Pioche shale:

1.	Quartzite and shaly sandstone, interbedded. Quartzite: dark purple (locally reddish-purple); medium-grained; 3- to 5-foot beds; some low-angle cross-bedding. Shaly sandstone: olive green; thin but irregular bedding; locally platy; very micaceous; sheen on bedding surfaces; trails or fucoids along bedding planes; thin, tapering, funnel-like silt-filled holes at right angles to the bedding, most likely Scolithus.	299.2

Tintic quartzite:

1.	Quartzite. Dark brown; medium- to coarse-grained; medium- to thick-bedded; dark brown coloration is secondary, mainly along fractures.	165.9
2.	Quartzite. White to reddish-brown; medium-grained; low-angle cross-bedding present in some units; upper contact heavily limonite stained; unit is brecciated.	642.2
3.	Shale. Greenish-purple to variegated red-brown (color also changes laterally); micaceous phyllitic; some fine sandy olive beds.	4.8
4.	Quartzite. White, medium-grained; brecciated and sheared.	129.1
5.	Quartzite. Brown to brownish-green; medium-grained; thick-bedded.	5.0
	Total Tintic quartzite, partial section	947.0

Tintic quartzite:

Continuation of the above, white to buff, cross-bedded quartzite.

SECTION C-9 OF THE OPEX FORMATION AND COLE CANYON FORMATION IN SOUTHERN PART OF THE WEST LOOKOUT HILLS, SEC. 35, T. 8 S., R. 7 W., TOOELE COUNTY, UTAH

Upper Cambrian

Ajax dolomite:

Conformable distinct contact; dark gray to black; medium-grained sugary dolomite containing "worm-like" lighter gray markings parallel with bedding throughout the rock.

Opex formation:

1.	Limestone. Blue-gray; medium- to fine-grained; thin-bedded; alternates with gray, silty limestone; bedding planes slightly undulatory. Fossil locality C-25: *Billingsella* cf. *B. coloradoensis* Walcott, *Acrotreta ophirensis* Walcott., *Acrotreta* cf. *A. microscopica* Walcott., *Lingulella* sp., *Eoorthis desmopleura* Walcott, linguloid brachiopods, *Taenicephalus* cf. *T. hyrumensis* Resser, *Taenicephalus shumardi* Hall, *Parabolinoides contractus* Fredrickson, *Taenicephalus* spp. und., *Taenicephalus* cf. *T. striatus* Resser, *Maustonia* sp.	15.2
2.	Limestone. Blue-gray; medium-grained; medium-bedded; weathers to form ledges; contains an abundance of irregular tan chert inclusions dispersed evenly parallel with bedding.	10.1
3.	Limestone. Blue-gray to dark blue-gray; fine- to medium-grained; thin-bedded; weathers flaggy; forms ledges; trilobite fragments and reddish-	59.1

tan silty partings. Fossil locality C-35: *Elvinia montis* Resser, *Elvinia* sp.

4.	Limestone. Blue-gray; oolitic; some light red cement.	20.0
5.	Shale. Bluish-green; very fissile; mostly covered.	12.0
6.	Dolomite. Pinkish-gray; fine-grained; thin-bedded; laminated.	5.1
7.	Covered. Green to gray-green; very fissile shale as float on dip slope.	15.2
8.	Limestone. Blue-gray; medium-grained; thin- to medium-bedded; flaggy.	30.3
9.	Limestone. Blue-gray; medium-grained; thin-bedded; weathers gray and rough.	167.0
10.	Covered. Green; very fissile shale float.	10.1
11.	Limestone. Blue-gray; medium- to fine-grained; medium-bedded; contains silty and calcite sand stringers; also a few beds of intraformational conglomerates with tabular rounded pebbles up to 3 1/2 inches in diameter surrounded by a fine matrix with some trilobite hash.	45.5
12.	Dolomite. Blue-gray; sugary; medium-bedded; weathers light gray.	30.4
13.	Limestone. Blue-gray; medium-grained; thin-bedded with red silty inclusions and amoeba-shaped nodules; some beds of intraformational conglomerate.	45.5
14.	Dolomite. Dark gray and blue-gray; interbedded; medium-grained; thin-bedded; weathers gray and sandpapery; much cover.	242.9
15.	Dolomite. Blue-gray; fine-grained; thin-bedded; weathers to look like tan sandstone; contains very thin dark brown silty partings which weather in relief.	34.9
16.	Dolomite. Gray; medium-grained; thin-bedded to medium-bedded; weathers tannish-gray and sandpapery.	144.4
17.	Dolomitic limestone. Blue-gray; medium-grained; thin- to medium-bedded; oolitic; some intraformational conglomerates; weathers tan and sandpapery; forms few ledges. Fossil locality C-26: near base; *Coosella* spp., *Kormagnostus* cf. *K. simplex* (Resser), *Pseudoagnostus prolongus* (Hall & Whitfield), *Tricrepicephalus walcotti* (Lochman), *Lingulella* sp., *Hyolithes primordialis* (Hall), *Syspacheilus*? sp.	49.8
	Total Opex formation	937.5

Middle Cambrian: Conformable contact

Cole Canyon formation:

1.	FAULT ZONE: 18° to 20° northerly dip—northside thrust southward and west mainly a strike slip displacement.	229.8
2.	Limestone and dolomite, interbedded. Limestone: blue-gray; medium-grained; thin-bedded. Dolomite: gray; medium-grained; thin-bedded.	18.8
3.	Dolomite. Gray; coarse-grained; crystalline; thin-bedded.	18.8
4.	Limestone. Dark blue-gray; medium-grained; faintly thin-bedded; undulatory; dark gray silty partings.	28.1
5.	Limestone and dolomite, interbedded. Limestone: blue-gray; medium-grained; thin-bedded with tan undulatory silty partings up to 1/2 inch. Dolomite: gray; fine-grained; laminated; interbedded units 2 to 6 feet.	29.6
6.	Dolomite. Gray; fine-grained; laminated; weathers light gray.	4.9
7.	Limestone. Dark blue-gray; medium-grained; thin-bedded (1 to 1 1/2 inches), with gray undulatory silty interbeds (1/4 to 1/2 inch).	55.6
8.	Dolomite. Gray; similar to unit #6.	4.6
9.	Limestone. Dark blue-gray; similar to unit #7.	64.8
10.	Dolomite. Gray; similar to units #6 and #8.	138.9
11.	Limestone. Dark blue-gray; medium-grained; thin-bedded; tannish-gray; undulatory flattened nodules; cross-bedding but generally are parallel.	18.5
12.	Limestone. Blue-gray; medium-grained; thin-bedded; contains randomly scattered, short ivory dolomite inclusions which weather in relief.	4.6
13.	Limestone. Dark blue-gray; similar to unit #7. Dolomite. Gray; coarse-grained; massive distorted. pink secondary fine-grained calcite in fractures; may be fault zone.	157.4 27.8
14.	Limestone. Dark blue-gray; similar to unit #7.	91.7
15.	Dolomite. Gray; fine-grained; thin-bedded; weathers light gray with faint mottles; contains 6- to 8-inch band of black chert in center; chert is continuous and in bedding view appears to resemble small algal accumulations.	5.0
	Total Cole Canyon formation	898.9

Marjum formation:

Limestone. Blue-gray; mottled; undulatory bedding.

SECTION C-10 OF THE AJAX DOLOMITE AT THE SOUTH END OF THE WEST LOOKOUT HILLS, SEC. 35, T. 8 S., R. 6 W., TOOELE COUNTY, UTAH

			Feet
Lower Ordovician			
Pogonip group at the top: No unconformity detected. Limestone. Gray to light blue-gray; intraformational conglomerates; fine-grained; generally thin-bedded with tan and pink silty partings.			
Upper Cambrian			
Ajax dolomite:			
	1.	Dolomite. Blue-gray to gray; medium-grained; thin-bedded; flaggy; undulatory bedding surfaces; near top becomes gray and more massive and grades into overlying House limestone.	103.2
	2.	Dolomite. Blue-gray; medium-grained; medium-bedded; with tan boxwork of thin chert; weathers to form ledges.	32.9
	3.	Dolomite. Dark gray; sugary; weathers sandpapery.	272.0
Emerald Member	4.	Dolomite. Light gray; sugary (medium-crystalline); thin-bedded to massive; weathers rough; is upper part of Emerald member.	42.2
Emerald Member	5.	Dolomite. Very light gray; sugary (medium-crystalline); thin-bedded to massive; weathers rough; is middle part of Emerald member.	88.7
Emerald Member	6.	Dolomite, interbedded. Light and dark gray interbeds (4 to 6 inches); medium-grained; medium- to thick-bedded; separated by thin indistinct beds (1/4-inch or less); is lower Emerald member. Emerald member totals 150.6 feet.	19.7
	7.	Dolomite. Dark blue-gray; medium-grained; medium-bedded; contains scattered tan and silty chert; weathers rough.	177.5
	8.	Dolomite. Dark gray; medium-grained; thick-bedded to massive; contains gray "worm-like" inclusions and white and cream crystalline, curved rod-like shapes (1/16 to 1/8 inch by 1/2 to 1 inch); weathers coarse sandpapery.	138.0
	9.	Dolomite. Dark gray; medium-grained; massive; contains gray vertical mottlings which are indistinct; weathers medium sandpapery.	9.9
	10.	Dolomite. Gray; medium-grained; sugary; medium-bedded.	44.4
	11.	Dolomite. Dark gray; fine- to medium-grained; medium-bedded; contains light gray round "worm-like" inclusions; also some black chert in 6- to 8-inch elongate nodules; conformably contacts limestones of the Opex formation.	87.8
		Total Ajax dolomite	1016.3

Opex limestone:
Limestone. Blue-gray; fine-grained; thin-bedded; tan and pinkish-gray partings with trilobite fragments.

