BRIGHAM YOUNG UNIVERSITY RESEARCH STUDIES

Geology Series Vol. I No. 5 November, 1954

GEOLOGY OF THE CENTRAL BOULTER MOUNTAINS AREA, UTAH

by

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GEOLOGY OF THE CENTRAL BOULTER MOUNTAINS AREA, UTAH

A thesis

submitted to

the Faculty of the Department of Geology

Brigham Young University

In partial fulfillment

of the requirements for the degree

Master of Science

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by

Melvin O. Dearden

November, 1954

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ACKNOWLEDGMENTS

The writer gratefully expresses thanks to the Geology Department of the Brigham Young University for the use of field equipment, laboratory, and other facilities during the course of the study. The help of Dr. Harold J. Bissell, head of this department, who has read and revised the report is gratefully appreciated.

Graditude is expressed to Dr. J. Keith Rigby for his assistance in field work, identification of fossils, and timely suggestions and criticisms in the writing of this thesis.

Thanks is accorded to Dr. Kenneth C. Bullock for his help in the petrographic mineral study and for his suggestions concerning the writing of various phases of this report. Thanks is also given to Dr. E. John Eastmond of the Brigham Young University Physics Department for his cooperation and time spent in spectrographic analysis of altered sedimentary and igneous rock samples.

The writer thanks various geology graduate students of the Brigham Young University who helped in many ways during this study.

Last but not least, the writer expresses sincere thanks to his wife, Marion, for her understanding help and encouragment, especially during the completion of this study.

ABSTRACT

The central Boulter Mountains area contains rocks of seventeen Paleozoic formations ranging from Lower Cambrian to Upper Mississippian. A total thickness of 11,000 feet in the Paleozoic section is exposed. Tertiary vocanic deposits, and Quaternary alluvial sediments are also present.

The North Tintic anticline is the chief structural feature of the area. Two major tear faults displace the near vertical strata eastward. A low angle thrust fault joins the two tears and cuts out some formations.

Future economic development of clay and metallic minerals is possible but not probable.

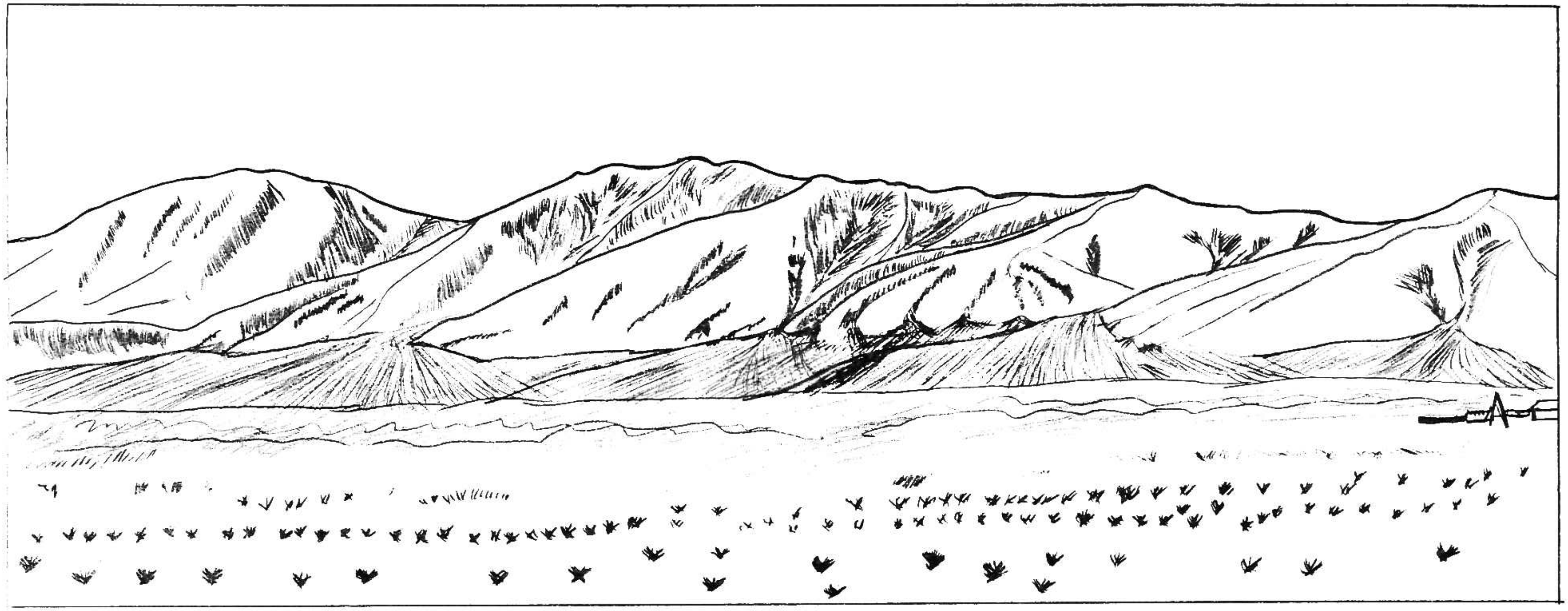

Fig. 1. - View showing the east side of the central Boulter Mountains. Note the large alluvial fans.

INTRODUCTION

LOCATION AND ACCESSIBILITY

The Boulter Mountains are located in southwestern Utah County, Utah, on the southwest side of Cedar Valley. The area in the central part of the range, between Bismark Hill on the south and Rattlesnake Spur on the north, was studied and mapped in detail for this report (see Plate 3). The mapped area extends approximately three and one-half miles west of the eastern margin of the mountains and lies between meridians 112° 07' 45" and 112° 10' 30" West Longitude, and parallels 40° 01' 30" and 40° 04' 25" North Latitude. Sections 10, 11, 12, 14, 15; and parts of sections 1, 2, 3, 4, 9, and 13; of T9S and R3W, and parts of sections 7 and 18 of T9S and R2W Salt Lake Base and Meridian are included in the mapped area (see Plate 3).

The area lies approximately forty-eight miles south of Salt Lake City and twenty miles west of Provo. It is approximately ten miles north of Eureka, Utah, in the mountains west of Allen's Ranch.

The area is accessible from the north by Utah State Highway No. 73 and Ten-mile Pass Road; from the south by Utah State Highway No. 6 and Homansville Pass Road; from the east by Utah State Highway No. 73 and Greeley Pass Road; and from the west by Twelve-mile Pass Road and Black Rock Canyon Road. All of the roads leading from the state highways into this area are improved gravel or dirt roads (see Plate 3).

The nearest railroad is a branch of the Denver and Rio Grande Western, eleven miles to the south via the Homansville Pass Road.

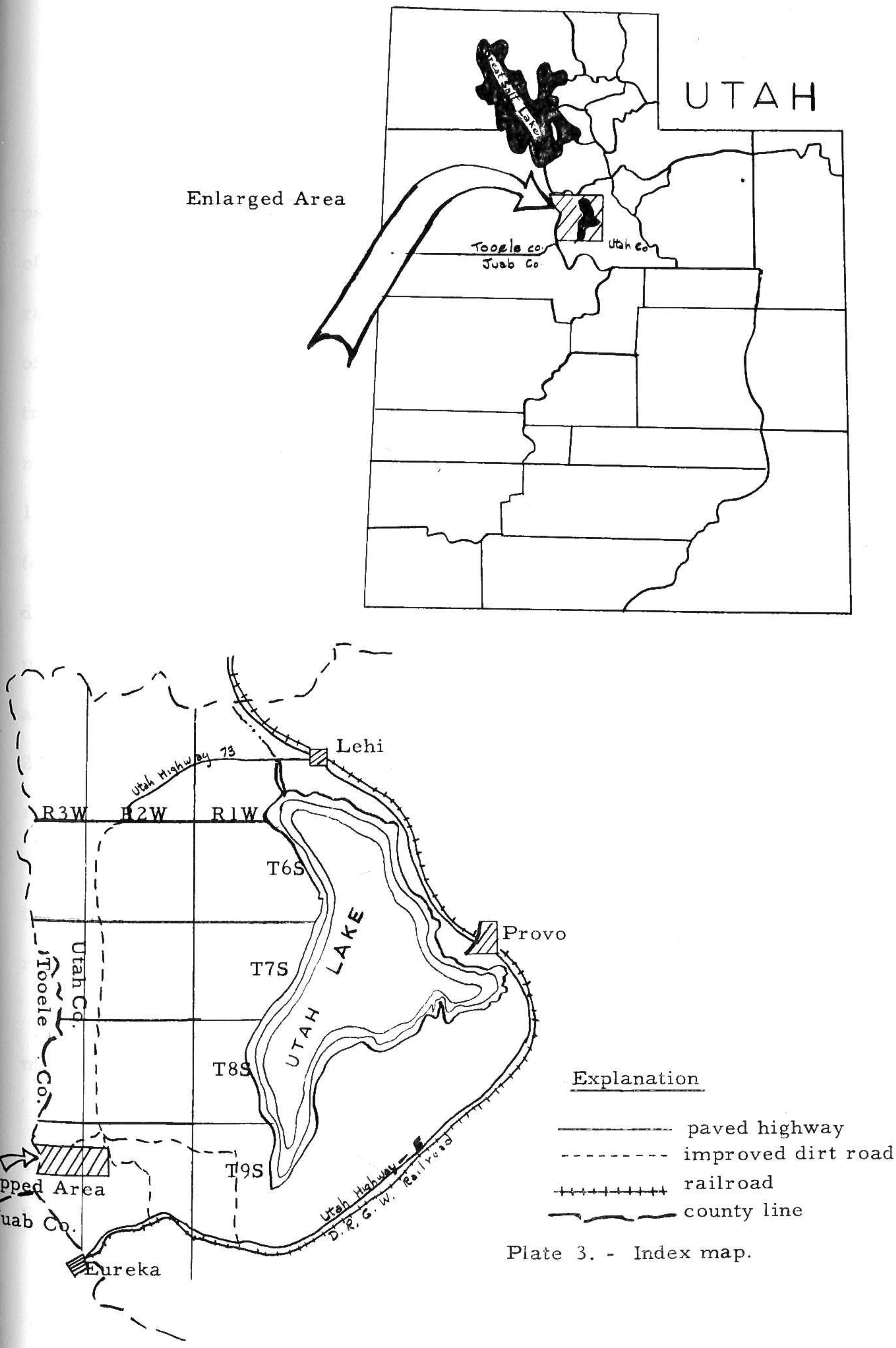

Plate 3. - Index map.

PHYSICAL FEATURES

The East Tintic Range is divided topographically into three nearly parallel north-trending mountain ranges which diverge immediately north of the northwest corner of the Tintic Quadrangle. The western and central ranges are separated by a prominent valley known as Broad Canyon. Portions of these ranges have been mapped for the present report. The north-south trending range east of Broad Canyon stands out as a prominent ridge in marked relief above Cedar Valley. The maxium relief is slightly over 1600 feet ranging from 5600 feet in the north part of Broad Canyon to 7200 feet on the ridge north of Bismark Hill. The altitude of the ridge gradually decreases toward the north until the ridge ends near Twelve-mile Pass. A mature stage of dissection is apparent as the result of extended erosional activity. In many places the steep canyon walls have slopes of approximately 27 degrees. Several large fans extend east and west from the base of the ridge (see fig. 1).

All streams within the area are intermittent and drain eastward into Cedar Valley or westward into Broad Canyon. The latter eventually reaches Cedar Valley to the north of the mapped area.

The climate is semi-arid. The mean annual rainfall at Bauer, 30 miles to the northwest, for the period 1944-1953 is shown in Table 1.

The scanty vegetation is typical of a semi-arid region. It consists of varied small cacti, sagebrush, rabbit brush, and scattered tufts of grass. Flowers, especially Sego lilies and Indian paintbrush are abundant in the spring.

TABLE 1

TOTAL ANNUAL PRECIPITATION
FOR TEN YEAR PERIOD

Year	In. of Ppt.
1944	18.45
1945	18.21
1946	14.03
1947	22.27
1948	16.43
1949	16.67
1950	13.80
1951	15.97
1952	15.67
1953	12.20
Total	163.80

Pinyon Pine, Juniper, and Mountain Mahogany are the common trees of the higher slopes. Maple thickets occur at lower elevations in the ravines, especially those on the eastern slopes of the area.

SCOPE OF REPORT

The report is concerned with the geologic features of the area. The stratigraphy and lithologic features of the eighteen Paleozoic formations present have been analyzed. Where any marked change from rocks found in the type locality is encountered, special mention is given in this report. Igneous rock types of the area were analyzed petrographically and comparison made with known types. Some of the rocks in certain areas have been altered by an extrusive flow or by faulting; this alteration was studied, and a short report of the results of the study is made.

PREVIOUS WORK

Much of the past geologic work in Central Utah has been confined to the Tintic mining district, five miles to the south. Mining commenced in the Tintic district in 1869. Wheeler (1875) made a report of the district in which he mentions Cedar Valley. This valley borders the area of the present report on the east. The valley is described as an intermontane type between north-trending parallel ridges and as being characteristic of the Great Basin type topography.

Lindgren and Loughlin (1919, pp. 265-266) in "U. S. G. S. Professional Paper 107" summarized earlier reports on the Tintic district, extended the mapped area and formalized the stratigraphic unit of the district. They define the North Tintic district briefly as that which includes all of the country in the East Tintic Range, north of the Tintic and East Tintic districts. They also mention an anticlinal axis which trends north-north-eastward through the northwest corner of the Tintic quadrangle, pitching northward beneath Broad Canyon.

Lovering et. al. (1949) published a thorough study of rock alteration in the East Tintic mining district and later (1951) redefined several stratigraphic units.

The northern part of the area of this report was mapped and described by Johns (1950) in an unpublished Master of Science thesis. An unpublished geologic report and a map of the adjacent seven and one-half minute Allen's ranch quadrangle has been recently complete by Proctor (1953). Renzetti (1952), Axenfeld (1952), and Sargent (1952) in Masters of

Science theses for the University of Indiana mapped and studied adjacent areas to the west, northwest, and southwest respectively. Foster, (Master of Science thesis, B. Y. U. 1954) mapped the area immediately to the south in 1953 and the early part of 1954. During the early part of the 1953 summer field season, the Brigham Young University Summer Field Group, under the direction of Bissell and Proctor, studied and mapped the adjacent area for several miles to the north.

FIELD WORK AND LABORATORY METHODS

Field work for this study was confined to the fall of 1953 and the spring and summer of 1954. Geologic data were plotted directly on aerial photographs of a scale of 1:12,000.

Formation contacts as well as major faults, key beds, and other boundaries were walked out within the area considered and simultaneously plotted on the photo. The geologic data were transferred later to a topographic sheet with a scale of 1:12,000. Attitudes of strata and other pertinent geologic data were also plotted on the base as geologic mapping proceeded. One mine was mapped in detail with a tape and a compass.

Laboratory investigations consisted of the following: (1) studies of thin-sections of unaltered limestone and dolomites; (2) petrographic studies of thin-sections of altered limestone, dolomite and igneous rocks, as well as some breccia dike material; (3) qualitative spectrographic analysis of altered sedimentary and igneous rocks. Standard procedure was followed in the above analyses.

GEOLOGY

STRATIGRAPHY

The East Tintic and North Tintic Ranges are composed of Paleozoic sedimentary and Tertiary igneous rocks.

The complete stratigraphic section consists of approximately 6000 feet of Cambrian quartzite, overlain by 8000 to 8500 feet of Lower and Middle Paleozoic limestone, dolomite and shale. Intrusive basalt porphyry and effusive rhyolites, latites, and andesites were mapped in the areas under consideration.

SEDIMENTARY ROCKS

Cambrian System

Tintic Quartzite

Distribution and Thickness. - The Tintic quartzite is the oldest formation exposed in the mapped area and occurs in two localities (see Plate 1). Exposures occur in the low-lying hills in Broad Canyon and on the west side of the Boulter Mountains near the bottom of Rattlesnake Canyon in section 14, T9S, R3W. This formation also crops out north of Taylor Canyon and occupies most of the crest and west side of the Boulter Mountains in section 11, T9S, R3W. The base of the formation is not exposed, but approximately 2000 feet of the upper Tintic crops out east of Broad Canyon in section 11, T9S, R3W. The upper contact was mapped at the highest quartzite bed which is overlain by the shale, slate, and phyllite of the Ophir formation.

Lithology. - Characteristically, the quartzite is light grey to pale pink on the weathered surface. It is commonly red-brown near faults and volcanic areas. A good example of this can be seen in the S. E. 1/4 section 14, T9S, R3W.

