GEOLOGY OF THE SOUTH FORK OF THE OGDEN RIVER AREA, WEBER COUNTY, UTAH

by

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ABSTRACT

The South Fork of the Ogden River area is in eastern Weber County, Utah approximately two miles east of the town of Huntsville and comprises a portion of the northcentral Wasatch Mountains.

The rocks exposed in the area range in age from Precambrian to Quaternary. The Precambrian consists of quartzite, quartzitic sandstone, arkosite, and phyllite ($10{,}000^{\pm}$ feet); the Cambrian rocks are meta-quartzite; limestone, dolomite and shale (3500^{+} feet); the Ordovician is limestone, dolomite and shale (600^{+} feet); the Silurian rocks are largely arenaceous dolomite ($243^{\pm}$ feet); the Devonian is dolomite, arenaceous limestone and dolomite, sandstone, and shale (1144 feet); the Mississippian system is represented largely by limestone and sandstone ($3300^{\pm}$ feet); the Pennsylvanian is limestone and sandstone. The Eocene Knight (?) formation, which once covered the entire area, is a cobble and boulder conglomerate with sandstone lenses; Quaternary deposits consist of Lake Bonneville sediments and alluvium. The Upper Cambrian and base of the Ordovician are not exposed in the area. The Paleozoic strata were found to correlate with the formations of the Logan quadrangle. Detailed measured sections are included.

Except for minor disconformities, sedimentation was probably continuous from Precambrian to Pennsylvanian time. No evidence for an unconformity could be found at the base of the Cambrian. The area is located very near the southern limit of Ordovician and Silurian deposition; neither system is represented in the Uinta Mountains to the south.

The most important structural feature of the area is a north-trending syncline. The trace of the Willard (?) thrust is believed to be exposed in the western part of the area near Ogden Valley.

ACKNOWLEDGEMENTS

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Aerial photographs of the area were generously provided by the Standard Oil Company of California.

Special thanks are due my parents for encouragement and financial help and to my wife Marilyn for her confidence and patience.