SECTION O-1 OF THE POGONIP GROUP IN THE SOUTHERN PART OF THE EAST LOOKOUT HILLS, SEC. 6, T. 9 S., R. 6 W., AND SEC. 31, T. 8 S., R. 6 W., TOOELE COUNTY, UTAH

Ordovician	Feet
Swan Peak quartzite:	
Quartzite. Gray; white and buff; medium rounded grains; some cross-bedding.	
Pogonip group	
Kanosh shale:	
1. Shale. Red; covered by reddish soil; weathers to form saddles. Fossil locality O-14: 125 feet above the base, *Didymograptus* cf. *D. artus*.	205.8
Juab limestone:	
1. Limestone. Blue-gray; fine- to medium-grained; thin- to medium-bedded; sand in tan bands and thin beds which in many places are interconnected and weather in relief; the limestone in these sections weathers gray and is set in large holes. Fossil locality O-3: near top, *Receptaculites ellipticus*, *Receptaculites* sp., *Orthambonites sublata*, *Lingula* sp., *Orthambonites* sp., *Anomalorthis* sp., *Macronotella*-like ostracods.	55.2
2. Sandstone. Tan; medium-grained; fine- to medium-bedded; calcareous.	5.0
3. Limestone. Blue-gray; similar to unit #1.	100.4
Total Juab limestone	160.6
Wah Wah limestone:	
1. Limestone. Blue-gray; medium-grained; thin- to medium-bedded; a few tan sandy mottles.	115.5
2. Sandstone, calcareous. Tan; 70 percent sand which is medium- to fine-grained.	30.1
3. Limestone, sandy. Gray; medium-grained; thin- to thick-bedded; 30 to 40 percent medium-grained sand; weathers reddish-brown. Fossil locality O-13: 185 feet above base, orthocone cephalopods, gastropods, brachiopod fragments, trilobite fragments; crinoid columnals.	310.7
Total Wah Wah limestone	456.3

House and Fillmore limestones - undifferentiated:

1.	Limestone. Gray; fossiliferous; medium-grained; thin tan-to-reddish-brown silty partings; thin- to medium-bedded; sandy; weathers pinkish. Fossil locality O-2: near base; *Ophileta*-like gastropod, *Pseudocybele* sp., cystoid plate, crinoid columnals, *Orthambonites*, sp.	84.2
2.	Limestone, silty, dark gray; medium-grained; medium- to thick-bedded; pinkish cast; red iron oxide replacing some limestone and fossils is evident on fresh surface. Fossil locality O-12: near base; gastropods and porifera.	92.6
3.	Limestone, silty. Gray; medium- to coarse-grained; thin silty, tan-to-reddish-brown partings on surface; weathers to a pink cast; some beds of intraformational conglomerates. Fossil locality O-1: at base; crinoid, trilobite, brachiopod, and gastropod fragments.	223.1
4.	Intraformational limestone conglomerate. Blue-gray; medium-grained with gray; tabular; rounded pebbles of thin-bedded, dense limestone; unit is thick-bedded.	134.3
5.	Limestone. Dark blue-gray; fine-grained; medium-bedded; some thick beds of intraformational limestone conglomerate.	181.7
6.	Intraformational limestone conglomerate. Blue-gray; similar to unit #4; weathers to a pink cast; much cover.	256.8
7.	Intraformational limestone conglomerate. Similar to unit #6 but weathers to light gray.	138.2
	Total House and Fillmore limestones - undifferentiated	1110.9
	Total Pogonip group	1933.6

Upper Cambrian

Ajax dolomite:

Dolomite. Gray to dark gray; medium-grained; thick-bedded; broken with secondary chert filling fractures and weathering in relief; some surfaces have brown splotched appearance but chert is not massive; dolomite weathers coarse sandpapery.

SECTION O-2 OF THE POGONIP GROUP IN THE SOUTHERN PART OF THE WEST LOOKOUT HILLS, SEC. 26 AND 35, T. 8 S., R. 7 W., TOOELE COUNTY, UTAH

Ordovician

Swan Peak quartzite:

Quartzite. Gray; glassy; hard; becomes tan and ivory upward; some zones friable; grains are medium and well rounded.

Pogonip group

Kanosh shale:

1.	Shale. Red to black; fissile; thin limestone interbeds range from 1/2 to 2 inches; gray; much cover; weathers to form reddish soil and saddles. Fossil locality O-16: near top, *Anomalorthis* sp., orthocone cephalopod, trilobite fragments, *Receptaculites* sp.	250.1

Juab limestone:

1.	Limestone. Blue-gray; medium-grained; thin- to medium-bedded; contains much sand; weathers to slab; 5 feet calcareous sandstone 100 feet above base; top of unit slightly shaly grading into maroon shales of overlying Kanosh shale; a few beds in this unit weather to form many holes; the peripheries supported by silica-cemented sands. Fossil locality O-15: silicified brachiopods at 178 feet; *Orthambonites sublata*, gastropods.	203.9

Wah Wah limestone:

1.	Limestone. Blue-gray; medium-grained; thick-bedded to massive; sandy; sands are in irregular stringers parallel with the bedding.	52.9
2.	Limestone. Blue-gray; medium-grained; medium-bedded; very sandy and cherty (20%) silicified sandy beds interconnect to give rock a tabular holey appearance; weathers light brown to reddish-brown; trilobite and brachiopod fragments.	169.9
3.	Limestone. Blue-gray; medium-grained; medium-bedded; tan sands and cherts weather in relief like those in above units.	119.3
4.	Limestone, jasperized. Light reddish-brown; thin-bedded; some intraformational limestone conglomerates; original limestone was dark gray; some mild brecciation; faulting suspected; displacement slight; crosses parallel with the bedding.	132.6
	Total Wah Wah limestone	474.7

House and Fillmore limestones - undifferentiated:

1.	Intraformational limestone conglomerate. Blue-gray; matrix medium-grained; medium-bedded; pebbles are small, averaging 1/2 inch in length; are dense and are thin-bedded; trilobite fragments (pink coloration in matrix is common).	70.7
2.	Limestone. Dark blue-gray; fine-grained; thick-bedded.	39.8
3.	Limestone, interbedded with intraformational limestone conglomerate. Limestone: dark	79.6

blue-gray; fine-grained; beds up to 6 feet; contains silty tan and pink mottles. Conglomerate: blue-gray; medium-grained matrix with gray tabular pebbles.

4.	Intraformational limestone conglomerate. Similar to unit #1 but with larger, up to 2-inch, pebbles and little pink coloration.	119.3
5.	Limestone. Blue-gray; medium-grained; medium-bedded; weathers very rough and pitted.	17.7
6.	Intraformational limestone conglomerate. Blue-gray; fine-grained to medium-grained; medium-bedded; weathers smooth; the intraformational character is hard to detect at a glance.	179.8
7.	Intraformational limestone conglomerate. Blue-gray; medium-bedded; weathers coarse sandpapery.	68.5
8.	Intraformational limestone conglomerate. Blue-gray; medium-bedded; prominent pebbles.	85.6
9.	Intraformational limestone conglomerate. Blue-gray; medium-grained; thin- to medium-bedded; weathers to a wavy rough surface; faintly conglomeratic.	266.7
10.	Limestone. Blue-gray; medium-grained; medium-bedded (10-14 inches); contains smooth, rounded, tan weathering gray cherts; limestone weathers smooth.	22.9
11.	Limestone. Gray; medium-grained; thin- to medium-bedded; thin silty and shaly partings which are tan and pink; some intraformational conglomerate interbeds; weathers to form cliffs.	137.1
	Total House and Fillmore limestones - undifferentiated	1087.7
	Total Pogonip group	1969.1

Cambrian

Ajax formation: at base

Dolomite. Gray; medium-grained; thick-bedded; broken with secondary chert filling fractures and weathering in relief; some surfaces have brown splotched appearance but chert is not massive; dolomite weathers coarse sandpapery.

SECTION O-3 OF SWAN PEAK QUARTZITE IN CENTRAL PART OF THE EAST LOOKOUT HILLS, SEC. 31, T. 8 S., R. 6 W., TOOELE COUNTY, UTAH

Ordovician

Fish Haven dolomite:

Dolomite. Dark gray; medium-grained; medium-bedded to massive; very cherty in upper portions.

Swan Peak quartzite:

1.	Quartzite. Cream to light gray; medium-grained; medium-bedded to massive.	61.2
2.	Sandstone, quartzitic. Cream; well rounded medium grains; medium-bedded to massive; weathers to a tan cast; many blocks have rounded corners.	268.6
3.	Quartzite. Gray; medium-grained; massive.	10.0
4.	Sandstone, quartzitic. Cream; round medium grains; cross-bedded; sandstone weathers out to form shallow holes several inches across; gives a "swiss cheese" effect.	40.2
5.	Quartzite. Gray to bluish-gray; medium-grained; medium-bedded; slightly fucoidal; contains shards of phosphatic shell? material with an undescribed assemblage of neurodontiform conodonts dispersed in quartz grains; phosphate weathers bluish-white; gives rock light gray cast.	5.0
6.	Quartzite. White to cream; few green-tinted beds; rounded medium grains; medium-bedded; weathers white.	80.3
	Total Swan Peak quartzite	465.3

Kanosh shale:

Shale. Red to green; few thin beds quartzite and limestone; very fossiliferous; containing graptolites and brachiopods.

SECTION O-4 OF SWAN PEAK QUARTZITE ON WEST END OF CENTRAL PORTION OF THE WEST LOOKOUT HILLS, SECS. 15, 22, T. 8 S., R. 7 W., TOOELE COUNTY, UTAH

Ordovician — Feet

Fish Haven dolomite:

Dolomite. Dark gray; medium-grained; medium-bedded to massive; very cherty in upper portions.

Swan Peak quartzite:

1.	Quartzite. White to cream; medium rounded grains; medium-bedded; some cross-bedding; much of unit hematite stained.	252.3
2.	Quartzite. Reddish-tinted; poorly exposed; fucoidal; base of unit is thin-bedded quartzite above gray shaly limestone.	95.7
	Total Swan Peak quartzite	348.0

Kanosh shale:

Shale. Red to green; few thin beds quartzite and limestone; very fossiliferous; containing graptolites and brachiopods.

SECTION O-5 OF FISH HAVEN DOLOMITE ALONG RIDGE CREST IN CENTRAL PART OF THE EAST LOOKOUT HILLS, SEC. 31, T. 8 S., R. 6 W., TOOELE COUNTY, UTAH

Silurian

Laketown dolomite:

Dolomite. Dark to light gray; fine- to medium-grained; thin- to medium-bedded; cherty.