The rock has an even fine grain and is composed almost entirely of quartz. Cross-bedding has been observed in the mapped area but is generally inconspicious. The only stratification is a partial development in the southern part of the area where the rocks are essentially vertical. The rock is so badly fractured and jointed in other places that bedding has been obscured.

Thin conglomerate beds are found throughout the formation in some localities. To the writer's knowledge conglomerates are not present in the area under consideration.

A local development of phyllitic slate was found very near the top of the formation in the vicinity of a latite flow in section 14, T9S, R3W in the south central part of the area. Slate occurrences in adjacent areas have been mentioned by Lindgren and Loughlin (1919, p. 23) and Johns (1950, p. 10), but in this area, the phenomena likely is the result of metamorphic activity near the contact of the Ophir formation and the volcanic material. Because of volcanic activity here, it is very difficult to distinguish the exact contact between the two formations as in other areas.

Under a hand lens the light pink quartzite appears to be frosted but very clean, comprised of well sorted and rounded quartz grains.

The work of the United States Geologic Survey (Tower and Smith, pt. 3, p. 620, 1898) just preceeding Lindgren and Loughlin emphasizes the following:

> Microscopic studies show it to be a very pure quartzite, the individual grains being well rounded and for the most part of very uniform size. Occasionally the grains are somewhat drawn out, as if by dynamic metamorphism. Corroded grains are not common, though present. In rare cases the quartz shows crystal facets. In many of the grains of quartz are particles of a dark mineral so abundant as to give the individual grains a very dirty appearance. The nature of these particles could not be determined. The lowest beds of quartzite contain some feldspar and muscovite, while nearly all of the beds show zircon and rutile. In one specimen from the upper portion greenish grains were observed tinged with brown on the rim, which were thought to be glauconite.

Correlation and Age. - The Tintic quartzite was mapped as a continuous unit by the writer from the area adjacent or to the south. While Mr. Jack Foster was a graduate geology student at Brigham Young University, he mapped that area and traced the Tintic formation northward from its type locality in the Tintic district.* The stratigraphic position of the quartzite at the bottom of the Paleozoic section, and its lithologic similarity with typical Tintic outcrops in other areas, indicate that this unit is equivalent to the type formation.

Loughlin (1919, p.24) correlates the Tintic quartzite with the Cambrian quartzite of the Wasatch, Oquirrh, and House Ranges in Utah. D. Peterson (1952, pp. 17-18) reported and photographed *Olenellus* in the Tintic quartzite at Long Ridge near Goshen, Utah. This is the first recorded fossil occurrence in the Tintic quartzite in this part of Utah. The discovery of *Ollenellus* would indicate at least that the upper part of the formation is Lower Cambrian age. It is possible that a Lower Cambrian fauna may occur

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*Personal communication, May 7, 1954.

in the Ophir shale of the Stockton-Fairfield area (Gilluly 1932, p. 9). At this locality the Lower Cambrian-Middle Cambrian boundary is placed a few feet above the base of the Ophir shale.

Ophir Formation

Distribution and Thickness. -The Ophir formation consists of slates, shales, and thin intercalated beds of sandstone and limestone. The name, Ophir, was proposed by B. S. Butler for the shales and intercalated limestone beds which overlie the Tintic quartzite and underlie the Teutonic limestone (Lindgren and Loughlin, 1919, p. 25). Outcrops of Ophir were mapped on the east side of Rattlesnake and Broad Canyons in section 11 and 14, T9S, R3W.

The formation is approximately 500 feet thick in the mapped area but varies considerably because of structural complications. This thickness compares to 320 feet at the type locality, 430 feet in the Twelve-mile Pass area and from 297 to 475 feet in the Tintic district. It is probable that a compete section of Ophir is probably present in the writer's area. Lindgren and Loughlin (1919, p. 26) note that there is considerable lensing and variation in thickness of the shale and limestone beds within the Ophir formation in the Tintic district.

Lithology. -The Ophir formation generally consists of light greenish-brown to reddish-brown shale which may change in color along cleavage places. The shale is fissile and has a platy weathering habit. It is also banded and in most cases shows marked cleavage or fissile structure in one or two directions, usually at low angles to the banding. Numerous limestone beds containing argillaceous partings occur as interbedded units within the shales.

The first noticeable limestone bed above the base appears to be the most massive. It has a banded and mottled appearance which could easily be mistaken for the overlying Teutonic, the Herkimer, or possibly the Opohonga formation. This particular bed weathers to a light reddish-brown leaving a red residual soil. Other limestone beds, stratigraphically higher, are dark to medium bluish-grey and contain the same distinctive argillaceous partings.

In the area where the section was measured the shale near the base is dark reddish-brown and phyllitic. A volcanic flow is present in the area and has probably altered the shale.

Correlation and Age. - Stratigraphic position and lithology indicate that this formation is correlative with the Ophir formation of the Tintic district.

The writer found two distinct fossil genera: (1) what appears to be lingulid type brachiopod; (2) pygidia of Asaphiscus sp. The latter are abundant in thin beds near the middle of the formation.

In recent years there has been a controversy concerning the age to which the formation should be assigned. After identifying Obolus mcconnelli and O. rotundatus, found 100 feet above the base, F. B. Weeks, in 1905 (Lindgren and Loughlin, 1919, p. 26) thought the age to be Middle Cambrian. Walcott, however, (1912, pp. 164-165) listed Obolus (Westonia) ella, Micromitra sp; Micromitra Paterina labradorica utahensis, Olenoides (?), all of which were assigned to the Middle Cambrian. Gilluly (1932, p. 11), however, noted that Dr. C. E. Resser reported Dolichometopus productus and Neolenus sp. found fifty feet above the base of the Ophir shale at its type locality and also in the nearby Wasatch Mountains give strong indication that the formation occupies a position below the middle of the Middle Cambrian. Ulrich (1911, pp. 619-620) maintained that Olenellus survived into the Middle Cambrian, but Walcott restricted the fossil to the Lower Cambrian and always maintained that it could not be given any other age even in the absence or presence of other fossils. At first Ulrich and Burling (Gilluly, 1932, p. 11) did not agree with Walcott as to this definite restriction, but later on Burling changed his mind and assigned the lower part of the Ophir formation to the Lower Cambrian as recommended by Walcott. Gilluly (1932, p. 27) agrees that the bottom part of the formation might possibly be Lower Cambrian. This is the present consensus.

Teutonic Limestone

Distribution and Thickness. - Lindgren and Loughlin (1919, p. 27) named the Teutonic limestone from the Teutonic Ridge in the Tintic district. They make the following statement concerning its lithologic similarity with the limestone units of the Ophir formation. ""The Teutonic limestone. . .is in fact an upward continuation of the limestone members of the Ophir formation."" The formation makes up a large part of the very steep west slope of the Boulter Mountains in section 14, T9S, R3W (see fig. 3). It extends from Taylor Canyon section 12, T9S, R3W, and is a steep slope former at the head of North Canyon. It is 626 feet thick in the mapped area as compared to 564 feet in the Tintic district.

Lithology. -The Teutonic is a mottled, shaly, and thin-bedded, dark-blue limestone which weathers blue-grey with discontinuous yellow, brown, or red-tinted argillaceous partings. Because of the close resemblance to both the Herkimer limestone and the Opohonga limestone definite determination can be made only by its stratigraphic position between the Ophir formation and the distinctive overlying Dagmar dolomite.

Correlation and Age. -A Middle Cambrian age is assigned to the Teutonic limestone because of its position between known Middle Cambrian beds. No fossils had been previously found in the Teutonic formation, but Muessig (1951, p. 23) reported fossils belonging to the Ehmania-Bolaspis-Clyphaspis faunal zone of the Cambrian section. The fossils are as follows:

Bolaspis labrosa (Walcott)
Glyphaspis sp. undet.
Undescribed trilobite genus.

The above faunal zone would indicate Lower Middle Cambrian and would suggest that the Teutonic limestone is correlative with the Swasey limestone of the House Range (Wheeler, 1948, Fig. 5, opp. p. 32).

Dagmar Dolomite

Distribution and Thickness. -Lindgren and Loughlin (1919, p. 27) named the Dagmar from the Dagmar mine in the Tintic district. The Dagmar dolomite makes a very distinctive boundary marker on the steep west side of the Boulter Mountains in section 13, T9S, R3W, and it can be distinguished clearly from a distance. Although, not as distinctive north of Taylor Canyon where it is on the east slope of the mountain, the Dagmar is 77 feet thick in the Boulter Mountains. Loughlin (1919, p. 27) reported a thinning from 100 feet at the type locality to 75 feet at the north boundary of the Tintic quadrangle.

Lithology. -In the mapped area the Dagmar dolomite is light grey with a slight pink tinge on fresh fracture. Its weathered surface is a uniform yellowish to greyish-white. Fine laminations characterize the rock, but they are more prominent on the weathered surface and occur in both fine and medium crystalline rocks.

Beds in the Cole Canyon formation have the same apparent lithology and blocky weathering habit, but they are interbedded with black beds and individually are not as thick as the Dagmar dolomite.

Its lithology makes the Dagmar a good marker bed for mapping purposes. The contact with the underlying Teutonic is somewhat gradational.

Correlation and Age. -The Dagmar in the mapped area is correlated with the same formation at the type locality on the basis of stratigraphic position and very distinctive lithology.

Recognizable fossils have not been found in the Dagmar, but Loughlin (1919, p. 27) indicates its age as Middle Cambrian on the basis of it stratigraphic position between definite Middle Cambrian beds.

Herkimer Limestone

Distribution and Thickness. -The Herkimer mine in the Tintic district is the type area for the Herkimer limestone (Lindgren and Loughlin, 1919, p. 28). The formation crops out in the west half of section 13, and the west half of section 12, T9S, R3W. The Herkimer is 225 feet thick in the Tintic district but aggregates 367 feet thick in the Boulter Mountains.

Lithology. -The Herkimer formation is composed of limestones with a few interbedded dolomites. The limestone is generally bluish-black to medium grey, weathering to the same color. The medium grained rock is medium to thick-bedded and usually contains light red to yellow argillaceous partings. Oolites are present in some parts of the formation. The dolomite is medium grey and has the same type of argillaceous partings common to the limestone. Because of the argillaceous partings, the formation has a very striking resemblance to both the Teutonic and Opohonga limestones. One small bed of very dark grey dolomite contains many white specks and spangles which cause it to superficially resemble the Bluebird dolomite.

Correlation and Age. -Lindgren and Loughlin (1919, p. 28) assigned a Middle Cambrian age to the Herkimer on the basis of relationship to beds of known age. No fossils were found or reported to help substantiate this fact, however, until Muessig (1951, p. 26) found several specimens of *Lingulella* which suggests *L. (Westonia) wasatchensis* Walcott and may be an indication of Middle Cambrian age.

Correlation is made with the type locality at Tintic on the basis of lithologic similarity and stratigraphic position.

Bluebird Dolomite

Distribution and Thickness. -The Bluebird dolomite received its name from Bluebird spur in the Tintic district (Lindgren and Loughlin, 1919, p. 28). Outcrops are found in two localities in the area. Along the top of the Boulter Mountains in section 13, T9S, R3W north of the Holdaway Canyon and south of Taylor Canyon, it forms the ridge crest. North of Taylor Canyon, it crops out in a narrow band which crosses the top of North Canyon.

A thickness of 175 feet was measured in the type locality (Lindgren and Loughlin, 1919, p. 28) and also in the writer's area. Johns (1950, p. 31) measured only 152 feet in the Twelve-mile Pass area immediately to the north.

Lithology. -The rock is characterized by a copious amount of white "twiggy" bodies, which gives the dark greyish-black dolomite a very unique lithology. The white "twiggy" bodies, effervesce slightly in dilute hydrochloric acid, and average about 10mm. in length and 1 to 2mm. in width. The black dolomite has a purplish hue on the weathered surface and does not effervesce. Upon fracturing a fetid odor is emitted.

Although the contrast is not so great between the white "bodies" and the darker dolomite, the "twiggy" bodies or short white rods are also found in the following formations: Herkimer limestone, Cole Canyon dolomite, Opex dolomite, and the Ajax limestone.

Correlation and Age. - The stratigraphic position and the above mentioned distinctive lithology make correlation possible with the Bluebird dolomite in the type locality of the Tintic district.

Because Middle Cambrian fossils occur both above and below the formation, it is assigned to Middle Cambrian age (Lindgren and Loughlin, 1919, p. 28). No fossils have been found to substantiate or refute the assignment for this area.

Cole Canyon Dolomite

Distribution and Thickness. -The Cole Canyon type locality found in the

Tintic district is named for a canyon not far from Mammouth, where the writer checked the type locality. The name was given to the formation by Lindgren and Loughlin (1919, p. 29). This formation is one of the most prominent in the area under consideration and is exposed in sections 1, 10, 12, 13, and 15; T9S, R3W.

The lower contact is drawn at the last dark dolomite with distinctive "twiggy" bodies and the beginning of the first white dolomite bed. The upper contact is taken at the top of the last "Dagmar-like" light-dolomite bed. This is near 50 feet of "Opohonga-like", limestone and is overlain by 40 or 50 feet of oolitic dolomite.

The measured thickness of the Cole Canyon in the writer's area is 838 feet. Lindgren and Loughlin (1919, p. 29) measured 500 feet to 510 feet in the Tintic district, and Johns (1950, p. 34) measured 540 feet in the Twelve-mile Pass area. Paul Dean Proctor (Geologist; Assistant Raw Materials Exploration Director; U.S. Steel Corp., Geneva, Utah)* who measured 1000 feet in the Allen's Ranch quadrangle informed the writer that the alternating light and dark beds of the formation vary greatly in thickness over given localities.

Lithology. -Alternating beds of light and dark dolomite characterize this formation. The dark type bed has the following lithology: dolomite, medium to dark grey-blue, crystalline fine to medium grained, massive bedded. Banding, mottling, and local oolitic beds distinguish this dark unit. The subordinate lighter type bed has the following lithology: dolomite, medium grey-blue to yellowish and pinkish grey, weathering prominent light grey to white. It is fine-grained to sublithographic. These beds are prominently lami-

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*Personal communication, March, 1954.

nated and resemble the Dagmar formation but are not as thick in individual beds.

The light and dark color difference is more marked in the lower part of the formation where the alternating light and dark beds are from 10 to 25 feet thick. One small part of the formation near the base resembles the Opohonga limestone.

Correlation and Age. -Stratigraphic position and the very distinctive light and dark banding make possible correlation with the formation in the type locality of the Tintic district.

A Middle Cambrian age was suggested by Lindgren and Loughlin (1919, p. 29) on the basis of *Obolus mcconnelli,* which ranges from lower to upper Middle Cambrian. No new fossil data has been reported from other areas, nor was the writer able to find fossils in the area of study.

Opex Dolomite

Distribution and Thickness. -Lindgren and Loughlin (1919, p. 29) named the Opex dolomite from the Opex mine in the Tintic district. This formation outcrops on both sides of Broad Canyon in sections 1, 10, 12, 13, and 15; T9S, R3W. (see Plate 1).

The formation thickens northward. In the Tintic district at the type locality it is 393 feet thick (Lindgren and Loughlin, 1919, p. 27); in the Boulter Mountains it is 453 feet thick; and in the Twelve-mile Pass area it is 700 feet thick (Johns, 1950, p. 41).

Lithology. -The Opex is characteristically composed of interbedded mottled limestones, brown sandstones, and mottled dolomite. Certain parts of the formation resemble the Opohonga and Teutonic limestones, and it may be easily mistaken if its stratigraphic position is not closely observed.

A mottled "Teutonic-like" dark-blue-grey to maroon limestone containing large oolites is found within 25 feet of the basal contact with the Cole Canyon. According to Allen M. Disbrow (Geologist, United States Geologic Survey, Eureka, Utah)*, this characteristic basal bed occurs at this position throughout the Boulter Mountain area. Immediately above this basal bed and as the oolites become smaller in size and hence less apparent, a light brown medium grained sandstone is interbedded with the limestones. Oolites also occur higher stratigraphically, but here they are in a medium to thick bedded, light-blue to blue-grey dolomite. Cross-bedded dolomite and flat-pebble conglomerates occur near the middle of the formation immediately below an Opohonga like limestone and shale sequence. An upper dark shaly limestone occurs approximately 75 feet below the upper contact. A medium dark-grey finely oolitic dolomite is the uppermost lithologic unit of the Opex and marks the formation's contact with the overlying Ajax.

