UTAH GEOLOGICAL AND MINERALOGICAL SURVEY
AFFILIATED WITH
THE COLLEGE OF MINES AND MINERAL INDUSTRIES
UNIVERSITY OF UTAH
SALT LAKE CITY, UTAH

MIDDLE ORDOVICIAN
DETAILED STRATIGRAPHIC SECTIONS
For Western Utah and Eastern Nevada

By GREGORY W. WEBB

Bulletin 57

March, 1956

Price $1.50

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.

The *Utah Code Annotated 1943, Vol. 2, Title 34,* as amended by *chapter 46 Laws of Utah 1949,* provides that the Utah Geological and Mineralogical Survey "shall have for its objects":

1. "The collection and distribution of reliable information regarding the mineral resources of the State.

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.

3. "The investigation of the kind, amount, and availability of the various mineral substances contained in State lands, with a view of the most effective and profitable administration of such lands for the State.

4. "The consideration of such other scientific and economic problems as in the judgment of the Board of Regents, should come within the field of the Survey.

5. "Cooperation with Utah state bureaus dealing with related subjects with the United States Geological Survey and with the United States Bureau of Mines, in their respective functions including field investigations, and the preparation, publication, and distribution of reports and bulletins embodying the results of the work of the Survey.

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.

7. "Any income from the sale of maps and reports or from gifts or from other sources for the Survey shall be turned over to the State Treasurer and credited by him to a fund to be known as the Survey Fund to be used under the direction of the Director of the Survey for publication of maps, bulletins or other reports of investigation of the Geological and Mineralogical Survey."

The Utah Geological and Mineralogical Survey has published maps, circulars, and bulletins as well as articles in popular and scientific magazines. For a partial list of these, see the closing pages of this publication. For other information concerning the geological and mineralogical resources of Utah address:

ARTHUR L. CRAWFORD, *Director*

UTAH GEOLOGICAL AND MINERALOGICAL SURVEY

College of Mines and Mineral Industries

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Salt Lake City, Utah

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FOREWORD

Should oil or gas ever be found in the Paleozoic sediments of he Great Basin, this Bulletin 57 will be of immediate, practical, nd impelling concern.

The Swan Peak and Eureka "quartzites," often friable and poous, are possible reservoirs for oil and gas. The thick limestone nd dolomite formations above and below these beds are possible etroliferous source rocks. There are few other formations in the hick Paleozoic sequence of western Utah which so well offer the ossibility of reservoir accumulation.

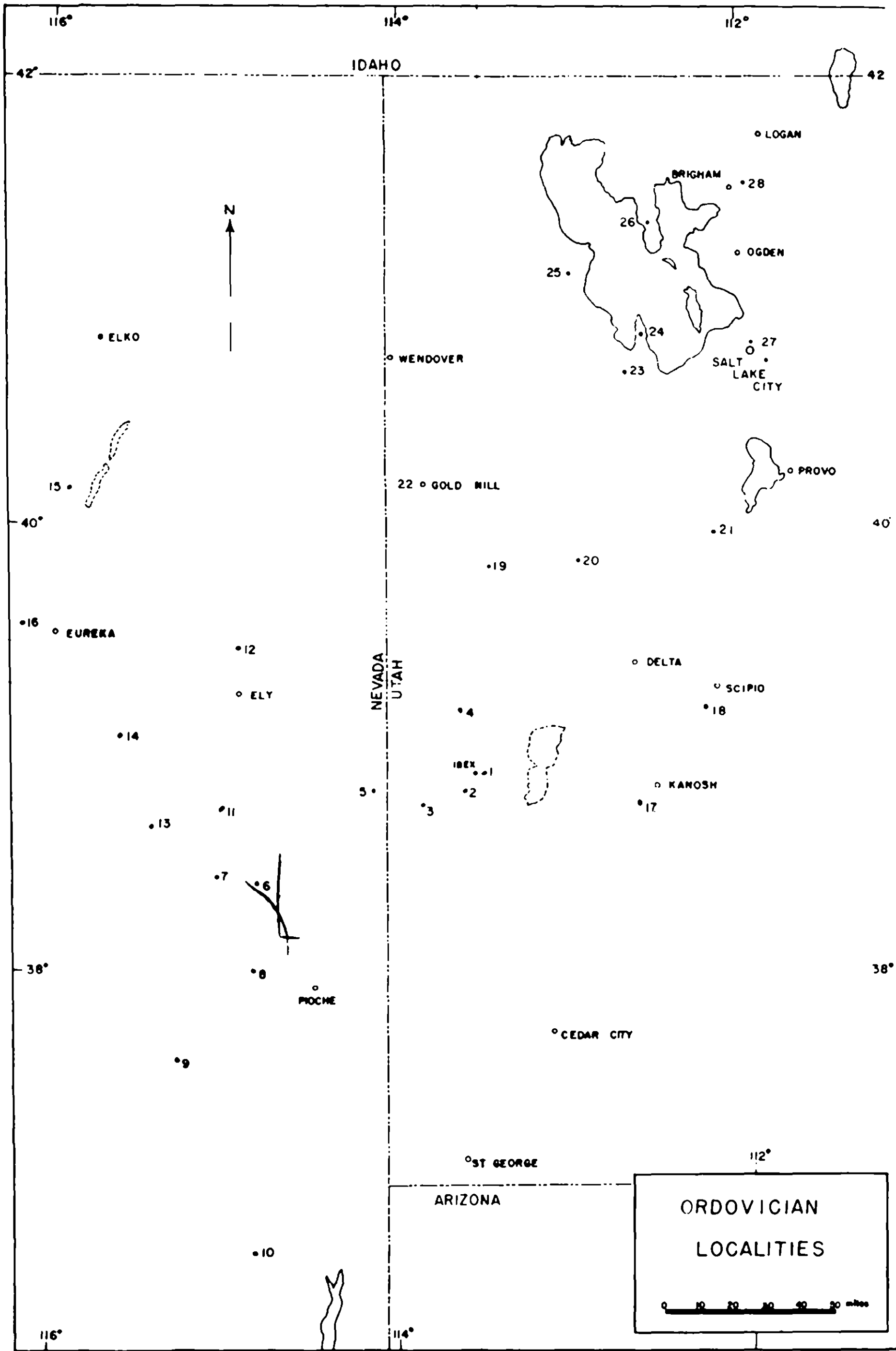
Aside from its economic implications, this bulletin has great cientific value. It represents the type of basic research necesary before applied studies can be made with any degree of confience.

In 1948 the new Utah Geological and Mineralogical Survey, then subdepartment under the Raw Materials Division of the Utah State epartment of Publicity and Industrial Development, had only a keleton staff with a budget too limited and a future too precarious olitically to justify or even make possible the employment of a taff adequate to discharge the duties placed upon it by the law reating the Survey and the directive from the Governor activating ts program. Hence, those in charge of the Survey cast about for nexpensive, cooperative methods of initiating fundamental research n stratigraphy and structural geology in Utah before trying to deelop bulletins on the oil and gas possibilities of Utah and other conomic problems constantly in the minds of those who would exploit ur resources. Dr. Webb, the author of this bulletin, was then a andidate for a master's degree at Columbia University and was one f a team of Columbia graduates doing field work in Utah as a basis or advanced degrees in geology. In consultation with their major rofessor, Dr. Marshall Kay, agreements were made between these gradates and the state of Utah to cooperate with the Utah Geological and ineralogical Survey. The problems which had been selected were such s to test their research capabilities and give promise of having nduring significance for the geologic profession.

Doctorate dissertations by two of these Columbia graduates ave given rise to Bulletins 38, 39, 48, and 53 of this series. imilar contracts with graduates from Utah and other universities ave furnished "grist for the mill" of the Utah Geological and ineralogical Survey.

Bulletin 57 by Dr. Webb was postponed until his master's thesis ould be enlarged, embellished, and completed as a doctorate disertation. The long investigations carried out by Dr. Webb for oth the master's and Ph.D. degrees have given him a grasp of the ubject seldom attained by an author of such a bulletin. In my pinion, Bulletin 57 will stand the test of time and will be conulted in years to come as long as students try to solve the intriate relations of sedimentation, paleogeography, and geomorphology, s well as the stratigraphic sequence in the Great Basin.

Arthur L. Crawford
Director, Utah Geological and Mineralogical Survey



THE ABOVE NUMERALS REFER TO NUMBERED STRATIGRAPHIC SECTIONS DESCRIBED IN THE TEXT

MIDDLE ORDOVICIAN

DETAILED STRATIGRAPHIC SECTIONS

FOR WESTERN UTAH AND EASTERN NEVADA

By Gregory W. Webb[1]

ABSTRACT

Stratigraphy of two Middle Ordovician quartzite formations is traced from the Ibex area of west-central Utah into eastern Nevada and eastward and northward in Utah. The higher formation is equivalent to the Eureka quartzite of Nevada, where it is transgressive in its type area. The lower quartzite is defined as a tongue of the Swan Peak quartzite, its supposed equivalent. The Eureka quartzite is thought to lie directly on the lower quartzite in central Utah, but westward a newly defined dolomite formation intervenes, bearing a widespread coral biostrome. Correlations with northern Utah formations remain in doubt, largely due to the lack of Middle Ordovician rocks on a broad arch-like area west of Provo. It is thought that some or all of the massive quartzites referred to the Swan Peak in northern Utah actually may be the younger, transgressive Eureka quartzite of Ibex and Nevada, rather than the equivalent of the lower quartzite of Ibex.

The lower, Chazyan, quartzite of the Ibex area records an important regression following Cambrian and Canadian carbonate deposition, although the sands remained largely restricted to west-central Utah. Succeeding dolomite deposition was followed by regressive sand deposition forming the lower portion of the Eureka quartzite. Uplift and erosion occurred in north-central Nevada and possibly in central and northern Utah as well. Transgressive Eureka sands blanketed eastern Nevada and possibly most of western Utah late in medial Ordovician. Subsequent emergence of the Eureka sands prior to burial by the thin later Ordovician dolomites is probable.

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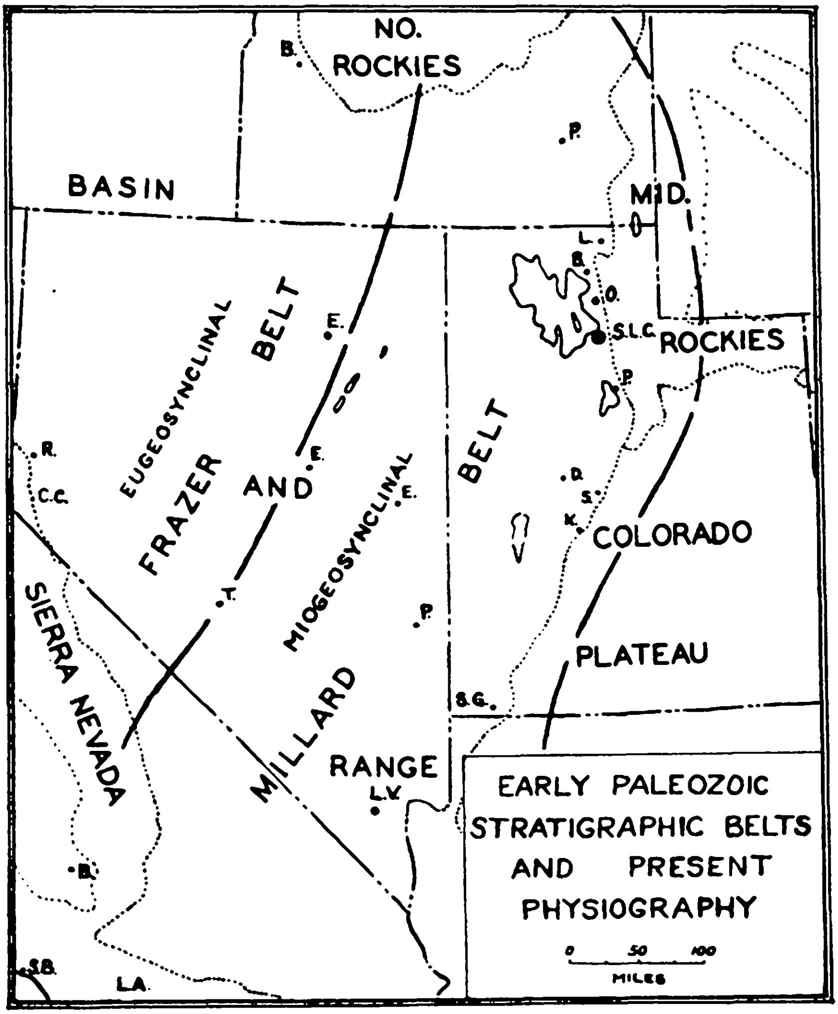
[1] Adapted from a dissertation presented to the Department of Geology, Columbia University, New York, 1954, in partial fulfillment of the requirements for the Ph.D. degree.


NO. ROCKIES
BASIN
MID.
ROCKIES
EUGEOSYNCLINAL
BELT
FRAZER
AND
MIOGEOSYNCLINAL
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COLORADO
PLATEAU
SIERRA NEVADA
MILLARD
RANGE
S.L.C.
S.G.
L.V.
L.A.
S.B.
C.C.
EARLY PALEOZOIC
STRATIGRAPHIC BELTS
AND PRESENT
PHYSIOGRAPHY
0 50 100
MILES

Figure 1

INTRODUCTION

Medial Ordovician sedimentary quartzites have long been recognized in the miogeosynclinal eastern Great Basin (Hague, 1892; Kirk, 1933) where they form a prominent interruption in the thick and otherwise continuous sequence of carbonatites which was deposited during early and medial Paleozoic. Scattered observations on the Eureka quartzite were summarized and analyzed by Kirk (1933). Ross (1949, 1951) discussed the Swan Peak formation in connection with stratigraphy of the underlying Garden City formation. Hintze (1951, 1952) discussed the stratigraphy and paleontology of the Pogonip group, and summarized the stratigraphy of the two quartzite formations. This report deals specifically with the Middle Ordovician stratigraphy of eastern Nevada and western Utah in greater detail.

The primary problems are the relationships of the two quartzite formations, and their distributions and origins. It is indeed fortunate that the Ibex area, used by Hintze (1951, 1952) as the type area for his Pogonip formations, also exposes both quartzite formations such that they are readily distinguished. Accordingly, the Ibex area is likewise considered as the reference area for the formations discussed in this report despite the location of the type sections of the quartzite formations at other localities.

Much of the field work was done in conjunction with Dr. Hintze and it is intended that this report and its detailed stratigraphic sections be considered as a companion to his excellent bulletins by those desiring detailed knowledge of the Ordovician.

Most of the sections are in the faulted desert ranges, which offer many excellent and long exposures of the stratigraphic column. The sections are located as well as possible, considering the inadequacy of the available base maps. Land plat, Forest Service, Grazing Service, highway, and available topographic and geologic maps were used where possible. Except for interior portions of the ranges, most of the desert country is served by passable roads and trails.

Outcrops were measured and described in the field and paleontologic and lithic samples studied in the laboratory. Correlations were made in the field except where the Eureka and Swan Peak quartzites could not be distinguished by megascopic characteristics and stratigraphic position. In such cases, microscopic observations aided in correlation.

ACKNOWLEDGMENTS

Valuable assistance has been received from many sources in the course of this study. I am particularly indebted to Professor Marshall Kay of Columbia University for his constant interest and guidance; to Professor Lehi F. Hintze, my field companion and co-worker, who first introduced me to the problem and offered many pertinent suggestions; to F. F. Hintze, H. E. Wheeler, and G. B. Maxey for aid in locating sections; to D. S. Hutchins of the Desert Range Experiment Station, Utah, and Max Wainwright of the Lehman Caves National Monument, Nevada, for hospitality and field information, and to other residents of the desert region for advice as to local conditions; to Dr. Keith Rigby and others at Columbia University for valuable informal discussions; and to my wife, Beverly, for understanding and able assistance in the field and laboratory and in preparation of the manuscript. All assistance was gratefully received but the writer alone assumes responsibility for all errors and shortcomings. The study was made possible by financial assistance from the Utah State Department of Publicity and Industrial Development, now the Utah Geological and Mineralogical Survey, and by grants from the Kemp Memorial Fund of Columbia University.

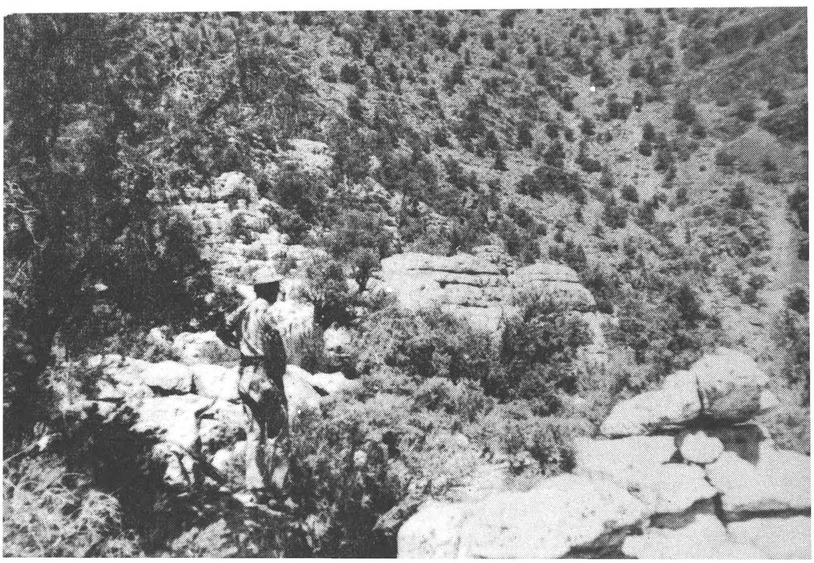


Figure 2. Eureka quartzite at Crystal Peak section; upper sandstone member showing knobby weathering ledges typical of the member in the Confusion Range area.

STRATIGRAPHIC UNITS

Pogonip Group

Hintze has restricted the previously loose term Pogonip to six Ordovician formations defined at and around Ibex in the Confusion Range of western Utah (Hintze, 1951). The House, Fillmore, and Wahwah limestones are Canadian; and the Juab limestone, Kanosh shale, and Lehman limestones and quartz arenites are Chazyan. Except for the Kanosh shales, these Pogonip formations continue westward to central Nevada with little change of lithology, fauna, or thickness. The Lehman calcilutites thicken westward from Ibex, replacing the overlying Swan Peak quartzites, the newly named Crystal Peak dolomite, the lower beds of the Eureka quartzite, and the underlying Kanosh shales.

In the Ibex area, the base of the Lehman formation was defined as the base of the lowest quartz sandstone ledge and the upper limit as the top of the highest calcilutite beneath the Swan Peak quartz sandstone ledges. The formation is thinly bedded bluish-gray weathering gray calcilutites and variously colored quartzites 195 feet thick. Below the 6-foot basal quartz sandstone lie 550 feet of siltstones and olive gray shales of the Kanosh formation. The sequence is essentially a gradational one upward from fine calcisiltites of the Juab limestone through argillites, calcilutites, and intercalated quartz sandstones to continuous quartzites of the Swan Peak formation. Hintze divided the faunas of the Kanosh and Lehman formations into two zones. The zone like zone M of Ross in northern Utah (Ross, 1949), characterized by <u>Orthis michaelis</u> Clark, <u>Anomalorthis utahensis</u> Ulrich and Cooper, <u>Macronotella</u> sp., <u>Leperditia</u> sp., and <u>Eleutherocentrus</u> sp. is in the lower 300 feet of the Kanosh shale. In northern Utah this zone is in the Swan Peak formation directly below its quartzites rather than 400 feet or more below them as at Ibex. The higher Kanosh shales and the overlying Lehman beds bear a fauna designated as zone N and characterized by abundant <u>Leperditia</u> sp. cf. <u>L. bivia</u> White.