Ordovician

Fish Haven dolomite:

1.	Dolomite. Gray; medium-grained; massive; fetid; weathers sandpapery to form cliffs.	94.1
2.	Dolomite. Dark gray; medium-grained; thin-bedded; in places contains gray and dark gray bands (1/8 to 2 inches); bottom 30 feet gradually changes to lighter gray; weathers sandpapery; faintly mottled and slightly cherty (boxwork); fetid.	113.5
3.	Chert. Dark brown.	2.0
4.	Dolomite. Dark gray; medium-grained; thin- to medium-bedded; in places is banded; 1/8 to 2 inches; gray and dark gray color gradually changes to lighter gray in top 29 feet; weathers sandpapery; whole unit slightly mottled and cherty; chert is in boxwork; fetid.	89.9
5.	Dolomite. Dark gray; medium-grained; medium- to massive beds; faintly mottled; weathers pocky to dark blue-gray; fetid.	149.8
6.	Dolomite. Dark gray; medium-grained; medium- to thick-bedded; dark brown chert nodules and cherty boxwork; darker mottles scattered throughout the unit, pentamerous crinoid columnals present; fetid.	72.7
7.	Dolomite. Dark gray to black; medium-grained; medium-bedded; small amount of chert in irregular boxwork; gray mottles on almost black surfaces.	55.6
8.	Dolomite. Dark gray; fine- to medium-grained; medium-bedded; tan and black chert bands; weathers rough with reddish cast (from a distance); secondary chert in boxwork fractures.	128.4
	Total Fish Haven dolomite	706.0

Swan Peak quartzite:
Conformable; gray; glassy; hard; quartzite becomes buff, ivory, and sandy toward middle of section.

SECTION O-6 OF FISH HAVEN DOLOMITE ON WEST END OF CENTRAL PORTION OF THE WEST LOOKOUT HILLS, SEC. 15, T. 8 S., R. 7 W., TOOELE COUNTY, UTAH

Silurian — Feet

Laketown dolomite:
Dolomite. Dark to light gray; fine- to medium-grained; thin- to medium-bedded; cherty.

Ordovician

Fish Haven dolomite:

1.	Dolomite. Alternating gray and dark gray units 10 to 20 feet thick; medium-grained; medium-	117.5

bedded to massive; very little scattered brown and gray chert as irregular inclusions and weathers to lighter grays with fine sandpapery surfaces; *Calapoecia* sp. and *Stromotopora* sp. 100 feet above base.

2.	Dolomite. Covered.	230.6
3.	Dolomite. Gray; medium-grained; medium- to thin-bedded; small amount (less than 5 percent) gray chert; weathers light gray.	21.8
4.	Dolomite? Covered on dip slope.	87.0
5.	Dolomite. Light gray; medium-grained; medium-bedded; gray and brown chert in boxwork.	21.8
6.	Dolomite. Dark blue-gray; medium-grained; medium-bedded; contains scraps of *Streptelasma* sp., *Syringopora* sp., and *Favosites* sp.	69.6
7.	Dolomite. Dark gray; medium-grained; medium-bedded; boxwork cherty.	130.5
8.	Dolomite. Dark gray; medium-grained; medium-bedded; brown chert dispersed as irregular nodules near base; quartzite of underlying Swan Peak included as irregular masses in basal beds.	21.8
	Total Fish Haven dolomite	700.6

Swan Peak quartzite:

Quartzite. Gray; glassy; hard; quartzite becomes buff, ivory, and sandy toward middle of section.

COMPOSITE SECTIONS S-1 AND S-2 OF LAKETOWN DOLOMITE ALONG RIDGE IN CENTRAL PART OF THE EAST LOOKOUT HILLS, SEC. 30, T. 8 S., R. 6 W., TOOELE COUNTY, UTAH

Devonian — Feet

Sevy dolomite:

Dolomite. Light gray; fine-grained to dense; thin- to medium-bedded; weathers blocky; sand-speckled.

Silurian

Laketown dolomite:

1.	Dolomite. Gray; aphanitic to fine-grained; indistinctly laminated; weathers small blocky to shaly near top.	130.9
2.	Dolomite. Gray; aphanitic; faintly laminated; some black chert in 1/4-inch bands; minor amount gray and ivory chert present in irregularly spaced boxwork; weathers gray.	11.2
3.	Dolomite. Gray; aphanitic; faintly laminated to massive; weathers very light bluish-gray.	269.0

4.	Dolomite. Dark gray to black; dense; fine-grained; medium-bedded; hard; some knobs of black chert present near base; toward top dolomite is lighter colored and chertless. Fossil locality S-2: near top; Favosites sp.	34.2
5.	Dolomite. Dark gray; fine-grained; medium- to thick-bedded; cherty nodules; weathers to fine sandpapery; rusty surface with holes resembling poorly developed geodes; forms ledges.	21.4
6.	Dolomite. Gray to dark gray; medium-grained; medium-bedded with chert beds 5 percent of unit from 6 inches to 5 feet thick near top.	214.0
7.	Chert. Pinkish-gray; massive with some gray dolomites as minor medium-grained beds; halysites present.	128.0
8.	Dolomite. Dark gray; medium-grained; thick-bedded; irregular cream to white blebs of coarse calcite; crinoid columnals.	59.9
9.	Dolomite. Dark gray; medium-grained; medium-bedded to massive; some beds are mottled with lighter gray dolomite; weathers sandpapery and forms cliffs. Fossil locality S-1: near base; Halysites sp., Stromotopora sp., brachiopod poorly preserved.	128.7
10.	Chert. Gray; massive; along strike changes to a cherty gray dolomite which has a "leopard skin" appearance; with reddish-tan chert forming the spots and weathering in relief.	4.0
	Total Laketown dolomite	1001.2

Ordovician

Fish Haven dolomite:

Dolomite. Dark gray; medium-grained; medium-bedded to massive; very cherty in upper portions.

SECTION S-3 OF LAKETOWN DOLOMITE ON WEST END OF CENTRAL PART OF THE WEST LOOKOUT HILLS, SEC. 15, T. 8 S., R. 7 W., TOOELE COUNTY, UTAH

Devonian

Sevy dolomite:

Mouse gray; contains small rounded sand grains dispersed in rock; weathers light gray to white.

Silurian

Laketown dolomite:

1.	Dolomite. Gray; aphanitic; unit mostly covered; forms dip slope.	283.1

2.	Dolomite. Gray; medium-grained; medium- to thick-bedded; contains many black chert nodules with rounded edges and as replacement of *Stromotopora* sp.; chert averages 12 to 14 inches in length being two to three inches thick. *Halysites* sp., *Syringopora*? sp., and *Stromotopora* sp. at top.	143.6
3.	Dolomite. Gray; medium-grained; thin- to medium-bedded; banded with brownish-gray chert in 1-inch bands, which do not persist along bedding, being up to 15 feet long.	21.8
4.	Dolomite. Gray; medium-grained; medium-bedded; chert as small inclusions.	113.1
5.	Chert. Cream to gray; contains 10 percent gray dolomite as irregular inclusions.	21.8
6.	Dolomite. Gray; medium-grained; medium-bedded; contains approximately 5 percent gray chert distributed irregularly, crossing bedding.	91.6
7.	Dolomite. Dark gray; medium-grained; medium-bedded; very little chert.	65.0
8.	Dolomite. Gray; medium- to fine-grained; medium-bedded; cherty, cream to gray; irregular with many holes filled with gray dolomite; chert comprises 15 to 20 percent of the unit; *Stromotopora* sp. at top.	69.6
	Total Laketown dolomite	809.6

Ordovician

Fish Haven dolomite:

Dolomite. Dark gray; medium-grained; medium-bedded to massive; very cherty in upper portions.

SECTION D-1 OF THE DEVONIAN FORMATION IN THE CENTRAL PART OF THE WEST LOOKOUT HILLS, SECS. 14, 23, T. 8 S., R. 7 W., TOOELE COUNTY, UTAH

Mississippian

Madison limestone:

Limestone. Blue-gray; cherty; with chert bands 1 to 3 inches; interbedded with 2- to 6-inch beds of medium-grained limestone.

Faulted contact: (unknown but small displacement).

Upper Devonian-Lower Mississippian undifferentiated:

(*Victoria quartzite*, *Pinyon Peak and Fitchville formations*?):

1.	Limestone. Blue-gray; medium-grained; thick-bedded to massive.	47.4
2.	Dolomite. Gray-tan; medium- to coarse-grained; massive; quartzitic; weathers sandpapery to an even gray.	90.9

3.	Dolomite. Dark gray; medium-grained; thick-bedded.	79.0
4.	FAULT ZONE. Brecciated gray dolomite with some pink cement; unknown displacement.	47.4
5.	Limestone, dolomitic. Gray; dolomite, dark gray; interbedded; thick-bedded; top of unit in brecciated zone.	142.2
6.	Limestone, dolomitic. Gray; medium-grained; medium-bedded.	146.2
7.	Dolomite. Gray; medium-grained; medium- to thin-bedded; sandy; weathers gray with buff with sand-speckled surface.	60.0
8.	Quartzite. White; interbedded with dolomite; gray; medium-grained; thin-bedded.	8.0
9.	Dolomite. Gray; medium-grained; medium-bedded; sandy; weathers gray-buff with sandy surfaces.	54.5
10.	Dolomite. Gray with irregular dark gray mottlings, medium-grained; medium-bedded; weathers sand-papery.	61.2
11.	Quartzite and dolomite, interbedded. Dolomite: gray. Quartzite: white; medium-grained; medium-bedded.	6.0
12.	Quartzite. Gray-buff; medium-grained; thin-bedded; low-angle cross-bedded quartzite; contains a few beds of sandy limestone; light gray, tan weathering.	32.5
	Total Upper Devonian-Lower Mississippian - undifferentiated	775.3

Middle Devonian

<u>Simonson dolomite</u>:

1.	Limestone, dolomitic. Dark gray; medium-grained; medium-bedded.	21.4
2.	Dolomite. Gray; medium-grained; thin-bedded.	12.8
3.	Dolomite. Black; medium-grained; indistinctly laminated to thick-bedded (6 feet); fossiliferous; fossils are cream and white; coarsely crystalline; only cross sections recognized.	102.4
4.	Dolomite. Gray; coarse-grained; thick-bedded; no fossils; weathers to coarse sandpaper finish.	27.5
5.	Dolomite. Black and dark gray; in 6- to 10-foot units; medium-grained; laminated to thick-bedded; fossiliferous; fossils recognized in cross sections as brachiopods and corals and are gray, buff, and ivory coarse dolomite crystals; a few light beds dispersed in unit are thin-bedded.	123.8

6.	Dolomite, interbedded. Light gray; fine-grained; thick-bedded (2 to 4 feet); and dark gray; laminated; in beds up to 15 feet thick.	34.4
7.	Dolomite. Dark gray; medium-grained; medium-bedded; slightly sandy.	23.7
8.	Dolomite. Gray to dark gray; medium-grained; medium- to thin-bedded; blocky.	142.1
9.	Dolomite. Buff; dense; weathers light gray with faint limonite-stained streaks of chert.	11.8
10.	Dolomite. Gray-tan; sugary; massive; sandpaper finish; blocky with rounded edges.	26.6
	Total Simonson dolomite	526.5

Devonian?