Correlation and Age. - In 1905 Weeks (Lindgren and Loughlin, 1919, p. 30) found upper Cambrian fossils in the Opex dolomite about 2000 feet above the Tintic quartzite. Billingsella sp., was found in the Opex formation twenty-five feet from the upper contact with the Ajax limestone in the area immediately to the south. Silicified Billingsella sp. were found in the Opex by the writer on the west side of Broad Canyon. These fossils are locally abundant in a certain zone. A boundary between Middle and Upper Cambrian has not been definitely established in Central Utah. Lindgren and Loughlin

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*Personal communication, September, 1954

(1919, p. 30) have arbitrarily placed the contact at the upper most light colored bed in the Cole Canyon dolomite; thus the Opex is considered as Upper Cambrian.

The Opex formation in the present area is correlated with that of the Tintic district on the basis of lithology and stratigraphic position.

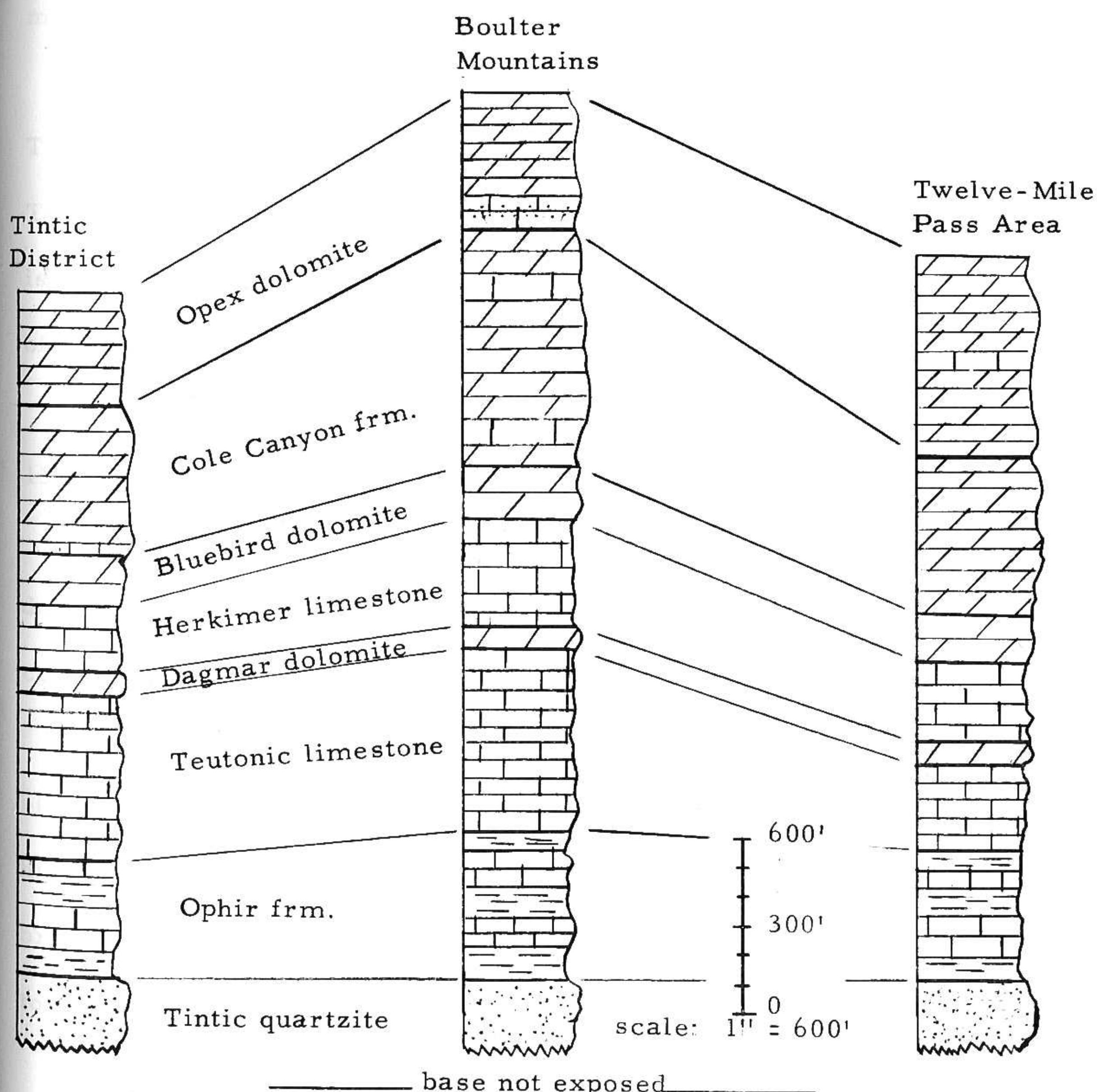


Fig. 2. - Generalized columnar sections of the Cambrian formations.

Cambrian-Ordovician (undivided)

Ajax Limestone

Distribution and Thickness. -This formation was named from the Ajax mine in the Tintic mining district by Lindgren and Loughlin (1919, p. 31). It includes the three members, an unnamed lower member, an Emerald member, and an unnamed upper member.

Lindgren and Loughlin (1919, p. 31) measured 540 feet of Ajax in the Tintic district to the south. Johns (1950, p. 45) measured 738 feet in the Twelve-mile Pass area, one mile north of the mapped area. The formation is 580 feet thick in the writer's area. These measurements indicate thickening of the Ajax formation toward the north.

Outcrops of the formation occur in sections 1, 3, 10, 12, 13, and 15; T9S, R3W (see Plate 1).

Lithology. -The Ajax is characteristically medium-grey to light-grey dolomite with some interbedded limestone. Chert bands and blebs are very common in the formation.

The lower portion of the lower member is dark-blue grey to medium-blue grey dolomite containing obscure "twiggy" bodies. Stratigraphically higher, the dolomite is light-to medium-grey, fine-to medium-grained with brown and black chert nodules. The number of chert beds increases upwards to the base of the Emerald member.

The Emerald member has not been mapped separately because it is not distinguishable everywhere in the area. The Emerald member is finely crystalline, light-tan to light-cream colored and varies from 30 to 40 feet thick. It lies about 200 feet from the top of the formation. In isolated outcrops the Emerald bed can be mistaken for one of the upper light colored units of the Cole Canyon formation.

The upper 200 feet of the Ajax formation is medium grey, thin-to medium-bedded, finely crystalline limestone. It characteristically contains distinctive stringers and nodules of pink to flesh colored chert.

Some pisolites occur 100 feet below the Emerald bed and are believed to be dolomitized Girvenella sp. Their internal structure has been obscured by dolomitization, but small radiating tubuals were observed.

Small crystalline rosettes of dolomite occur locally in the formation. Perhaps they represent replaced fossil fragments.

The upper most limestone grades into the overlying Opohonga limestone.

Correlation and Age -Lithologic similarity and stratigraphic position allow a correlation with the formation in the type locality of the Tintic district.

Fossil identification by Edwin Kirk indicate the formation is Lower Ordovician (Lindgren and Loughlin, 1919, p. 32). Muessig (1951, p. 37) found Lingulella sp. near the base of the lower member suggesting either a Lower Ordovician or Upper Cambrian age for the lowermost Ajax.

Ordovician System

Opohonga Limestone

Distribution and Thickness. -The Opohonga limestone was named from the

Opohonga mine in the Tintic mining district by Lindgren and Loughlin (1919, p. 32). Outcrops occur in sections 1, 3, 10, 12, and 13; T9S, R3W. The formation is 1107 feet thick in the Boulter Mountains as compared to 740 feet in the type locality. Johns (1950, P. 48) measured 1040 feet in the Twelve-mile Pass area to the north and, Renzetti (1952, p. 8) measured 960 feet in the area immediately to the west.

Lithology. -The Opohonga limestone is one of the most distinctive of the Paleozoic formations of the area. It is characterized by alternating partings of red and yellow argillaceous materials surrounding short, thin lenses of light-grey, fine-grained limestone. The Opohonga contains a great number of thin beds of flat-pebble conglomerates. The red and yellow argillaceous lenses of the Opohonga seems to be more persistant than those of the Teutonic or Herkimer limestones. Other formations have horizons within them which resemble the Opohonga limestone.

Where the Opohonga is less yellowish-red or where the Teutonic or Herkimer show extreme coloration, the three may be confused as local outcrops. The greater thickness of the Opohonga limestone and its contacts with the cherty Ajax limestone below and the Bluebell dolomite above aid in identifying it.

Correlation and Age. -Correlation with the Opohonga limestone of the Tintic district is made on the basis of distinctive lithology and stratigraphic position.

Loughlin (Lindgren and Loughlin, 1919, p. 33) found a few poorly preserved fossils in the Opohonga of the Tintic district. These occur about

100 feet below the base of the Bluebell dolomite and were determined by Edwin Kirk as Dalmanella cf. D hansburgensis Walcott, Cyrtolites sp., Ophileta sp. and Asaphus sp. (fragments) and were assigned to the lower Pogonip.

Hintze (1951, pp. 87-89) reports finding the following fossils in the upper Opohonga of the Tintic district:

Brachiopod:-Syntrophina cf. S. carinifera Ulrich and Cooper
(Slightly larger than S. carinifera)

Trilobites:- Protopliomerops superciliosa Ross
Hystricurus oculiluratus Ross
Goniophrys prima Ross
Pachycranium faciclunis Ross
Asaphellus? sp.

Cystid stem fragments

The above faunal collection is dated as early Canadian The trilobites are distinctive of a faunal zone found in northeastern Utah from 300 to 400 feet above the base of the Garden City formation. Hintze (1951, p. 88) believes that there is an hiatus from Lower to Upper Ordovician in the area between the Tintic district on the south and Ogden, Utah on the north.

Ordovician-Silurian (undivided)

Bluebell Dolomite

Distribution and Thickness. -The bluebell dolomite was named from the Bluebell mine in the Tintic district by Lindgren and Loughlin (1919, p. 34). The Bluebell has been divided into two parts by Lovering et. al. (1951, pp. 1505-1506). Because of structural complications, it was possible to measure only the Upper or Silurian Bluebell section which is 736 feet thick. The

Ordovician Bluebell has an estimated thickness of 320 feet. The total estimated thickness is 1056 feet, and in this report the Ordovician and Silurian parts were mapped as one unit.

Renzetti (1952, p. 9) measured 980 feet in the Scranton area, and Johns (1950, p. 56) measured 920 feet in the Twelve-mile Pass. It is noted that the thickness of the Bluebell dolomite can not be accurately stated because of an unconformity at its top (Lindgren and Loughlin, 1919, p. 34).

Lithology. -The Bluebell dolomite consists of a series of alternating beds that weather light and dark bluish-grey. The rock varies in texture from finely crystalline to coarsely crystalline in certain parts of the section. The bedding ranges from thick to medium. A series of thin bedded dolomite is present near the Ordovician-Silurian boundary. The Ordovician Bluebell is composed of dark-blue-grey mottled dolomite while the Silurian is generally lighter and has no mottling but contains laminated, wavey, or contorted beds.

The Ordovician Bluebell is characterized by a great amount of light mottling on the dark dolomite surface. Because of this peculiar characteristic, field names such as "black tiger bed" or "leopard bed" have often been applied. The contact between the Ordovician and Silurian is drawn at the top of the highest mottled beds in the stratigraphic section.

The light blue-grey beds of the Silurian comprise a thicker somewhat monotonous unit with interbedded finely laminated crinkley or curley dolomite. Only one bed having the crinkley undulating appearance was found in the central Boulter Mountains, and it is located approximately 600 feet from the base. These beds are thought to be algal biostromes.

Numerous white dolomitized pentamerid ? brachiopods occur in some of the massive dolomites of the Silurian Bluebell. One such bed is 27 feet thick in the Boulter Mountains area.

The Bluebell dolomite is overlain by the Victoria dolomite; the contact between the two is quite distinct and indicates a possible erosional break.

Correlation and Age. - Two lots of poorly preserved fossils were found by Lindgren and Loughlin in the Bluebell dolomite of the Tintic district (Lindgren and Loughlin, 1919, p. 35). These were identified by Mr. Kirk, and they indicated a correlation with the Pogonip of Nevada, the Garden City limestone of northeastern Utah, and the El Paso limestone of Texas. The Pogonip is now considered to be Lower Ordovician. The fossils Maclurea annulate Walcott and Helicotoma sp. were considered to be Beekmantownian (Lower Ordovician age). Some gastropods, Solenopora sp., Streptelasma sp., and Orthis sp. were found on Pinyon Peak, about 400 feet below the top of the dolomite. This assemblage is considered post-Beekmantown. These fossils, according to Mr. Kirk (Lindgren and Loughlin, 1919, p. 35) would make the Bluebell in part correlative with the Lone Mountain limestone of the Eureka district, Nevada and in part with the Fish Haven dolomite of northeastern Utah.

Lindgren and Loughlin (1919, p. 35) concluded that the Bluebell dolomite ranges from Lower to Upper Ordovician with the possibility that the upper 400 feet on Pinyon Peak may be either Silurian or Devonian. Additional fossils were recently discovered in the Tintic district by members of the U.S.G.S. (Lovering, Morris, Proctor, and Lemish, pp. 1505-06), and the current deliniation of the Ordovician-Silurian boundary was made.

Lithologic similarity and stratigraphic position indicate correlation of the Bluebell dolomite of the mapped area with the same formation in the Tintic district.

Devonian System

Victoria Quartzite

Distribution and Thickness. - Outcrops of the Victoria quartzite occur in a highly faulted area in the NW 1/4 of section 18, T9S, R2W just north of Holdaway Canyon and in a thin outcrop band in the mid-part of section 12, T9S, R3W north of D and B Canyon.

The Victoria quartzite was named from the Victoria mine in the Tintic mining district by Lindgren and Loughlin (1919, p. 38). It has a thickness of 205 feet at the south end of the Boulter Mountains. Originally, Lindgren and Loughlin (1919, p. 38) reported 85 feet in the Tintic district. Crane (Lovering, 1949, p. 7) recently measured 100 feet in the same area. To the north Renzetti (1952, p. 10) measured 160 feet in the Scranton area, and Johns (1950, p. 61) measured 148 feet in the Twelve-mile Pass area. The Victoria was deposited on an erosional surface, therefore, it is possible that the formation could thicken and thin in the Boulter Mountains.

Lithology. - The Victoria although known as a quartzite, consists of interbedded quartzites and dolomites. The disconformable contact with the underlying Silurian Bluebell is marked by a five-foot medium to dark grey dolomite containing small white dolomite blebs or round specks. This bed has received the field name of "porphyry bed." Three feet stratigraphically higher, a bed of medium grey dolomite occurs which contains white inclusions resembling human eyes. This bed has received the field name "eye bed." The remainder of the formation consists of interbedded quartzites and dolomites. The quartzite is tan to light-brown, weathering to a darker reddish-brown. It is fine-grained and medium-to thick-bedded. The dolomites of the formation are medium olive grey, weathering lighter, are sublithographic to medium crystalline, and are medium to thick bedded. The contact with the overlying Pinyon Peak limestone is commonly quite distinct.

On Long Ridge the quartzite is a definite ledge former, but in the area under consideration the formation is a slope former, and in many places is difficult to map.

Correlation and Age. - In the original description (Lindgren and Loughlin, 1919, pp. 36-38) the Victoria quartzite was improperly designated as being between the Pinyon Peak limestone and the Gardner dolomite. The Victoria was then assigned a Lower Mississippian age. Muessig (1951, p. 44) reports that Upper Devonian fossils were found a short distance above the Victoria quartzite by members of the geologic survey in the Tintic district. Lovering, et. al.(1951, pp. 1505-06) placed the Victoria quartzite between the Bluebell dolomite and the Pinyon Peak limestone, the latter is in turn overlain by the Gardner dolomite. They assigned the Victoria to the Devonian, and noted that the strongly channeled contact on which it rests is taken provisionally at the base of the Devonian in the Tintic Mountains.

Pinyon Peak Limestone

Distribution and Thickness. - The Pinyon Peak limestone was mapped in two small areas of section 13 and 15, T9S, R3W north of Holdaway Canyon and north and south of Taylor Canyon (see Plate 1). The section was measured and described in the Boulter Mountains south of the writer's area, where it has a thickness of 201 feet compared to 150 feet in the Tintic mining district. Renzetti (1952, p. 11) measured only 50 feet in the Scranton area.

The formation was named from its type locality on Pinyon Peak in the Tintic district by Lindgren and Loughlin (1919, p. 36).

Lithology. -The Pinyon Peak limestone ranges from very light grey to light blue-grey. Some beds locally weather light brownish-red. It is sublithographic to fine-grained, and in some places exhibits shaly partings.

The upper contact is arbitrary and gradational and is drawn about twenty feet below the appearance of the corals Syringopora, and Caninia in the Lower Gardner dolomite.

Correlation and Age. - On the basis of stratigraphic position and similar lithology the Pinyon Peak of the Boulter Mountains area is considered equivalent to the formation at its type locality. Lindgren and Loughlin (1919, p. 36) found fossils of Upper Devonian age in the Pinyon Peak.