Swan Peak Quartzite

The Swan Peak quartzite in northern Utah and southeastern Idaho is defined as consisting of all beds above the Garden City limestones and dolomites and below the Upper Ordovician dolomite (Ross, 1949; Richardson, 1913). Its lower portion is almost identical in lithology and fauna with the Kanosh shale of western Utah, and its upper vitreous member closely resembles the Swan Peak (?) quartzite of the same area, but the intervening Lehman limestone is absent northward (Hintze, 1951).

At Smooth Canyon, Ibex, the 243-foot Watson Ranch tongue of the Swan Peak quartzite is described and named for Jack Watson's Ibex ranch. It is divided by numerous strongly developed bedding planes. In general, its quartz arenite beds weather to an iron oxide-stained, reddish-brown colored surface, although many of its lower beds are light gray or yellow weathering. The lower 108 feet of white or gray quartz sandstones and quartzites are ledge forming, especially in the lower part. A succeeding 65-foot bluff of very thickly bedded, reddish weathering quartzites forms the most prominent exposure; it is overlain by 8 feet of dolomitic calcisiltite and 62 feet of thinner-bedded, cross-laminated, reddish-brown weathering light gray quartz sandstones with thin seams of fucoidal shales. The section on the southeast nose of the Ibex Hills, about 4 miles to the east, is similar, though perhaps more massive.

The Watson Ranch tongue of quartzite at Ibex is correlated tentatively with the Swan Peak quartzite of northern Utah because of similar lithology and similar stratigraphic position above similar and synchronous fossiliferous beds; the Ibex occurrence is believed to be of the same age as that currently assigned to the Swan Peak of northern Utah. Correlation with the Swan Peak serves to emphasize the distinction between early Middle Ordovician quartzites and the younger Eureka quartzite. It does not, however, take into account a possible alternative, the correlation of the northern Utah Swan Peak with the Eureka quartzite, as suggested recently by Ross (1953). These problems are discussed in greater detail later in this paper.

Crystal Peak Dolomite

The dolomite separating the Watson Ranch tongue of the Swan Peak quartzite from the overlying Eureka quartzite in west-central Utah is 85 feet thick at Smooth Canyon, sharply bounded at the base but gradational into the Eureka formation. The dolomites are closely parted by reddish or yellow silt seams, are gray or black-colored, and fine or medium in grain. About 50 feet from the base are thin intercalations of quartz sandstones and siltstone, below more completely dolomitic rocks. The beds yielded *Pseudomera* sp. and an orthocone cephalopod near the base, and at 60 feet a fragment of coralline limestone, apparently *Eofletcheria* sp.

The dolomite, the "dolomite member" of Hintze (1951), is better seen at the Crystal Peak section, 10 miles to the southwest of Smooth Canyon, and is defined there as the Crystal Peak dolomite. Eighty-nine feet thick, it is composed of dolomites and some intercalated limestones, separated from the underlying Swan Peak quartzites with a sharp boundary but grading upward into the Eureka quartzites. Thirty-nine feet of medium gray-weathering calcarenites and calcilutites, shale-parted and silty, form a long basal slope, overlain by 16 feet of silty, intercalated olive-weathering dolomites and bluish-gray calcilutites, followed in turn by 38 feet of medium-grained dark gray-weathering silt-parted finely grained dolomites. At 66 feet from the base, and for 2 feet upward, colonies of Eofletcheria sp. form a prominent ledge.

Eureka Quartzite

The Eureka quartzite was named by Hague in the Eureka district (Hague, 1883). Sections in the disturbed rocks of the district are poor, so Kirk designated exposures on the southwest side of Lone Mountain about 18 miles northwest of Eureka, as the type section of the formation (Kirk, 1933). That section completely exposes the quartzite and parts of the overlying Hanson Creek and underlying Pogonip formations. He divided the Eureka quartzite into three parts: (1) the basal 75 feet or so of brownish cross-bedded quartz sandstones and underlying quartz sandy dolomites, believed to be a thinner facies of the argillaceous sediments of the Antelope Valley area; (2) the main mass, 150 feet or so of dense, vitreous white quartzite; and (3) the uppermost 0 to 3 feet of dolomitic sandstones forming the basal beds of the Upper Ordovician rocks, which Kirk thought to lie disconformably on the Eureka formation.

The Eureka quartzite at Lone Mountain is considered by the writer to be restricted to 181 feet of relatively pure, brownish, cross-bedded quartz sandstones and the overlying dense white quartzites. Forty feet of dolomites at the base now are assigned to an unnamed formation of the Pogonip group rather than being included as a dolomitic facies of the lower Eureka. Exclusion of the dolomite from the Eureka will involve a redefinition of the Lone Mountain section, chosen by Kirk (1933) as the redesignated type section to replace the original type area of Hague (1883) in the Eureka district. Such formal redefinition awaits a later paper.

The writer believes that the 40 feet of dolomites excluded from the Eureka at Lone Mountain is separated from the Eureka by a disconformity which becomes of greater magnitude northward in Nevada, but which is not recognizable in Utah. The Eureka quartzite is divisible into lithic members in central Nevada, two of which are recognizable in western Utah; the remainder of the formation in western Utah is the equivalent of the other four Eureka members of central Nevada. The members recognized in Nevada are used in the present report where applicable.

At Lone Mountain the restricted Eureka quartzite consists of 35 feet of vitreous quartzite weathering yellowish-brown to dark reddish-brown, 95 feet of massively to thinly bedded and cross-bedded white quartz sandstones and quartzites, and an upper member, 48 feet thick, of grayish quartz sandstones; the upper member has a sharp contact with the middle member but grades upward into three feet of quartz sandy dolomite, which in turn is overlain by dark gray dolomites with a sharp contact. The Lone Mountain section is a good type section in that it is typical of the Eureka quartzite in the area surrounding Eureka, Nevada; within the central Nevada area, however, the Eureka quartzite includes a dolomite member; and eastward in Nevada the formation includes three quartz arenite members not represented within the type Eureka quartzite. They are to be discussed in more detail in a future paper.

Post-Eureka Carbonatites

In Utah and eastern Nevada, dark dolomites overlie the Eureka quartzite, or lie on older formations where the Eureka is absent. The dolomites are referred to the Fish Haven formation, which was defined in southeastern Idaho, where it disconformably overlies the Swan Peak quartzite (Richardson, 1913). In Nevada, the equivalent dolomite is the Hanson Creek formation (Merriam and Anderson, 1942; Merriam, 1940).

Only locally are the dolomites fossiliferous; within the area of this report, the writer was unable to verify their age classification, except at the Steptoe section, near Ely, Nevada. Both at Steptoe and in northern Utah they are Upper Ordovician, but in central Nevada some are believed older.

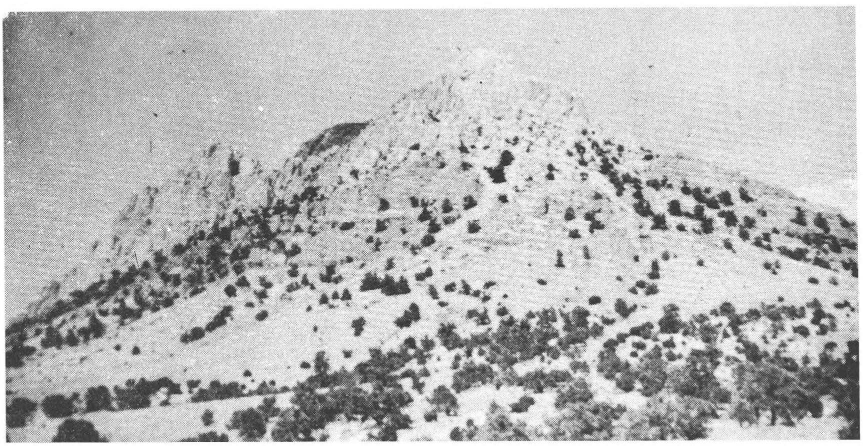


Figure 3. Tunnel Spring Mountain, Desert Range Experiment Station. Uppermost white formation is Eureka quartzite, underlain by darker Crystal Peak dolomite; sandstone and quartzite ledges in slope below dolomite are the Watson Ranch tongue of the Swan Peak formation.

CLASSIFICATION

Hintze (1951) has classified Pogonip formations at Ibex as Canadian and Chazyan. House, Fillmore, and Wahwah limestones are Canadian; Juab limestone and Kanosh shale are early Chazyan; and Lehman limestones and Swan Peak shales and quartzites are later Chazyan. The Swan Peak quartzite of northern Utah, which includes the equivalents of the Lehman and Kanosh formations, is classified as Chazyan by Ross (1951). Hintze concluded that the trilobite-brachiopod limestone facies of the Pogonip group did not readily correlate with the cherty carbonate-molluscan facies of the Lower Ordovician of the southern and eastern United States, finding only the lowermost Pogonip fauna to be comparable to faunas found eastward. Younger Pogonip formations and faunas remain as a standard for the Cordilleran miogeosyncline without detailed correlations with Canadian and Chazyan formations elsewhere.

Juab limestone and Kanosh shale faunas are compared with the Chazyan Joins formation of Oklahoma, and the Lehman formation is provisionally correlated with the Oil Creek formation (Hintze, 1951). In general, the Chazyan faunas of the Juab and overlying formations bear similarities with Appalachian faunas believed Chazyan as well as to those of the Arbuckle area. The Watson Ranch tongue of the Swan Peak quartzite is Chazyan, with the upper boundary in probably the later Chazyan. At Crystal Peak *Eleutheroceutrus* sp., *Macronotella* sp., and a small *Leperditia* sp. were found in intercalations within the quartzites; and *Orthis* sp. cf. *O. michaelis* Clark was found in the *Eofletcheria* zone in the overlying Crystal Peak dolomite. These forms are typical of the Chazyan Lehman formation, indicating little faunal changes during the spread of the Swan Peak sands.

The age of the Crystal Peak dolomite itself remains less certain. Its meagre fauna suggests Chazyan age. In addition, regional correlations imply that both the Crystal Peak and the basal Eureka beds of Utah are older than a fossiliferous unnamed pre-Eureka formation in the Antelope Valley area of central Nevada, which is believed by the writer to be Trentonian and possibly later Bolarian. Regressive sand deposition formed the basal portion of the Eureka quartzite of the Ibex area, post-dating the Crystal Peak accumulation. Allowing some time for the basal Eureka regression, the Crystal Peak formation should be no younger than earlier Bolarian. Accordingly, the Chazyan-Bolarian boundary is tentatively located at or near the widespread *Eofletcheria* zone of the Crystal Peak dolomite.

An older age for the Crystal Peak may be postulated as an alternative. The brachiopod *Sowerbyites* forms a prominent zone near the base of the fossiliferous Bolarian

(?)-Trentonian sequence in the Antelope Valley area of Nevada. In the eastern United States Sowerbyites is found only in the upper Chazyan, suggesting Chazyan age for at least part of the beds in Nevada, and hence Chazyan age for the presumably older Crystal Peak and upper, unfossiliferous Swan Peak sequence. Sowerbyites, however, is found associated with a Trentonian fauna in Arctic Canada (Teichert, 1937), so post-Chazyan age for the Antelope Valley sequence, as assumed by the writer, is not inconsistent.

The lower portion of the Eureka quartzite is believed to be Bolarian and possibly earliest Trentonian on the basis of correlations with the Antelope Valley sequence. Pre-Eureka erosion is prominent in north-central Nevada, and synchronous reworking, and possibly erosion, may have taken place in the Ibex area; its diastemic or erosional surface is not recognized, however, as the lower Eureka quartz arenites are very similar to and apparently continuous with the later, transgressive, Eureka deposits. The latter are believed to be later Trentonian, as they lie on the fossiliferous Trentonian formation in the Antelope Valley area and are overlain by shaly limestones with a Trentonian fauna in the Roberts Mountains to the north of Antelope Valley.

The dolomite above the Eureka in Utah and eastern Nevada is later Cincinnatian (Richmondian) where dated. The silicified faunule from the dolomites immediately above the Eureka quartzite at Steptoe, Nevada, bears a close resemblance to faunules from the later Richmondian Maquoketa shale of Iowa. To the writer's knowledge no early or medial Cincinnatian faunules have been described from localities within the area of this report. Apparently marine Cincinnatian deposition was limited to Richmondian as was the case in much of North America.

REGIONAL STRUCTURAL CONSIDERATIONS

Paleozoic and later rocks in the central and eastern Great Basin have been deformed by folding and faulting and penetrated locally by intrusions. Normal faulting has long been considered a major factor in the development of the present structure and topography of the ranges, and folding and thrust faulting have been recognized in many localities.

The Paleozoic engeosyncline, or outer and volcanic geosyncline, was deformed by the growth of the Manhattan geanticline in west-central Nevada in Devonian (Nolan, 1943 p. 142). Ferguson (1933) and the present writer record disturbances of a lesser nature in central and northern Nevada in Silurian and Ordovician. Subsidence of the geanticline was followed by extensive folding and eastward overthrusting which developed along the westerly margin of the miogeosyncline in later Paleozoic and post-Paleozoic orogenies (Kay, 1952; Roberts and Arnold, 1952). Thrust faulting is recognized along much of the Wasatch trend of central Utah, which is the boundary between the miogeosyncline and the craton, as well as in central Nevada. In addition, several thrusts are reported within the miogeosynclinal Millard Belt of eastern Nevada and western Utah. Folding and thrusting continued into Tertiary and were succeeded by block faulting (Nolan, 1943).

The western argillites and included volcanics (Vinini) were carried onto the miogeosynclinal Pogonip and Eureka facies by the late Paleozoic thrusts in central Nevada, rendering a strong stratigraphic contrast which serves to outline remnants of the thrust plate (Merriam and Anderson, 1942). Within the broad miogeosyncline, however, the Ordovician rocks studied generally have such gradual lateral variations that large displacements may actually exist without causing stratigraphic anomalies which define such structures.

Possibly anomalous situations do exist both to the north and south of the ill-defined arch in the Tooele County area. The Stansbury Island section of over 1,000 feet of Ordovician quartzites and intercalations is only about 10 miles north of the northern Stansbury Range section, which has no quartzite; southward, a 590-foot quartzite section is described in the Thomas Range, which lies between the thin quartzite section at Fish Springs and the Tintic district, which has no Middle Ordovician rocks. These contrasts, of course, may be solely stratigraphic.

Strike-slip faulting has not been widely recognized in the Great Basin, but the linearity and fault-bounded nature of the ranges is suggestive of the California Coast Ranges, where major strike-slip faulting is known. Also, the isopach patterns shown in figure 5 may be taken to suggest the existence of one or more northwesterly trending rifts in the vicinity of the Stansbury Island section, at least, which could have carried the thick sequence into its present position. However, as no major horizontal displacements have been shown to affect the rocks discussed in this paper, it has been assumed for purposes of paleogeographic interpretations that all of the localities have remained essentially in their original relative geographic positions.

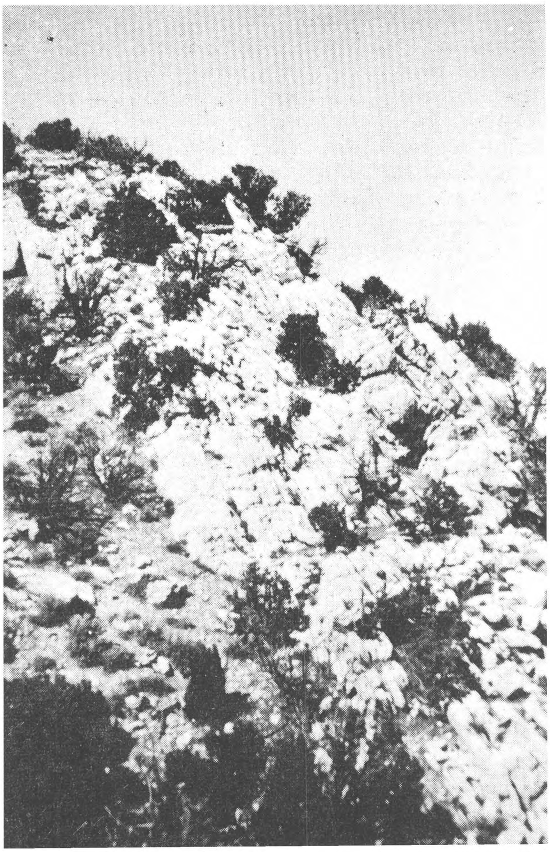


Figure 4. Swan Peak quartzite, Stansbury Island section. Steeply dipping beds across gulch illustrate the large scale cross-bedding.

ORDOVICIAN GEOLOGIC HISTORY AND PALEOGEOGRAPHY

In the Millard Belt of Nevada and Utah, early Ordovician environments and tectonic behavior were similar to those of the later Cambrian in the Millard Belt (Hintze, 1951). Marine carbonate sediments accumulated on a broad unda form, or shallow topographic shelf, receiving only minor amounts of terriginous detritus from the craton during the lengthy and thick accumulation, implying that the interior remained very low lying or, more likely, submerged, the present patchy distribution of Cambrian and early Ordovician sediments notwithstanding. The geosynclinal limestones and dolomites represent the most consistently marine portion of a long and important sedimentary cycle.

Within medial Ordovician, in contrast, the cratonal interior emerged, shedding regressive detritus into the western sea, and an arch or offshore uplift to the west of the present Uinta Mountains appeared, segmenting the miogeosyncline into an eastern Nevada-West-central Utah basin and a complimentary southeastern Idaho-northeastern Utah basin. At the same time, northern Nevada suffered uplift and erosion; uplift may have occurred locally to the southwest as well along the outer margin of the miogeosynclinal area, the site of Silurian (?) and later movements. Perhaps related to the uplift in northern Nevada is Ross' suggestion that the quartz sands of the northern Utah Swan Peak may have come from the northwest (Ross, 1951) and also the loosely dated positive behavior in the Raft River Range area (Stokes, 1952).

Late medial Ordovician saw transgressive Eureka sand deposition over much if not all of the miogeosynclinal area now included in the Great Basin, but not until latest Ordovician did the sea again cover both the geosynclinal area and much of the craton, forming the Hanson Creek-Fish Haven-Bighorn dolomites.

Volcanic bearing argillites of the Vinini formation in central Nevada are thought to have been deposited in a fondo or down-slope clino environment in deeper water than were the miogeosynclinal rocks treated in this report.

At Ibex, the first appreciable amount of cratonal terriginous detritus was deposited in the form of silt in the Wahwah limestone, but the succeeding Juab limestone again is relatively clean (Hintze, 1951). The craton became important as a source area in early Chazyan with the deposition of the siltstones and shales of the Kanosh shale in west-central Utah and the correlative lower Swan Peak shales in northern Utah. The shales of the Ibex area and Scipio and Kanosh are very much like the northern Utah beds, indicating that the change to terriginous detrital deposition occurred rather uniformly along the eastern portion of the miogeosyncline.