<u>Sevy dolomite</u>:

1.	Dolomite. Light gray; dense; fine- to medium-bedded; speckled with medium sand grains.	71.0
2.	Dolomite. Dark gray; dense; medium- to thin-bedded; weathers gray.	35.5
3.	Dolomite. Light gray; dense; medium- to thin-bedded; speckled with sand (rounded grains).	58.2
4.	Sandstone, dolomitic. Tan; medium-grained.	1.0
5.	Dolomite. Light gray; dense; medium- to thin-bedded; speckled with sand.	122.8
6.	Dolomite. Gray; dense, cherty boxwork.	1.5
7.	Dolomite. Gray; dense; thin-bedded; weathers as small blocks; light gray with pinkish cast.	65.1
8.	Quartzite, dolomitic. Light gray; medium-grained; thin-bedded; weathers ivory.	50.3
9.	Dolomite. Gray; medium- to fine-grained; thick-bedded; weathers to light gray with much secondary chert in fractures.	26.6
10.	Dolomite. Gray; dense; thin- to medium-bedded; with small round sand grains scattered throughout unit; weathers light gray.	59.2
	Total Sevy dolomite	491.2

PARTIAL SECTION D-2 OF DEVONIAN FORMATION IN THE WEST PART OF THE WEST LOOKOUT HILLS, SEC. 15, T. 8 S., R. 7 W., TOOELE COUNTY, UTAH

Upper Devonian?

Undifferentiated:

Dolomite. Gray and black; interbedded; medium-grained; units roughly laminated; base, 30 feet, white, medium-grained quartzite.

Middle Devonian

Simonson dolomite:

1.	Dolomite. Gray and blue-gray; interbedded; medium-grained; thin- to medium-bedded; much cover.	90.8
2.	Limestone. Blue-gray; medium-grained; medium-bedded; fossiliferous; contains black chert nodules. Fossil locality DM-1: *Proetus*? sp., Athyroid brachiopod, *Brachythyris*? sp., *Camarotechia*? sp., *Chonetes* sp., *Cyctina*? sp., *Leptostrophia*? sp., *Productids*, *Spirifer* sp., cf. *Syringothyris*, *Tylothyris*? sp., Straparolloid gastropod.	47.2
3.	Dolomite. Dark gray to black; medium-grained; medium-bedded; much cover.	58.1
4.	Dolomite. Tan to gray; sugary; much cover on dip slope.	254.1
	Total Simonson dolomite	450.2

Devonian?

Sevy dolomite:

1.	Dolomite. Mouse gray; aphanitic; dense; some units sandy; random sand grains dispersed in mass; weathers white.	355.7

Silurian

Laketown dolomite:

Dolomite. Gray; dense; thin-bedded; much cover.

SECTION D-3 OF DEVONIAN FORMATIONS IN THE CENTRAL PART OF THE EAST LOOKOUT HILLS, SEC. 30, T. 8 S., R. 6 W., TOOELE COUNTY, UTAH

Upper Devonian? — Feet

Undifferentiated:

Quartzite. White; 25 to 30 feet thick below 440-foot limestone series which conformably? underlies cherty banded Madison limestone.

Middle Devonian

Simonson dolomite:

1.	Dolomite. Gray and black; interbedded; units medium-grained; laminated.	484.0
2.	Dolomite. Dark gray; medium-grained; irregular lamina; weathers rough.	79.0
	Total Simonson dolomite	563.0

Devonian?

Sevy dolomite:

1.	Dolomite. Light gray; aphanitic; dense; weathers gray.	250.2
2.	Dolomite. Gray; aphanitic; dense.	26.3
3.	Dolomite. Light gray; aphanitic; dense; contains few sand grains; weathers gray.	206.3
4.	Dolomite. Gray; aphanitic; dense; thinly laminated; much cover; near base thin intraformational conglomerates; 3-foot dolomitic sandstone at top; unit weathers bluish-white.	561.0
	Total Sevy dolomite	1043.8

Silurian

Laketown dolomite:
Dolomite. Gray; aphanitic; dense; slightly cherty; weathers light gray.

PARTIAL SECTION DM-1 OF DEVONIAN? FORMATIONS IN CENTRAL SECTION OF THE EAST LOOKOUT HILLS, SEC. 25, T. 8 S., R. 7 W., TOOELE COUNTY, UTAH

Mississippian — Feet

Madison limestone:
Limestone. Blue-gray; medium-grained; cherty; chert bands from 1 to 3 inches thick and limestone interbeds of 2 to 6 inches.

Upper Devonian?

Upper Devonian-Lower Mississippian undifferentiated:

1.	Limestone. Gray to dark blue-gray; medium-grained; medium-bedded; crinoid columnals at base; chert is absent or scarce.	187.2
2.	Limestone. Gray; fine- to medium-grained; medium-bedded; fossiliferous; Productid? brachiopods.	37.4
3.	Quartzite. Ivory; medium-grained; thin-bedded; weathers as ledge.	28.1
4.	Dolomite. Gray; sandy and blue-gray interbedded; both medium-grained; thin- to medium-bedded; in 6- to 10-foot units.	42.1
5.	Quartzite and dolomite; interbedded. Quartzite: grayish-tan; fine-grained. Dolomite: gray; fine-grained; in medium interbeds.	23.4
6.	Dolomite. Blue-gray; medium-grained; massive.	9.4
7.	Dolomite. Gray; sandy; medium-grained; thin-bedded; contains a few thin tan quartzite beds and some sands as low-angle cross beds in the dolomite; weathers tan, sandpapery.	18.7

8.	Dolomite. Gray; fine-grained; thick-bedded; contains a few ivory dolomite inclusions; weathers gray with fine sandpapery texture on a meringue surface.	9.4
9.	Dolomite. Dark gray; medium-grained; thick-bedded; contains ivory dolomite mottles and dolomitized brachiopods.	32.4
10.	Dolomite. Gray; medium-grained; interbedded with dolomite, dark blue-gray; medium-grained; massive; interbeds 4 to 6 feet thick; units weather sandpapery.	60.2
11.	Dolomite. Sandy; light gray; medium-grained; thin-bedded; contains thin low-angle cross-bedded sand streaks.	19.8
12.	Dolomite. Dark gray to black; medium-grained; faintly thin-bedded to massive; contains ivory coarse crystalline dolomite inclusions; some round; weathers sandpapery.	102.7
	Total measured Basal Mississippian - Upper Devonian	570.8

Devonian

Dolomite. Dark gray; much cover; end measured section.

SECTION M-1 OF THE MADISON LIMESTONE IN THE NORTHERN PART OF THE EAST LOOKOUT HILLS, SECS. 24, 25, T. 8 S., R. 7 W., TOOELE COUNTY, UTAH

Feet

Mississippian

Deseret and Humbug formations (undifferentiated): Gray limestone, calcareous sandstone with some quartzitic sandstone; sandy reddish-tinted limestones near base.

FAULT: Displacement unknown but mainly strike slip at right angles to dip of strata.

<u>Madison limestone</u>:

1.	Limestone. Gray; medium-grained; medium-bedded; brecciated; near fault.	14.2
2.	Limestone, dolomitized. Gray with creamy zebra banding; coarse-grained; thick-bedded.	170.6
3.	Limestone. Blue-gray; fine- to medium-grained; medium-bedded; cherty; black chert in 1- to 2-inch bands between 3- to 6-inch beds of limestone; unit is dolomitized near fault.	72.0

FAULT:

4.	Limestone. Blue-gray; cherty; similar to unit #3; is not dolomitized.	66.8
5.	Limestone. Blue-gray; medium-grained; medium-bedded; with silty chert bands.	28.1

6.	Limestone. Blue-gray; medium-grained; medium-bedded; smooth weathering; contains irregular gray and tan silt and chert nodules lying parallel with bedding.	46.8
	Total Madison limestone	398.5

Devonian

Undifferentiated Upper Devonian or Lower Mississippian: White quartzites; blue-gray limestones; and blue-gray and black dolomites in 30- to 50-foot units.

SECTION M-2 OF THE DESERET AND HUMBUG FORMATIONS UNDIFFERENTIATED AT THE NORTH END OF THE EAST LOOKOUT HILLS, SEC. 19, T. 8 S., R. 6 W., TOOELE COUNTY, UTAH

Mississippian — Feet

Great Blue formation:
Limestone. Blue-gray; medium-bedded to massive; separated by black shale and quartzites of the Chiulos shale member.