Lovering, et. al. (1951, pp. 1505-06) note that the Pinyon Peak limestone as redefined, comprises the beds formerly included in the three lower units of the Gardner dolomite, now known to contain an Upper Devonian fauna. They further state that the Pinyon Peak is, at least in part, correlative with the Upper Devonian Three Forks shale of Montana.

Mississippian System

Gardner Dolomite

Distribution and Thickness. - The Gardner dolomite outcrops in sections 1, 12, and 13; of T9S, R3W and in the NW 1/4 of section 18, T9S, R2W where it forms a narrow band from the ridge south of D and B Canyon north to North Canyon (see Plate 1).

The measured section in the Boulter Mountains indicates a thickness of 943 feet for the formation. The Gardner is about 700 feet thick in the Tintic district where it was named by Lindgren and Loughlin (1919, p. 34) for the "spur west of Gardner Canyon." Johns (1950, p. 65) measured 885 feet in the Twelve-mile Pass area, and Renzetti (1952, p. 12) measured 725 feet in the Scranton area.

Lithology. - The Gardner is essentially a limestone in the Boulter Mountains. Generally the rock is light- to medium-olive-grey and weathers to light-grey, but some rocks are medium- to dark-grey and weathers to medium-grey. It is fine- to coarse-grained and is medium- to massive-bedded. The entire formation is fossiliferous, especially in the upper part. The lower contact of the formation is taken about twenty feet below the first appearance of Caninia and Syringopora. The upper contact of the formation is taken at the first appearance of the brown to black cherts of the basal part of the Pine Canyon formation. The formation is divided into Upper and Lower Gardner at the "Curley" bed. The contorted unit is included as the top bed of the lower member. The "Curley" bed is immediately underlain by a five-foot bed of pink lithographic limestone which is slightly laminated. In the writer's area the Lower Gardner grades from limestone to a high magnesium limestone or dolomite. The rock is dark grey to light olive grey in color, sublithographic to finely crystalline, and has medium to massive bedding. Fossils are less abundant in the Lower Gardner than in the Upper Gardner (see Appendix A). Throughout the writer's area the Upper Gardner is a limestone. The rock is dark-blue-grey to light blue-grey, fine to medium grained often having a sachroidal appearance on the weathered surface. The bedding is medium to thick. Several fossiliferous zones are present throughout the member. The sediments immediately overlying the "Curley" bed are somewhat clastic in appearance.

The "Curley" bed varies from two to five feet in thickness. In the writer's area the bed is two and one-half feet thick and is composed of lithographic limestone. The wavey, crinkley, and "curley" laminae are much like that found in the "crinkley" beds of the Bluebell dolomite, but the Gardner bed is more pronounced. A considerable amount of speculation has been advanced concerning the possible origin of the "Curley" bed. It has been considered by some geologists to be a result of slumping during sedimentary processes, but because of its wide areal distribution (over 600 square miles), this theory is becoming obselete. David Clark (1954, p. 30) postulates a biostromal origin. There is a general concensus that the similarity of the "Curley" bed laminations with the algal genus <u>Codonophycus</u> as illustrated by Fenton and Fenton (1939, Plate 11) is evidence of its algal origin.

Correlation and Age. - Correlation with the Gardner dolomite of the Tintic district is made on the basis of stratigraphic position, lithology, and faunal assemblage.

Fossils collected by Lindgren and Loughlin (1919, p. 40) were identified by G. H. Girty of the United States Geologic Survey. He concluded that the combined fauna indicated equivalency with the Madison limestone of Lower Mississippian age.

In a recent work D. Clark (1954, p. 6) has summarized the occurrence of the 31 fossil genera found in the Gardner of Central Utah. Clark (1954, p. 6) concluded:

> The widespread occurrence of zaphrentid type corals, Spirifer centronatus, Syringopora surcularia, and Eumophalus luxus would designate these forms as excellent guide fossils for the Gardner formation. In addition, the presence of Lithostrotionella sp., Triplophyllites sp., Caninia sp., Multithecopora sp., Loxonema sp., and the foraminifera Plectogyra sp., also unquestionably confirm a Gardner age.

He also (1954, p. 8) states that the Gardner is Lower Mississippian age; Kinderhookian below and Upper Kinderhookian--Lower Osagean above the "Curley" bed.

Pine Canyon Limestone

Distribution and Thickness. - The Pine Canyon limestone was named by Lindgren and Loughlin (1919, p. 40) from Pine Canyon in the Tintic district. It has an estimated thickness in the Tintic district of 1000 feet, as compared with a measured thickness of 840 feet in the Boulter Mountains.

Outcrops of this formation occur in section 7, T9S, R2W and in sections 12 and 13, T9S, R3W where it forms a relatively broad continuous band from D and B Canyon to North Canyon (see Plate 1).

Lithology. - The lower part of the Pine Canyon limestone is medium blue-grey sublithographic to finely crystalline and has thick to massive bedding. The lower part is characterized by beds and stringers of brown to black chert. The color of the chert grades vertically upward from sandy brown to black. In the middle part of the section the chert is absent, and the beds have a platy weathering habit. The limestone is light-grey to pinkish-grey and finely crystalline. Because of the resonant sound emitted by the rock when struck by another object, it has received the field name, "tinkley bed." In the upper part of the formation blebs and nodules of chert are present but become less plentiful vertically upward. Encrinitic limestone is characteristic of the higher portion. The rock is medium grey, coarse-grained and has thick to massive bedding. A sand streaked appearance is noticeable at the top of the section.

The lower contact is taken at the base of the first prominent chert bands. The upper contact is taken at the highest chert beds at the bottom of an eight foot encrinite bed which occurs at the base of the overlying Humbug formation.

Correlation and Age. -Correlation of the Pine Canyon in the central Boulter Mountains with that in the type locality and other areas is easily made on the basis of distinctive lithology and stratigraphic position. Wherever abundant chert banding or cherty beds are found in a section of Mississippian strata, it is ordinarily correlated with the Pine Canyon limestone. Lindgren and Loughlin (1919, p. 40-41) correlate the cherty beds with the Madison and the upper coarse-grained limestone beds with the Upper Mississippian.

Muessig (1951, p. 52) found Syringothyris texta in the Pine Canyon of Long Ridge, and H. Petersen (1953, p. 39). reports a similar occurrence. This fossil is Middle Osagean in age according to Weller (1914, p. 398).

Calderwood (1951, p. 39) found Endothyra, ss in the upper part of the Pine Canyon limestone. These were identified by Zeller (Calderwood, 1951, p. 39) as being Meramec and probably Lower Meramec in age.

Humbug Formation

Distribution and Thickness. - The Humbug formation was named for the Humbug mine in the Tintic mining district by Tower and Smith (1898, p. 625). It outcrops in a continuous band from D and B Canyon to North Canyon in section 12, T9S, R2W. The Humbug is 811 feet thick in the Boulter Mountains. Renzetti (1952, p. 13) measured 850 feet of Humbug in the Scranton mine area. The entire formation was not exposed in the type locality where only 250 feet was measured by Lindgren and Loughlin (1919, p. 41).

Lithology. - The Humbug formation consists of alternating limestone, sandstone, quartzite, and dolomite beds. The medium-to finely crystalline limestones and dolomites are characteristically medium grey to olive-grey weathering somewhat lighter. The sandstones and quartzites are generally reddish-brown to yellowish-brown, medium-to fine-grained and medium-to thin-bedded. Dolomites and cross-bedded sandstones occur most frequently in the lower half of the formation. The sandstones are somewhat friable and form topographic lows. The dolomites contain many sandy streaks and are much more resistant to weathering than the sandstones.

The contact with the Pine Canyon formation is taken at the base of a sandy-appearing eight-foot encrinite bed. The contact with the Great Blue limestone is taken at the beginning of the first massive, blue-grey limestone above the highest quartzite beds.

Correlation and Age. - Correlation is made with the type locality at the Tintic area through lithologic similarity and stratigraphic position.

Lindgren and Loughlin (1919, p. 42) considered the Humbug to be Upper Mississippian in age. Calderwood (1951, pp. 48-49) found mico-fossils of the genus *Endothyra* in the Lower Humbug and Upper Pine Canyon formation. These were identified by Thompson and Zeller as Lower Meramacian in age.

Great Blue Limestone

Distribution and Thickness. - The Great Blue limestone, named by Spurr (1895, pp. 374-376) in the Mercur mining district, was not named from any specific locality, however, the name has become accepted through usage. Only the lower part of the formation is exposed in the central Boulter Mountain area. In the mapped area outcrops occur on the ends of the ridges between Holdaway and Taylor Canyons in sections 7 and 18, T9S, R3W and section 12, T9S, R3W (see Plate 1).

Lithology. - The Grat Blue formation is commonly a medium blue, fine- to medium-grained thick-bedded limestone. Brown chert bands and blebs are characteristic of the lower units. Red platy limestone and shale occurs immediately above the cherty limestones. Horn corals are abundant especially in certain zones.

Correlation and Age. - The Great Blue limestone in the central Boulter Mountains is correlated with the Great Blue limestone of the Stockton and Fairfield quadrangle (Gilluly, 1932, p. 29) on the basis of its stratigraphic position above the Humbug formation as well as the lithologic similarity of the limestone and overlying shale to the type section. It is Upper Mississippian, possibly Upper Meremecian and Lower Chesturian.

Quaternary System

Alluvium

The sediments mapped as Quaternary alluvium in this report comprise the alluvial fans, talus, mudflow ridges, and other unconsolidated materials. The processes of erosion and deposition have been active since the mountains were originally uplifted. Most of the intermittent stream valleys, noteably Broad Canyon are veneered with this heterogeneous debris. Large alluvial fans extend out into Cedar Valley from the mouths of Holdaway, D and B, Taylor and North Canyons (see fig. 1).

IGNEOUS ROCKS

General Features

It is assumed by the writer that the igneous rocks of the mapped area are similar to those of the East Tintic district. Lovering (1949, p. 10) notes that the igneous rocks of the East Tintic district comprise an early series of effusive rocks ranging from tuffs and agglomerates to quartz latite flows.

He also mentions a later series of biotite-hornblende latite flows and tuffaceous breccias.

Extrusive Rocks

According to Morris (1947) two principal extrusive igneous rock types have been defined in the Tintic district. These types are the Packard rhyolite and the younger Laguna latite. Distinction between the Packard rhyolite and Laguna latite is made on the basis of mineral composition as follows: (1) Packard rhyolite contains orthoclase, plagioclase, quartz, biotite, but little or no hornblende. (2) Laguna latite contains plagioclase, orthoclase, hornblende, biotite, but very little or no quartz.

Field investigations of the igneous rocks on the west side of Broad Canyon in the NE 1/4 of section 15, T9S, R3W shows that the first volcanic deposits to accumulate were ash and coarse ejectamenta. Tuffaceous material which contains euhedral quartz crystals is found in several places throughout the mapped area (see Plate 1). Lovering (1949, p. 10) apparently considers this material to be part of the Packard rhyolite. The tuff was the result of an explosive activity and was followed by the extrusive flows. Where the tuff is in contact with Paleozoic sediments, silification has taken place. This can be observed on the west side of Broad Canyon in sections 10 and 15, T9S, R3W (see Plate 1).

A petrographic study of an overlying igneous flow rock was made by Dr. Kenneth C. Bullock and the writer The rock was sampled immediately above the tuff on the west side of Broad Canyon in the NE 1/4 of section 15, T9S, R3W. Primary minerals present in the rock are quartz, plagioclase, augite with possible biotite, and hornblende. Alteration was so intense in biotite and hornblende that positive identification could not be made. The accessory minerals are apatite and magnetite. Kaolinite, sercite, and the iron oxides, hematite and limonite, are present as alteration products. The above mineralogy suggests that the flow sample belongs to the Packard rhyolite series. No Laguna latite is known to be present in the area.

A basalt flow which is later than the other flows of the area and which may have come from a separate source is also present. Samples taken from the flow at two localities in Broad Canyon were analysed petrographically and found to be similar (mineralogically). The primary minerals present are augite, plagioclase, small amounts of altered hornblende, and possibly some altered biotite. The accessory minerals present are apatite and magnetite. The iron oxides, hematite and limonite, are common alteration products. This mineralogy suggests a basalt.

Lindgren and Loughlin (1919, p. 70) make the following statement concerning basalt in the Tintic district, " ". . . it may be equivalent to the basalts found elsewhere in Utah that were erupted in Late Tertiary and Early Pleistocene time." " Bullock (1951, p. 33) mentions a basalt flow which overlies the Salt Lake formation in the Lake Hills at the south end of Lake Mountain. Hoffman (1951, p. 55) notes that an overlying basalt flow which he has correlated with the East Tintic district is present in the Mosida Hills. Basalt flows were also mapped in the area approximately 6 miles to the east near Wanlass Hill by Rigby (1949, p. 81). The basalt of the writer's are is probably correlative with these other flows.

Intrusive Rocks

Johns (1950, p. 90) reports finding an intrusive olivine basalt dike on the east side of the Boulter Mountains near the top in the NW 1/4 of section 12, T9S, R3W. This same dike was found by the writer. The dike is four and one-half to five feet thick, essentially vertical and striking approximately N 20° E. The exact lateral extent was not determinable, but the intrusive is confined to the ridge crest. Petrographic analysis of the dike material was made by Dr. Kenneth C. Bullock and the writer. The mineral assembledge was found to be the same as that present in the basalt flows of Broad Canyon, but augite phenocrysts are much more abundant. The texture of the dike rock is somewhat coarser than that of the flow rock. The dike rock is a typical diabase.

It is the opinion of Dr. Bullock and the writer that this dike may have been the source for the basalt flows in Broad Canyon.

Age of Igneous Activity

The igneous activity took place in Tertiary time with the basalt flow being the last volcanic event. The extrusive Packard rhyolite and Laguna latite which must have followed closely can be dated as post Miocene. These flows followed the normal faulting in the Selma Hills (Rigby, 1949, p. 105) but were later faulted by east-west faults in the same region (Rigby, 1949, p. 106). Bullock (1951, p. 36) considers that the volcanic rocks of the Lake Hills region are much younger than the folding and mature dissection of the Paleozoic rocks but older than Lake Bonneville since they show wave cut features. At the southern part of the East Tintic Mountains (Tower and Smith, 1899, p. 673) and in the southern Wasatch Mountains (Eardley, 1933) the volcanism was later than the Wasatch conglomerate of Eocene age. Lindgren and Loughlin, (1919, p. 70) date the basalt flow as late Tertiary or early Pleistocene.

STRUCTURE

GENERAL

Evidence of folding and faulting are present in the area of this report. Certain complexities in the general structural pattern have thus resulted.

Folds

Major Folds

The regional fold pattern of central Utah is one of large asymmetric anticlines and adjacent synclines. The principal structural feature of this area is the asymmetric North Tintic anticline; Broad Canyon in eroded near its axis. The Boulter Mountains lie along the east limb of the anticline; according to Lindgren and Loughlin (1919, p. 274), this limb also forms the west limb of the Tintic syncline. The strata along the east limb of the North Tintic anticline are dipping very steeply to the west with an average dip of 70 degrees overturned to the west (see Plate 1 and fig. 3). The more gentle western limb of the anticline has an average dip of 30 degrees to the west. The trend of the aniclinal axis is north-westerly, but it is off-set to the east by faulting. Directly north of the area of study near Twelve-mile Pass, the anticline plunges approximately 20 degrees northward.

Minor Folds

Small local folds are present in three areas. A north plunging syncline with a poorly defined axis and an adjacent north plunging asymmetric anticline were mapped in the locality of Barlow Canyon.

Several local anticlines and synclines have been mapped on the eastern flank of the North Tintic anticline near the mouth of Holdaway Canyon. Lindgren and Loughlin (1919, p. 274) suppose that these are drag folds and mark the approach to the principal axis of the Tintic syncline beneath Cedar Valley (see Fig. 4). These small drag folds are more numerous south of the area of study.

Two small synclines were mapped in the Opohonga formation in the northwest corner of the thesis area. These are also considered to be drag because of their proximity to the axis of the North Tintic anticline.

Faults

Compressional Faults

Tear Faults. - Two major tear faults have been mapped in the thesis area. Johns (1950, Plate 1) mapped the northern one of these in the southern part of his thesis area and named it the Cedar Valley fault. It can be traced from the SE 1/4 of section 11, T9S, R3W in Broad Canyon north-eastward across the crest of the range into the headwaters of Taylor and North Canyons. It disappears beneath the alluvium at the mouth of North Canyon in the eastern part of section 1, T9S, R3W. Stratigraphic displacement on the fault is approximately 2000 feet, and puts the Cole Canyon formation against the Tintic quartzite, and the Ophir shale against the Opex dolomite. The alteration product along this fault is essentially ferruginous calcite (see Appendix B).