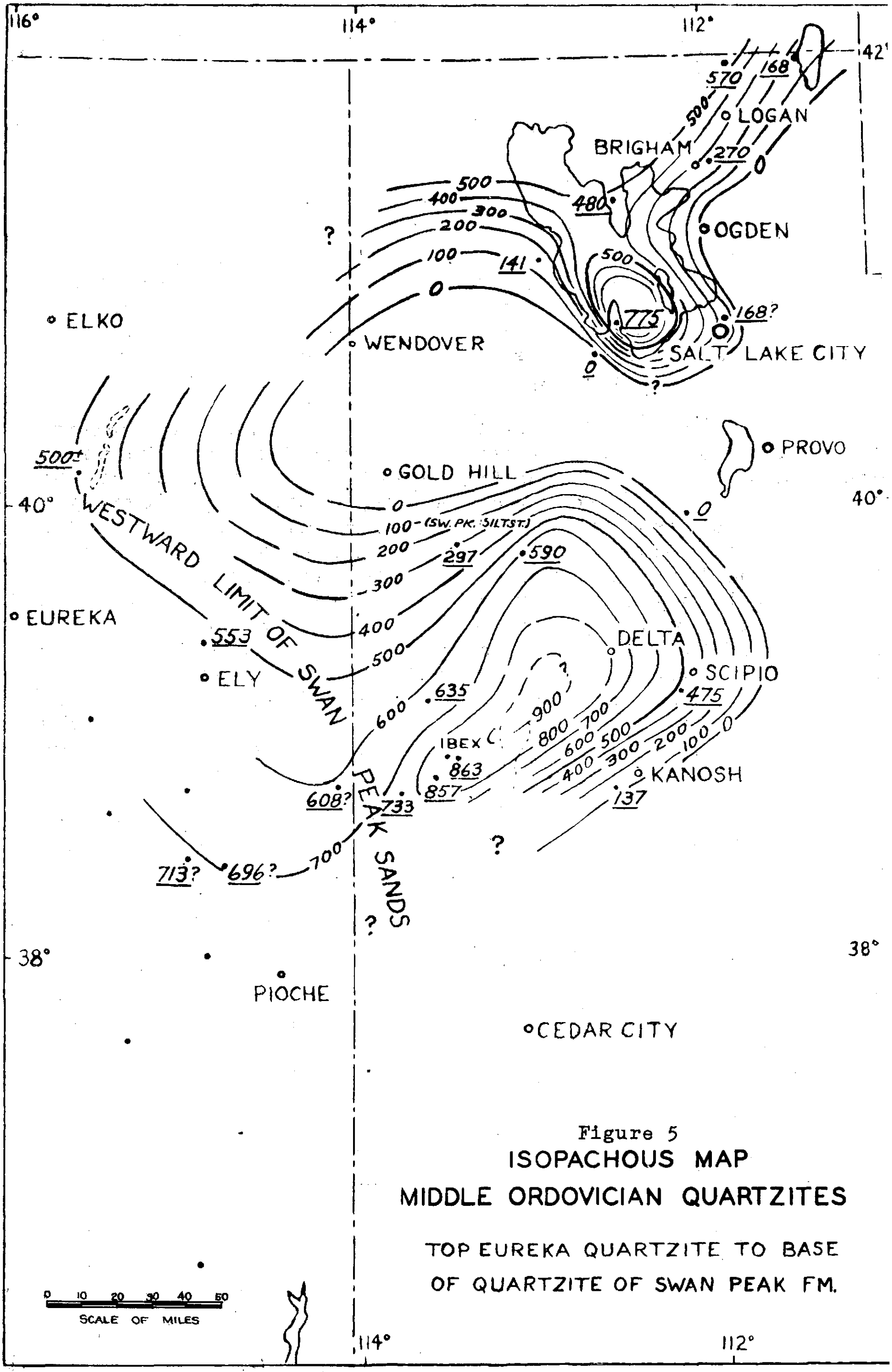


Figure 5
ISOPACHOUS MAP
MIDDLE ORDOVICIAN QUARTZITES

TOP EUREKA QUARTZITE TO BASE
OF QUARTZITE OF SWAN PEAK FM.

The Kanosh shale, typically olive to gray shales with calcareous siltstone and coquinal calcarenite interbeds, represents shallow water mud bank deposition, possibly lagoonal, with intermittent development of rough open sea waves or swift channel currents to form the coarse-grained limestones. In eastern Nevada, the Kanosh shale grades laterally into Pogonip calcisiltites. These limestones are irregularly silt parted, forming a nodular structure typical of shallow water fine-grained deposits (Rich, 1951). The lime-silt banks were the open water continuation of the Kanosh mud banks and extended to central Nevada. The supply of terriginous mud was insufficient to blanket the entire shallow water shelf.

Following Kanosh deposition the supply of argillaceous matter became insignificant in west-central Utah and all of the shallow bank deposits again were lime muds, forming the irregularly silt-parted Lehman calcilutites. The Lehman formation forms a tongue reaching into central Utah from the offshore Nevada area, separating the Kanosh shale from the younger quartz sand deposits. The Lehman calcilutite is present at the Kanosh section but is represented at Scipio either by part of the Kanosh shale, or, more likely, by the overlying quartz sands, despite the fact that the Scipio section is the more geosynclinal, judging from comparative thicknesses of the other formations. The source for much of the Chazyan terriginous muds and sands appears to have been somewhat northward from Kanosh and Scipio in order that Kanosh should have been beyond the reach of the detritus during the Lehman interval. It is thought that most or all of the Swan Peak beds at Kanosh are absent beneath the Eureka formation due to disconformity.

In northern Utah the Swan Peak quartz sands directly overlie the lower Swan Peak shales (Kanoshian). The basal portion of the Swan Peak quartzites in northern Utah is older than the corresponding quartzites of the Ibex area by the amount of time consumed during Lehman deposition, unless the massive Swan Peak quartzites of northern Utah actually are post-Chazyan and disconformable on the lower intercalated Swan Peak beds. In west-central Utah, at least, the basal beds of the Watson Ranch tongue of the Swan Peak overlie the Lehman calcilutites with a gradational relationship.

In the west-central Utah area the Watson Ranch tongue of the Swan Peak quartzite is regressive, indicating that the cratonal source area again became active. The quartz sands are clean and reasonably well sorted, indicating that the source was probably a sedimentary terrane and that much washing and reworking occurred before the sands were permanently deposited. The sands are thought to have accumulated on a broad shallow water or intermittently exposed sand bank area, with shifting bars and beaches. Westward and southwestward the sands grade into calcilutites of the Lehman lithofacies. A siltstone facies at Fish Springs is thought to represent the Watson Ranch tongue. The presence of supposedly correlative argillites at the Steptoe locality near Ely and also of incompetent sandstones in the Ruby Range (Sharp, 1942) indicates that the zone of facies change swings away from the Utah border towards north-central Nevada. The pronounced westward curve in the sand edge implies that the arch area west of Provo was becoming active during the Watson Ranch deposition within Chazyan.

The correlative calcilutites of eastern and central Nevada are identical to and inseparable from the Lehman lithofacies, and so the beds are there included within the Lehman formation. Shallow water lime mud accumulation continued through the interval of sand deposition shoreward.

In west-central Utah a newly defined formation, the Crystal Peak dolomite, overlies the Watson Ranch tongue. Probably the terriginous source again became ineffective, permitting the carbonate deposition to extend into Utah. At Crystal Peak the dolomites and interbedded limestones bear an Eofletcheria sp. coral biostrome which has been found as far westward as the White Pine Range in Nevada (Hintze, 1952). Its widespread occurrence serves to mark the horizon of the Crystal Peak at the localities beyond the extent of the Watson Ranch sands, and demonstrates the separation of the Watson Ranch and Eureka cycles of sand deposition. At these outer localities the time equivalents of the dolomites are largely calcilutites of the Lehman lithofacies, dolomites being restricted to the highest beds. The Crystal Peak dolomite is believed to span the Chazyan-Bolarian boundary.

The initial Eureka sand deposits are regressive and, in the gross, gradational with the Crystal Peak dolomites. Basal Eureka sands are interbedded with the dolomites at the Desert Range Experiment Station; farther westward the Eofletcheria zone diverges from the lowest quartz arenites and the Eureka thins, in part, at least, due to the facies change. The upper boundary of the regressive portion of the Eureka is not defined in Utah, but the writer thinks the member to be about 100 feet thick at Ibex. Lithic similarity of the regressive member and the overlying transgressive Eureka deposits and possible reworking by the transgressing sea makes separation of the two phases unreliable.

The transgressive Eureka quartzite of west-central Utah is the time-rock equivalent of the entire (postmedial?) Trentonian Eureka quartzite of the type section and adjacent areas. It is present at the Desert Range Experiment Station, Crystal Peak, the Ibex sections, and Tule Valley. It is believed present at Fish Springs and is thought to be at least partially represented at Scipio and Kanosh. Thus with the possible exception of localities south of Gold Hill and possibly the apparently anomalous 590-foot Ordovician quartzite section in the Thomas Range (Staatz and Bauer, 1952), neither

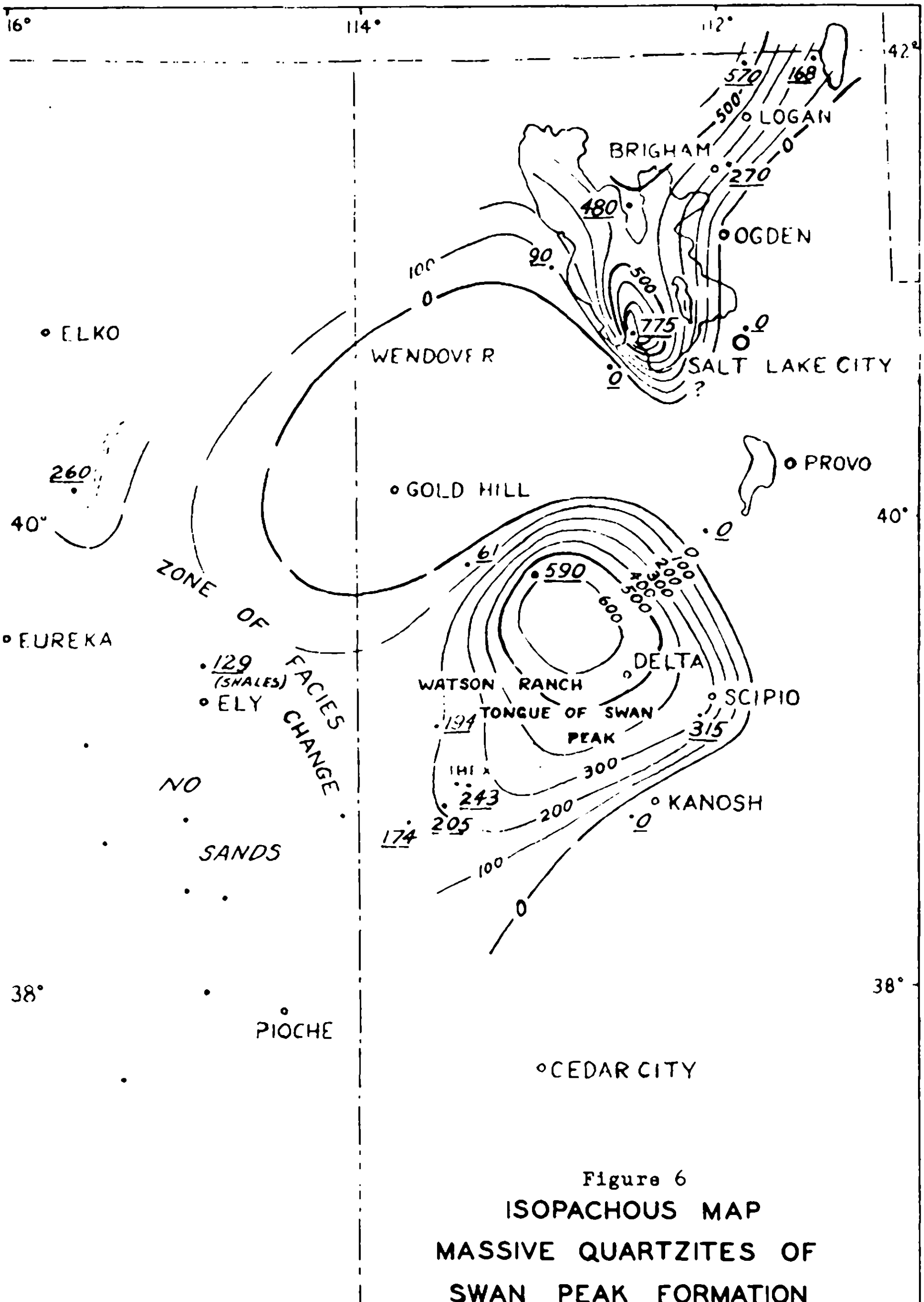


Figure 6

ISOPACHOUS MAP

MASSIVE QUARTZITES OF

SWAN PEAK FORMATION

UNRESTRICTED

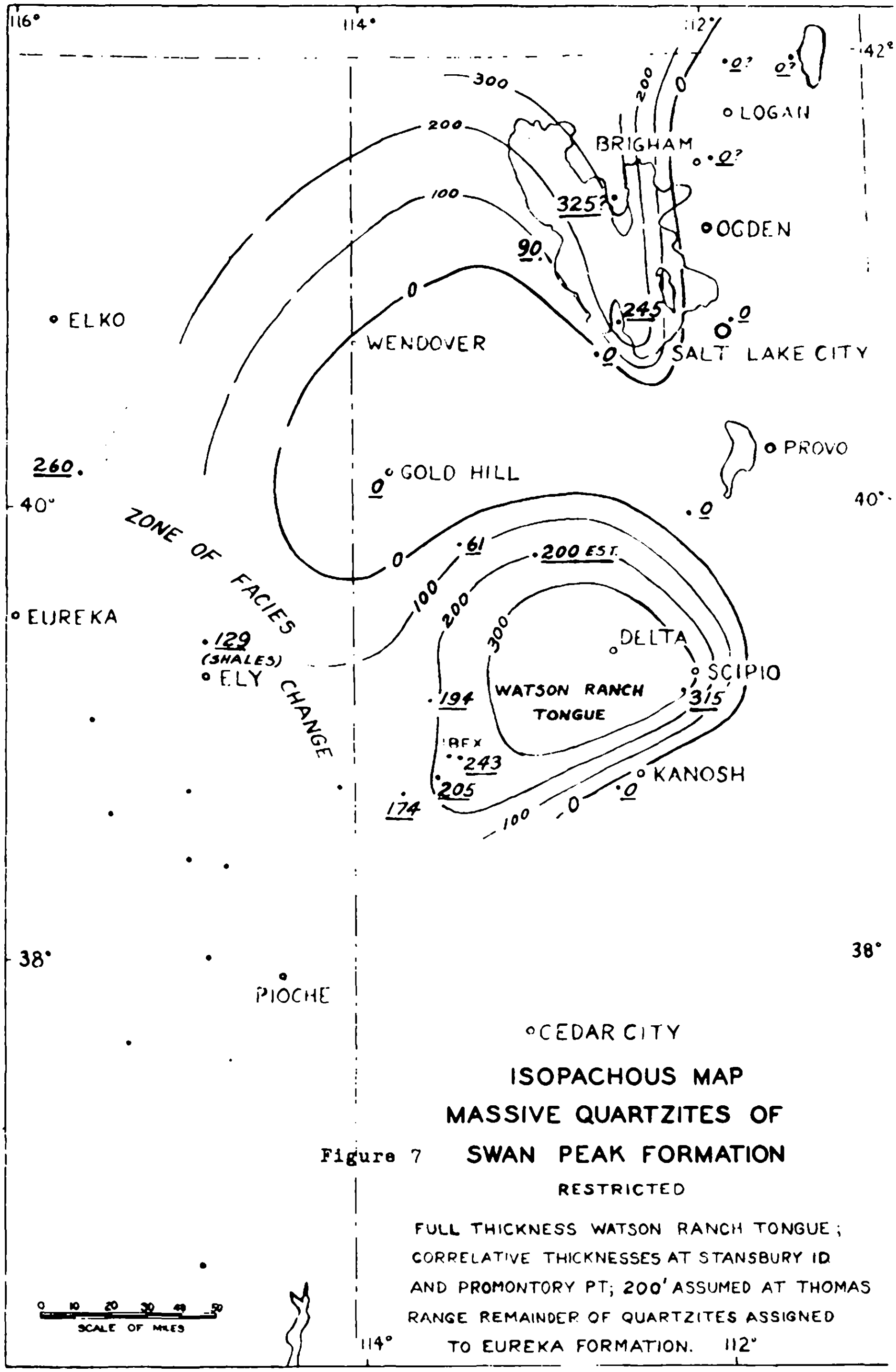


Figure 7 ISOPACHOUS MAP MASSIVE QUARTZITES OF SWAN PEAK FORMATION RESTRICTED

FULL THICKNESS WATSON RANCH TONGUE; CORRELATIVE THICKNESSES AT STANSBURY ID AND PROMONTORY PT; 200' ASSUMED AT THOMAS RANGE REMAINDER OF QUARTZITES ASSIGNED TO EUREKA FORMATION.