Deseret and Humbug formations (undifferentiated):

		Feet
1.	Limestone. Gray; medium-grained; massive; top is sandy with 1- to 6-inch beds of sandstone; is last of quartzites and sandstone; contains horn corals.	32.0
2.	Limestone. Blue-gray; medium-grained; massive; faulting here, breccia and abundant secondary calcite; zone 6 feet wide; displacement undetermined.	27.4
3.	Sandstone. Tan; medium-grained; thin-bedded flaggy; in places is a good quartzite.	9.1
4.	Limestone. Blue-gray; medium-grained; massive; contains horn corals and crinoid columnals.	68.6
5.	Limestone. Light gray; medium- to fine-grained; thin-bedded (almost fissile); weathers tannish-gray.	32.0
6.	Limestone. Gray; medium-grained; thin-bedded; flaggy; sandy.	18.3
7.	Limestone. Blue-gray; medium-grained; massive; weathers rough.	9.1
8.	Sandstone. Grayish-tan; medium-grained; medium- to thin-bedded; a few scattered sand grains dispersed in beds.	18.3
9.	Limestone. Gray; medium-grained; medium- to thin-bedded; a few scattered sand grains dispersed in beds.	13.7
10.	Limestone. Grayish-tan; medium-grained; thin-bedded; flaggy; sandy.	18.3

11.	Limestone. Gray; medium-grained; low-angle cross-bedded; sandy; cross-beds in slight relief.	45.7
12.	Sandstone, quartzitic. Tan; medium-grained; massive; bottom half is limy; weathers reddish-tan.	18.3
13.	Limestone. Blue-gray; medium-grained; medium-bedded; contains a little sand which increases near bottom.	22.9
14.	Sandstone. Tannish-gray; medium-grained; thin-bedded; limy.	9.1
15.	Limestone. Gray; medium-grained; thin-bedded; with sandstone as thin bedding streaks.	22.9
16.	Sandstone. Tan; medium-grained; thick-bedded.	2.0
17.	Limestone. Gray; similar to unit #15.	20.8
18.	Limestone and sandy limestone, interbedded. Limestone: gray; medium-grained; thin-bedded; flaggy; in units 4 to 14 feet thick. Sandy limestone: grayish-tan; medium-grained; medium-bedded; in units 6 to 10 feet thick. Bottom 1/3 of unit has a few 4-foot beds of blue-gray, sand-speckled, cherty (small nodules) limestone.	91.4
19.	Limestone. Light gray; medium-grained; thin-bedded; flaggy; sandy; weathers tan.	9.1
20.	Limestone. Dark gray (bluish) to blue-gray; medium-grained; massive; contains a few scattered flat sandy tan nodules which are parallel with the bedding; crinoid columnals and horn corals.	13.7
21.	Limestone, sandy. Pinkish to gray; medium-grained; thin-bedded; flaggy; weathers reddish-tan to light red.	13.7
22.	Limestone. Blue-gray; medium- to coarse-grained; cross-bedded; crinoidal; contains sand streaks.	9.1
23.	Limestone. Dark gray; similar to unit #20; crinoid and horn corals.	41.1
24.	Sandstone. Tan; medium-grained; thick-bedded; lime cement; breaks and weathers in irregular blocks.	36.6
25.	Sandstone. Tan; medium-grained; medium-bedded; limy; weathers reddish-tan.	32.0
26.	Limestone. Blue-gray; medium-grained; massive; pure.	9.1
27.	Limestone, sandy. Similar to unit #21; contains bryozoans, brachiopods and crinoid columnals.	64.0
28.	Limestone. Blue-gray; similar to unit #22.	9.1
29.	Limestone, sandy. Similar to units #21 and #27.	32.0

30.	Limestone. Blue-gray; similar to units #22 and #28.	22.9
31.	Limestone, sandy. Similar to units #21, #27, and 29.	312.3
32.	Sandstone. Tan to light brown; medium-grained; calcareous; thin-bedded; flaggy.	39.1
33.	Limestone, sandy. Light blue-gray; medium-grained; thin-bedded; thin flaggy; weathers with reddish tint.	18.3
	Total Deseret and Humbug formations (undifferentiated)	1142.0

Madison limestone:

Limestone. Blue-gray; with chert bands 1 to 3 inches; interbedded with 2- to 6-inch beds medium-grained; blue-gray limestones.

SECTION M-3 OF THE DESERET AND HUMBUG FORMATIONS UNDIFFERENTIATED AT THE NORTH END OF THE WEST LOOKOUT HILLS, SECS. 11, 14, T. 8 S., R. 7 W., TOOELE COUNTY, UTAH

Mississippian

Great Blue formation:

Limestones. Blue-gray; medium-bedded to massive; separated by the black shale and quartzites of the Chiulos shale member.

Deseret and Humbug formations (undifferentiated):

1.	Limestone. Gray; medium-grained; thick-bedded; this unit contains lighter and darker gray limestone which occurs as small mottles; white, secondary calcite occurs as fracture fill in thin stringers; some of the beds are cross-bedded with fine sand and silt particles distinguishing the bedding.	89.8
2.	Limestone. Gray; medium-grained; medium-bedded; flaggy; some beds weather tan to buff and are silty.	32.6
3.	Limestone, sandy. Gray; coarse-grained; medium-bedded; sand streaks occur as low-angle lenses and cross-beds; some thin streaks are only a few millimeters thick; the unit weathers rough (coarse sandpaper) with cross-beds in relief.	28.6
4.	Limestone. Gray; medium-grained; medium-bedded; contains a few brown sand streaks and weathers rough.	50.9
5.	Limestone. Grayish-tan; medium-grained; medium-bedded; slightly sandy; this unit weathers tan.	37.0
6.	Limestone. Gray; medium-grained; massive; this unit weathers rough (rasp-like), contains colonial cigar-shaped corals and some silicified brachiopod valves.	41.7

7.	Limestone. Gray; sandy; similar to unit #3. contains bryozoans, are in a few flaggy thin, tan silty limestone beds dispersed throughout unit.	83.3
8.	Sandstone. Tan; fine- to medium-grained; thin-bedded; flaggy; contains lime cement; weathers reddish-tan.	4.6
9.	Limestone. Gray; sandy; similar to units #3 and #7; crinoid columnals present.	101.9
10.	Sandstone and limestone, interbedded. Flaggy; medium-bedded. Sandstone: tan; medium-grained. Limestone: gray weathering tan being slightly sandy which in a few beds has a purple to pink hue; weathers to form saddles; crinoid columnals present.	146.2
11.	Limestone. Gray; medium-grained; thin-bedded; sandy; flaggy; contains a few thin beds of medium-grained sandstone.	36.6
12.	Sandstone. Grayish-tan; medium- to fine-grained; thin-bedded; breaks in 3- to 6-inch blocks; much cover; weathers to slope with tannish-purple hue.	182.8
13.	Sandstone and limestone, interbedded. Flaggy; medium-bedded. Sandstone: limy; medium-grained; weathers tan with pink cast; fossil fragments on bedding planes. Limestone: gray; sandy; breaks flaggy; units #11, #12, and #13 form slopes; contains fragments of bryozoans, crinoids, and brachiopods.	137.1
14.	Limestone. Light gray; fine-grained; thin-bedded; contains chert bands, brown-black, 1/2 to 1 1/2 inches thick, which have undulatory bedding surfaces.	22.9
15.	Limestone. Gray; medium- to fine-grained; medium-bedded; weathers pocky and rough; short chert bands near base; horn corals at top.	86.8
16.	Limestone. Gray; medium-grained; thin-bedded; in places contains pinkish cement; bedding is very faint; in places brown cherts occur as small nodules.	27.4
17.	Limestone. Gray; medium-grained; thin- to medium-bedded; flaggy; sandy; weathers pinkish-gray.	54.8
	Total Deseret and Humbug formations (undifferentiated)	1165.0

Madison limestone:

Limestone. Blue-gray; with chert bands 1 to 3 inches interbedded with 2- to 6-inch beds, medium-grained; blue-gray limestone.

SECTION M-4 OF THE LOWER MEMBER OF THE GREAT BLUE FORMATION AT THE NORTH END OF THE WEST LOOKOUT HILLS, SEC. 11, T. 8 S., R. 7 W., TOOELE COUNTY, UTAH

Mississippian		Feet
Great Blue formation		
Chiulos shale member: Thin-bedded dark shale and tan, medium-bedded quartzites, some of which are dark greenish-gray; except for the quartzites the shale forms prominent saddles.		
<u>Lower limestone member</u>:		
1.	Limestone. Gray and blue-gray; medium-grained; medium-bedded to massive; some beds are cherty with tan and reddish-brown cherts as irregular short lenses and nodules.	246.1
2.	Limestone. Blue-gray; medium-grained; medium-bedded; weathers smooth; contains some tan, medium-grained sandstones in thin beds which represent about 5 percent of the total unit; sòme black chert nodules are present in the limestone.	68.8
3.	Limestone. Blue-gray; medium-grained; thick-bedded; a few beds have discontinuous black chert bands (4 to 6 inches thick) spaced 1 to 3 feet apart; colonial cigar-shaped corals found; dispersed throughout the unit are some 5- to 6-foot beds of dark gray limestones containing a little chert and which weather extremely rough (meringue); spaghetti corals found near top; unit forms cliffs and dip slope. Fossil locality M-18: 240 feet above base; largely syringoporid coral.	424.9
4.	Limestone. Tan-gray; medium-grained; medium-bedded; flaggy; interbedded with 2- to 5-foot beds of massive blue-gray limestones; corals and brachiopods present; weathers to a pink cast.	63.2
5.	Limestone. Blue-gray; medium-grained; thick-bedded; contains corals.	35.6
6.	Limestone. Tan-gray; fine- to medium-grained; thin-bedded; flaggy; silty; weathers smooth.	31.6
7.	Limestone. Blue-gray; medium-grained; massive; weathers rough; contains horn corals.	41.7
	Total lower member of Great Blue formation	911.1
Deseret and Humbug formations (undifferentiated): Limestones. Blue-gray; medium-grained. Sandstone: tan; calcareous.		

PARTIAL SECTION M-5 OF THE CHIULOS MEMBER OF THE GREAT BLUE FORMATION AT THE NORTH END OF THE WEST LOOKOUT HILLS, SEC. 11, T. 8 S., R. 7 W., TOOELE COUNTY, UTAH

Mississippian

Great Blue formation

Upper member of the Great Blue formation:
Limestone. Blue-gray; medium-grained; medium-bedded; with a few black chert bands and nodules.

Chiulos member:

1.	Covered red, gray, green-tinted, tan quartzite float over black shale and silty light blue-gray, tan weathering sandy limestone; few beds of quartzite characterized by 1/16- to 1/8-inch rust spots in fairly regular distribution; in other areas of limited exposure some gritty beds and shell conglomerate were present, as well as cross-bedding in limestone which was demarked by sand grains; this unit is not complete and is in fault contact with the upper Great Blue.	562.5
2.	Quartzite. Tan; limonite-stained; cross-bedded; medium-grained; in places limonite staining is heavy and bleached; some diffusion on bands but these are not abundant; *Calamites* sp. present in this unit; quartzite debris covers much of the unit.	450.0
3.	Shale. Black; fissile; limonite in fractures.	180.0
4.	Quartzite. Tan; reddish; medium-grained; much cover.	90.5
5.	Covered. Dip slope on top of lower Great Blue limestone; probably shale; base concealed.	535.0
	Total exposed Chiulos member of Great Blue formation	1818.0

Lower member of the Great Blue formation:
Blue-gray; medium-grained; medium-bedded limestone; with abundant corals, especially large horn corals.