Large crystals of white calcite occur where the fault trace crosses the ridge between Taylor and North Canyon. Silicification is present along the fault zone on the main ridge between Taylor and Broad Canyons.

The southern tear mapped by the writer is continuous with the Tintic Prince fault to the south (Disbrow, 1954, personal communication). It crops out on the southern slope of Bismark Hill in the headwaters of Rattlesnake and Holdaway Canyons.

The Tintic Prince Fault trends north-east bringing Cambrian Bluebird against Mississippian Humbug where it crosses the main ridge between Holdaway and Rattlesnake Canyons. The strata on the south side of Holdaway Canyon dip gently eastward, but on the north side of the canyon they are vertical to overturned westward. Extensive hydrothermal alteration is present along the fault zone in the northwest corner of section 23, T9S, R3W on the main ridge. The fault trace is covered by alluvium in Holdaway Canyon, but drag folds can be seen on the north side of the canyon wall. The Tintic Prince tear is the lateral component of a thrust sheet, and its horizontal movement is expressed from Holdaway Canyon northward to Taylor Canyon.

Thrust Faults. - The horizontal movement along the leading edge of the thrust sheet is marked by several thrust faults. All of these could not be shown on the map because of the small scale, but the three most prominent faults are shown on the map (see Plate 1). The writer proposes the name Tintic-Humbolt thrust fault for the most prominent of these three. It passes through the abandoned Tintic-Humbolt mine in D and B Canyon where extensive hydrothermal activity is observed along its trace. The trace of the Tintic-Humbolt thrust faults can be seen near the mouth of Holdaway Canyon in the SE 1/4 of section 13, T9S, R3W where it terminates against the Tintic Prince tear fault (see Plate 1). In this vicinity it brings the Lower Mississippian Gardner dolomite into juxtaposition with the Upper Mississippian Humbug formation. It trends northward toward D and B Canyon where it converges with a thrust fault of less displacement near the Tintic-Humbolt mine. In the opinion of the writer the later fault forms a splinter with its trace carrying northward from Holdaway to D and B Canyon entirely within the Bluebell formation. The trace of the Tintic-Humbolt fault extends across the ridge between D and B and Taylor Canyon and terminates to the north against the Cedar Valley tear fault where it is entirely within the Opohonga formation. The stratigraphic displacement on this fault is greatest at the southern end where it is approximately 1400 feet compared to an estimated 700 feet where it terminates against the Cedar Valley tear fault. Although it undoubtedly changes in other localities, the attitude of the fault surface in D and B Canyon was computed and found to have a strike of north 25 degrees west with a dip of 24 degrees to the west. The alteration product along the fault is essentially ferruginous calcite (see Appendix B), but in D and B Canyon the rocks south of the Tintic-Humbolt mine have been subjected to hydrothermal alteration, and their lithologic features are not distinctive.

A thrust fault, which is named the D and B thrust fault in this report, was mapped on the ridge between Holdaway and D and B Canyon in the west half of section 18, T9S, R2W (see Plate 1). The D and B thrust fault places the Mississippian Pine Canyon formation in juxtaposition with the Great Blue limestone at its northern extent, and Pine Canyon limestone against Humbug limestone with a large portion of both formations missing as the result of the faulting at its southern end. A small tear fault terminates against the D and B thrust indicating that local tear faulting came before thrusting. The alteration product along the D and B thrust fault is highly silicified breccia. The fault trace does not appear north of D and B Canyon.

Other Small Compressional Faults

Tear Faults. - A number of small tear faults are present on the east slope of the Boulter Mountains and on the main ridge between Broad Canyon and Cedar Valley. These tear faults fit into one system; the average strike is north 65 degrees east. The displacements range from 100 to 300 feet. Tear faults also occur on the west side of Broad Canyon where they seem to fall into two systems: north 40 degrees east and north 35 degrees west. The dips appear to be nearly vertical, and displacements range from several tens of feet to 600 feet. Most of these faults can be distinguished by ferruginous calcite alteration, but in some cases silicious alteration material is also present.

Thrust or Reverse Faults. - On the west side of Broad Canyon in the southwest part of the area of study, some small reverse faults or high angle thrusts have been mapped. Some faults repeat the older beds up the hill which would indicate that they dip steeper than the strata. The faults show very little alteration, and essentially they parallel the strike of the beds; they are distinguished on the basis of a lithologic difference between formations.

In the south central portion of section 15, T9S, R3W, a high angle reverse fault which trends approximately north 25 degrees east was mapped. This fault has approximately 800 feet displacement; truncates a small anticline and puts Cambrian Teutonic against Cambrian Cole Canyon. Highly silicified breccia is present along the fault trace.

A small reverse fault was mapped in the NW 1/4 of section 18, T9S, R2W (see Plate 1). This fault trends approximately north-south and dips very steeply to the east, and brings Mississippian Humbug up against Mississippian Great Blue limestone. The actual stratigraphic displacement was not determined. Alteration is not in evidence.

Normal Faults

Most of the faulting activity in the mapped area was the result of compressional forces but in a few instances relaxation after the compressional movement resulted in normal movements. One such fault occurs at the drift face of the mine mapped for this report (see Plate 1 and Plate 2). Many small faults occur in the mapped area, but in order to avoid confusion and cluttering of the map, no attempt was made to plot them for this study.

Dating of the Tectonics

Exclusive of the post-Archean and post-Algonkian disturbances, Eardley (1951, pp. 325-336) has noted five possible phases of orogenic movement for most of Utah. In ascending order these are: (1) early or mid-Cretaceous phase--Cedar Hill Orogeny, (2) Montana phase--Early Laramide Orogeny, (3) Paleocene phase--middle Laramide Orogeny, (4) Eocene phase--late Laramide Orogeney, and (5) Oligocene phase--Absarokan Orogeny.

Spieker (1946, p. 117, 149-156) recognizes three orogenic disturbances in the central Utah area between the late Mesozoic and early Cenozoic. They are: (1) mid-Cretaceous movement; probably in early Colorado time, (2) early Laramide movement, between middle and late Montana times, and (3) pre-Flagstaff movement; not certainly dated but probably in Paleocene time.

To the north Gilluly (1932, p. 73) states that the probabilities point to late Cretaceous or very early Eocene time for the Oquirrh folding.

Lindgren and Loughlin (1919, pp. 103-104) report that an Eocene conglomerate rests unconformably upon folded strata in the Wasatch Range near Santaquin, Utah which is 15 miles east of the Boulter Mountains.

Evidence in the mapped area indicates that the youngest rocks involved in the tectonic activity are Mississippian age. At the mouth of North Canyon in the SE 1/4 of section 1, T9S, R3W, the essentially flat-lying Oligocene volcanics lie unconformably upon the eroded surface of the folded Mississippian strata and also cover the trace of the Cedar Valley tear fault. From this evidence it is possible to date the tectonic activity as pre-Oligocene. In the opinion of the writer the various phases of the tectonic activity in the Boulter Mountains (see fig. 5) are correlative with the movements as discussed by Eardley, Spieker, and Gilluly as cited above.

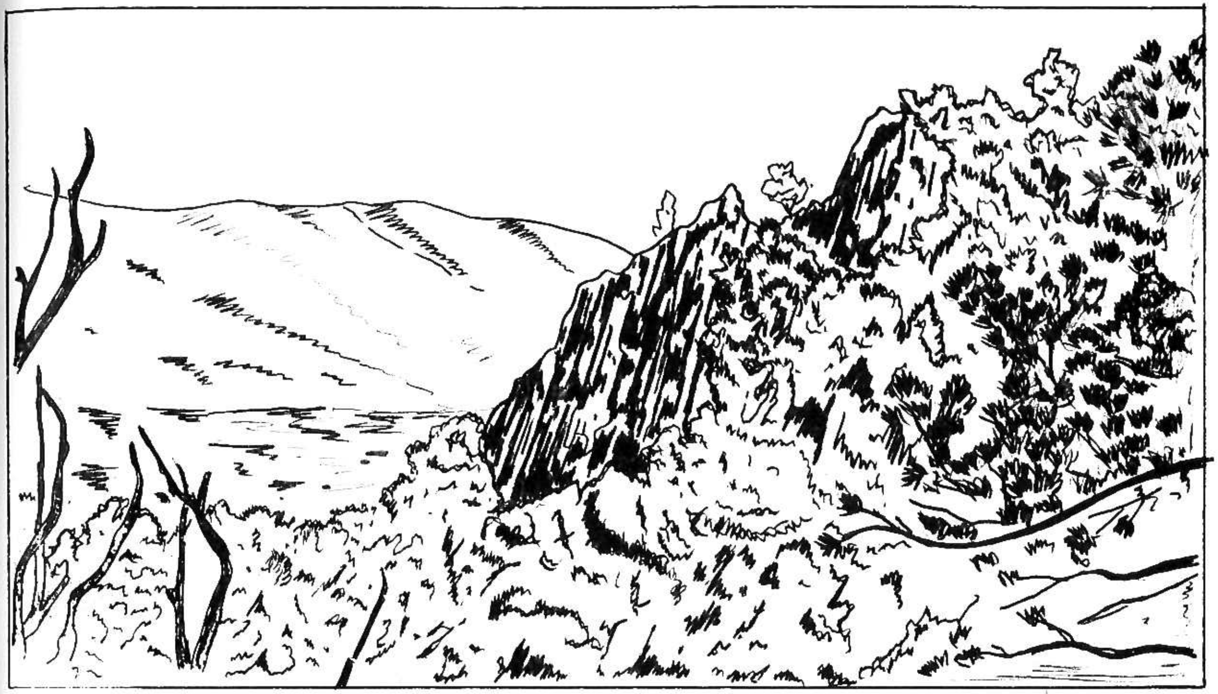


Fig. 3. - View looking north on the east side of Broad Canyon showing the Teutonic limestone overturned to the west.

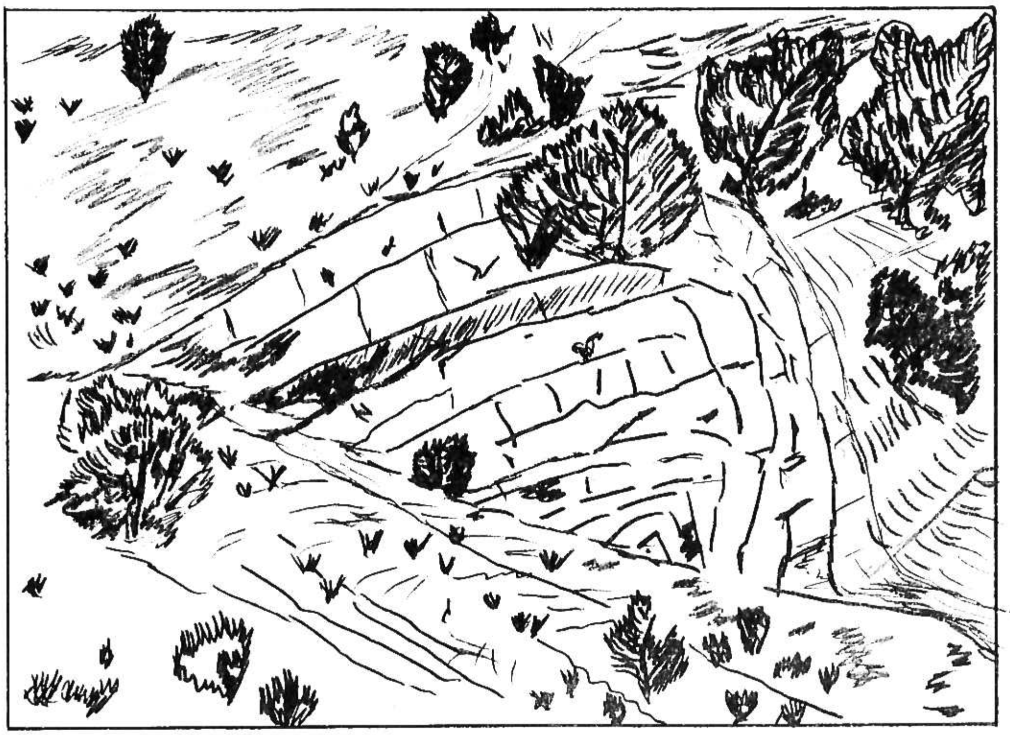
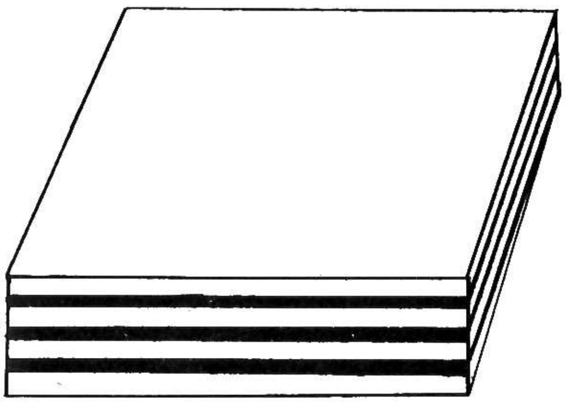
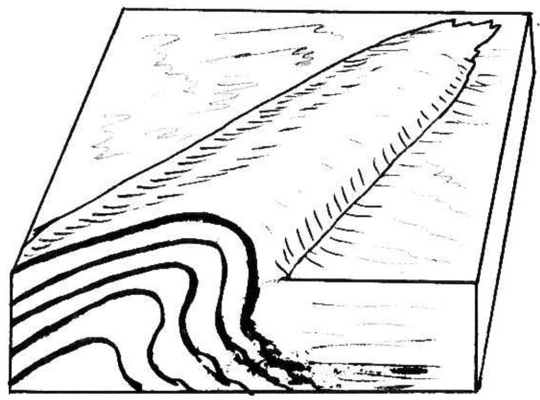


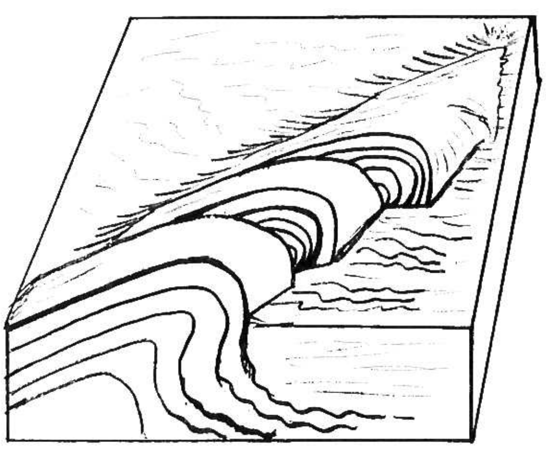
Fig. 4. - View showing a small well exposed fold in the area northeast of Holdaway Canyon. Fold was probably the result of drag near the synclinal axis.



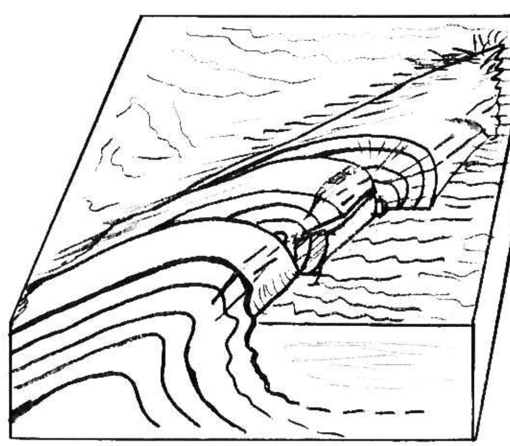
(1) Flat lying sediments



(2) Asymmetric folding



(3) Development of tear faults



(4) Development of thrust faults

Fig. 5. - Block diagrams 1, 2, 3, and 4 showing probable sequence of local tectonic activity.

ECONOMIC GEOLOGY

GENERAL STATEMENT

Many prospect pits and some old mines are located in the central Boulter Mountains area. None of these mines have produced on a commercial basis in the past. Two of the mining properties have been reclaimed and are being further explored by week-end prospectors at the present time. A claim has also been filed for a nonmetallic deposit on the west side of Broad Canyon.

METALLIC PROSPECTS

Most of the prospects and mines of the area were developed in hopes of extending the boundaries of the rich Tintic Mining District toward the north. The Scranton mines lie approximately due west of the area of this report, and must have been an incentive to the prospector. Relatively large dumps indicate that four of the mines in the area must have involved a considerable amount of labor and money.

A mine in the SE 1/4 of section 13, T9S, R3W is located near the large Tintic Prince tear fault and has recently been worked by week-end prospectors (see Plate 1). It is assumed that much of the alteration in this mine is associated with the fault surface.