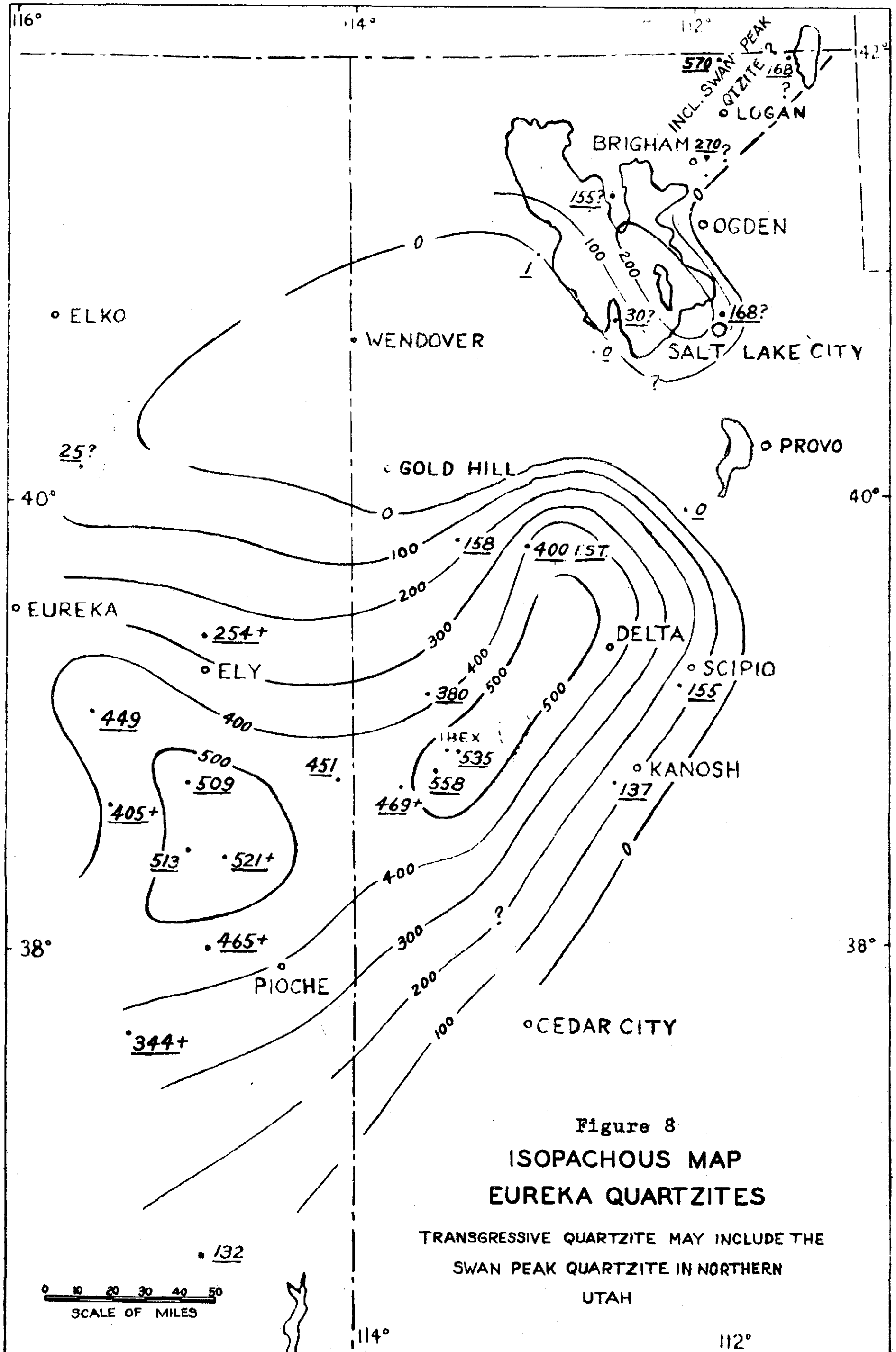


Figure 8

ISOPACHOUS MAP

EUREKA QUARTZITES

TRANSGRESSIVE QUARTZITE MAY INCLUDE THE SWAN PEAK QUARTZITE IN NORTHERN UTAH section having been seen by the writer, all Ordovician quartzite localities in the west-central Utah depositional basin appear to have the Eureka quartzite as well as the Watson Ranch tongue of the Swan Peak quartzite. Like the Swan Peak and lower Eureka deposits, the transgressive Eureka quartzite is massive, well-sorted ferruginous to siliceous quartz arenite, representing shallow neritic and beach deposition which kept pace with gradual subsidence. A prominent zone in the upper portion of the Eureka consists of thickly bedded to massive partially cross-bedded quartz sandstones which weather into distinctive knobs and ledges, as illustrated in figure 2. It is the "upper sandstone member" of Nevada and is overlain by equivalents of the "upper vitreous quartzite" member (Webb, 1953). The rocks outcropping immediately behind Watson's cabin at Ibex are of the upper sandstone member, which may represent aeolian deposition.

Cincinnatian dolomites lie on the Eureka quartzite, so it is not known what deposition, if any, immediately followed that of the Eureka quartzite in Utah. Although some part of the highest Eureka sands may in fact be the basal deposits of the Cincinnatian marine sequence, reworked from the exposed Eureka sands, the Eureka-Fish Haven contact essentially is an horizon of non-deposition or erosion, presumably representing much of Cincinnatian time. The Cincinnatian transgression covered the miogeosyncline as well as the western portion of the craton, the source areas exposed during the medial Ordovician. The resultant dolomites are of nearly equal thickness on either side of the Wasatch line, implying no differential subsidence across that cratonal boundary.

The arch or arch-like area separating the west-central Utah basin from that of northern Utah is defined primarily by the Tintic destrict, Gold Hill, the northern Stansbury Range, and the Lakeside Mountain sections, which have little or no Ordovician quartzites or no Middle Ordovician at all, and central Wasatch localities, which apparently lack any Ordovician. Presence of Cincinnatian rocks at all but the Wasatch localities indicate intra-Ordovician non-deposition and erosion, as corroborated by the distribution of the Watson Ranch sands and shales of the Swan Peak along the south flank of the arch as discussed above. In addition, Rigby found that the early Ordovician limestones thin northward from Tintic by convergence as well as by later erosion (Rigby, personal communication, 1952). The Uinta trend is as old as medial Ordovician or Canadian in the miogeosyncline and presumably is at least as old on the craton.

The thin quartzite at the Lakeside section is so persistent in its outcrop that it is thought to be Eureka or basal Cincinnatian rather than an erosional remnant of the Swan Peak. Presumably it lies disconformably on the lower Swan Peak shales (Kanosh shale of Ibex) which underlie it.

The thick section of Ordovician quartzites in the Stansbury Island anticline is only a few miles from the arch area lacking Ordovician quartzite. The quartz arenites are essentially gradational with the unfossiliferous Garden City dolomites below and exhibit large scale cross bedding believed to be aeolian in origin. Should the deposits be subaerial in large part, they would appear to have been deposited as subaqueous near-beach, and subaerial back-beach dune sands, which accumulated on the north flank of the emergent arch during the several regressions and transgressions of the medial Ordovician. At least the higher portion of the sequence is thought by the writer to include time equivalents of the Eureka quartzite.

The significance of the thick quartzite in the Thomas Range is not yet clear. Staatz has indicated that it is correlated with the Swan Peak quartzite of northern Utah and with the quartzite at the nearby Fish Springs section (Staatz, personal communication, 1953). The quartzite at Fish Springs is thought by the present writer to be Eureka, and he concurs that the Thomas Range sequence is Eureka in large part or in entirety. The writer has long felt that much or all of the northern Utah Ordovician quartzite ultimately would turn out to be Eureka equivalents (hence probably post-Bolarian and transgressive) lying on the Chazyan intercalated beds of the Swan Peak, a correlation suggested recently by Ross (1953, p. 22-26). Lacking personal knowledge of most of the northern Utah sections, however, the writer can only present the alternative correlations. First, the Eureka quartzite may be entirely absent in the northern Utah area, with the possible exception of higher portions of at least the Stansbury Island and Promontory Point sections. All or most of the quartzites of northern Utah would remain as pre-Eureka, presumably Chazyan, Swan Peak. Figure 6 illustrates this correlation, with the entire Thomas Range sequence included as Swan Peak, unrestricted. If the correlation be correct, the regressive Swan Peak sands accumulated thickly in northern Utah and then were largely preserved during subsequent emergences, but the transgressive Eureka sands were only thinly developed there, if at all. The second possibility, as mentioned above and illustrated by figure 7, is that most of the northern Utah Swan Peak is fully correlative with the Eureka quartzite in the sense of rock continuity and approximate synchroneity. This would imply that the regressive Kanoshian sands and shales are the youngest pre-Eureka rocks common to both west-central and northern Utah; whatever subsequent Chazyan and Bolarian deposits may have accumulated in northern Utah were stripped off prior to deposition of the thick transgressive Eureka sands. Judging from the Trentonian age of the pre-Eureka rocks on the Antelope Range of Nevada, it appears that transgressive Eureka sands of northern Utah should be at least as young as Trentonian. In that case, the only extensive and thick Chazyan sand would be the Watson Ranch tongue (of the Swan Peak), which then would properly have a formation name other than Swan Peak. Figure 7 shows the restricted Swan Peak distribution, assuming that cratonward sections of northern Utah have only Eureka while the lower portion of sections west of Ogden contains a wedge of Chazyan (?) Swan Peak sand beneath the overlapping Eureka sands. Figure 8, an isopachous map of the Eureka quartzite, assumes correlation with the upper portion or all of the "Swan Peak" quartzites of northern Utah and the upper 400 feet of the Thomas Range section; it should be viewed in conjunction with figure 7.

The quartzites at Beck's Spur and Neff's Canyon are post-Cambrian and pre-Devonian, probably Ordovician. If they were Swan Peak, they should regressively overlie older Ordovician rather than Cambrian. It is assumed, therefore, that they are transgressive Eureka equivalents. What other pre-Devonian strata may have covered them is not known.

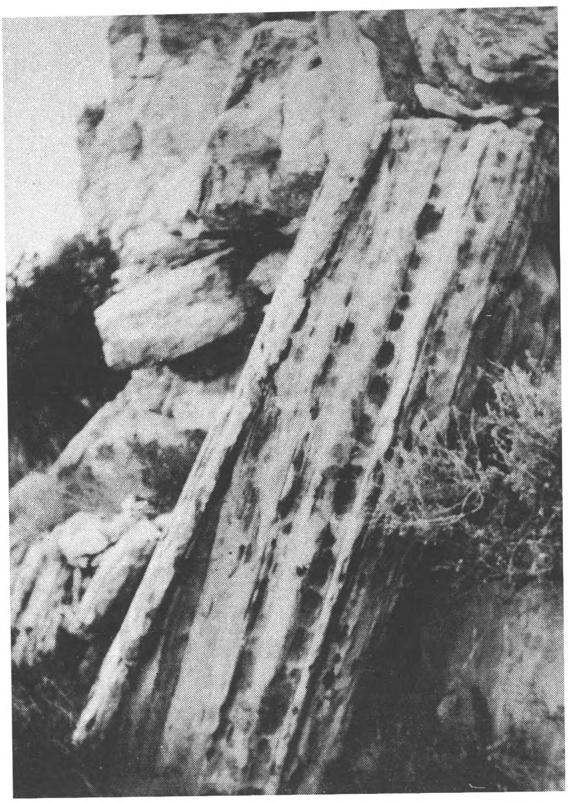


Figure 9. Swan Peak quartzite, Stansbury Island section. Close-up of steeply dipping ledge showing typical cross-bedding.

PETROGRAPHY

Samples of the quartz arenites were studied microscopically in order to determine rock properties and to permit lithic correlations. Suites from Scipio, Kanosh, Smooth Canyon, and Sunnyside sections were sectioned and photographed; grain size counts were made from the prints. Many other samples were studied with the binocular microscope and compared with the sectioned samples. Reliable correlations of members of the Eureka quartzite in west-central Utah cannot be made by sample study alone, with the possible exception of a high ledge-forming member having slightly larger than usual grains.

The Eureka quartzite often can be distinguished from the Watson Ranch tongue, however, on the basis of grain size and sorting. Although much of the Watson Ranch material is virtually indistinguishable from Eureka, many beds throughout the Watson Ranch in the Ibex area are less well sorted and bear larger grains than do the Eureka samples from that area. Accordingly, the quartzites at Scipio and Kanosh were separated largely on the basis of lithic correlations to Ibex. Quartzites at the Fish Springs section and those to the west of Ibex are readily recognized by stratigraphic position; the westernmost Watson Ranch deposits are very fine sandstones and siltstones and cannot be recognized by lithic correlations to Ibex.

The Eureka quartzites of the Ibex area have mean sizes of 3.0 to 3.5 phi (0.125 to 0.088 mm.) by numerical count of grains from thin sections; corresponding means of weight distribution (which would be comparable to results obtained by sieve analysis of friable or loose sand) would appear to be lower than 3.5 phi (greater than 0.125 mm.). Such grains are considered as fine sand by Wentworth's classification (Wentworth, 1922). Binocular comparison of samples indicates that middle Eureka modal grain sizes, comparable to weight distribution modes as obtained by sieve analysis, are slightly coarser in eastern Nevada than in the Ibex area. Many samples from eastern Nevada have estimated modes of 1/4 mm. or slightly larger, compared to 1/4 to 1/8 mm. modes in western Utah. The highermost Eureka and lowermost, regressive, Eureka modal sizes coarsen gradually eastward to about 1/4 mm. Only at Kanosh is there a noticeable vertical progression, from 1/4 mm. basally up to 1/8 mm.

Watson Ranch tongue samples from Ibex are estimated to have weight distribution modes ranging from 1/32 mm. (silt size) to 1/4 mm., with no vertical progression. Samples of small modal sizes are poorly sorted and contain some grains almost as large as those of the larger modal sizes. Watson Ranch sands at Scipio and correlative sand beds in the Lehman at Kanosh have modes of 1/4 mm., 1/2 mm. or more, and are easily distinguished by eye as being medium to coarse sands.

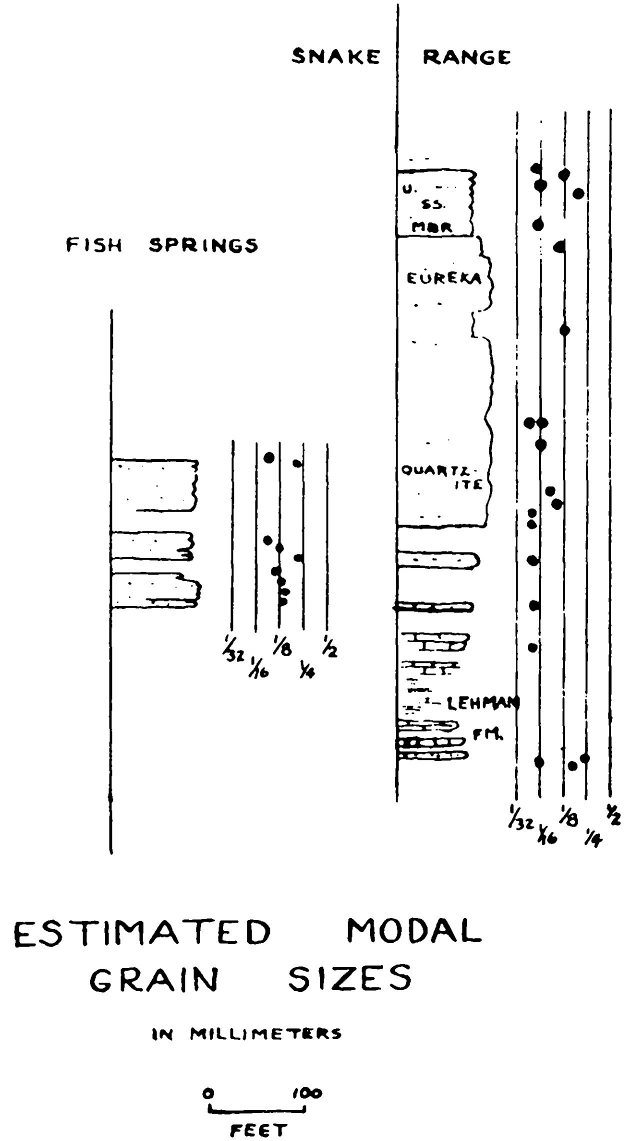
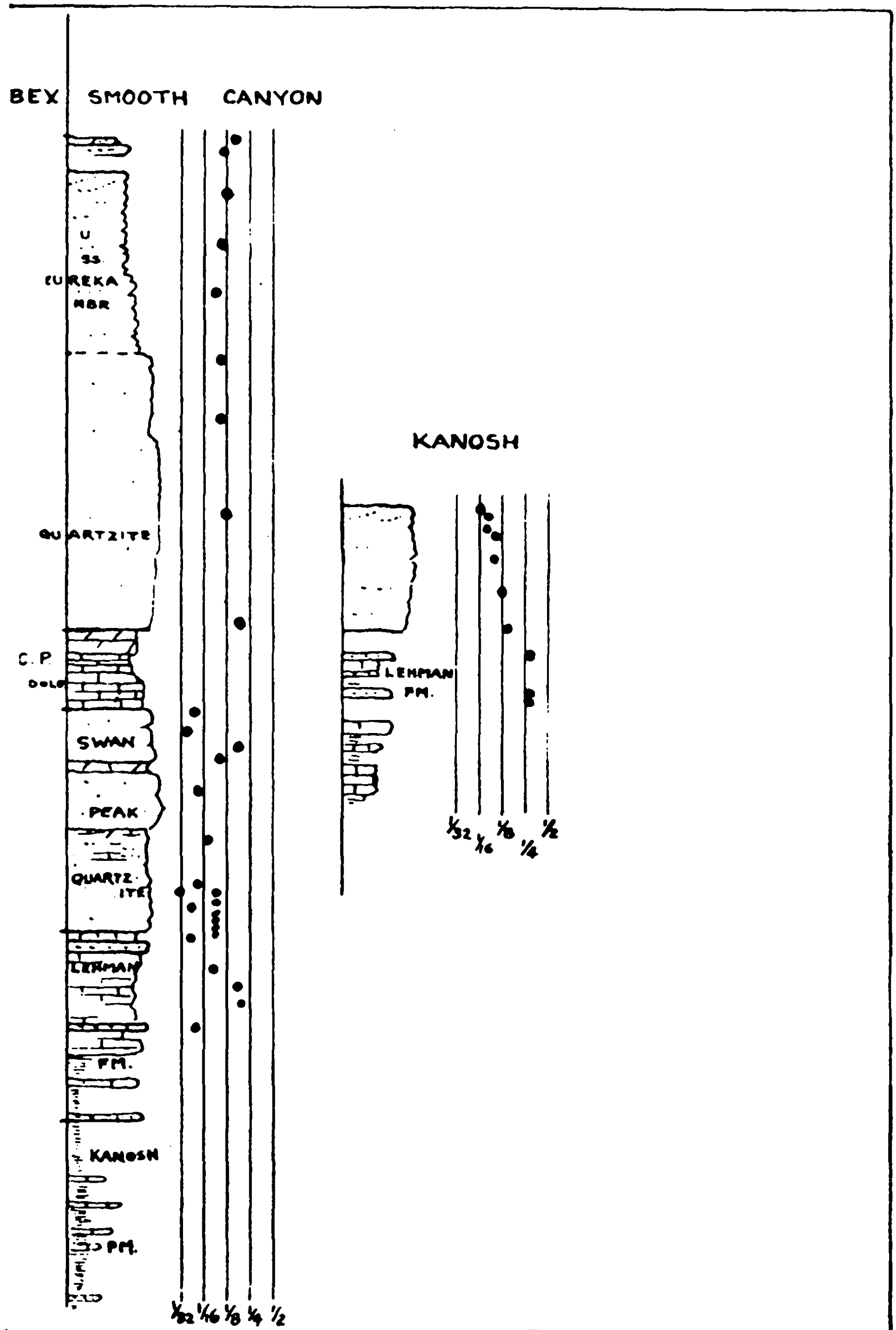

SNAKE RANGE
FISH SPRINGS
U. SS. MBR
EUREKA
QUARTZITE
LEHMAN FM.
1/32 1/16 1/8 1/4 1/2
1/32 1/16 1/8 1/4 1/2
ESTIMATED MODAL GRAIN SIZES
IN MILLIMETERS
0 100
FEET

Figure 10



BEX SMOOTH CANYON
U SS EUREKA MBR
QUARTZITE
C. P. DOLO
SWAN
PEAK
QUARTZ ITE
LEHMAN
FM.
KANOSH
FM.
1/32 1/16 1/8 1/4 1/2
KANOSH
LEHMAN FM.
1/32 1/16 1/8 1/4 1/2

Grain shapes vary, as seen in section. In general, the larger grains have moderate to low sphericity; the finer, high sphericity. Watson Ranch sands might be distinguished from those of the Eureka by differing average sphericities, but the more obvious and more readily measured distinction is the difference in maximum or modal grain sizes. Angularity of grains appears to vary widely, but it is felt that the major causal factor is the differing degree of cementation. Incompletely cemented quartz sandstone grains always appear to have better rounded grains than do the quartzites. Angularity is thought to be useless for correlative or paleogeographic purposes.

No special effort was made to record the presence of heavy detrital minerals, as these are virtually lacking in the samples studied. Apparently the Watson Ranch, Swan Peak, and Eureka sands were derived from pre-existing sands, themselves the product of weathering of an older igneous-metamorphic or possibly sandstone terrane. Advance weathering and mineralogical sorting occurred at least once prior to Watson Ranch sand deposition. It is thought the direct sources for the Watson Ranch sands were the basal Cambrian and later pre-Cambrian sands of the Rocky Mountain area; Eureka sands were derived from the same source and also from emergent Watson Ranch (Swan Peak ?) sands.