PARTIAL SECTION M-6 OF THE UPPER MEMBER OF THE GREAT BLUE FORMATION AT THE SOUTH END OF THE ONAQUI MOUNTAINS, NORTH OF LOOKOUT PASS, SEC. 6, T. 8 S., R. 6 W., TOOELE COUNTY, UTAH

Mississippian — Feet

Surface: Erosion interval, removal of between 200 and 300 feet of the upper member of the Great Blue formation.

Great Blue formation

Upper limestone member:

1.	Erosion interval of 200 to 300 feet (est.).	200-300

2.	Limestone. Gray; medium-grained; medium-bedded; some small dark gray twig-like bodies.	172.4
3.	Limestone. Gray; medium-grained; medium-bedded; weathers to a pinkish tint; crinoid columnals present.	60.7
4.	Limestone. Medium-grained; medium-bedded; dark gray and black chert as isolated bands and nodules.	59.6
5.	Limestone. Dark gray; fine- to medium-grained; medium-bedded; contains tan silt dispersed in weak (evasive visually) swirl-like masses.	16.5
6.	Limestone. Gray-tan; fine-grained; silty; weathers blocky.	11.0
7.	Siltstone. Tan; fine-grained; thin-bedded; calcareous; weathers irregular platy; some beds weather reddish.	5.5
8.	Limestone. Blue-gray; medium-grained; medium-bedded; cherty bands black, 1 to 2 inches thick spaced at 4 to 6 inches.	82.7
9.	Limestone. Gray; medium-grained; brecciated.	27.6
10.	Limestone. Dark blue-gray; medium-grained; medium-bedded; smooth weathering.	49.6
11.	Limestone. Gray; jumbled blocks; faulting.	66.1
12.	Limestone. Gray; medium coarse-grained; medium-bedded; a few brown and gray chert nodules; weathers sandpapery; unit consists of many blocks.	49.6
13.	Limestone. Gray; similar to above unit, but is not broken.	93.7
14.	Limestone. Blue-gray; medium-grained; medium-bedded; cherty; chert nodules and bands, black, 1 to 4 inches thick; limestone beds 2 to 4 inches thick.	33.1
15.	Limestone. Blue-gray; medium-grained; medium-bedded; a few black chert nodules.	33.6
16.	Limestone. Blue-gray; medium-grained; medium-bedded; contains irregular sandy, calcareous blocks which weather tan.	5.5
17.	Limestone. Dark blue-gray; medium-grained; medium-bedded; bands of chert 1 1/2 to 8 inches thickly spaced 24 to 30 inches apart; corals present; unit is shaly near top with some pink coloration in thin partings; unit weathers rough and is a cliff former.	247.3
18.	Limestone. Blue-gray; medium-grained; medium-bedded; black and dark gray chert nodules are scarce but those present lie as undulatory masses parallel with the bedding; silicified corals and a few poorly preserved brachiopods and	109.6

gastropods are present. Fossil locality M-21: at 50 feet above base; *Lithostrotion*?

19.	Limestone. Blue-gray; medium-grained; medium-bedded; weathers to form steps with interbedded units of thicker bedded zones (10 feet) and thinner beds (4 to 5 feet). Fossil locality M-20: near top, productid; *Faberophyllum*.	158.9
20.	Limestone. Dark blue-gray; medium-grained; massive with a few medium beds; weathers smooth; some reddish cement at base of section. Fossil locality M-19: at base, *Lithostrotionella* sp., large horn coral, *Caninia* sp.?	126.7
21.	Base faulted down - not exposed.	———
	Total exposed upper member of the Great Blue formation	1409.7

Shales. Black, tan, reddish. Quartzites. Green.

A P P E N D I X B

FOSSIL LOCALITIES

Period	Localities	Pages
Cambrian	C-1 through C-35	178-183
Ordovician	O-1 through O-22	183-186
Silurian	S-1 through S-6	186-187
Devonian	D-1	187
Devonian-Mississippian	DM-1 and DM-2	187-188
Mississippian	M-1 through M-23	188-192
Cretaceous-Tertiary	KT-1	192

F O S S I L   L O C A L I T I E S

Cambrian

C-1
Location: SW, SW, SW, Sec. 20, T. 9 S., R. 6 W., Tooele County
Shale, green
Millard formation
Ehmaniella sp.
Glossopleura sp.
Polypleuraspis sp.
Identified by: A. R. Palmer

C-2
Location: SW, SW, SW, Sec. 20, T. 9 S., R. 6 W., Tooele County
Shale, green
Condor formation
Scraps of linguloid brachiopods
Identified by: A. R. Palmer

C-3
Location: NW, SW, SW, Sec. 20, T. 9 S., R. 6 W., Tooele County
Limestone, blue-gray
Wheeler formation
Elrathia ? sp.
Identified by: A. R. Palmer

C-4
Location: NW, SW, SW, Sec. 20, T. 9 S., R. 6 W., Tooele County
Limestone, blue-gray
Wheeler formation
Elrathina? sp.
Identified by: A. R. Palmer

C-5
Location: SW, NW, SW, Sec. 20, T. 9 S., R. 6 W., Tooele County
Shale, green
Complex area--near fault
Scraps of linguloid brachiopods
Identified by: A. R. Palmer

C-6
Location: C, NE, SE, Sec. 19, T. 9 S., R. 6 W., Tooele County
Shale, green
Complex area--near fault
Scraps of linguloid brachiopods
Identified by: A. R. Palmer

C-7
Location: NW, NE, NE, Sec. 28, T. 9 S., R. 6 W., Tooele County
Shale, green
Millard formation
Glossopleura sp.
Identified by: A. R. Palmer

C-8
Location: NW, NE, SE, Sec. 12, T. 9 S., R. 7 W., Tooele County
Shale, green
Millard formation
Glossopleura sp.
Identified by: A. R. Palmer

C-9
Location: NW, NE, SE, Sec. 12, T. 9 S., R. 7 W., Tooele County
Shale, green
Condor formation
Scraps of linguloid brachiopods and a trilobite pygidium
Identified by: A. R. Palmer

C-10
Location: NW, SE, NE, Sec. 12, T. 9 S., R. 7 W., Tooele County
Limestone, blue-gray
Wheeler formation
Zacanthoides sp.
Identified by: A. R. Palmer

C-11
Location: SW, NE, NE, Sec. 12, T. 9 S., R. 7 W., Tooele County
Shale, tan to olive
Marjum limestone
Scraps of linguloid brachiopods
Identified by: R. E. Cohenour

C-12
Location: SW, NE, NE, Sec. 12, T. 9 S., R. 7 W., Tooele County
Limestone, dark blue-gray
Marjum limestone
Indeterminate trilobite cf. *Meteoraspis* or *Modocia*
Identified by: A. R. Palmer

C-13
Location: SW, NE, NE, Sec. 12, T. 9 S., R. 7 W., Tooele County
Limestone, dark blue-gray
Marjum limestone
Indeterminate trilobite
Identified by: A. R. Palmer

C-14
Location: SW, SE, SE, Sec. 34, T. 9 S., R. 6 W., Tooele County
Shale, green
Millard formation
Glossopleura sp.
Identified by: A. R. Palmer

C-15
Location: SW, SW, SW, Sec. 35, T. 9 S., R. 6 W., Tooele County
Limestone, blue-gray
Wheeler formation
Elrathia sp.
Identified by: A. R. Palmer

C-16
Location: NW, SE, SW, Sec. 35, T. 9 S., R. 6 W., Tooele County
Shale, green
Burnt Canyon formation
Scraps of Linguloid brachiopods
Identified by: A. R. Palmer

C-17
Location: NW, SE, NE, Sec. 1, T. 9 S., R. 7 W., Tooele County
Limestone, blue-gray, pinkish-tan silty partings
Opex formation
Billingsella sp.
Conaspid trilobite fragments
Conodonts
Acrotretids of Upper Cambrian type
Problematicum I - described by Westergard (Geologiska Foreningens I Stockholm Forhandlinger, Bond 75, Heft 4, pp. 465-468, 1953) from Upper Cambrian beds in Sweden
Identified by: A. R. Palmer

C-18
Location: SE, NE, SW, Sec. 11, T. 9 S., R. 7 W., Tooele County
Shale, green
Millard formation
Glossopleura sp.
Identified by: A. R. Palmer

C-19
Location: SW, SE, NW, Sec. 35, T. 8 S., R. 7 W., Tooele County
Limestone, blue-gray, pinkish-tan silty partings
Opex limestone
Conodonts
Acrotretid brachiopods of Upper Cambrian type
Identified by: A. R. Palmer

C-20
Location: SW, SW, NE, Sec. 11, T. 9 S., R. 7 W., Tooele County
Shale, tan, micaceous, fucoidal
Pioche shale
Trilobite track
Identified by: R. E. Cohenour

C-21
Location: SW, SW, NE, Sec. 11, T. 9 S., R. 7 W., Tooele County
Limestone, blue-gray, sandy
Busby formation
Caborcella cf. *C. Arrojosensis* Lochman
Kootenia spp.
Onchocephalus ? sp.
Ptarmigania or *Ptarmiganoides* sp.
Pelagiella-like grastropod
Helcionella sp.
Scenella sp.
Brachiopods
Identified by: R. C. Bright

C-22
Location: NE, SW, NE, Sec. 11, T. 9 S., R. 7 W., Tooele County

Shale, green
Millard formation
Glossopleura sp.
Identified by: R. C. Bright

C-23
Location: SE, NE, NW, Sec. 11, T. 9 S., R. 7 W., Tooele County
Shale, green, silty, micaceous
Condor formation
Ehmaniella sp.
Acrothele sp.
Identified by: R. C. Bright

C-24
Location: NE, NE, NE, Sec. 11, T. 9 S., R. 7 W., Tooele County
Limestone, blue-gray, platy
Wheeler formation
Elrathia sp.
Peronopsis interstrictus (White)
Protospongia sp.
Identified by: R. C. Bright