The abandoned Tintic-Humbolt Mine is located near the mouth of D and B Canyon in the NE 1/4 of section 13, T9S, R3W. Loughlin (Lindgren and Loughlin, 1919, pp. 274-275) visited the locality and made the following observation concerning it:

> . . . the immediate country rock is the upper part of the Pine Canyon limestone. . . The dip is vertical to very steep westward (where slightly overturned). Two shafts have been sunk, one 100 feet and one 20 feet deep. . . The outcrops at the collar of the 100 foot shaft is of cherty limestone cut by veinlets of white to brownish calcite of columnar to coarse granular character, containing a few small lumps and grains of "steel" and "cube" galena with a little zinc blende. . . The ore minerals were followed for 15 feet down the shaft and a picked sample is said to have assayed 26 ounces of silver to the ton and 44 per cent of lead. . . The shaft continues downward along an iron-stained fissure and a short crosscut from its base is said to pass through 8 feet of kaolin into some silicious materials full of iron and manganese oxides, which assays traces of gold and silver. . . The facts observed suggest that in this direction mineralization at the surface has nearly reached its northern limit.

Proctor* has traced a thrust fault into the mine area and considers the above mentioned eight foot kaolin zone in the mine to be fault gouge resulting from the thrust. A resurvey was not attempted for the present report.

Another mine is located in Rattlesnake Canyon in the extreme south central part of the thesis area in the NW 1/4 of section 24, T9S, R3W. This mine has the largest dump of any in the area but has caved at the entrance so investigation could not be made. The entrant was made in the Ophir formation, but Herkimer limestone is present in the drifts which indicates that the mine must have gone in horizontally approximately 800 feet.

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*Personal communication, Oct. 14, 1954.

An active prospect on the west side of Broad Canyon was mapped by the writer (see Plate 2). A large fault at the mine portal caused alteration which apparently excited investigation and mining. At the mine portal a shaft is being excavated at the present time. Large pieces of altered material from the fault are being brought up in the workings. The drift is in the Ajax formation but encountered down-dropped Opohonga limestone at the end of the drift face (see Plate 2). No large quantities of ore were found in the operation.

Several smaller mines and prospects are present in the area, and most of them are associated with tear, thrust, or normal fault zones.

NONMETALLIC PROSPECTS

A claim has been filed on a highly altered area on the west side of Broad Canyon (see Plate 1). A small prospect pit has been dug on the western margin of the altered zone in the NE 1/4 of section 15 T9S, R3W. The workings are not extensive, but some high grade clay materials have been recovered. A clay sample collected by the writer was identified as haloysite by E. P. Hyatt. The deposit is small and probably not commercial.

SUMMARY OF GEOLOGIC EVENTS

The first sediments deposited in the area of study make up the formation known as the Tintic quartzite. The continuation of a geosynclinal environment of deposition in the Cordillerian geosyncline is evident from the great amount of carbonates overlying the quartzites. These carbonates are interbedded with clastics. Conditions of sedimentation throughout the Cambrian varied from tidal flat conditions through stable shelf infraneritic environments to medium depth still water conditions. Washing and wave action took place at the close of the Cambrian period.

Conditions of sedimentation during the early Ordovician in part were similar to those during the Cambrian. An hiatus is present locally from the Canadian through the Upper Cincinnatian epochs. During the remainder of Ordovician-Silurian time sediments were deposited in a moderately shallow sea with little wave activity. Warm water conditions and a stable shelf environment suitable for algal growth were present over a relatively wide area. Pentamerid brachiopods were abundant but are poorly preserved in the Silurian rocks.

The unconformable contact of the Bluebell dolomite and Devonian Victoria quartzite represents a period of non-deposition and erosion. Sedimentation during the early Mississippian time took place in a relatively still water environment. Conditions suitable for an algal growth, similar to those of the Silurian period, were present over a vast area.

Some form of volcanic activity took place during the Osage or Meramac time introducing a great quantity of silica into the waters. This silica was carried in collidial suspension to the central Utah area where it was deposited in an infraneritic environment. During the time of deposition of the Humbug formation the waters in which deposition took place were more shallow than during the time of the Pine Canyon deposition. Fluctuating seas and strong littoral currents were active accounting for the alternating cross-bedded quartzites, encrinites, and coarse-grained, fossiliferous, fragmental limestones. Deposition in an infranentic zone marked the close of Paleozoic sedimentation as evidenced by the Great Blue limestone of Upper Mississippian age. These sediments are the youngest Paleozoic rocks exposed in the Boulter Mountains.

Rocks exposed in the Oquirrh Mountains several miles to the north (Gilluly, 1932, p. 34) indicate the sedimentation was continuous there until the Permian. There is no record of Mesozoic deposition in the Boulter Mountains although Triassic, Jurassic, and Cretaceous rocks occur in the nearby Wasatch Mountains. The Boulter Mountains perhaps functioned as part of the source area for these sediments.

Folding and faulting took place sometime during the period from late Jurassic to late Montana time. The thrusting in the Boulter Mountains followed the folding and initial faulting, and the near strike faults could have developed simultaneous to the thrusting. Volcanic activity took place following the faulting and continued intermittently until late Pliocene or early Pleistocene. Five miles to the east there is evidence of normal faulting in an east-west direction after volcanism; this faulting displaced the flows and blocked the present structure of the range.

A climatic change during the Pleistocene climaxed during the development of Lake Bonneville. At its highest level the shores of this lake closely approached the eastern margin of the Boulter Mountains. Later in the Quaternary, Lake Bonneville dried up leaving Great Salt Lake and Utah Lake as its remnants. Fluvial processes were going on in the Boulter Mountains during the Pleistocene, much as they are at the present time.

Appendix A

Detailed Measured Stratigraphic Sections

Stratigraphic Sequence of the Great Blue Limestone, Humbug Formation and Pine Canyon Limestone.

Measured by John M. Foster and the writer south of Rattlesnake Spur in Section 12, T9S, R3W, Utah County, Utah June 4, 1954.

Great Blue Limestone

Description

Top not exposed.	Thickness (feet)
Limestone, dark blue-grey which weathers to a lighter shade of grey. Fine grained, massive bedded. Occasional brown chert lenses and blebs, and fragmental ("hashy") fossil beds.	180
Limestone, same as below.	82
Limestone, same as below, except some appears light blue-grey on weathered surface and some is dark blue-grey. This section is quite fossiliferous, 150 feet from the base there are large corals, braciopods are fragmental and not identifiable.	92
Limestone, same as below with the below-mentioned interbedded shale occurring throughout. The color from a distance is light blue.	83
Limestone, dark blue-grey which weathers a slightly lighter shade of grey. Fine grained, massive bedded. Occasional chert lenses and blebs. About 35 feet from base a shaley bed appears, it is a thin bedded light brown calcareous shale. Some fossils present: Horn corals (unidentified) and large brachiopods (unidentified).	81
Total Thickness	518

Conformable Contact

Measured by John M. Foster, Vaughn E. Livingston, Charles Hyde and the writer, south of Rattlesnake Spur in Section 12, T9S, R3W, Utah County, Utah, May 15, 1954.

Humbug Formation

Description	
Orthoquartzite, yellowish-brown, weathering to reddish-brown, medium to coarse grained, thin to medium-bedded, cross-bedding which dips to the north.	7
Orthoquartzite, 3 feet thick, reddish-grey which weathers the same color, fine grained, thin bedded, banded with scintillating bands. Underlain by 37 feet of dark grey limestone weathering to light bluish-grey, fine to medium grained, thin to thick-bedded. A 2 foot orthoquartzite bed is in middle of this unit. Black chert blebs and silicious brachiopods are present.	40
Limestone, reddish-dark-grey weathers to medium grey, crystalline to coarse-grained, medium-bedded, with saccharoidal weathering habit; silicious. Black chert blebs and horn corals are present.	11
Limestone, pinkish grey, weathers the same color, crystalline to coarse grained, thin-bedded, encrinitic. Underlain by 11 feet of yellow-brown orthoquartzite which weathers reddish-brown, fine-grained, thin-bedded with red bands.	12
Limestone, dark grey which weathers the same color, crystalline to medium-grained, medium-bedded.	4
Limestone, dark grey, weathers dark to medium-grey, fine to coarse-grained, medium-bedded Underlain by 3 feet of buff-grey orthoquartzite, fine-grained and thin-bedded. .	6
Limestone, medium olive-grey which weathers medium-grey, fine to medium-grained, thin to medium-bedded, mottled at the base. Saccharoidal weathering habit. Underlain by 3 feet of reddish-grey orthoquartzite, fine to medium-grained with saccharoidal weathering habit.	19
Limestone, dark to medium-grey which weathers to same color, crystalline, thin-bedded with saccharoidal weathered texture, underlain by 5 1/2 feet of reddish-grey orthoquartzite, fine-grained, thin-bedded, with scintillating bands.	9 1/2

(Continued)

Humbug Formation (Continued)

Orthoquartzite, 14 feet, reddish-grey which weathers the same color, fine-grained, thin-bedded, with scintillating bands; underlain by 1 foot limestone bed, light olive-grey which weathers to light-grey, sub-lithographic. This is underlain by 19 feet of orthoquartzite of the same description as the upper part of this unit.	34
Limestone, light olive-grey, weathers to light grey, medium-bedded, sub-lithographic with meringue appearance on weathered surfaces.	19
Limestone, 12 feet, light brownish-grey weathers to light grey, sub-lithographic, thick-bedded, an exsolution limestone. This is underlain by 11 feet of buff orthoquartzite which weathers the same color, fine grained and thin bedded. .	23
Limestone, pink, weathers to medium-grey, crystalline, thick-bedded with saccharoidal weathered appearance. This is 16 feet thick and is underlain by 26 feet of cover with orthoquartzite float.	42
Limestone, 5 foot bed, light brown which weathers the same color, sub-lithographic, medium-bedded. Small 1/16 inch darker brown bodies are present. This is underlain by 59 feet of orthoquartzite outcrops and float.	64
Limestone, 8 feet, dark to medium-grey, weathers medium to light grey, crystalline, fine-grained, medium-bedded, meringue weathering; underlain by 3 feet of dolomite, olive-grey which weathers white; underlain by 35 feet of orthoquartzite, reddish-grey, weathers the same color, fine-grained and thin-bedded.	46
Orthoquartzite, reddish-grey weathers to the same color, fine-grained, thin-bedded, banded with scintillating bands. Underlain by 3 feet of olive-grey dolomite which weathers white.	26
Dolomite, medium-grey weathers to magnesium-white, fine-grained, medium-bedded, calcareous; underlain by 4 feet of limestone, dark grey, weathers medium to light grey, fine-grained, medium-bedded, possibly algal. Underlain by 4 feet of olive-grey dolomite which weathers magnesium-white, fine-grained, medium-bedded and calcareous. . . .	11

(Continued)

Humbug Formation (Continued)

Dolomite, light brownish-grey weathers to a magnesium-white, crystalline, thin bedded, calcareous, meringue weathered texture. Underlain by 2 feet of reddish-brown orthquartzite, which weathers reddish-brown, fine to medium-grained, medium-bedded.	3
Limestone, medium-grey weathers the same color, crystalline to fine-grained, thick-bedded. White twiggy bodies present near the top, possibly algal.	32
Dolomite, medium-grey weathers to light grey, fine grained, thin-bedded, with saccharoidal weathering habit.	1 1/2
Orthoquartzite, maroon, weathers to brown, fine to medium-grained, thin-bedded.	9
Limestone, olive to pinkish-brown, weathering to the same color, sub-lithographic, medium-bedded.	2
Orthoquartzite, medium-grey to reddish-grey, weathering to reddish-brown. Coarse-grained, thin to medium-bedded. Cross-bedding dips to the southwest.	35
Limestone, olive-brown, weathers to medium-grey, crystalline, medium-bedded, with saccharoidal weathering habit and small white "twiggy" bodies.	10
Orthoquartzite, reddish-grey weathers brown, coarse-grained, medium-bedded.	4
Limestone, olive-brown, weathers to light grey, sub-lithographic, thick-bedded.	10
Orthoquartzite, same as the 47 feet described below.	23
Limestone, light grey, weathers to medium-grey, crystalline, medium-bedded, silicious; with saccharoidal weathering habit.	4
Orthoquartzite, buff to pink-grey, weathers to reddish-brown, medium to coarse-grained, thin to medium-bedded. Cross bedding present; dips south, north, east. Two foot orthoquartzite breccia bed, and 2 feet of white orthoquartzite 10 feet from the base.	47

(Continued)

Humbug Formation (Continued)

Dolomite, olive-brown to grey, weathers to light-grey, crystalline to fine-grained, thin-bedded with 1/32 inch brown chert stringers. Weathers with slightly saccharoidal appearance.	10
Orthoquartzite, yellowish-brown weathers to light-brown, coarse-grained, thin-bedded cross-bedding near the middle dips to the south.	20
Limestone, medium-grey, weathers the same color, crystalline to coarse-grained, thick-bedded with cross-bedded encrinites. Cross bedding dips to the south.	9
Orthoquartzite, pinkish-grey, weathers to dark reddish-brown, fine-grained, medium-bedded with dark red bands. . . .	9
Dolomite, greyish-pink, weathers olive-grey to light-grey, crystalline to fine-grained, thin-bedded with platy weathering habit, becomes medium-bedded at top. . . .	40
Orthoquartzite, pink-grey, weathers to reddish-brown, fine-grained to medium size grains, thin-bedded.	9
Sandstone, pink-grey, weathers to brownish-grey, coarse-grained, thin to medium-bedded, slightly calcareous. . . .	18
Sandstone, light-grey, weathers the same color, coarse-grained, laminated, thin-bedded, sub-angular grains presenting a saccharoidal texture on weathered surfaces, with calcareous cementing of grains.	42
Limestone, olive-grey, weathers to light brownish grey, medium to coarse-grained, medium to thick-bedded, fetid on fresh fracture, interbedded with orthoquartzite beds.	56
Limestone, light grey which weathers slightly darker, medium to coarse-grained, encrintic. Medium to thick to massive-bedded. Fetid on fresh fracture.	44
Total thickness	811

Conformable contact

Pine Canyon Limestone

Measured by John M. Foster, and the writer, June 8, 1954.

Limestone, olive-grey with a maroon tinge which weathers to white or light cream. Sub-lithographic to fine-grained. Thick to massive-bedded. Contains some chert in the upper part. Some fossils present which include Lithostrotionella sp. (a round type--not hexagonal). 54

Limestone, medium grey-blue which weathers light blue-grey. Fine-grained, thick to massive-bedded. Contains blebs, stringers, nodules, and bands of light brown chert which become darker up section. 59

Limestone, same as above. This is massive ledge-former with sandy weathering surface. Some chert in large blebs is black colored. Chert stringers are generally brown with sandy appearance. 51

Limestone, medium-grey which weathers to a lighter grey, coarse-grained, encrinitic, thick to massive-bedded, sand streaked. In lower part very little chert is present. 42

Limestone, same as above but more encrinitic. The lower 13 feet stands out in relief due to weathering habit. 60

Limestone, medium-grey which weathers the same, crystalline to fine-grained, thick to massive-bedded. A 3 foot "porphyry" bed is present consisting of white calcite inclusions 2 to 5 mm in diameter. Chert occurs again down section and forms brown lenses, nodules, and bands and becomes more black in color. A sand-streaked bed is near the middle of this unit. 121

Limestone, same as above, but more sand-streaked, chert is less plentiful and consists of a few black nodules and blebs. . . 50

Limestone, light grey which weathers lighter but with a sandy appearance. Coarse-grained to very coarse-grained, encrinitic. Massive ledge-former near top of unit. Very little chert in upper part of unit, but some calcite stringers are present. Encrinite content disappears down-section, chert increases. 89

Limestone, light grey which weathers to the same color, fine-grained, thin-bedded. This is silicious and has a very

(Continued)

Pine Canyon Limestone (Continued)

shaly weathering habit. It is one of the two "tinkley" beds of this formation. A breccia dike is present locally in the basal 20 feet. This "tinkley" bed becomes more shaly down-section and changes to a reddish-pink color. At 159 feet a 1 1/2 foot limestone bed is present containing chert. At base all beds contain plentiful black chert beds. 161

Limestone, medium-grey which weathers to a lighter color, fine-grained, thin to medium-bedded. Bedding becomes thicker down-section, becomes a ledge-former, finely laminated. Black bands of chert present in upper part of unit change to medium-brown in basal part. 101

Limestone, medium dark grey which weathers the same. Very coarse-grained. Thick to massive-bedded, encrinite bed 10 feet thick. Down-section from the encrinite bed the limestone is ledge-forming and has specks and streamers that are white. Chert beds and blebs become abundant, the chert is medium-brown in clor. The contact is taken at the lower-most black chert bed. Syringopora sp. within 20 feet of the contact and Lithostrotionella sp. within 50 feet, both in the Upper Gardner dolomite help identify this contact. 52

Total thickness 840

Conformable contact

Stratigraphic Sequence of the Gardner dolomite, Pinyon Peak limestone, Victoria quartzite, Bluebell dolomite, Opohonga limestone, Ajax limestone, and Opex dolomite formations.