Cementation of the sands varies. The Eureka quartzites of Nevada and, to a lesser extent, in Utah are quartzites in the full sense, being silica cemented for the most part, iron oxide cemented to a lesser degree. Such rocks are completely impervious and may be very tough and resistant; where moderately deformed, however, they may be closely fractured. Iron oxide cementation or incomplete silica cementation is more common in the Eureka of Utah, and is common in the Watson Ranch tongue of the Swan Peak in west-central Utah. Eureka and Swan Peak beds intercalated with shales, and carbonatites are frequently iron oxide and carbonate cemented. Small flecks of iron oxide cement occur in many of the most indurated quartzites, causing the tiny differentially weathered "pockets" on quartzite exposures. Apparently the iron oxides accumulated early, locally inhibiting the later and more durable silica cementation.

STRATIGRAPHIC SECTIONS

The following stratigraphic sections are arranged in the order thought to be most instructive to the student of the Ordovician of the eastern Great Basin. The Ibex localities are considered as the standard for west-central Utah and hence are described first; correlations then extend westward and southwestward into Nevada and eastward and northward in Utah.

Lithic members of the Eureka are recognized in Nevada but in most of Utah the formation is too nearly homogeneous to permit valid subdivision. In the following lists the members are designated where distinguished in the field. Three of the six members are to be defined in central Nevada and will be treated more fully in a future paper which will discuss problems of that area. They are outlined here in order that the correlations in eastern Nevada may be clarified for the reader. Three other members are to be defined in eastern Nevada and are of greater significance in the area of this report.

The type section of the Eureka, at Lone Mountain, is to be divided into three members, the upper gray quartzite member, the white quartzite member, and the lower discolored quartzite member, in descending order. These members are recognized in central Nevada only. At the Grant Range locality, south of Currant, Nevada, the uppermost two members, the upper vitreous quartzite member and subjacent upper sandstone member, are recognized; also a lower member, the shaly quartzite member, is recognized as forming the older, regressive phase of the Eureka. The higher two members, and possibly the lowermost as well, are distinguished in westernmost Utah.

The figures in the left-hand column of each section description are the thickness in feet of the individually described units; those in the right-hand column are cumulative thicknesses from the base of the formation or base of measurement. Measurements were made with Abney hand level, steel tape and Brunton compass, and hand tape as convenient.

Lithologies were distinguished in the field. Quartzites are quartz detrital rocks firmly cemented with silica; they are usually composed of sand-sized grains, but grain sizes in the "finely" and "very finely" grained quartzites range down into the silt class. Quartzites are vitreous when extremely well indurated; when less so, they weather to a grainy surface. Weakly cemented quartz detrital rocks are quartz sandstones and siltstones, ranging in induration from quartzitic to friable. Argillites range in structure from massive and blocky to shaly. Calcite rocks are limestone intraformational conglomerates, calcarenites (sand texture), calcisiltites (silt texture), and calcilutites (clay texture); coarsely, medium, and finely grained dolomites are equivalent in texture to the smaller three limestone classes. The following bedding thickness usage is employed: fissile and very thinly bedded, 0 to 1/4 inch; thinly bedded, 1/4 inch to 2 inches; medium bedded, 2 inches to 12 inches; thickly bedded, 12 inches to 48 inches; massive, above 48 inches. Flaggy beds are 1/2 inch to 4 inches thick, weathering to separate beds.

IBEX-SMOOTH CANYON (1): On the north side of Smooth Canyon, Confusion Range, in section 24, T.22S., R.15W., there is a well-exposed section ranging from the Kanoshian to at least the Upper Ordovician. Fossil Mountain, on the south side of Smooth Canyon, is composed of the Eureka quartzite and older rocks, and is cut by several faults. Both sections are about 1-1/2 miles west of the abandoned Watson Ranch (Ibex).

Upper Ordovician:		
Dolomite, medium-grained, cherty, light gray. Thickness not measured. Sharp basal contact.		
Eureka Quartzite:		
Quartz sandstones, white, harder and gray at top; dolomitic in upper 1'.	8	535
Dolomite, medium-grained, gray weathering, cherty.	7	527
Quartz sandstone, gray, buff-gray weathering.	10	520
Covered; base of upper vitreous (upper white) quartzite member equivalents.	10	510
Quartz sandstones, white, broadly cross-bedded in higher 3' and lower 2'; beds inclined southwestward and jointed.	10	500
Quartz sandstones, white, in two large ledges; bedding planes exposed.	15	490
Quartz sandstones and quartzites, sporadically pocketed, cross-bedded in part; forms large over-hanging bluffs; broad bedding plane at base.	105	475
Quartz sandstones, white and pink, pocketed, regularly bedded, weathers to flat, rounded boulders on slope. Base of upper sandstone member gradational.	70	370
Quartzites, white, largely vitreous, closely pocketed in much of the higher 105', and again down to 210' from top; medium-bedded, grainy weathering; lowest 100' form a vertical cliff, higher portion is cliffs and ledges. Unit is equivalent to	300	300

all Eureka quartzite members below the upper sandstone member in Nevada. Gray at base.		
Crystal Peak Dolomite:		
Dolomite, iron oxide-stained, finely grained, silt-parted, argillaceous, quartz sandy in higher 5'; _Eofletcheria_? sp. at base.	29	85
Quartz sandstone, calcareous and argillite-parted.	6	56
Dolomite, finely grained, yellowish and reddish silt-parted, purplish-brown to blue-gray weathering. _Pseudomera_ sp., orthocone.	50	50
Swan Peak Quartzite - (Watson Ranch Tongue):		
Quartzites and quartz sandstones, in part interbedded, light gray, laminated and cross-laminated, bluff-forming; 3' of argillaceous shale beds 22' from top; member generally more reddish-brown weathering than Eureka quartzite.	62	243
Calcisiltite, dolomitic.	8	181
Quartzite, vitreous, light gray, massive, cross-laminated in part; forms very prominent vertical cliff; overhangs underlying beds.	65	173
Quartz sandstones, thinly bedded, incompetent, dark brown weathering.	35	108
Quartz sandstone, white, tan weathering, prominent ledge.	10	73
Quartz sandstones and quartzites, brownish weathering and yellow to white weathering respectively, intercalated.	35	63
Quartzite, white, grades to yellowish-gray quartz sandstone.	10	28
Quartzite, vitreous light gray, pearl-like, cross-laminated, reddish-brown weathering.	18	18
Lehman Formation:		
Calcisiltite, dolomitic, laminated.	6	197
Quartzite, gray, reddish-brown weathering, cross-laminated and purplish at base.	20	191
Calcilutite, yellow silt-parted, bluish-gray weathering, somewhat calcareous, with thin argillites; calcarenitic at base. _Leperditia_ sp., _Barrandia_? sp.	51	171
Quartz sandstone, cross-laminated, gray to orange-buff weathering.	5	120
Calcisiltite, silt-parted, cobbly weathering.	10	115
Quartzite, vitreous, orange weathering, shale-parted.	5	105

Calcarenite grading to calcilutite; *Leperditia* sp., *Macronotella* sp., small gastropods.	20	100
Argillaceous shales, calcareous, reddish-brown.	20	80
Calcisiltites, irregularly yellow silt-parted but bluff-forming; argillaceous and quartz sandy in lower 8'.	53	60
Quartzite, laminated and cross-laminated, whitish to gray, dark red weathering.	7	7
Kanosh Formation (in part after Hintze, 1951):		
Limestones, calcarenites to calcilutites, gray, thinly bedded, silty and argillite-bearing; *Anomalorthis* sp., *Orthis* sp., *Leperditia bivia* White, *Pliomerops* sp.	115	271
Siltstones, yellowish, and argillaceous shales, olive gray and brown, with thinly bedded calcarenites and calcilutites; *Anomalorthis utahensis* Ulrich and Cooper, *Orthis michaelis* Clark, *Leperditia bivia* White, *Bathyurellus* sp. cf. *B. feitteri* (Holliday), from the zone M fauna. Lower 279' of the formation, consisting of shales, siltstones and occasional calcarenites, exposed across Smooth Canyon, where all 500' may be measured.	156	156

IBEX - SOUTHEAST IBEX HILLS (1): The southern face of the Ibex Hills is formed by a fault (or fault line?) scarp of Eureka quartzite, which rises so that at the southeasternmost part of the hills the bluff exposes rocks as far down as the upper part of the Lehman formation. The measured section is practically identical to that of Smooth Canyon, except that a 10' quartz sandstone ledge appears to occur in the Crystal Peak dolomite in a position to include the *Eofletcheria* horizon; in addition, the Swan Peak quartzites appear to be more massive in the southeastern Ibex Hills area than at Smooth Canyon.

At a point 12.7 miles north of the southeast Ibex Hills and near the north end of Gettel Playa, the Eureka and Crystal Peak formations are exposed. The Crystal Peak dolomite is approximately 40 feet thick, in contrast with the 80 feet or more at Smooth Canyon and other adjacent sections. To what extent the thinning may be due to facies change is not apparent.

CRYSTAL PEAK (2): Cliff-forming Ordovician quartzites form a continuous cliff along the south side of the Crystal Peak Hills and face the white Crystal Peak intrusive about a mile south and across the Garrison-Black Rock road. The section was taken at the southernmost nose, with the foot of the section near the road, in sections 23-24, T.23S., R.16W.

Upper Ordovician:		
Dolomite, coarsely grained, very cherty, rough weathering. Thickness not measured.		
Eureka Quartzite:		
Quartzite and quartz sandstone, laminated, dolomitic, gray; gradational.	8	563
Quartz sandstones, cross-laminated (original dip northerly), vitreous, gray, grayish weathering; weather into re-entrant; base of upper vitreous quartzite member.	8	555
Quartzite, light orange weathering, grainy.	20	547
Quartz sandstone and semi-quartzite, white, with large scale cross-bedding dipping to the northwest and west-northwest; ledge-forming.	35	527
Quartz sandstones, white, grainy, thickly bedded, bulbous weathering, ledge-forming, pocketed in lower 100'; large scale cross-bedding; gradational base of upper sandstone member.	135	492
Quartzite and quartz sandstone, white, light reddish-brown weathering, grainy, generally thickly bedded; forms steep cliffs; pocketed in higher 153'. Equivalents of the three type Eureka members and shaly quartzite member.	335	357
Quartz sandstones, argillaceous and thinly bedded, fissile in part, dark brown weathering; gradational above and below.	22	22
Crystal Peak Dolomite:		
Dolomite, finely grained, silt-parted, blocky weathering; 1' *Eofletcheria* sp. biostrome 23' from top, and sporadically above; with *Öpikina* sp. and *Orthis* sp. cf. *O. michaelis* Clark.	34	89
Calcilutite, irregularly silt-parted, slope-forming.	9	55
Dolomite, brownish.	2	46
Calcilutite.	3	44
Dolomite, brownish.	2	41
Calcilutite, silt-parted, with calcarenite at base; argillaceous and platy.	39	39
Swan Peak Quartzite - (Watson Ranch Tongue):		
Quartzite, yellowish-brown and gray weathering, cliff-forming.	27	205

Quartz sandstones, thinly bedded, dark brown weathering, laminated and cross-laminated.	14	178
Calcilutites and dolomites, black, silt-parted; bluish-gray weathering, Leperditia sp.	28	164
Quartz sandstone, thinly bedded, calcareous, orange-brown to dark gray.	10	136
Quartzites and argillaceous shales, reddish, orange-spotted and pocketed, white at top.	18	126
Calcarenites, dolomitic, siliceous and laminated, intercalated with sandy argillaceous shales.	7	108
Dolomitic quartzite, silt-parted, thinly bedded, reddish weathering.	19	101
Quartz sandstones, brownish weathering, pocketed, laminated and cross-laminated or thinly bedded; whitish and more indurated near top.	51	82
Covered; Leperditia sp. in float, with Eleutherocentrus sp. and Macronotella sp.	23	31
Quartz sandstones, brownish.	4	8
Calcarenite.	2	4
Quartz sandstone, orange-brown to dark gray.	2	2
Lehman Formation:		
Covered.	40	169
Calcarenites, with calcilutite interbeds; silt-parted, intermittently exposed, grades to	24	129
Calcilutites, gray, weathering medium to light bluish-gray, regularly and irregularly silt-parted; Hormotoma sp., Leperditia sp., Orthis sp.	20	105
Calcilutites, as immediately above, rubbly weathering.	85	85
Kanosh Shale:		
Calcarenites, bluff-forming, finely grained, argillaceous and silt-parted.	15	245
Calcilutites and calcarenite ledges, argillaceous, silt-parted, flaggy, weathering dark gray to olive brown, and intercalated argillites. Zone N. fauna, including Leperditia sp. and Orthis sp.	80	230
Argillaceous shales and thinly bedded siltstones, olive brown and occasionally reddish weathering, and intercalated argillicalcilutites and calcarenites; Leperditia sp., Anomalorthis sp., Orthis sp., in zone M fauna. Base of exposure.	150	150

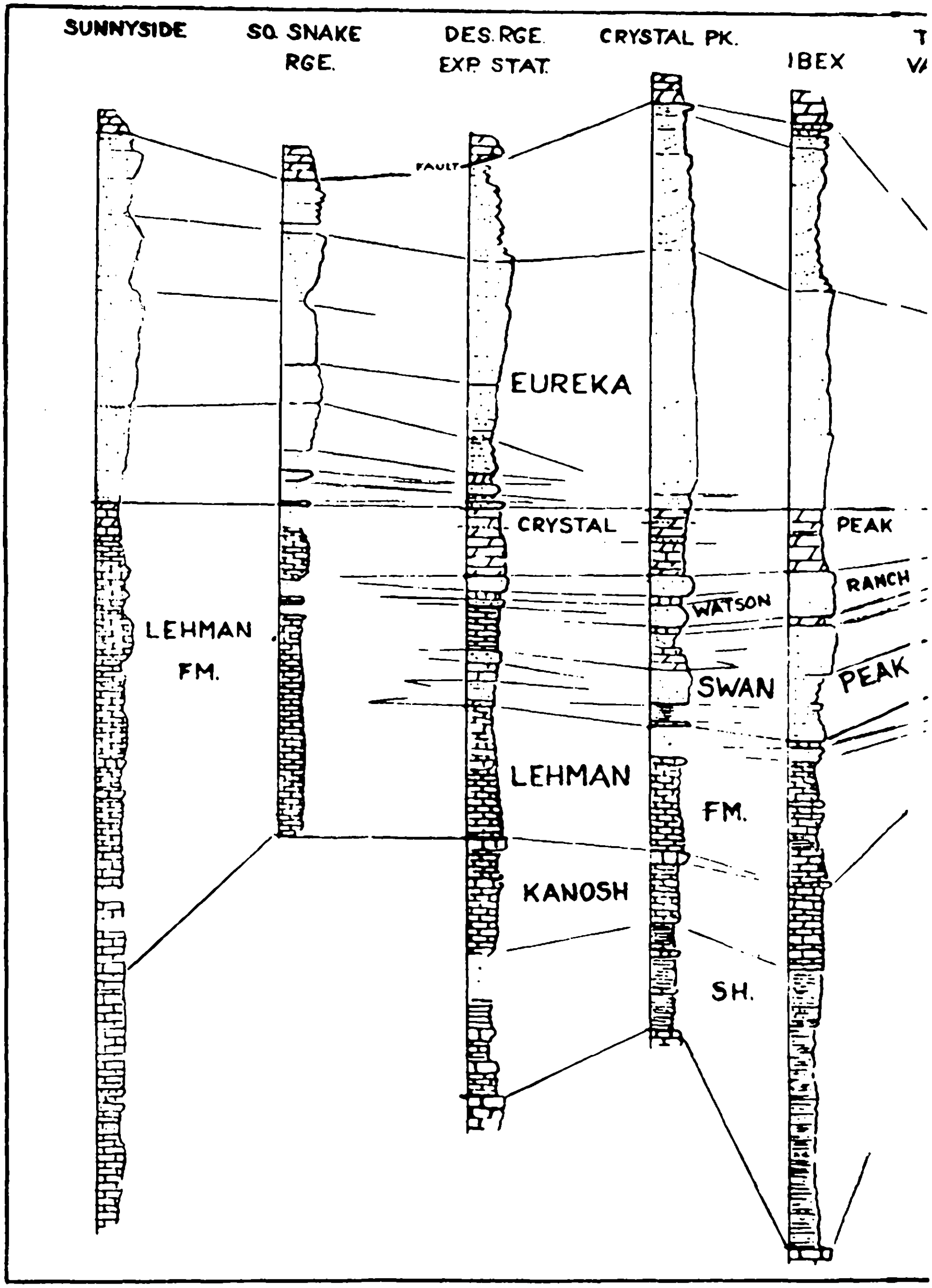
DESERT RANGE EXPERIMENT STATION (3): Ordovician rocks are widely exposed on the west flank of the Tunnel Spring Hills; the section was measured on the southwest and west side of Tunnel Spring Mountain in sections 4-5, T.24S., R.17W.

Upper Ordovician:		
Dolomite, medium-grained, light gray weathering, cherty. Thickness not measured. Strike fault contact with quartzite, offset believed small.		
Eureka Quartzite:		
Quartz sandstones, slope-and ledge-forming, laminated at top, white and grayish. Upper sandstone member grades to	133	467
Quartzites, vitreous, white, light yellowish-stained, closely pocketed, cliff-forming but badly jointed.	170	334
Quartzite, vitreous, white, light yellowish-stained, jointed with small faults, not pocketed.	45	164
Quartzite, vitreous, gray, pocketed, with reddish weathering interbeds. Approximate base of type Eureka equivalents.	26	119
Quartzite, red and orange weathering; foot of main cliff.	5	93
Quartzite, vitreous, light gray, with thin brown and yellow quartz sandstones, most prominent at base.	40	88
Dolomite, medium-grained, thinly bedded and silt-parted.	14	48
Quartzite, thickly to thinly bedded, light orange-brown; silty.	14	34
Siltstone and argillitic shale, olive and yellow weathering.	13	20
Quartzite, vitreous and gray, and cross-laminated orange sandstones. Base of shaly quartzite member.	7	7
Crystal Peak Dolomite:		
Dolomite, finely and coarsely grained, black and argillaceous; irregularly silt-parted, massive outcrops. _Eofletcheria_ sp. ledge 21' to 24' from top; _Eleutherocentrus_ sp., _Macronotella_ sp., _Orthis_ sp. cf. _O. swanensis_ Ulrich and Cooper at base.	92	92
Swan Peak Quartzite - (Watson Ranch Tongue):		
Quartzites and quartz sandstones; gray quartzite at top, medium to coarsely grained quartz sandstones below.	21	174
Calcilutite, thinly bedded.	12	153

Quartzite, closely pocketed, brown weathering, cross-laminated.	6	141
Calcilutite, closely silt-parted, rubbly.	15	135
Calcilutite, hard and siliceous; gradational.	5	120
Calcilutite, irregularly silt-parted, light bluish-gray weathering; closely parted and rubbly interbedded with smoothly weathering beds.	39	115
Quartz sandstones, quartzitic in part, thickly bedded, brownish, white at top; shale seams.	13	76
Calcarenite, silty reddish silt-parted, reddish-stained, thinly to thickly bedded; Leperditia sp., Hormotoma sp.	26	63
Quartz sandstones and quartzites, thinly bedded, calcareous, orange and brown weathering, intercalated with thin argillites and calcarenites. Hesperonomia? sp. near base. Base of Swan Peak equivalents.	37	37
Lehman Formation:		
Calcilutites, medium dark gray, bluish-gray weathering, closely and irregularly silt-parted, rubbly, ledge-forming, with occasional calcarenite in higher 95'; Hintze (1951) identified Leperditia bivia White, large Pliomerops sp., large Cybelopsis sp., Barrandia sp., Illaenus sp., Clathrospira sp.-like impressions, bryozoans, and orthid brachiopods from the higher 95', and Barrandia? sp., Leperditia bivia White in the lower 75'.	180	180
Kanosh Shale (After Hintze, 1951):		
Limestones, variable, argillaceous, thinly bedded and slope-forming.	150	355
Covered, limestone float.	70	205
Argillaceous shale, olive gray and brown, with interbedded fossiliferous medium brown weathering calcarenites.	135	135
Formation contains zones M and N, the former characterized by Eleutherocentrus sp. cf. E. petersoni Clark, Pliomerops sp., Anomalorthis utahensis Ulrich and Cooper, Orthis michaelis Clark, and Receptaculites mamillaris Walcott; and the latter zone, more calcareous, by Anomalorthis sp., Orthis sp., Pliomerops sp., and Leperditia sp.		
Juab Limestone:		
Calcisiltites.	45	45

TULE VALLEY (4): On the east face of the Confusion Range in T.19S., R.15W., due west of Notch Peak across Tule Valley, there is a section from Kanoshian at least into the Upper Ordovician, the Eureka quartzite forming a prominent cliff line.