C-25
Location: SW, NW, NW, Sec. 35, T. 8 S., R. 7 W., Tooele County
Limestone, blue-gray, silty
Opex limestone--near top
Acrotreta cf. *A. microscopia* Walcott
Acrotreta ophirensis Walcott
Billingsella cf. *B. Coloradoensis* Walcott
Eoorthis desmopleura Walcott
Lingulella sp.
Linguloid brachiopods
Pelagiella-like gastropod
Moustonia sp.
Parabolinoides contractus Fredrickson
Taenicephalus cf. *T. hyrumensis* Resser
Taenicephalus shumardi Hall
Taenicephalus cf. *T. striatus* Resser
Taenicephalus spp.
Identified by: R. C. Bright

C-26
Location: SE, NW, SW, Sec. 35, T. 8 S., R. 7 W., Tooele County
Limestone, gray, silty, oolitic, intraformational
Opex limestone--near base
Coosella spp.
Kormagnostus cf. *K. simplex* (Resser)
Pseudoagnostus prolongus (Hall & Whitfield)
Tricrepicephalus walcotti (Lochman)
Lingulella sp.
Hyolithes primordialis (Hall)
Syspacheilus? sp.
Identified by: R. C. Bright

C-27
Location: NE, SW, NW, Sec. 34, T. 8 S., R. 7 W., Tooele County
Limestone, gray, yellowish, oolitic
Opex limestone--basal

Trilobite pygidium affinity
Upper Cambrian
Identified by: R. C. Bright

C-28
Location: NE, NW, SE, Sec. 12, T. 9 S., R. 7 W., Tooele County
Limestone, light blue-gray, sandy
Millard formation, lower member
Kootenia sp.
Helcionella sp.
Identified by: R. C. Bright
Pachyaspis? sp.
Identified by: Christina Lochman Balk

C-29
Location: NE, NW, SE, Sec. 12, T. 9 S., R. 7 W., Tooele County
Shale, green
Millard formation
Glossopleura sp.
Identified by: R. E. Cohenour

C-30
Location: NW, SE, SE, Sec. 27, T. 9 S., R. 6 W., Tooele County
Limestone, blue-gray, sandy
Busby formation
Dolichomitopsis sp.
Kochaspis sp.
Olenoides sp.
Oryctocephalites cf. *O. resseri* Rasetti
Identified by: R. C. Bright

C-31
Location: SW, NE, SE, Sec. 27, T. 9 S., R. 6 W., Tooele County
Limestone, blue-gray, mottles
Millard formation, lower member
Helcionella sp.
Identified by: R. C. Bright

C-32
Location: SW, NE, SE, Sec. 27, T. 9 S., R. 6 W., Tooele County
Shale, green
Millard formation
Glossopleura sp.
Identified by: R. C. Bright

C-33
Location: NE, NE, SE, Sec. 27, T. 9 S., R. 6 W., Tooele County
Shale, dark green, blocky
Burnt Canyon limestone
Scraps of linguloid brachiopods
Identified by: R. C. Bright

C-34
Location: SE, NW, SW, Sec. 26, T. 9 S., R. 6 W., Tooele County
Limestone and shale, interbedded, blue-gray, olive green
Condor formation

Ehmaniella cf. *E. burgessensis* Rasetti
Elrathina? sp.
Hyolithes cf. *H. cercops* Walcott
Iphidella sp.
Micromitra? sp.
Identified by: R. C. Bright

C-35
Location: SW, NW, NW, Sec. 35, T. 8 S., R. 7 W., Tooele County
Limestone, blue-gray, reddish silty partings
Opex limestone--near top
Elvinia montis Resser
Elvinia sp.
Identified by: R. C. Bright

Ordovician

O-1
Location: SW, SW, SW, Sec. 31, T. 8 S., R. 6 W., Tooele County
Limestone, blue-gray, intraformational conglomerate
House-Fillmore limestone--near top
Crinoid stems
Trilobite fragments
Brachiopod fragments
Gastropod fragments
Identified by: R. C. Bright

O-2
Location: SE, NW, SW, Sec. 31, T. 8 S., R. 6 W., Tooele County
Limestone, blue-gray
House-Fillmore limestones
Pseudocybele sp.
Ophileta-like gastropod
Orthambonites sp.
Cystoid columnals - plates
Identified by: R. C. Bright

O-3
Location: NE, NW, SW, Sec. 31, T. 8 S., R. 6 W., Tooele County
Limestone, blue-gray, silty
Juab limestone
Receptaculities ellipticus
Receptaculites sp.
Anomalorthis sp.
Orthambonites subalata
Orthambonites sp.
Lingula sp.
Ostrocods - *Leperditia*-like
Identified by: R. C. Bright

O-4
Location: NW, NE, NW, Sec. 31, T. 8 S., R. 6 W., Tooele County
Dolomite, dark blue-gray
Fish Haven dolomite
Streptelasma sp.
Syringopora sp. ?
Identified by: R. E. Cohenour

O-5
Location: NE, SE, NE, Sec. 21, T. 8 S., R. 7 W., Tooele County
Limestone, blue-gray, intraformational
House-Fillmore limestone
Gastropod, indeterminate
Identified by: R. C. Bright

O-6
Location: NW, NW, NW, Sec. 22, T. 8 S., R. 7 W., Tooele County
Limestone, blue-gray, cherty
Wah Wah limestone
Hesperonomia cf. *H. fontinalis*
Maclurites sp.
Identified by: R. C. Bright

O-7
Location: NW, NW, NW, Sec. 22, T. 8 S., R. 7 W., Tooele County
Limestone, blue-gray, sandy
Juab limestone
Orthambonites subalata
Identified by: R. C. Bright

O-8
Location: NW, NW, NE, Sec. 26, T. 8 S., R. 7 W., Tooele County
Dolomite, dark blue-gray
Fish Haven dolomite
Halysites cf. *H. catenularia*
Syringopora sp.
Crinoid columnals
Identified by: R. E. Cohenour

O-9
Location: NE, SE, SE, Sec. 15, T. 8 S., R. 7 W., Tooele County
Dolomite, blue-gray, cherty
Fish Haven dolomite
Halysites sp.
Small horn coral
Crinoid columnals
Identified by: R. E. Cohenour

O-10
Location: SW, NW, SW, Sec. 15, T. 8 S., R. 7 W., Tooele County
Dolomite, dark blue-gray
Fish Haven dolomite--near base
Streptelasma sp.
Identified by: R. E. Cohenour

O-11
Location: NW, NE, SE, Sec. 24, T. 9 S., R. 7 W., Tooele County
Dolomite, blue-gray
Fish Haven dolomite
Syringopora sp.
Halysites cf. *H. catenularia*
Identified by: R. E. Cohenour

O-12
Location: SE, NW, SW, Sec. 31, T. 8 S., R. 6 W., Tooele County

Limestone, blue-gray
House-Fillmore limestones
Gastropods--indeterminate
Porifera?
Identified by: R. C. Bright

O-13
Location: SE, NW, SW, Sec. 31, T. 8 S., R. 6 W., Tooele County
Limestone, blue-gray, silty
Wah Wah limestone
Orthocone cephalopods
Gastropods
Brachiopods fragments
Crinoid columnals
Trilobite fragments
Identified by: R. C. Bright

O-14
Location: NE, NW, SW, Sec. 31, T. 8 S., R. 6 W., Tooele County
Shale, purple
Kanosh shale
Didymograptus cf. *D. artus*
Identified by: R. C. Bright

O-15
Location: SW, SE, NW, Sec. 26, T. 8 S., R. 7 W., Tooele County
Limestone, blue-gray, cherty
Juab limestone
Orthambonites subalata
Gastropods
Identified by: R. C. Bright

O-16
Location: NW, SE, NW, Sec. 26, T. 8 S., R. 7 W., Tooele County
Shale, red and black, calcareous
Kanosh shale
Anomalorthis sp.
Orthocone cephalopod
Trilobite fragments
Receptaculites sp.
Identified by: R. C. Bright

O-17
Location: NE, SW, NE, Sec. 26, T. 8 S., R. 7 W., Tooele County
Shale and quartzite, red, tan and black
Kanosh shale and Swan Peak transition
Conodonts--mostly undescribed fauna
Oistodus sp.
Stereoconus sp.
Identified by: R. C. Bright

O-18
Location: SE, SE, NW, Sec. 7, T. 10 S., R. 6 W., Tooele County
Dolomite, blue-gray
Fish Haven dolomite
Halysites sp.
Identified by: R. E. Cohenour

O-19
Location: NW, NE, NE, Sec. 19, T. 10 S., R. 6 W., Tooele County
Dolomite, dark blue-gray
Fish Haven dolomite
Halysites sp.
Identified by: R. E. Cohenour

O-20
Location: NE, NW, NW, Sec. 7, T. 10 S., R. 6 W., Tooele County
Dolomite, dark blue-gray
Fish Haven dolomite
Halysites sp.
Identified by: R. E. Cohenour

O-21
Location: NW, NE, NE, Sec. 5, T. 12 S., R. 6 W., Juab County
Dolomite, dark blue-gray
Fish Haven dolomite
Halysites sp.
Streptelasma? sp.
Identified by: R. E. Cohenour

O-22
Location: SW, NE, SW, Sec. 18, T. 10 S., R. 7 W., Tooele County
Shale, green and khaki
Kanosh shale
Eleutherocentrus petersoni
Goniotelus sp.
Lingulella sp.
Lingula sp.
Gastropods
Ostracods - *Leperditia*-like
Didymograptus artus
Protocycloceras sp.
Orthocone cephalopods
Modiolopsis sp.
Identified by: R. C. Bright

Silurian

S-1
Location: SW, SE, SW, Sec. 30, T. 8 S., R. 6 W., Tooele County
Dolomite, dark gray, cherty
Laketown dolomite
Halysites sp.
Stromotoporid coral
Brachiopod, poorly preserved
Identified by: R. E. Cohenour

S-2
Location: SE, NW, SW, Sec. 30, T. 8 S., R. 6 W., Tooele County
Dolomite, dark gray
Laketown dolomite
Favosites sp.
Identified by R. H. Waite

S-3
Location: NW, SW, SE, Sec. 30, T. 8 S., R. 6 W., Tooele County
Dolomite, dark gray, cherty
Laketown dolomite
Camarotoechia sp.
Identified by: R. H. Waite

S-4
Location: SW, NW, SE, Sec. 30, T. 8 S., R. 6 W., Tooele County
Chert, gray to brown, near top
Laketown dolomite
Howellella? sp.
Halysites sp.
Streptelasma sp.
Stromotopora sp.
Identified by: R. H. Waite

S-5
Location: NW, SE, SW, Sec. 30, T. 8 S., R. 6 W., Tooele County
Chert, gray to brown, near top
Laketown dolomite
Eospirifer? frag.
Douvillina cf. *D. genicalate*
Identified by: R. H. Waite

S-6
Location: SW, SE, NW, Sec. 15, T. 8 S., R. 7 W., Tooele County
Dolomite, light gray, chert banded
Laketown dolomite
Pentamerus ? sp.
Favosites
Halysites sp.
Stromotopora sp.
Identified by: R. H. Waite

Devonian

D-1
Location: SE, NE, NW, Sec. 23, T. 8 S., R. 7 W., Tooele County
Dolomite, black, crystalline
Simonson dolomite
Brachiopod cross sections
Cladopora? sp.
Identified by: R. E. Cohenour

Devonian-Mississippian

DM-1
Location: NW, SE, NE, Sec. 15, T. 8 S., R. 7 W., Tooele County
Limestone, blue-gray
Victoria? formation
Proetus? sp.
Athyroid? brachiopod
cf. *Brachythyris*? sp.
Camarotoechia ? sp.
Chonetes sp.
Cyctina?
Leptostrophia?