Measured in the north half of Section 26, T9S, R3W, Utah County, Utah. The Gardner dolomite, Pinyon Peak limestone, Victoria quartzite, and Bluebell dolomite measured by John M. Foster, Mack Croft and the writer on April 24, 1954.

Upper Gardner Dolomite

Limestone, medium to dark blue-grey which weathers light blue-grey, fine grained with saccharoidal weathered appearance; thick-bedded. Thick, dark, black and brown bands of chert

(Continued)

Upper Gardner Dolomite (Continued)

disappear down section after becoming thinner and lenses or blebs of the same kind of chert. Just below the most distinctive chert the fossils are abundant. Euomphalus sp., Lithostrotionella sp., Triplophyllites sp., (also found in lower Pine Canyon fm.). Other types of gastropods and numerous crinoid stems and fossil fragments. The limestone has a fetid odor. 34

Limestone, medium blue-grey, weathers medium to light blue-grey; fine-grained with saccharoidal weathered appearance; thick-bedded with a fetid odor. Decrease in fossil abundance. Fossils present include Triplophyllites sp. (abundant), and Euomphalus sp. near the upper part of unit; several encrinite beds. 151

Limestone, medium to dark blue-grey, weathers medium blue-grey, very fine-grained; medium to thick-bedded. At the top of this unit is a biozone. Abundant fossils include the following genera: medium-sized Euomphalus, Loxonema, a high-spired-gastropod, Triplophyllites, Small Caninias, Productid-type brachiopods, Unidentified brachiopod, encrinites. Several fossiliferous beds present throughout this unit. 62

Limestone, dark olive-grey, weathers light to medium-grey with slight yellowish hues, very fine-grained, thick-bedded (thicker bedded than above); fetid odor on fresh fracture. Fossils also very abundant in this unit. Approximately 30 feet from the top, genera present include: Multithecopera, Triplophyllites, Euomphalus, another high-spired-gastropod, large Caninia (first appearance), Lithostrotionella, a long lean type of coral (not Zaphrentid), Spirifer centronatus (a few), Orthid type (?) brachiopod, encrinites, Productid "hash". 162

Limestone, same as above but laminated appearance on weathered surfaces begins. Near the "Curly bed" the beds have a sandy appearance. Euomphalus sp. becomes more plentiful together with small brachiopods and Triplophyllites sp. 78

Total thickness of Upper Gardner dolomite 487

Conformable contact

Lower Gardner Dolomite

Limestone, 2 1/2 feet thick, medium-grey, wavy laminated. This is the "Curley" bed. No chert bed found overlying it. The "Curley" bed is immediately underlain by pink lithographic limestone with a few blebs of limestone that weather with a sandy appearance, this comprises a 5 foot bed.	7 1/2
Limestone, light olive-grey, weathers to light grey, very fine-grained to lithographic, thick-bedded. Some magnesium limestones, contains sandy-weathering blebs. Fossils less abundant include following genera: Caninia, Euomphalus, Multithecopera, a Zaphrentid type and thin lean brachiopods.	15 1/2
Limestone, same as above, but more massive-bedded except at the top of unit beds are thick.	61
Dolomite or high magnesium limestone, dark blue-grey, weathers to medium blue-grey, very fine-grained, thick-bedded to massive-bedded. Small calcite blebs and stringers present. This might be the "black dolomite" of Lindgren and Loughlin.	41
Limestone, medium to dark-grey which weathers to medium-grey, very fine-grained, thick-bedded. Colonies of Syringopora sp. are very common, there are a few Euomphalus sp., and Caninia sp.	91
Limestone, medium olive-grey, weathers to light olive-grey, fine-grained, massive-bedded. Stringers of red to purple FeCaCo3 on fractured surfaces.	37
Limestone, dark olive-grey, weathers pink to light olive-grey, fine to very fine-grained, medium to thick-bedded. . . .	40
Limestone, medium olive-grey which weathers medium to light olive-grey, medium-grained, massive-bedded. A pink tinge is present but the pink weathering habit is not as pronounced as above. Zaphrentid type corals and the long lean type brachiopod mentioned above.	91
Limestone, light olive-grey which weathers approximately the same color, medium to coarse-grained, massive-bedded	

(Continued)

Lower Gardner Dolomite (Continued)

Large Syringopora sp. are present together with *Caninia* sp. and other *Zaphrentid* types of coral.	72
Total thickness for Lower Gardner dolomite	456

Gradational contact

Pinyon Peak Limestone

Limestone, light olive-grey, which weathers the same color. Medium to coarse-grained with massive-bedding. The following genera are present: large *Syringopora, Caninia* and probably other *Zaphrentid* type corals. Lower in section the bedding becomes thinner and begins to display an argillaceous appearance, thin shaly weathering beds occur. . . .	24
Limestone, same as above but with shaly limestone weathering to a light brownish-red color. Something like Opohonga limestone in weathered appearance.	177
Total thickness	201

Victoria Quartzite

Orthoquartzite, tan to light brown which weathers to a darker reddish-brown, fine-grained, medium to thick-bedded. .	10
Dolomite, medium olive-grey, weathers light to medium grey, sub-lithographic to very fine crystalline, thick-bedded. The beds become more massive down-section and become laminated in part, they also weather alternating light and dark. An "eye" bed and a "porphyry" bed appear at bottom of this unit.	90
Dolomite, olive-grey which weathers to light olive-grey, fine to medium crystalline, thick to massive-bedding.	29
Orthoquartzite, same as described above, interbedded	15
Dolomite, dark olive-grey which weathers the same color, very fine crystalline, thick-bedded. Interbedded light and dark dolomite.	33
Orthoquartzite, same as described above.	10

(Continued)

Victoria Quartzite (Continued)

Dolomite, medium grey with white inclusions the size of eyes. This type of bed is called an "Eye bed". It is underlain by a 3 foot bed of orthoquartzite, which is underlain by a 5 foot "Porphyry bed" consisting of medium to dark grey dolomite with numerous white "pimples". This sequence marks the contact of the Devonian Victoria quartzite and the Silurian Bluebell dolomite.	18
Total thickness	205

Disconformable contact

Silurian Bluebell Dolomite

Quartzite, tan to light brown, fine-grained, medium to thick-bedded.	11
Dolomite, dark to medium olive-grey, weathers to light tannish-grey to light blue-grey. Very fine to fine-grained. Massive bedding becomes thick to massive down-section. The color becomes more medium-grey down-section. Blebs and spangles of $CaCO_3$ and some small veinlets of $CaCO_3$. . . .	87
Dolomite, medium-grey, medium-grained, slightly mottled. . . .	35
Dolomite, olive-grey, weathers to light tan with pink staining, fine-grained. This is 1 1/2 feet thick and is underlain by dolomite which gradually changes a lighter shade to medium-grey.	63
Dolomite, medium olive-grey which weathers light grey to tan. Fine-grained and thin-bedded. Characteristic shaly weathering with argillaceous appearance. In the basal part of this unit there is 25 feet of coarse-grained dolomite.	98
Dolomite, light olive-grey, weathers slightly lighter, medium-grained, medium-bedded. This has a pseudo cross-bedded sandy appearance on weathered surfaces and is weakly mottled. A fetid odor is emitted upon fracturing. . . .	62
Dolomite, laminated bed.	17
Dolomite, "Pentamerid bed" (containing numerous white inclusions thought to be fossil remnants).	26

(Continued)

Silurian Bluebell Dolomite (Continued)

Dolomite, medium olive-grey which weathers light grey, medium to coarse-grained, thin to medium-bedded. This becomes slightly darker colored and fine-grained down section and weathers somewhat shaly with occasional cherts.	143
Dolomite, light to medium grey which weathers light grey to cream color, fine-grained. This weathers to a light colored shale. Occasional large chert bands in the thin to medium-bedded rocks. A 2 foot laminated bed is present in the basal part of this unit.	100
Dolomite, medium to dark grey which weathers light to medium and to dark grey with slightly mottled appearance. Light and dark dolomite is interbedded. Medium-grained, medium to thick-bedded.	94
Total thickness	736

Conformable contact

Ordovician Bluebell Dolomite

Note: Because of structural complications (excessive faulting) the writer was unable to obtain an accurate measured section of the Ordovician Bluebell. The thickness as estimated from measured sections in near-by areas is 320 feet.

Estimated thickness 320

Opohonga Limestone

Measured by John M. Foster, and the writer, June 4, 1954.

Dolomite, (slightly calcareous), blue-grey to olive-brown, weathers slightly lighter color. Fine to medium-grained, thin to medium-bedded. Considerable argillaceous partings which are yellow-brown and light red. Contact is taken at the last mottled dolomites in the Ordovician Bluebell formation. Becomes less dolomitic toward base.	183

Opohonga Limestone (Continued)

Limestone, same description as above with increasing amount of light red-colored partings. Bedding slightly more massive. . 91

Cover, float is the same typical lithology as the Opohonga formation. 286

Limestone, yellowish-grey which weathers to a medium-grey. Fine to medium-grained, medium to massive-bedded. Highly mottled with yellow to dull red mildly-argillaceous partings. Partings form a series of oval like inclusions about 18 mm. to 25 mm. long and half that thickness. A cross section view of this outcrop reveals that the axis of elongation of the partings is dipping 62^{o} to the west. 7

Limestone, yellowish-grey which weathers to a medium-grey. Fine to medium-grained, medium to massive-bedded. Highly mottled with yellow to dull red argillaceous partings. Red coloration becoming less prominent. . . . 58

Limestone, same as above except color becomes more yellow and less red and less intense. Color in general becomes more dull down section. 102

Limestone, dull medium-grey which weathers the same color. Medium to coarse-grained, and thick to massive-bedded. The argillaceous partings are present but are dull-yellow and brown, not very colorful. 40

Limestone, same as above with more intense coloration. Some flat pebble conglomerate beds are present. Prominent ledges formed. 76

Limestone, same as above but not ledges, some cover of Opohonga-like float. 98

Limestone, same as above, but with fewer argillaceous partings in the bottom half of this unit. 132

Dolomite and limestone, interbedded, thin to medium bedded. This marks the transitional zone and gradational contact between the Opohonga and Ajax formations. 34

Total thickness 1107

Conformable contact

Ajax Limestone

Measured by John M. Foster, Paul J. Jorgenson, and the writer April 24, 1954.

Upper Ajax Limestone

Limestone, medium olive-grey weathers to light or medium-grey with argillaceous red to brown partings, Opohongish-appearance. Crystalline to fine-grained weathering to a sucrose texture, thin-bedded with shaly weathering. A few light-grey chert blebs are present. 59

Limestone, light olive-grey, weathers to light blue-grey and light brown-grey. The argillaceous partings are almost completely absent. Medium to coarse-grained, medium to thick-bedded, thickening toward bottom of this unit. Black chert stringer 1/4 inch to 1 1/2 inches thick. 62

Limestone, medium olive-grey, weathers to light or medium grey with argillaceous red to brown partings, but not as numerous as in previous section described. Crystalline to fine-grained texture, thin-bedded with shaly weathering. Some light-colored chert blebs present ("ice cream chert").

This unit contains interbedded quartzites which are medium tan in color, weathering to light tan, crystalline medium, and coarse-grained, with thin to medium bedding. 61

Limestone, highly magnesium, possibly hydrothermally dolomitized, light blue-grey with a pink hue weathering to light tan-grey. Crystalline to medium texture and thick-bedded. Large pink chert stringers ("ice cream chert") minute calcite stringers, sandy appearance when weathered. 57

Total thickness 239

Conformable contact

Emerald Bed

Dolomite, light blue-grey, weathers to cream, crystalline to fine-grained, massive bedded. Chert absent. 22

Total thickness Upper Ajax Limestone 261

Conformable contact

Lower Ajax Limestone

Dolomite, dark blue-grey, weathers to medium blue-grey crystalline to fine-grained, thick to massive-bedded. Dark chert blebs and stringers 1 inch to 1 1/2 inches thick. Thinner light-pink chert stringers ("ice cream chert"). Pisolites or "carrot bodies" 100 feet from the Emerald bed. These "pisolites" are probably "Girvanella". 199

Dolomite, medium-dark blue-grey, weathers to the same color but slightly mottled, crystalline to fine-grained, thin to medium-bedded. Twiggy bodies throughout 3 mm. to 10 mm. long (carrot bodies?). Black borders reported in other areas on twiggy bodies indistinquishable. A few light colored chert bands. The twiggy bodies and pisolites 52-74 feet from base. Near the base wavy laminations alternately light and dark-colored are present. These are 1/2 inch thick and spaced 1/2 inch to 1 inch apart. They are probably a feature of sedimentation, rather than local alteration. Underlying the wavy laminations is a bed containing rosettes, these are generally spherical and about 5 to 10 mm. in diameter. They appear to be white $CaCO_3$, but are dolomite (probably replaced fossil remnants.) The basal contact taken at and above the presence of first dark oolites (very small), and "hashy" appearing beds. 120

Total thickness of Lower Ajax limestones 319

Disconformable contact

Opex Dolomite

Dolomite, medium dark-grey, weathers to light medium-grey, crystalline, fine, medium-grained, thin to massive-bedded, increasing in bedding-size going down the section. Contains small blebs of chert. Some beds are mottled and the mottled beds are lighter in color. Small beds of "hashy" material which are probably fossil remains. Twenty-five feet from the contact with the Ajax limestone a 3 inch bed contains Billingsella (identified by Dr. J. Keith Rigby), an Upper Cambrian brachiopod. This is the first reported time-rock occurrence of this species in this area. 75

Limestone, medium-grey, medium-grained thin to medium-bedded. Yellow argillaceous partings and platy

(Continued)

Opex Dolomite (Continued)

weatherings gives this the appearance of Opohonga limestone.	39
Dolomite, medium blue-grey weathering to light-grey, crystalline to fine-grained, thick to massive-bedded. No oolites present. Thin platy beds of Opohongish appearing magnesium limestone with yellow argillaceous partings extend throughout.	57
Limestone, medium blue-grey weathering to light grey, fine-grained to medium, thick-bedded. This is a magnesium limestone with numerous calcite stringers. Sandy appearance on weathered surfaces.	22
Shale, yellowish-tan, same color on weathered surfaces, some red-brown colored zones present, but probably due to alteration. Clay size grain, fissile.	5
Dolomite, medium blue-grey weathering to light blue-grey and light tan, fine to medium-grained, medium to thick-bedded. Upper part has sandy weathering appearance which shows cross-bedding on weathered surface. In the lower portion a light-blue color becomes prominent Flat-pebble conglomerate and some laminations are present.	78
Dolomite, medium-blue to tan-blue, fine-grained, thick-bedded. The tan-blue colored material appears to be arenaceous.	42
Dolomite, light to medium blue-grey, weathers to light or medium-grey, with a tan hue, oolitic, massive-bedded grading to thin-bedded near Opohongish-appearing dolomite the Opex-Cole Canyon contact. This entire unit is oolitic, the oolites are more abundant and larger in size than at the Opex-Ajax contact. Flat pebble conglomerate is located 10 feet from the Cole Canyon contact.	60
Total thickness	378

Conformable contact

Stratigraphic sequence of the Cole Canyon dolomite, Bluebird dolomite, Herkimer limestone, Dagmar limestone, Teutonic limestone, and Ophir formations, all measured by John M. Foster and the writer east of Rattlesnake Canyon in the east half of section 14 and west half of section 13, T9S, R3W, Utah County, Utah, July 17, 1954.