Upper Ordovician Dolomite:		
Dolomite, siliceous silt-parted and cherty, medium gray weathering, thickly bedded, slope-forming in lower 100'.		
Eureka Quartzite:		
Quartz sandstone, dolomitic, gradational.	4	380
Covered.	3	376
Quartz sandstones and semi-quartzites, white, slope-and thickly bedded ledge-forming, vitreous in part; intermittently pocketed, partially reddish-brown weathering; gradational above and below, grayish and vitreous in highest bed. Upper sandstone member.	105	373
Quartzites, white, hard and semi-vitreous, cliff-forming; pocketed at top, again from 45' to 70' from top, slightly so elsewhere; grainy and reddish-brown weathering.	90	268
Quartz sandstones, white, closely pocketed and sponge-like, friable; gradational boundaries.	40	178
Quartz sandstones, friable and pocketed, intercalated with quartzites, vitreous and pocketed, grade down to cross-laminated, closely pocketed friable white sandstone at base; reddish-brown weathering.	35	138
Quartz sandstones, very friable, closely pocketed, cross-laminated; base may be the same as that of the overlying 35', repeated by faulting; strike faults probably present.	25	103
Quartz sandstones, slightly orange-spotted, white, reddish-brown weathering, weathers with large pockets and holes; cross-laminated at base, beds inclined to the northwestward.	35	78
Quartz sandstones and semi-quartzites, laminated and thinly bedded at base, reddish-brown and grainy weathering, a few vitreous white beds.	43	43
Crystal Peak Dolomite:		
Dolomite, siliceous and argillaceous.	2	61
Dolomite, finely grained, thinly bedded.	12	59
Dolomite, medium-grained, thinly bedded in higher 3'.	12	47


SUNNYSIDE
SO. SNAKE RGE.
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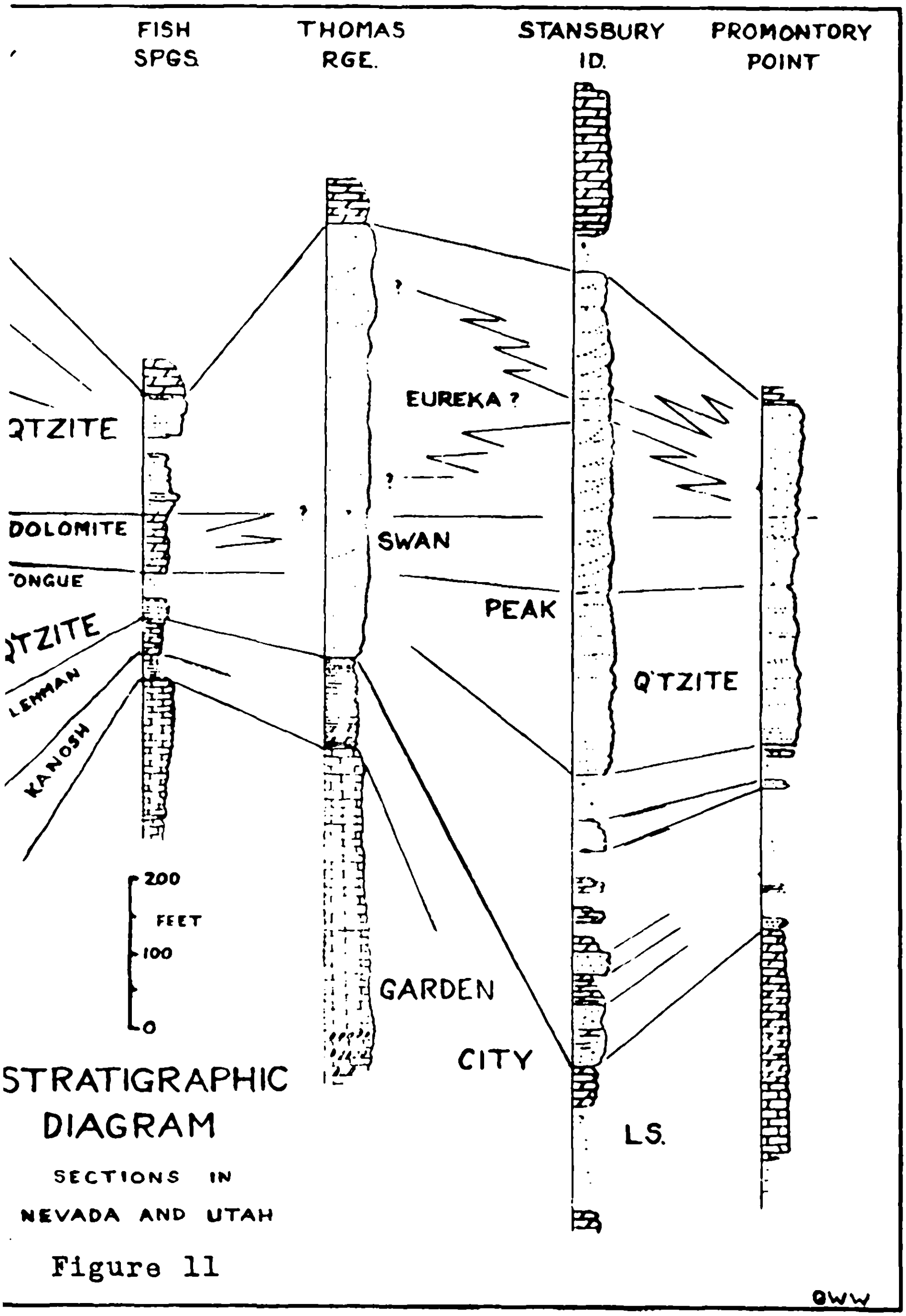
FISH SPGS.
THOMAS RGE.
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STRATIGRAPHIC DIAGRAM
SECTIONS IN NEVADA AND UTAH
OWW

Figure 11

Dolomite, quartz sandy.	3	35
Dolomite, medium- to finely grained, irregularly silt-parted, heavy-ledged, dark bluish-gray, weathering light olive gray.	32	32

Swan Peak Quartzite - (Watson Ranch Tongue):

Quartzite, grainy, dark reddish-brown weathering, laminated to medium-bedded, argillite-parted; cliff-forming in higher 21'.	26	191
Quartzite, very finely grained, thinly bedded, argillaceous, rubbly-weathering, fucoidal; gray-orange, dark red and purplish weathering.	4	165
Quartz sandstone, dolomitic, gray and reddish-brown.	6	161
Quartzites, medium-bedded, reddish-brown weathering.	7	155
Dolomite, medium-grained, closely silt-parted, thinly bedded in higher 8', light gray weathering.	15	148
Quartzites, whitish, light reddish-brown weathering, slightly pocketed; gradational with	33	133
Quartzites and quartz sandstones, whitish and very light orange, medium-bedded, ledge-forming, grainy and reddish-brown weathering, pocketed, cross-laminated; cliff-forming in lower part.	22	100
Covered.	5	78
Quartz sandstones, alternating medium-bedded and thinly bedded argillite-parted, pocketed; dark gray, weathering orange-brown; intercalated shales.	20	73
Quartz sandstones, ledge-forming, with thin cross-laminated quartzite beds, pale pink to dark orange-brown weathering.	9	53
Quartz siltstone, calcareous, argillaceous.	11	44
Quartz sandstones, thinly bedded in part, ledge-forming, calcareous, with argillite interbeds and partings.	13	33
Covered.	9	20
Quartz sandstones, orange-brown weathering, slightly pocketed, medium- and thinly bedded, argillite-parted, fucoidal.	11	11

Lehman Formation:

Calcilutite, irregularly yellow silt-parted, weathering bluish-gray, occasionally thickly bedded; much yellowish and reddish argillutite and siltstone.	31	137
Quartz sandstone, orange-brown to dark reddish-brown weathering, massive and quartzitic in center part, argillaceous and fissile at top and bottom.	16	106

Calcilutite, with coquinal interbeds, ledge- and slope-forming; irregularly silt-parted, largely nodular, medium bluish-gray, argillaceous and reddish in part. <u>Orthis</u> sp.; <u>Bolbocephalus</u>? sp., <u>Leperditia</u> <u>bivia</u> White.	90	90
Kanosh Shale:		
Argillite shale, fissile, yellowish, with thinly bedded calcilutites and coquinas; <u>Anamalorthis</u> <u>utahensis</u> Ulrich and Cooper, <u>Orthis</u> <u>michaelis</u> Clark, gastropods.	40	40
Covered; float indicates abundance of argillaceous shales with orthid brachiopods. Much of the shale is red to a greater extent than the reddish Kanoshian shales at Crystal Peak. No red shales were seen at the Ibex section.		

SOUTHERN SNAKE RANGE, NEAR BIG SPRING (5): On the east face of the range, midway between Big Spring Ranch and Chokecherry Canyon, in T.11N., R.69E.

Upper Ordovician:		
Dolomite, dark gray to black, light gray weathering, cherty. Thickness not measured.		
Eureka Quartzite:		
Quartz sandstone, dolomitic, bluish-gray; gradational above and below.	3	451
Quartzites and quartz sandstones; poorly exposed, gray-weathering, white quartzite grading downward to white sandstones, ledge-forming; base of upper sandstone member exposure.	60	448
Covered.	10	388
Quartzites, white, grainy, massive, pocketed, bulbous weathering, yellowish weathering; weathered pockets to 1/2" in diameter.	83	378
Quartzites, vitreous, and pink sandstones; closely pocketed, in 20' re-entrant.	12	295
Quartzite, white, grainy, pocketed, jointed, slightly grayish to base. Sharp contact with basal 6-inch purple quartzite bed.	90	283
Quartzite, white, grainy, thickly bedded to massive, slightly yellowish and reddish-brown weathering; cliff-forming.	55	193
Quartzites, vitreous gray at top, brownish weathering, and white, grainy and jointed downward.	23	138

Quartzite, whitish in higher 7', red- and orange-stained, laminated and cross-laminated, white and grainy below.	17	115
Quartzite, medium- to thinly bedded, white, finely grained; grainy and whitish weathering in higher 5', dark red to pink weathering below. Base of equivalents of type Eureka members and possibly the underlying shaly quartzite member.	20	98
Covered, quartzite talus.	25	78
Quartz sandstone, hard to friable, pinkish-white.	8	53
Quartzitic sandstone, massive, calcareous at base, reddish-brown weathering; ledge.	7	45
Covered.	32	38
Calcilutites, silt-parted, continuously exposed.	3	6
Quartz sandstone, calcareous, yellowish-brown. Possible base of time equivalent of lowest Eureka quartzite of Ibex area.	3	3

Lehman Formation (including Crystal Peak and Swan Peak equivalents):

Covered, _Eofletcheria_ sp. float near base; may be equivalent to Crystal Peak; calcilutite float.	32	457
Calcilutites, irregularly silt-parted but massive, black, bluish-gray weathering; partially exposed. Ledge 35' to 52' from top yielded _Öpikina_ sp., _Orthis michaelis_ Clark in abundance, and _Michelinoceras_? sp.	70	425
Covered, calcilutite float.	25	355
Calcilutite, as above.	10	330
Covered, calcilutite float.	13	320
Quartz sandstone, calcareous, finely grained, partially quartzitic, orange and buff weathering; possible base of Swan Peak equivalents.	7	307
Calcilutites, silt-parted, to base of Lehman formation.	(app.300)	

CAVE VALLEY (6): On the east side of Cave Valley, on the west flank of the northern portion of the Ely Range; about 11 miles east of the Sunnyside section, in T.7N., R.64E.

Upper Ordovician:

Dolomite, medium gray, coarsely grained; thickness not measured.

Eureka Quartzite:		
Quartzite, silty, reddish-gray, reddish and purplish weathering; thinly bedded, fucoidal markings.	14	521
Quartzite, vitreous, white; sharp upper contact; jointed; base of upper vitreous quartzite member at sharp crest of hill. Grades downward to	42	507
Quartz sandstone and quartzite, intercalated and intertongued; grading to	30	465
Quartz sandstones, thinly bedded and laminated, occasionally cross-laminated, orange weathering; quartzite nodules in boudinage structure; base of upper sandstone member, gradational.	50	435
Quartzite, grainy, rather closely pocketed, some pockets as large as 1 inch in diameter, white, light tan-white weathering; massive, cliff-forming.	260	385
Quartzite and quartz sandstones, white, yellowish weathering, forms base of cliff.	25	125
Quartz sandstone, white, grayish weathering.	50	100
Quartz and quartz sandstone; vitreous quartzite, finely mottled, laminated and cross-laminated in part, bulbous, orange weathering; grades to white, gray-banded, grainy sandstone, thinly bedded at base; base of exposure of equivalents of type Eureka members and shaly quartzite member.	50	50
Lehman Formation:		
Covered.	52	760
Calcisiltite, silty, siliceous, dolomitic, tan weathering.	3	708
Covered.	10	705
Calcisiltite, dolomitic, thinly bedded, silty, buff-gray weathering with reddish stain. Possibly Crystal Peak equivalents.	10	695
Calcilutite, irregularly silt-parted, medium gray weathering; calcarenites and intraformational conglomerate beds in higher 80' to 100', which may be Swan Peak equivalents.	240	685
Calcilutites, less well exposed, irregularly yellow silt-parted, ledges and float only in lower part. *Leperditia* sp.; orthid brachiopods in lower part. Restricted type Lehman equivalents.	445	445
Kanoshian:		
Calcilutites and calcarenites, yellow silt-parted, with calcarenite intercalations	255	365

in poorly exposed calcilutites, nearly exclusively poorly exposed calcarenites downward. *Leperditia* sp. throughout, *Receptaculites* sp. common in lower 150'.		
Calcarenites with occasional calcisiltites and calcilutites, yellow silt-parted, mainly float and unexposed. *Leperditia* sp. and *Receptaculites* sp. may be float from above.	110	110

Juab Limestone:

Calcisiltites, poorly exposed to covered, for about 300'.

SUNNYSIDE (7): On the west side of the Egan Range about 6 miles north of Sunnyside Ranch, on the first bluff south of the road into Cave Valley, in T.7N., R.62E.

Upper Ordovician Dolomite:

Dolomites, dark gray, medium gray weathering, siliceous and quartz sandy in lower part; undulating contact with quartzite below. Thickness not measured.

Eureka Quartzite:

Quartzite, poorly indurated, gray and dolomitic at top, jointed and poorly exposed; hard quartzite nodules.	23	513
Quartzite, white and grainy, massive, bluff-forming, light pink weathering; base of upper vitreous quartzite member.	40	490
Quartz sandstones, white, cross-laminated and thinly bedded, intercalated with medium-bedded sandstones; pink-tinged at base; upper sandstone member.	50	450
Quartzites and quartz sandstone, bluff-forming, with 20' weak zone starting 85' from top, weathered into ledges and broad bedding planes.	105	400
Quartzites, grainy weathering, tan and pink weathering, massive and cliff-forming; faintly banded on weathered surfaces, cross-laminated in higher portion.	157	295
Pebble conglomerate, white quartz sandstone pebbles in pink sandstone matrix. Base of equivalents of members of type Eureka.	3	138
Quartzite, white to light gray, pinkish weathering, grainy in part.	90	135
Quartzites, thinly bedded, alternating thinly bedded, laminated and cross-laminated with argillaceous shaly quartzites; yellowish-brown weathering; base of shaly quar+zite member and of formation.	45	45

Pogonip Group:		
Dolomites and calcisiltites, partially interbedded and partially intergrading laterally, gray, buff-gray weathering. This highest Pogonip dolomite is the "Dolomite member" of Hintze (1952), restricted from the Lehman formation.	50	50
Lehman Formation:		
Calcilutite, gray and black, light bluish-gray, occasionally reddish, weathering yellow silt-parted so as to weather rubbly in places; 35 feet from top of unit is a thin pebble conglomerate, the top of a 15-foot bluff. Similar bluff top 15 feet below base of former bluff. _Eofletcheria_ sp. biostrome at base of latter bluff, 80 feet from top of unit; _Orthis_ sp. coquinas in higher 40 feet, with _Leperditia_ sp.	100	600
Calcilutite, as above, silt-parted and evenly, thinly bedded forming massive ledges; cliff-forming in higher 65', partially covered for 20', lower 15' a cliff.	100	500
Calcilutite, black, weathers medium bluish-gray, reddish-stained, thinly bedded, yellow silt-parted, with thin intercalations of intraformational conglomerate and calcarenite; intermittently exposed; _Leperditia_ sp., gastropods and brachiopod outlines.	230	400
Calcisiltites, irregularly silt-parted, black, light gray and partially reddish-gray weathering; largely covered.	170	170
Kanoshian:		
Covered; float indicates closely silt-parted bluish-gray-weathering calcilutites, partially reddish-stained.	156	184
Quartz sandstone and siltstone, calcareous, yellowish, interbedded with coarsely grained limestones in higher 5'.	13	28
Calcisiltite, gray; _Receptaculites_ sp.	5	15
Quartz sandstone and siltstone, calcareous, reddish- and yellowish-weathering, limestone intercalations.	10	10
Lower portion of formation not measured. Hintze (1952) records another 325' of the Kanoshian; argillaceous and unfossiliferous calcisiltites.		

PAHROC RANGE (8): In T.2N., R.63E. On the east side between two roads crossing the range westward from the Pioche road in Cave Valley to the Sunnyside-Hiko road.