Productid
Spirifer sp.
cf. *Syringothyris*
Tylothyris?
Straporolloid gastropod
Identified by: M. A. Stainbrook

DM-2
Location: SE, NW, NE, Sec. 30, T. 8 S., R. 6 W., Tooele County
Limestone, gray--above 6-foot white quartzite
Victoria? formation
Brachiopods
(specimens lost in transit to USGS)
Identified by: R. E. Cohenour

Mississippian

M-1
Location: NE, NE, NW, Sec. 30, T. 8 S., R. 6 W., Tooele County
Limestone, blue-gray
Madison limestone--near base
Chonetes loganensis
Ostracods
Crinoid fragments
Coral fragments
Identified by: R. E. Cohenour and W. L. Stokes

M-2
Location: SE, SE, SW, Sec. 19, T. 8 S., R. 6 W., Tooele County
Limestone, blue-gray
Madison limestone
Large horn corals
Crinoid fragments
Identified by: R. E. Cohenour

M-3
Location: C, SW, Sec. 19, T. 8 S., R. 6 W., Tooele County
East Lookout Hills Section
Limestone, blue-gray, sandy
Deseret-Humbug formation (undifferentiated)
Crinoid fragments
Identified by: R. E. Cohenour

M-4
Location: NE, NW, SE, Sec. 19, T. 8 S., R. 6 W., Tooele County
Limestone, blue-gray
Great Blue formation--Lower limestone member
Horn coral, polished section is too high thru the calyx to identify satisfactorily.

Faberophyllum sp., neanic stage of growth. About 50 major septa at 19 mm O. D.; length of minor septa about 1/3d of radius, no axial structures observed; tabulae are concave toward calyx. This is a young, immature horn coral. The species have been established on mature individuals; until someone describes the ontogeny of these corals, it is unsafe to state what species this specimen represents. The genus *Faberophyllum* is quite characteristic of the lower Great Blue.

Identified by: W. Sadlick

M-5

Location: C, NW, Sec. 13, T. 8 S., R. 7 W., Tooele County
Limestone, blue-gray, sandy, some chert
Deseret-Humbug formations (undifferentiated)

Faberophyllum cf. araneosum - Septal formula: K19A12C(F) 12A19 at 30 mm O. D., 65 major septa; length of major septal 1/3d radius; fossula on convex side. This species commonly occurs in the upper part of the Humbug and lower part of the lower limestone member of the Great Blue limestone. Incidentally, I was considering naming this lower limestone the Flux limestone formation and elevating the Great Blue to group status.

Blastoid fragment -

Triplophyllities (Triplophyllites) cf. clinatus - Septal formula: K9A7C7A9 at 10 mm O. D. by about 14 mm O. D. The two diameters given mean that this is a cuneate horn coral: i.e., flattened; 34 major septa, minor septa only in counter quadrants. This species was recently described by W. H. Easton who said the species occurs in the Salem and Warsaw limestones in the type Mississippian area.

Fenestella cf. nodulosa Phillips - 21/15/?/? about three zooecia per fenestrule, pentagonal shaped zooecia. This is a British form, or is related to that British form. I do not think an age determination is possible as yet.

Identified by: W. Sadlick

M-6

Locations: C, NE, Sec. 10, T. 8 S., R. 7 W., Tooele County
Limestone, blue-gray
Great Blue formation--Lower limestone member
Fossils not diagnostic
Identified by: W. Sadlick

M-7

Location: SE, SW, SE, Sec. 14, T. 8 S., R. 7 W., Tooele County
Limestone, blue-gray
Madison limestone--near base
Exochops sp.
Martinia rostrata, Girty
Composita humilis
Productus gallatinensis
Schuchertella chemungensis
Straparollus ophirensis
Identified by: R. E. Cohenour and W. L. Stokes

M-8

Location: SE, NE, SE, Sec. 10, T. 8 S., R. 7 W., Tooele County
Limestone, blue-gray
Great Blue formation, lower limestone member
Faberophyllum sp.
Spirifer haydenensis?
Gastropod
Spiriferoid n. sp. aff. spirifer bifurcatus (poorly preserved)
Identified by: W. Sadlick

M-9

Location: NW, NE, NW, Sec. 15, T. 8 S., R. 7 W., Tooele County

Limestone, blue-gray
Madison limestone
Spirifer centronatus
Identified by: R. E. Cohenour

M-10
Location: NW, SE, SW, Sec. 20, T. 8 S., R. 6 W., Tooele County
Limestone, gray, sandy
Deseret-Humbug formations (undifferentiated)
Bryozoans
Brachiopod fragments
Identified by: R. E. Cohenour

M-11
Location: SE, SW, NW, Sec. 20, T. 8 S., R. 6 W., Tooele County
Limestone, blue-gray
Lower member of the Great Blue formation
Small syringoporid coral
Lithostrotion sp.
Linoproductus aff. Striatifera brazerianus
Faberophyllum?
Identified by: W. Sadlick

M-12
Location: C, SW, NW, Sec. 19, T. 8 S., R. 6 W., Tooele County
Limestone, blue-gray
Great Blue formation, upper limestone member
Striatifera brazerianus
Echinoconchus aff. E. genevievensis
Dictyoclostus aff. D. burlingtonensis
Composita trinuclea
Cleiothyridina n. sp.
Reticulariina spinosa, small form
Identified by: W. Sadlick

M-13
Location: NE, NE, SW, Sec. 18, T. 8 S., R. 6 W., Tooele County
Limestone, blue-gray, cherty
Great Blue formation, upper limestone member
Rhipidomella aff. R. carbonaria
Identified by: W. Sadlick

M-14
Location: SE, NW, NW, Sec. 18, T. 8 S., R. 6 W., Tooele County
Conglomerate; limestone and quartzite pebbles subrounded with shell hash 15 to 20 feet thick
Great Blue formation, Chiulos member, near top
Diaphragmus? very poor
Identified by: W. Sadlick

M-15
Location: SE, NW, NW, Sec. 18, T. 8 S., R. 6 W., Tooele County
Limestone, sandy, gray-tan
Great Blue formation, Chiulos member--near top
Linoproductus n. sp. aff. Striatifera brazerianus
"Productus" aff. "P." arkansanus
Antiquatonia n. sp.
Diaphragmus? sp.

Spirifer aff. *S. increbencens*
Identified by: W. Sadlick

M-16
Location: SW, NW, NW, Sec. 18, T. 8 S., R. 6 W., Tooele County
Limestone, tan, silty, and shaly
Great Blue formation, Chiulos member--near top
Linoproductus aff. *magnispinus*
Identified by: W. Sadlick

M-17
Location: SW, SW, NW, Sec. 18, T. 8 S., R. 6 W., Tooele County
Quartzite, tan, limonite specks
Great Blue formation, Chiulos member--near middle
Calamites sp.
Not diagnostic
Identified by: Roland W. Brown

M-18
Location: NE, SE, SW, Sec. 11, T. 8 S., R. 7 W., Tooele County
Limestone, blue-gray
Great Blue formation, lower limestone member
Large syringoporid coral
Identified by: W. Sadlick

M-19
Location: SE, NW, NW, Sec. 6, T. 8 S., R. 6 W., Tooele County
Limestone, blue-gray
Great Blue formation, upper limestone member--near base
Lithostrotionella sp.
Caninia? sp.
Identified by: W. Sadlick

M-20
Location: SE, NW, NW, Sec. 6, T. 8 S., R. 6 W., Tooele County
Limestone, blue-gray
Great Blue formation, upper limestone member
Productid
Faberophyllum? sp. (If correct, this genus ranges much higher than heretofore believed)
Identified by: W. Sadlick

M-21
Location: SW, NE, NW, Sec. 6, T. 8 S., R. 6 W., Tooele County
Limestone, blue-gray
Great Blue formation, upper limestone member
Lithostrotion? sp.
Identified by: W. Sadlick

M-22
Location: NW, NW, SW, Sec. 18, T. 8 S., R. 6 W., Tooele County
Limestone, blue-gray, lens
Great Blue formation, Chiulos member
Linoproductus n. sp. aff. *Striatifera brazerianus*
Lithostrotion sp.

Euomphalid gastropod
Horn coral, poorly preserved
Identified by: W. Sadlick

M-23
Location: SW, NW, SW, Sec. 18, T. 8 S., R. 6 W., Tooele County
Limestone, blue-gray, lens
Great Blue formation, Chiulos member
Spiriferoid n . sp. aff. *Spirifer bifurcatus*
Dictyoclostis aff. D. *inflatus*
Linoproductus cf. *L. pileiformis*
Identified by: W. Sadlick

Cretaceous-Tertiary

KT-1
Location: NE, SE, SE, Sec. 3, T. 8 S., R. 7 W., Tooele County
Conglomerate, reddish-brown
Cretaceous-Tertiary?
Impressions of stems and pieces of wood
Identified by: Roland W. Brown
Plant remains (if they are such) are pieces of driftwood
Identified by: Chester A. Arnold

I N D E X

Pleistocene, 14, 103, 108, 112

Utah Geological and Mineralogical Survey

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