Cole Canyon Dolomite

Dolomite, dark grey, weathers to medium grey, crystalline to medium-grained, massive-bedded. Some mottling is present. Beds of this description alternate approximately every 10 to 25 feet with lighter-colored beds as follows:	
Dolomite, light grey to white, weathers to light cream, fine to medium-grained, massive-bedded, somewhat mottled. Approximately 147 feet from the top of the formation the beds grade into a greyish-black dolomite with numerous white "twiggy" bodies, similar to the Bluebird dolomite, this sequence is 84 feet thick.	442
Dolomite, light grey to white, weathering to light cream, fine to medium-grained, massive-bedded. Some mottling and banding is present. Some Opohonga-like shaly dolomite with red argillaceous partings occurs.	89
Dolomite, greyish-black, weathers to dark-grey, crystalline to fine-grained, thick to massive-bedded with numerous white "twiggy" bodies. This resembles the Bluebird dolomite, but grades into limestone. In general this unit is not as dark colored as the Bluebird dolomite.	157
Limestone and dolomite, dark grey with light grey mottling, highly mottled, mottling is in bands often 4 feet thick, overlain by Dagmar-type dolomite that is somewhat darker grey than the Dagmar, overlain by light grey dolomite, overlain by 30 feet of Bluebird type dolomite. This forms a massive ledge.	60
Dolomite, greyish-black, weathers to dark grey, thick to massive-bedded. Prominent white "twiggy" bodies. This resembles the Bluebird dolomite formation but the white inclusions are less numerous. Ledge-forming.	50
Dolomite, same as above but with less prominent white inclusions and with bands of lighter grey color. This is overlain by a medium-grey dolomite without the white inclusions.	40
Total thickness	838

Conformable contact

Bluebird Dolomite

Dolomite, greyish-black, weathers to dark grey with a purple hue; crystalline to fine-grained, thick to massive-bedded, with numerous white "twiggy" bodies from 1 to 4 mm. wide, 5 to 18 mm. long, with an average width of 1 to 2 mm. and length of 10 mm.	175
Total thickness	175

Conformable contact

Herkimer Limestone

Limestone, medium-grey, weathers to the same color, medium-grained, medium to thick-bedded. Pink argillaceous partings. Oolites are present at 40 feet from bottom of this unit. . . .	48
Limestone, same as above except this is a ledge-former with a 2 foot bed of oolites 12 feet from the base of this unit. Argillaceous partings are not as pink, become yellowish-brown.	55
Limestone, same as above, but no oolites.	19
Limestone, same as above, but with greyish-pink argillaceous partings and well developed mottling. Ledge-former. . . .	20
Dolomite, medium-grey with pink to yellowish-brown argillaceous partings which weather at 40 feet and from 43 to 55 feet into a pinkish-red shale, resembling the weathered product of Opohonga limestone. In the basal part of this unit is a small bed of very dark grey dolomite with many white specks and spangles which cause this part of the unit to resemble the Bluebird dolomite. Many streaks of white $CaCO_3$. A ledge is present in the basal part of the unit. . .	61
Limestone, medium grey, medium-grained and medium-bedded. Argillaceous partings present but not colored as much as up section. At 10 feet from base of unit a small bed of Bluebird-type rocks (as described above) is present. . . .	51
Limestone, medium grey, very fine-grained with argillaceous partings but not colored as much as up section. At 24 to 36 feet a bed of small oolites is present which give a sandy appearance. At 60 feet this unit is a ledge-former. .	63
Limestone, medium grey which weathers to the same color. This is medium-grained and medium-bedded and becomes somewhat "sand" streaked up section.	50
Total thickness	367

Conformable contact.

Dagmar Limestone

Dolomite, light olive-grey, weathers to a light greyish-white with a tannish hue, very fine-grained to sublithographic, medium-bedded. Laminated throughout which weather into fine ridges. Reticulated banding by $CaCO_3$ stringers 1/4 or 1/2 mm. wide.	13
Dolomite, same as above but less laminated.	64
Total thickness	77

Conformable with a gradational contact.

Teutonic Limestone

Limestone, near contact with the Dagmar formation it is banded, some of the bands are wavy and oolitic. Underlain by very dark grey, almost black limestone with many white specks. .	30
Limestone, medium bluish-grey weathering the same, fine-grained, medium to thick-bedded. Some mottling but generally more streaked by a darker grey superimposed on medium-grey than it is mottled.	41
Limestone, medium bluish-grey, fine-grained, medium to thick-bedded. In the lower 15 feet of this unit there is a bed of medium-sized oolites. At 67 feet in this unit there is a bed resembling Opohonga limestone, but with more subdued coloration.	53
Limestone, same as above but the upper 36 feet is a massive ledge-former with some beds of medium-sized oolites. . . .	31
Limestone, same as before, but dull grey at the base of the unit. .	42
Limestone, same as before, but ledge-former at the base. Pisolites present at 24 to 31 feet from base. This is generally well mottled and greyish tan.	41
Limestone, same as above. Pisolites at 24 to 26 feet from base of unit.	66
Limestone, same but more massive forming a ledge at 24 to 41 feet and without pisolites.	66
Limestone, same general description as before.	90

(Continued)

Teutonic Limestone (Continued)

Limestone, same general description as before. Mottling has decreased and is no longer as highly colored. Mottling here consists of yellowish-grey blotches.	92
Limestone, same general description as before, not mottled, oolitic. Mottling increases up section.	74
Total thickness	626

Conformable with a gradational contact.

Ophir Formation

Cover, float consists of shale particles.	90
Limestone, olive-brown, weathers to yellowish-grey, sub-lithographic, thick to massive-bedded. This may be slightly altered.	34
Limestone, medium grey, fine-grained, medium to thick-bedded. At 69 feet this unit becomes sand-streaked and 6 foot bed of very small oolites is present.	78
Cover, medium-grey limestone float of lighter color than previous float.	69
Limestone, medium-grey to reddish-brown, weathers medium-grey to yellowish-brown, sub-lithographic, thin-bedded. Argillaceous partings.	30
Cover.	76
Cover. Limestone float, probable shale underneath.	97
Limestone, medium-grey to reddish-brown which weathers medium-grey to yellowish-brown, fine-grained, medium to thick-bedded. Argillaceous partings.	21
Phyllite, dark purple (weathers same), with some darker bands 1 inch wide. Micaceous, thick-bedded. Blocky weathering. Iron content prominent in the darker streaks.	13
Shale, reddish-brown, weathers the same, fine grained, micaceous, Probably altered by hydrothermal activity.	39
Total thickness	547

Conformable and gradational contact.

Tintic Quartzite

Measured by John M. Foster, Paul J. Jorgenson and the writer on Skyline Ridge in the west half of section 26, and nearly all of section 27, T9S, R3W, Utah and Juab Counties, Utah, April 24, 1954.

Quartzite, light to medium-brown with variations to white. Ranging from crystalline to coarse-grained and from thin to massive-bedded. Cross-bedding prominent in some areas, but generally inconspicuous. Some beds of conglomerate, particularly in lower part of section.	1000+
(Base not exposed)	
Total thickness	*1000+

*An additional 2500 feet ± is indicated by the width of outcrop.

Conformable and gradational contact.

Appendix B

SPECTROGRAPHIC ANALYSIS

Four rock samples were analyzed using qualatative methods of spectrographic analysis.

Sample 29 was taken from the igneous dike rock discussed in the text (see p. 39) and found in the NW 1/4 of section 12, T9S, R3W. Sample 30 is highly altered Teutonic limestone adjacent to the same dike. Sample 40 is hydrothermally altered Pine Canyon limestone in the NE 1/4 of section 12, T9S, R3W. Sample 42 is altered Gardner associated with a fault located in the SE 1/4 of section 12, T9S, R3W. This sample is characteristic of the ferruginous calcite found along this and other fault zones.

Results are estimates made by visual comparison with exposures of Bureau of Standards samples of known composition. The following report was made by Dr. E. John Eastmond of the Physics Department of Brigham Young University:

TABLE 2 (A)

ANALYSIS FOR CERTAIN MAJOR CONSTITUENTS OF SELECTED ROCK SAMPLES*

Sample No.	MgO	SiO_2	CaO	Al_2O_3	Fe_2O_3	MnO	TiO_2
29	10.0%	25.0%	5.0%	10.0%	3.0%	0.2%	1.00%
30	1-2.0%	1-2.0%	25.0%	0.1%	2.0%	0.2%	.01%
40	0.1%	40.0%	1.2%	5.0%	1.0%	0.1%	.02%
42	0.2%	1-2.0%	25.0%	0.1%	2.0%	0.2%	.01%

*(Oxides assumed)

TABLE 2 (B)

ANALYSIS FOR CERTAIN MINOR CONSTITUENTS OF SELECTED ROCK SAMPLES

Sample No.	Pb	Zn	Ag	Cu relative figure only (probably .01%)
29	0.1%	--	--	Strongest (10)
30	0.1%	--	t (?) (trace)	Weakest (1)
40	0.1%	--	t (?)	Weak (4)
42	0.3%	--	t (?)	Weak (4)

-- = None detected by method used (1% would be easily found)

The occurrence of one per-cent titanium oxide in the igneous dike is of special interest but of no commercal importance.

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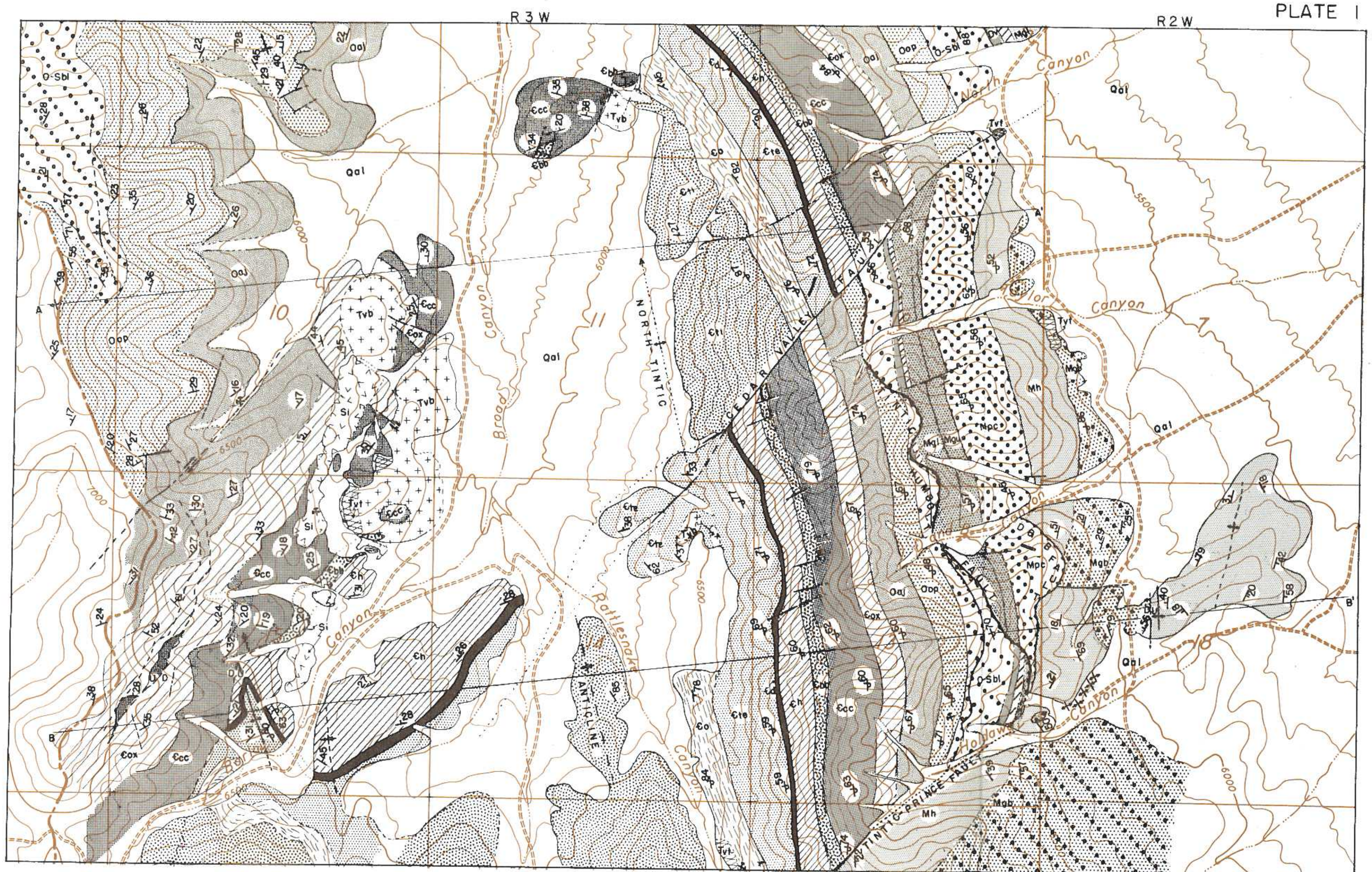
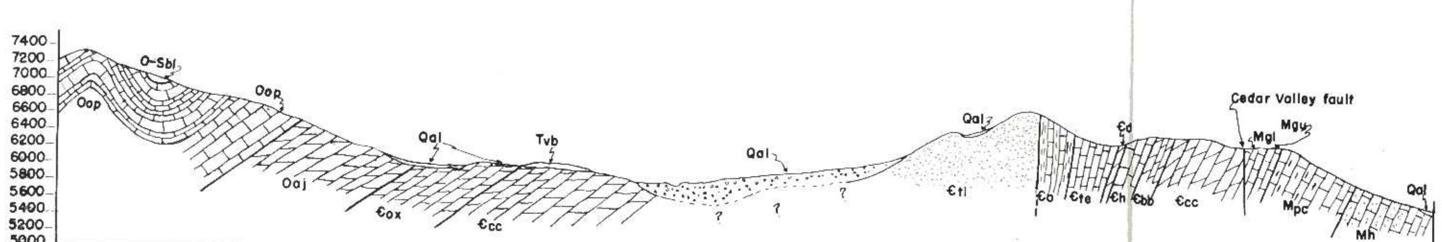
PLATE I

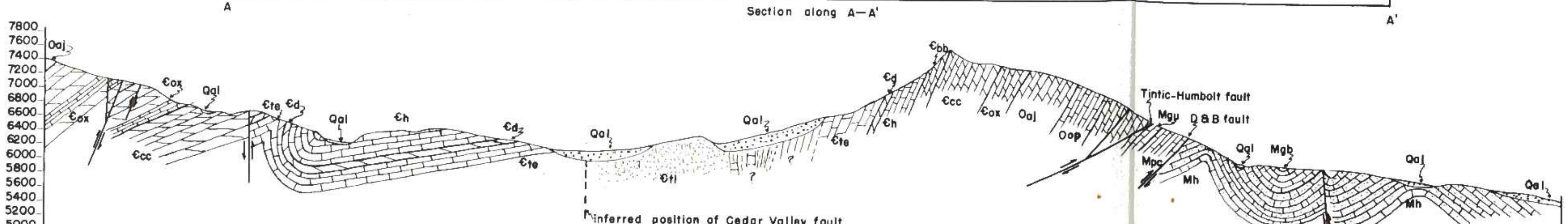


Base Map traced from enlarged U.S.G.S. Boulter Mountains Quadrangle

Mapped on 1:12,000 Aerial Photographs During 1953-54



Section along A—A'



Section along B—B'

EXPLANATION

SEDIMENTARY ROCKS

QUATERNARY
- Qal — Alluvium

MISSISSIPPIAN
- Mgb — Great Blue limestone
- Mh — Humbug formation
- Mpc — Pine Canyon limestone
- Mgu / Mgl — Gardner dolomite (upper & lower) divided at curley bed

DEVONIAN
- Dpp — Pinyon Peak limestone
- Dv — Victoria quartzite

ORD-SIL.
- O-Sbl — Bluebell dolomite

CAMBRO-ORD ORD
- Oop — Opohonga limestone
- Oaj — Ajax limestone

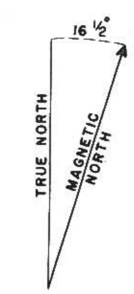
CAMBRIAN
- €ox — Opex dolomite
- €cc — Cole Canyon dolomite
- €bb — Bluebird dolomite
- €h — Herkimer limestone
- €d — Dagmar limestone
- €te — Teutonic limestone
- €o — Ophir formation
- €tl — Tintic quartzite

IGNEOUS ROCKS

TERTIARY
- Tvb — basalt
- Tvt — volcanic tuff
- Si — silicified country rock

SYMBOLS

- 40 — Dip and Strike
- 78 — Strike of Overturned Beds
- 90 — Strike of Vertical Beds
- D / U — Fault—dashed where doubtful dotted where concealed, D= downthrown side, U=upthrown
- Fault showing relative movement
- Thrust Fault (Saw—teeth on side of upper plate)
- Anticline (Showing trace of axial plane and bearing and plunge of axis Dashed where approximately located)
- Syncline (Showing trace of axial plane and bearing and plunge of axis Dashed where approximately located)
- Dike
- Mine



GEOLOGIC MAP AND CROSS SECTIONS OF THE CENTRAL BOULTER MOUNTAINS AREA, UTAH

by

MELVIN O. DEARDEN

1954

1000 500 0 1000 2000 3000 4000 5000 feet

Contour interval 100 feet