Upper Ordovician:		
Dolomites, medium gray, coarsely grained; bluff-forming for about 100' at base; thickness not measured.		
Dolomites, quartz sand-bearing; gradational sequence.	5	5
Eureka Quartzite:		
Quartzites and quartz sandstones, vitreous in part, white, gray weathering; gradational with	21	465
Dolomite, light gray weathering, quartz sandy; base of equivalents of upper vitreous quartzite member; lower sharp contact.	10	444
Quartzite, brown-stained on top surface, grayish.	2	434
Quartz sandstones, white, slightly mottled, more coarsely grained than above or below, intermittently laminated and cross-laminated, medium-bedded, grainy and bulbous-weathering; upper sandstone member.	82	432
Quartzite, medium-grained, thickly bedded, white, orange-pocketed, bulbous-weathering; cliff-forming; re-entrant 20' from top, lower 15' weathered back. Possible base of upper gray quartzite member.	95	350
Quartzite, mostly thickly bedded, white to very light gray, largely grainy, weathers light pinkish-gray; gradational with	165	255
Quartzite, very thickly bedded and massive, light pinkish-white, yellowish and pink to dark reddish-brown weathering, finely grained, grainy weathering; base of equivalents of members of type Eureka.	40	90
Quartzite, laminated and cross-laminated, black and white banded.	34	50
Quartzites and quartz sandstones, thinly bedded, orange silt- and shale-seamed, white, pink and buff weathering.	16	16
Pogonip Group:		
Covered; dolomite and quartzite float, probably concealing dolomites.	83	941
Dolomite, finely grained, argillaceous.	4	858
Covered, with argillaceous calcilutite and calcisiltite float.	38	854
Calcilutite, black, argillaceous, intermittently exposed; closely silt-parted. *Eofletcheria* sp. 30' from top, orthid brachiopods; dolomitic in lower 25'.	100	816

Dolomite, medium- to coarsely grained, black, dark gray weathering, massive; white-mottled.	57	731
Calcilutite, yellow silt-parted, bluff-forming in higher 72', ledge-forming below, light bluish-gray and occasionally reddish-gray weathering. *Orthis* sp. cf. *O. michaelis* Clark, 7' from top, pliomerids, large *Leperditia* sp. up to 75' from top.	183	649
Calcilutites, argillaceous and as above, with calcisiltites, silt largely reddish rather than yellow; some red argillite shales; *Leperditia* sp., small in lower part, which is closely yellow silt-parted and rubbly weathering.	140	435
Calcarenites, some black calcisiltites upward, medium gray, dark gray weathering; thickly bedded; *Leperditia* sp. float.	19	295
Calcilutites, silty and closely silt-parted, black, calcite-flecked; *Leperditia* sp., large.	107	276
Covered and float.	76	169
Calcisiltite, black, silty, irregularly yellow silt-parted; ledge-forming, cherty in highest ledge; *Leperditia* sp., orthid brachiopods; some intraformational conglomerate.	72	93
Calcisiltites and finely grained calcarenites, black, calcite-flecked, medium gray weathering, irregularly silt-parted, outcropping in thick rough ledges; *Receptaculites* sp., orthocones. Base of exposure.	21	21

HIKO (9): In the Worthington Mountains, 7 miles north of Hiko and 3/4-mile west of the Hiko-Sunnyside road. In T.3S., R.59E.

Upper Ordovician:

Dolomite, light buff-gray weathering, with light gray chert in nodules and seams. Thickness not measured.		
Quartz sandstone, dolomitic, mottled and purplish-gray weathering; gradational with dolomites above.	3	21
Covered.	18	18

Eureka Quartzite:

Quartz sandstone, purplish and buff-gray weathering, massive, mottled and pocketed; thin vitreous quartzite beds. Cliff-forming.	14	344

Quartz sandstones, thinly bedded, gray, gray and reddish weathering, siliceous nodules; largely covered; base of upper white quartzite member.	16	330
Quartz sandstone and semi-quartzite, large scale cross-bedding, massive, cliff-forming, vitreous at top; cross-beds with original westerly dip.	47	314
Quartz sandstones and quartzites, alternating in 4'-5' units; sandstones friable and coarsely grained, laminated and cross-laminated; 3' cross-bedded unit near base truncated at base, as if face of dune; quartzite fills 1' deep channel in underlying sandstone. Base of upper sandstone member.	32	267
Quartzites and quartz sandstones, generally laminated and cross-laminated, platy; zone of quartzitic concretions 7' from top; reddish-brown weathering.	17	235
Quartzite, reddish-brown weathering, grainy, laminated in part; weathered back in higher 58'; cliff-forming and darker reddish-brown in lower part. Grades to	133	218
Quartzite, white, orange-pocketed, yellow-stained, grainy, semi-vitreous. Broken by jointing, slope-forming. Base of exposure, still in equivalents of type Eureka members; fault drops Upper Ordovician dolomite in front of quartzite.	85	85

ARROW CANYON RANGE (10): In T.14S., R.63E. West side, 15 miles WNW of Moapa. Eureka quartzite forms prominent light band in cliff of dark carbonatites.

Upper Ordovician:

Dolomite, medium-grained, very cherty, black; thickness not measured.		
Dolomite, coarsely grained, light gray; fills cracks and channels, to 1' deep, in underlying rocks.	15	15

Eureka Quartzite:

Quartz sandstone, very dolomitic, laminated and cross-laminated, gray-brown weathering.	3	132
Covered.	4	129
Quartzites, dolomitic, laminated and cross-laminated, dark reddish-brown weathering, gray, vitreous.	12	125
Covered.	24	109
Quartz sandstone, white, slightly gray and buff, dark reddish-brown weathering in part, laminated in part.	40	85

Covered.	4	45
Quartz sandstones, white, dark reddish-brown weathering, largely thinly bedded; grades to	25	41
Quartzite, white to very light gray, vitreous, weathering gray, also reddish; grainy.	16	16

Pogonip Group:

Calcisiltites and calcilutites apparently dolomitic, light gray weathering, cherty; silt-parted, light bluish-gray and buff weathering.	45	390
Calcilutites and calcisiltites, dolomitic in part, closely silt-parted, rough-weathering, brownish-gray weathering; largely rubbly-weathering, ledge- and talus slope-forming. *Receptaculites* sp. at base and to 270' above the base. Remainder of section not measured.	345	345

LUND (11): 12 miles south of Lund, on the west face of the Egan Range, in T.10N., R.62E.

Upper Ordovician:

Dolomite, coarsely grained, gray weathering, chert band 4' above quartzite. Sharp basal contact. Thickness not measured.

Eureka Quartzite:

Quartzite, vitreous, light gray, darker and reddish at top.	15	509
Quartzite, cross-laminated with 10°-15° initial dip to SE.	5	494
Quartz sandstone, massive, grainy weathering; forms base of upper vitreous quartzite member.	45	489
Quartzite and quartz sandstones, white, weathers to broad bedding planes and ledges; upper sandstone member.	48	444
Quartz sandstones, fissile, and thin quartzites, closely pocketed, white.	17	396
Quartzites and quartz sandstones, white, cross-laminated in upper 15', closely pocketed; prominent re-entrant 85' from top.	130	379
Quartz sandstones, coarsely grained in part, laminated and cross-laminated, very closely pocketed.	30	249
Quartzites, massive, grainy weathering, closely pocketed; 2' re-entrant at base; possible base of equivalents of type Eureka quartzite.	100	219

Quartzite, grainy and yellow weathering, white; pocketed, especially in upper 15'.	80	119
Quartzite, vitreous, light yellow weathering, weathered pockets frequent and up to 1/4-inch in diameter at base.	25	39
Quartzite, vitreous, white, iron oxide-stained.	5	14
Quartzite, buff-gray weathering, mottled dark gray and white. Base exposed Eureka quartzite.	9	9
Pogonip Group:		
Covered.	36	1175
Dolomites and dolomitic calcilutites; argillaceous, thinly bedded, rubbly-weathering; poorly exposed.	82	1139
Calcilutites, slightly silt-parted, form rough-surfaced bluff.	49	1057
Calcilutites and calcisiltites, thinly bedded and irregularly silt-parted; bluish-gray weathering; occasional coquinal bed. Higher 173' bluff-forming, lower portion intermittently exposed. <u>Leperditia</u> sp. abundant to within 88' from top; orthid brachiopods and <u>Hormotoma</u> sp. in lower portion.	302	1008
Calcarenite, black-and calcite-flecked, weathering medium bluish-gray; irregularly silt-parted, cherty; some intraformational conglomerate.	82	706
Calcilutites, irregularly silt-parted, forming ledges and slopes, weathering light gray; <u>Leperditia</u> sp.	131	624
Argillitic shales and siltstones, olive and dark brown weathering.	30	493
Calcilutite, yellow silt-parted, bluish-gray weathering, rubbly; <u>Leperditia</u> sp. and <u>Endoceras</u>? sp. at base.	125	463
Calcarenite, yellow silt-parted, finely grained; <u>Receptaculites</u> sp. to within 15' of top.	87	338
Calcisiltite, argillaceous, irregularly silt-parted, rubbly-weathering; fine-grained basally; <u>Leperditia</u> sp. and <u>Receptaculites</u> sp. at base.	96	251
Covered; <u>Leperditia</u> sp., orthid brachiopods, and <u>Hormotoma</u> sp. in float.	65	155
Calcarenite.	3	90
Covered, calcilutite float, occasional calcarenite; <u>Receptaculites</u> sp., <u>Leperditia</u> sp., <u>Hormotoma</u> sp. float in higher 7'.	27	87
Calcarenite, coquinal, light gray and orange-spotted.	10	60

Calcilutites and thin calcarenites, closely silt-parted and argillacecus, light gray weathering, dark gray, calcite-veined; ledges, and bluff in lower 10'; _Receptaculites_ sp. down to 14' from top. Base of measured section.	50	50

STEPTOE (12): On the east face of the Egan Range due west of McGill Smelter; in section 30, T.19N., R.63E.

Upper Ordovician:

Dolomite, medium gray, weathering light gray, coarsely crystalline, chert nodules; irregular bedding. Silicified faunule 9'-12' above the quartzite. _Dalmanella_ (_Resserella_) _ignota_ Sardeson, _Hypsitycha_ (_Rynchotrema_) _neenah_ Wang, _Plaesiomys bellistriatus_ Wang (_Dinorthis subquadrate_ of Schuchert and Cooper, 1932), _Zygospira_ sp.

The dolomite lies in channels to 1' deep in the quartzite.

Eureka Quartzite:

Quartzite, weathered and spongy-looking.	2	339
Quartzite, vitreous gray and pocketed, grading to white and grainy in lower 15'; base of upper vitreous member.	72	337
Quartz sandstone, hard, white, yellowish weathering, broadly cross-bedded in lower part; upper sandstone member.	25	265
Quartzite, hard to grainy weathering, large weathered pockets frequent (to 2" in diameter); white and light gray.	48	240
Quartzite, whitish, weathered into hollow.	17	192
Quartzite, white, yellow-stained, medium-bedded, much pocketed in middle 20'; friable sandstone seam at 18' from top.	40	175
Quartzite, massive, vitreous light gray in higher 15', white and grainy, pink weathering below; occasionally pocketed; cross-laminated 10' from top. Base of equivalents of type Eureka members.	37	135
Covered.	3	98
Quartzite, thinly bedded and pebbly at base, red and yellow, grainy; ledge; part of shaly quartzite member.	10	88
Covered; formational boundary not located.	85	85

Crystal Peak Formation:		
Calcilutites, closely yellow silt-parted, rubbly, dark gray, bluish-gray weathering; occasional calcarenite and limestone pebble beds.	85	85
Swan Peak (?) Quartzite - (Watson Ranch Tongue):		
Covered, bluish-gray weathering, calcilutite and some red argillite shale in float.	68	129
Calcilutite, bluish-gray weathering, closely silt-parted; ledge.	4	61
Covered, as next above.	54	57
Quartz sandstone, reddish and yellow-brown weathering, ledge.	3	3
Lehman Formation:		
Covered, calcilutite float.	12	146
Calcilutites, thinly bedded and silt-parted, occasional thin calcarenite coquina and intraformational conglomerate beds; cross-laminated in part; yellow sandstone and argillite float 50' from top. _Leperditia_ sp. and orthid brachiopods in lower part, especially in basal calcarenite bed.	134	134
Kanosh Shale (in part after Hintze, 1952):		
Calcisiltites, dark gray, medium dark gray weathering, with fine coquinas and occasional calcilutites; partly covered; _Orthis_ sp., like _O. michaelis_ Clark.	319	319
Juab Limestone:		
Calcisiltites.	135	135

GRANT RANGE (13): On the west side of the Grant Range, on the east side of the Nyala road, 9.8 miles from Currant, in T.8N., R.56E.

Upper Ordovician (?):		
Dolomite, light gray, darker above; thickness not measured.		
Dolomitic quartzite, apparently gradational sequence.	5	5
Eureka Quartzite:		
Quartz sandstone, white; crest of ridge.	15	405
Quartzite, vitreous, white, light gray and brownish weathering, massive; cliff-forming. Base of upper vitreous quartzite member.	70	390
Quartz sandstone, light yellow weathering, friable, forming upper sandstone member.	50	320

Quartzite, slope-forming, light gray; white in lower 10'.	60	270
Quartzite, slope-forming in higher 10', vitreous, becoming a remarkably uniform gray downward; a weathered zone 95-100' from top; base of equivalents of type Eureka quartzite.	110	210
Covered.	10	100
Quartz sandstone, easily friable, reddish, orange weathering.	5	90
Covered.	2	85
Quartzite, thinly bedded, slightly dolomitic, coarsely grained in part, argillite-parted, reddish- and yellowish-gray.	18	83
Covered, apparently argillites.	16	65
Quartzites and dolomites, black and olive brown argillitic shale intercalations, quartzites very thinly bedded, dark gray, reddish-brown to olive brown weathering; form ledges and slopes.	50	50
Pogonip Group:		
Covered; probably as exposed below.	27	530
Calcareous and possibly phosphatic argillilutites and siltites.	3	503
Dolomites, black, finely grained, largely covered.	73	500
Calcilutite, black, irregularly silt-parted and striped, ledge.	12	427
Covered.	25	415
Calcilutites as above, more irregularly silt-parted in lower part; form prominent bluff.	105	390
Calcilutites, intermittently exposed, very irregularly yellow silt-parted; Leperditia sp. up to 65' from top.	85	285
Calcisiltite, black, irregularly silt-parted, light to dark bluish-gray weathering; ledge.	5	200
Calcilutites with thin beds of calcarenite and coquinal debris, red silt-parted.	57	195
Covered.	88	148
Calcarenites, occasional intraformational conglomerates, and medium gray weathering black, calcite-flecked calcilutites; closely yellow silt-parted, rubbly, intermittently exposed; Leperditia sp., orthid brachiopods at base of exposure.	60	60

WHITE PINE RANGE (14): On the west face of the range, on the northernmost portion of Duckwater Mountain, about 1 mile east of the end of the Black Rock Canyon road in T.13N., R.58E.

Upper Ordovician:		
Dolomite, medium-grained, dark bluish-gray, weathering light gray; cherty; *Streptelasma* sp.	300	300
Eureka Quartzite:		
Quartz sandstone, gray and red, dolomitic.	5	448
Quartzite, whitish-gray, slightly pocketed.	14	443
Quartz sandstone, irregularly laminated, reddish-orange-and purple-stained, siliceous nodules.	10	429
Quartzite, white, slightly yellow-stained, thickly bedded, less quartzitic downward; base of upper vitreous quartzite member.	45	419
Quartz sandstone, laminated, red.	10	374
Quartz sandstone, white, friable in part, with large cross-bedding; base of upper sandstone member.	25	364
Quartzites and quartz sandstones, white, grainy weathering, occasional red spots, especially at base; re-entrant 40' from top and at base.	135	339
Quartzite, hard, grainy weathering, white.	25	204
Quartzite, thickly bedded and massive, grainy weathering, white, reddish-stained.	39	179
Quartzite, thickly bedded, grainy weathering, white.	31	140
Quartzite, hard and white in higher 15', grading to grainy, dark reddish-brown weathering, very thickly bedded; base of equivalents of type Eureka quartzite.	30	109
Argillitic shale and friable quartz sandstones, intercalated, yellowish-brown weathering.	14	79
Quartzite, reddish-gray and mottled.	15	65
Argillitic shale and quartz sandstones, intercalated.	10	50
Quartz sandstones, yellow-stained, thinly bedded, friable, with argillite interbeds in lower 11'.	21	40
Quartzite, vitreous, gray, red-stained, laminated.	5	19
Covered, base of shaly quartzite member of Eureka quartzite; contact with dolomite concealed.	14	14
Pogonip Group (Remainder of section after Hintze, 1952):		
Section offsets across canyon.		
"Dolomite Member":		
Dolomite, medium dark gray, weathers brownish-gray, and yellowish-gray, thick-bedded, ledge-forming, cherty in upper few feet.	27	2990

Lehman Formation:		
Calcilutites, silty, thick-to thin-bedded, weathers gray to bluish-gray, ledges in higher part. 1-1/2'-thick Eofletcheria bed 15' from top, *Anomalorthis* sp., *Orthis* sp., *Barrandia*? sp., *Cybelopsis* sp., *Leperditia* sp., branching bryozoa, all 122' or more below top.	397	2963
Kanoshian:		
Calcilutites and calcisiltites, silty, covered in part. *Receptaculites mammilaris* Walcott and *R. elongatus* Walcott, abundant 300' to 354' from top; *Anomalorthis* sp., *Orthis* sp., *Barrandia*? sp., *Cybelopsis* sp., *Illaenus* sp., *Leperditia* sp., large branching bryozoa all common 60' to 90' from top, *Bathyurellus pogonipensis* Hintze 186' from top.	510	2566
Juab limestone and lower Pogonip formations.	2056	2056

SOUTHERN RUBY MOUNTAINS (15): In approximately T.24N., R.56E. Sharp (1942) describes the section on the south side of the North Fork of Lindsay Creek; a similar section is exposed in the Willow Creek Canyon. The Silurian Lone Mountain dolomites overlie poorly exposed Ordovician. Eureka quartzite is present locally where preserved beneath the Silurian but the thickness of the vitreous white quartzites is not stated nor was this writer able to determine it at Willow Creek. The following is a summary of Sharp's section:

Limestone (calcilutites), argillite-parted.	225	3650
Limy quartzite and sandstone, brown weathering and leached, limestone intercalations.	260	3425
Limestone, finely crystalline, locally cherty and argillaceous.	265	3165
Argillaceous limestone.	75	2900
Limestone, thinly bedded, argillaceous partings.	200	2825
Limestones, intraformational conglomerates, and argillaceous limestones.	2625	2625

The lower limestones contain the early Canadian *Kainella* fauna, and higher beds contain *Endoceras* sp., *Leperditia* sp., and *Pliomerops canadensis* Billings. The highest 225' of beds may be referred to the Crystal Peak interval, and the subjacent quartz arenites to the Swan Peak; argillaceous limestones below the quartz arenites would be the Lehman and Kanosh equivalents.

LONE MOUNTAIN (16): In T.20N., R.51E., about 18 miles northwest of Eureka, and 3 miles north of the Lincoln Highway (U.S. 50) is the (redesignated) type section of the Eureka quartzite, on the west face of Lone Mountain.

Hanson Creek Formation:

Thickness not measured, reported to be 318 feet (Merriam and Anderson, 1942); dark gray medium-grained dolomite, has sharp contact with quartzite.

Eureka Quartzite:		
Quartzite, dolomitic, gradational with lower beds.	3	181
Quartz sandstone and quartzite, light gray, brown weathering and slightly calcareous at top, grades down into cross-laminated grayish-white sandstone at the base; forms upper gray quartzite member. It has a sharp contact with	48	178
Quartzite, laminated, light gray, vitreous, orange weathering in part.	42	130
Quartzite, strongly cross-laminated, whitish, tan to reddish-brown weathering.	13	88
Quartzite, massive, tan and red-brown weathering, slightly laminated and pocketed; extends to base of white quartzite member.	31	75
Quartzite, whitish, somewhat grainy weathering.	9	44
Quartzite, hard and vitreous in part, partly tan, weathers purplish.	5	35
Quartzite, very dense, vitreous, tan and red weathering, red and brown discolored quartzite, with 3' whitish bed 15' from the base. This is the base of the lower discolored quartzite member, and base of the formation.	30	30
Unnamed Formation:		
Covered, weathered re-entrant.	3	43
Quartz sandstone and sandy dolomite, dark gray weathering to tan and red weathering upward; more quartz sand upward.	40	40
Pogonip Group:		
Covered.	19	828
Calcilutite, black, rough-weathering, silt-parted, becoming partially blue-gray weathering downward; exposed in ledges with occasional calcisiltites. *Leperditia* sp. near base.	104	809
Calcisiltite, almost calcarenite, bluish-gray, *Leperditia* sp., *Hormotoma* sp.	83	705

Calcisiltites, occasional calcilutites and calcarenites; yellow silt-parted, (bluish) gray weathering, cherty in higher 75'. _Orthis_ sp., aff. _O. michaelis_ Clark, _Macronotella_ sp., _Pseudomera_ sp. 110' below top.	210	622
Calcarenite, dark gray, gray and slightly reddish weathering, irregularly silt-parted; 15' intraformational conglomerate 90' from the top; cherty in lower part. Irregularly silt-parted and bedded, some calcilutite, in lower 30'. _Receptaculites_ sp. 60' from top; _Orthis_ sp. (sp. B of Ulrich and Cooper, 1938), _Hesperonomia_? sp. and _Pseudomera_ sp. 110' from the top.	150	412
Calcisiltites and occasional dolomites, irregularly silt-parted, rough weathering, medium gray, to base of good exposure.	262	262

KANOSH (17): About 13 road miles southwest of Kanosh, Utah, on highway U.S. 91 in Baker Canyon, Ordovician rocks are exposed along the road and on adjacent hillsides, in section 26, T.24S., R.7W. These exposures are part of a scattered line of exposures along the highway from Dog Valley, 1 mile south, to White Sage Flat, 5 or 6 miles to the north-northeast. The description of the Kanosh shale and lower formations is by Dr. L. F. Hintze (Hintze, 1951), whose father, Dr. F. F. Hintze, made a special trip to locate the section for his son and the present writer. The quartzite descriptions are from two overlapping but incomplete exposures about 300' apart, and are believed to be essentially correct despite the fact that the beds are overturned, dipping 40°-80° to the northwest.

Upper Ordovician (?) Dolomite:

Dolomite, medium-grained, cherty, light gray weathering; intermittently exposed for several hundred feet but structure uncertain. Sharp basal contact.

Eureka (?) Quartzite:

Quartzite, purplish and pinkish-gray, grading to white 8'-10' from the top; vitreous, medium to finely grained, white quartzite has vivid red and purple streaks. Intermittently exposed below uppermost 15'.	100	137
Quartzite, below small crest, poorly exposed;	37	37

Lehman Formation:

Covered, possible sandstone outcrop at base.	30	57
Quartz sandstone, gray-, tan- and purple-tinged, coarsely grained.	4	27
Calcisiltites, light to dark gray.	23	23

Kanosh Shale:

Calcarenite, silty and yellow-brown weathering, with brown argillite intercalations; *Orthis michaelis* Clark, bryozoans, cystid fragments, pliomerid.	45	45

Juab Limestone:

Calcisiltite, medium gray, silty; *Orthis* sp., *Pliomerops* sp.; 231 feet of variable Fillmore limestones were measured (See Hintze, 1951, for detailed description).	70	70

SCIPIO (18): Ordovician rocks were measured at the west foot of the Pavant Range in sections 3 and 10, T.19S., R.3W., about 5 miles south of Scopio. The section is reached by following a truck trail about a mile to the southeast from the point where highway U.S. 91 crosses the Canyon Range-Pavant Range divide. The beds dip 80° at the base and 20° at the top, N. 60° E. Ordovician quartz sandstones are overlain by Paleozoic limestones and dolomites beneath the capping Cretaceous or Eocene conglomerates.

Upper Ordovician or younger:

Calcilutites and finely grained dolomites, black, mostly in float; ledge 150' from base.		

Eureka (?) Quartzite:

Quartz sandstone, light pink and tan, in float only, on long slope.	155	155

Swan Peak (?) Quartzite:

Quartzite and quartz sandstones, white to light gray, light pink and yellow weathering, silty spots; medium-to coarsely grained, coarsely grained and friable in lower 20'.	108	320
Quartz sandstones, whitish, coarsely grained, yellowish weathering.	33	212
Quartz sandstones, yellowish-brown; occasionally white, weathering pink; mostly float, more rock seen in higher 15'; ledge at base.	109	179
Covered, quartz sandstone and quartzite float, with calcarenite and calcilutite float. Hintze (1951) assigns 83' of these beds to the underlying Kanosh shale.	70	70

Kanosh Shale:

Argillaceous shales, mostly covered, with intercalated dark gray calcarenites, weathering medium brownish gray; *Orthis michaelis* Clark, cystid plates, *Pliomerops* sp.	284	284

Juab Limestone:

Calcarenite, ledge forming, silty.	72	72

FISH SPRINGS (19): Ordovician quartzite forms the crest of the Fish Springs Range and part of its western dip slope overlooking the re-entrant occupied by the various workings of the Fish Springs district. Hintze's section (1951) starts at the base of the Ordovician, in a southern arm of the eastward-draining canyon utilized by the Pony Express trail in crossing the northern part of the range from the present Thomas Ranch. In T.11S., R.14W.

Upper Ordovician Dolomite:

Dolomite, alternating 5' to 15' light and dark gray units; whitish stains. Thickness not measured.

Eureka Quartzite:

Quartz sandy and silty dolomite.	2	160
Covered.	4	158
Quartz sandstones and quartzite, alternating, reddish-brown weathering; 18-inch greenish friable sandstone 17' from top.	39	154
Quartzite, very light gray, partially reddish-brown weathering.	15	115
Covered.	19	100
Quartzite, vitreous, light gray, medium to dark brown weathering.	10	81
Quartz sandstone, friable, pebbly, yellow-brown.	4	71
Quartzite, massive, light gray, vitreous, mottled.	3	67
Quartz sandstone, laminated, yellow.	4	64
Quartzite, light gray to brownish-gray, vitreous.	6	60
Quartz sandstone, hard, irregularly bedded and laminated, yellowish-brown; cross-laminated near base.	26	54
Quartzite, grainy, reddish-brown weathering, massive.	10	28
Quartz sandstone, white, light grayish and yellow weathering.	10	18
Quartz sandstone, yellow-brown to black, friable.	5	8
Quartzite, purplish-white, very finely grained.	3	3

Crystal Peak Dolomite (in part after Hintze, 1951):

Dolomite, coarsely grained, medium light gray, light brownish-gray weathering, ledge-forming.	78	78

Swan Peak Formation:		
Covered.	33	61
Quartz siltstone, thinly bedded, buff and reddish-brown weathering.	28	28
Lehman Formation:		
Calcilutite, medium bluish-gray, closely silt-parted, vuggy in lower part; _Hormotoma_ sp.	33	50
Dolomite, coarsely grained, buff-gray weathering, somewhat silt-parted, slight orange discoloration; ledge-forming.	17	17
Kanosh Shale:		
Calcarenite and argillaceous shale; _Orthis michaelis_ Clark, _Pliomerops_ sp., _Macronotella_ sp.	23	33
Quartz siltstone, calcareous, thinly bedded, yellowish, brown; _Orthis_ sp.	11	11
Juab Limestone:		
Calcisiltites, thinly bedded, medium gray; _Orthis_ sp., _Pliomerops_ sp.	188	188

Hintze (1951) describes the lower 993 feet of the Ordovician mostly assigned to the Fillmore limestone. Highest Cambrian rocks are thickly bedded, dark gray, cliff-forming dolomites.

THOMAS RANGE (20): In the Thomas Range to the east of Fish Springs, Staatz and Bauer (1952) report measuring 590 feet of Ordovician quartzite. Staatz (personal communication, 1953) has kindly given further details. The section is described as follows:

Dolomite; thick main portion Silurian, lower portion fossiliferous Ordovician Fish Haven equivalent.		
Quartzite, clean, white; almost identical lithology from top to bottom, no shale partings, occasionally cross-bedded; unfossiliferous; "Swan Peak." (Eureka of present writer.)	590	590
Shale; interbedded near base with brick-red dolomite and toward the top with brick-red quartzite, variations gradational.	120	120
Limestone; light gray; edgewise conglomerates near the base; richly fossiliferous at several horizons; "Garden City;" base unexposed, so total thickness unknown.	400-500	400-500

TINTIC MINING DISTRICT, UTAH (21): No Middle Ordovician rocks are preserved in this district. Early reports dated the Ajax limestone (625') as Lower Ordovician, the Opohonga limestone (825') as Lower Ordovician, and the Bluebell dolomite (894') as Lower to Upper Ordovician. Hintze reviews Lovering's reassignment of Upper Ordovician, Silurian, and Devonian formations, which placed all but 180' of the Bluebell dolomite in the Silurian (Hintze, 1951); Hintze restricts the Bluebell to the Upper Ordovician, on the basis of a zone F faunule found in the Upper Opohonga limestone, showing equivalence to the middle Fillmore limestone of the Ibex area. Thus a thickness of 1000-2000 feet of limestone and several hundred feet of quartz arenites are absent in the Tintic district, by non-deposition in part and, probably, later erosion. Rigby (personal communication, 1952) observed that the Opohonga limestone thins northward by convergence as well as by subsequent disconformity, dating the beginning of the relatively lesser subsidence and eventual uplift as within early Ordovician.

GOLD HILL (22): Nolan reports that Middle Ordovician quartzites are lacking, although the Lower and Upper Ordovician carbonatites are present (Nolan, 1935); nondeposition, subsequent erosion, or both, rather than structural complications, are believed to be the cause. Such quartzites are reported to be present farther south in the same range, and are visible about 7 miles south of Robison Ranch, in T.15N., R.70E., on the east flank of the north Snake Range (Hintze, 1951).

NORTH STANSBURY RANGE (23): In T.2S., R.6-7W., the northeasternmost nose of the Stansbury Range is composed of Garden City limestones. Hintze found faunal zones G and J of Ross (1949, 1951) in them and zone M in a series of hard olive-green siliceous shales overlying the Garden City (Hintze, 1951). No quartzite or quartz sandstones are present beneath, presumably, the Upper Ordovician, in contrast with the Stansbury Island section about 10 miles to the northeast. Evidently the northern Stansbury Range was on the rather abrupt northern edge of the area of lesser subsidence in west-central Utah.

STANSBURY ISLAND (24): On the east limb of the prominent anticline on the south end of Stansbury Island. In T.2N., R.6W.

Fish Haven Dolomite:

Dolomite, black, weathering dark gray, extremely cherty, 200 feet or thicker.

Covered, 40 to 65 feet.

Swan Peak [and Eureka (?)] Quartzite:

Quartzite, dark reddish-stained, hard and vitreous; gradational with	50	1065
Quartz sandstone, magna cross-bedded, coarsely grained.	120	1015
Quartzite, white, vitreous, finely grained; (may be Eureka quartzite equivalents).	30	895
Quartz sandstones, laminated to thinly or medium-bedded, strongly cross-bedded, with a vuggy zone 175' to 215' down; becomes gray and sub-vitreous at the base.	230	865
Quartz sandstones, vuggy at the top, thickly bedded to laminated; coarsely grained, white at the top, grades down to dirty orange weathering white, coarsely grained; in lower 50 feet and especially at base sandstones are fissile and laminated light orange-colored; occasional quartzite beds; strongly cross-bedded throughout.	245	635
Covered.	58	390
Quartzite, red.	2	332
Quartz sandstone, yellow and covered.	40	330
Covered, float is quartz sandstone and orange-buff to brick-red quartz siltstone.	35	290
Dolomite and covered.	100	255
Quartz sandstone and quartzite, thinly bedded, light brown, light orange-buff weathering; flow structures prominent.	30	155
Dolomite, laminated, dark, and covered.	40	125
Quartzites, buff and brick-red, dolomites; quartzite 40' from top and at base.	85	85

Garden City Formation:

Dolomite, gray, light to dark weathering, medium- to coarsely grained and covered in higher part.	55	433
Covered, float is dolomite, coarsely and finely grained, and quartz arenites from above.	140	378
Dolomite, siliceous?, hard, coarsely grained, grading down to	140	238
Siltstones and limestones; higher siltstones grade down into reticulate silt-parted calcisiltites and calcilutites, light blue-gray weathering, with occasional intraformational conglomerate.	98	98
Section closed, but Hintze (1951) reported 1070 more feet of dolomites, above the Cambrian (?), and includes another 565' of the reticulate silt-parted limestones.		

LAKESIDE MOUNTAINS (25): Southerly dipping Paleozoics expose Ordovician rocks in the central part of the range on the west side of Great Salt Lake. Eleven and three-tenths road miles north of Delle, Utah, and 4 miles west on a narrow road up Cramer Gulch is an abandoned mining shack and dump; one mile southwestward up Mine Gulch on a foot trail are other workings, the base of section being at a small dump in the gulch, SE 1/4, section 23, T.2N., R.9W. Description of the Garden City and the lower part of Swan Peak formations after Hintze, 1951.

Fish Haven Dolomite:

Thickness not measured, rests with sharp but not angular or channeled contact on quartzite, contains Streptelasma sp.

Swan Peak Formation (highest bed may be Eureka quartzite or younger):

Quartzite, finely grained, light gray.	1	141
Argillite, yellow-brown, interbedded with limestone, Anomalorthis sp., Orthis cf. O. swanensis Ulrich and Cooper.	25	140
Covered, float indicates same as above.	15	115
Quartz siltstone, pale yellow-brown, poorly exposed, Orthis swanensis Ulrich and Cooper.	50	100
Limestone, intraformational conglomerate, and intercalated argillites, bearing Anomalorthis utahensis Ulrich and Cooper, Hesperonomiella? sp., Eleutherocentrus sp., Pliomerops sp., cystid plates.	50	50

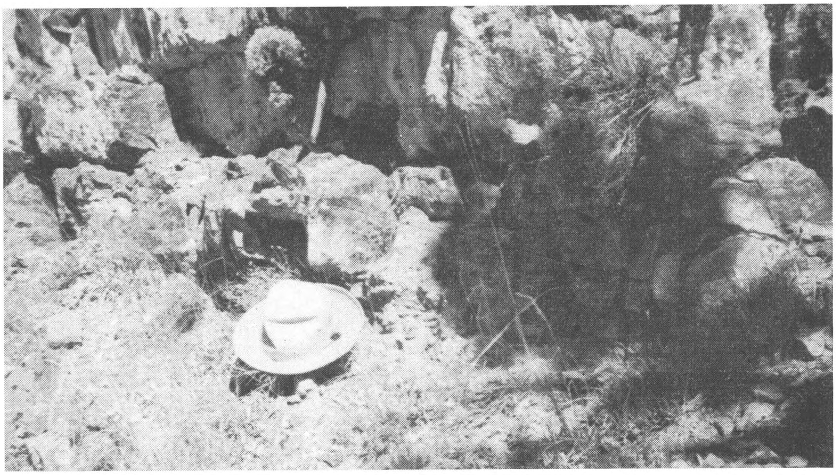

Figure 12. Eureka (?) quartzite at Lakeside Mountains section; one foot-thick quartzite from hatbrim to hammer head; lies between Pogonip and Fish Haven formations.

Garden City Formation:

699 feet of the formation measured, including variable limestones and intraformational conglomerates; the fauna from 294 to 419 feet down appears to be similar to that of the Wahwah limestone (zone J).

PROMONTORY POINT (West side) (26): In T.8N., R.6W. About 9 miles south of the Golden Spike Monument at Promontory, there is a good exposure of parts of the Swan Peak (?) and Garden City formations on the west side of the promontory. The intercalated lower portion of the Swan Peak is poorly exposed, but the quartzites and the Garden City formation are well exposed.

Fish Haven Dolomite:

Thickness not measured. The dolomites are dark gray to black weathering and have only a 3- to 4-inch gradational dolomitic quartz sandstone bed at the base. It apparently represents reworked sand deposited just prior to dolomite deposition.

Swan Peak Formation (or Eureka and Swan Peak Formations):

Quartzite, whitish, vitreous, light gray weathering, yellow-brown and orange surfaced with large cross-laminations; (could be Eureka quartzite).	155	711
Quartzite, white, light gray weathering with very pale orange surfaces; hematite inclusions 30' from the top; gradational to	90	556
Quartzite, white, red-banded, darker gray, reddish and orange weathering with grainy surfaces; becomes darker reddish downward.	219	468
Quartz sandstone, light gray, coarsely grained; forms re-entrant.	6	247
Quartzite, orange and red weathering.	10	241
Quartzite float and talus blocks, no other lithology seen.	33	231
Quartzite, jointed, thickly bedded, orange weathering.	12	198
Covered, quartzite talus; may be shales.	130	186
Argillites and argillaceous calcilutites, gray and black weathering; partially micaceous, *Orthis michaelis* Clark.	8	56
Covered, limestone and argillite float bearing *Orthis michaelis* Clark, *Receptaculites mamillaris* Walcott, cystid fragments.	34	48
Quartz sandstone, gray-brown weathering, irregularly bedded.	7	14
Covered.	7	7

Garden City Formation (After Hintze, 1951):		
Dolomites, dark gray, weathering light gray below top, unfossiliferous.	208	1472
Limestones, variable, and occasional intraformational conglomerates; comprising faunal zones J to F of Ross (1951), remainder concealed.	1264	1264

BECK'S SPUR and NEFF'S CANYON (27): On Beck's Spur, 2 miles north of Salt Lake City and about 1/2-mile east of highway U.S. 91, a 168-foot quartzite sequence is found lying between Cambrian and Devonian limestones, and is again found at Neff's Canyon, to the south of Salt Lake City. At Beck's Spur the lower 100 feet are white quartzites and quartz sandstones, yellowish-and pink-tinged, thinly bedded and laminated in large part. The higher 68 feet are white quartzite and quartz sandstones, buff and gray weathering, so closely pocketed with black-lined holes as to appear black from a distance of 20 or 30 feet. About 30 feet of covered beds and purplish mudstones, with beds of conglomerate of purplish shale pebbles, separates the quartzites from the overlying limestone ledges.

BRIGHAM-MANTUA AREA (28): Two exposures of Ordovician rocks near Brigham, Utah, were examined by the writer. At Round Hill, about 1-1/2 miles north of Mantua, the Ordovician quartzite referred to as Swan Peak is exposed. It is variable, largely thinly bedded and reddish and reddish-brown weathering, and finely grained. The other section, on the very crest of the first Wasatch ridge about 5 miles north of Brigham, appears to be similar to the Round Hill exposure. As described earlier in this report, the grain characteristics at Round Hill are similar to those of the quartzites at Promontory Point, and are closer to those of the Eureka quartzite of the Confusion Range than to the Watson Ranch tongue of the Swan Peak quartzite of the Confusion Range and Scipio. The possibility that the quartzites of the Brigham-Promontory area are Trentonian and correlative with the transgressive Eureka quartzite rather than being Chazyan is discussed above.

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*In the interest of brevity, formational names, where they occur in the stratigraphic sections, have not been indexed.

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