INTRODUCTION

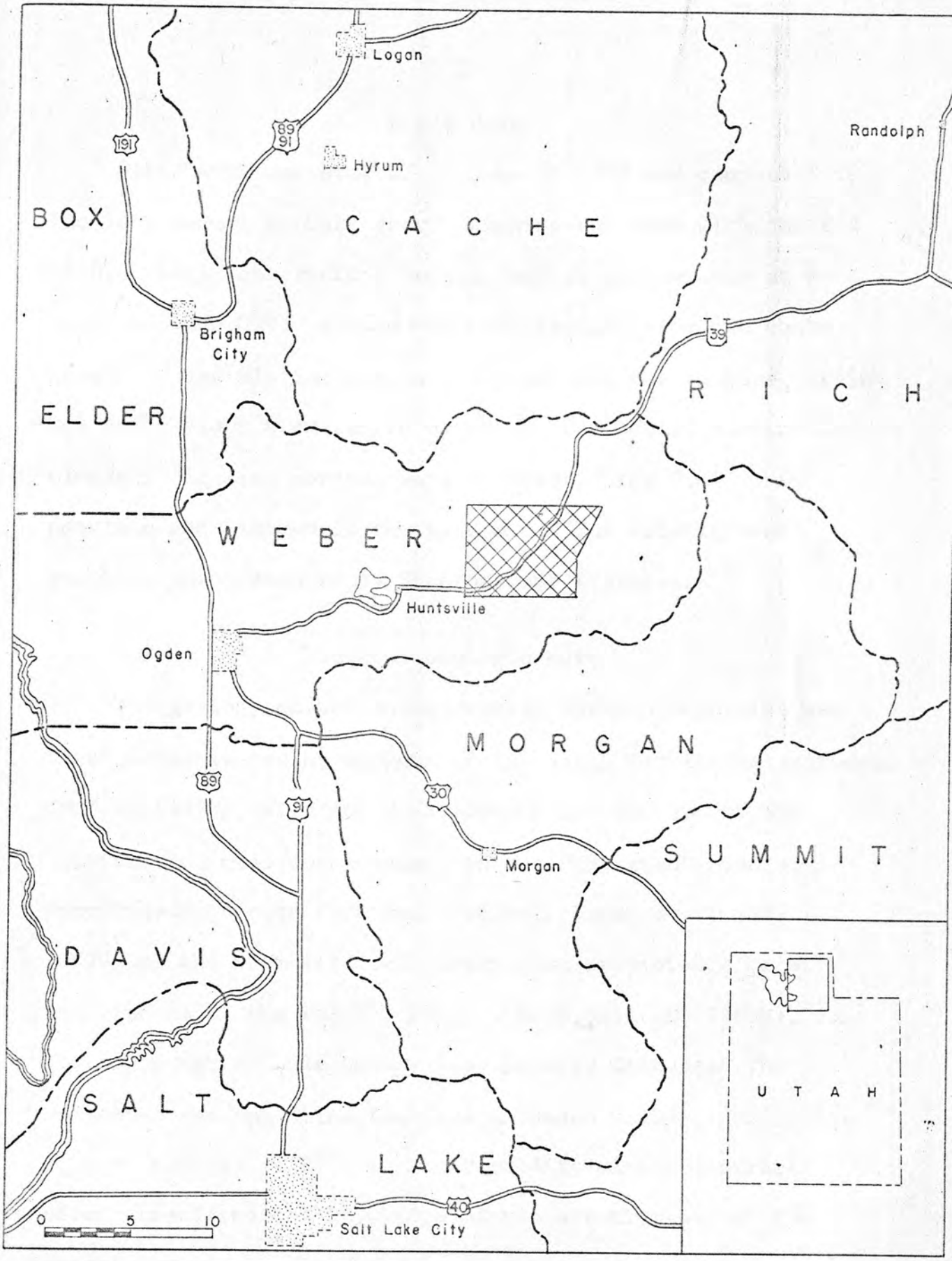
Location

The South Fork of the Ogden River area is in eastern Weber County, Utah approximately two miles east of the town of Huntsville. It comprises 85 square miles in parts of Townships 6 and 7 North, Ranges 2 and 3 East, Salt Lake Base and Meridian. The area is part of the north-central Wasatch as designated by Eardley (1944). It is bounded on the south by the South Fork of the Ogden River, on the north by Township line 8 North, on the west by Ogden Valley, and on the east by a divide known as Lightning Ridge.

The area may be reached from Huntsville via Utah Highway 39, a paved secondary road which follows the course of the South Fork of the Ogden River. Excepting the routes of Utah Highway 39 and the Camp Kiesel Canyon road, the area is accessible only by "jeep", horseback or foot.

Purpose

The chief purposes of the investigation were to map the area in detail, to measure and describe a stratigraphic section of the Paleozoic formations, and to correlate the exposed rocks with those in adjacent areas.



INDEX MAP SHOWING LOCATION OF SOUTH FORK OF THE OGDEN RIVER AREA — FIG. 1

Field Work

Field work was started in June of 1957 and completed in the late summer of that year. Mapping was done with the aid of U.S. Soil Conservation Service aerial photographs at a scale of 1:20,000. A base map was prepared from the photographs by the slotted template method, and the culture, drainage and geology transferred by means of a radial planimetric plotter. Section corners were located in the field when possible and plotted on the base map. The stratigraphic sections were measured by Brunton-tape traverse.

Previous Geologic Work

The geology of the north-central Wasatch Mountains was first investigated by workers of the early Territorial surveys. Bradley (1872), with the U. S. Geological Surveys of the Territories, made observations in the "Whasatch" Mountains from Ogden, Utah to Fort Hall, Idaho. Hague and Emmons (1877) of the 40th Parallel Survey also presented a brief description of the Wasatch Range. G. E. Gilbert (1890), in his monograph on Lake Bonneville, briefly discussed the sediments and shoreline features in Ogden Valley. Extensive work by Boutwell (1907) in the Park City mining district added greatly to the knowledge of the stratigraphy of the general area.

Blackwelder (1910a) made the first studies of the South Fork area in connection with a report on the phosphate deposits of northern Utah. Blackwelder (1910b) also reported on the geology in the vicinity of Ogden and Ogden Valley. In 1927 Mansfield published a comprehensive report on the geology and mineral resourses of southeastern Idaho which contributed greatly to the knowledge of that region.

Detailed studies of the Randolph quadrangle by Richardson (1941) and of the Logan quadrangle by Williams (1948) contributed to the knowledge of the geology of north-eastern Utah. Several papers pertaining to the structure, stratigraphy and geologic history of the region have been published by Eardley (1930, 1940, 1944, 1951). Also a number of unpublished theses on local areas have been written by University of Utah students under the Direction of Doctors A. J. Eardley and N. C. Williams.

The study of the South Fork area of the north-central Wasatch Mountains was undertaken by the writer in the Spring of 1957 at the suggestion of Dr. William Lee Stokes, Head of the Department of Geology, University of Utah.

GEOGRAPHY

Topography and Drainage

Elevations in the thesis area range from 5100 feet in Ogden Valley, to approximately 6600 feet on Highway 39 at the northern edge of the area. The land surface rises abruptly from the flood plain of the South Fork of the Ogden River to the extremely level terrain of the Herd Mountain surface. The area north of the river is characterized by rolling hills, except where the tributaries have cut below the Tertiary conglomerates to expose the Paleozoic rocks. In these deeper canyons the topography is very rugged.

The area is drained by the South Fork of the Ogden River and its major tributaries, Magpie Creek, Cobble Creek, Bear Wallow Creek, and Beaver Creek. The South Fork flows westward to the Pine View Reservoir and thence through Ogden Canyon to the Great Salt Lake.

Climate and Vegetation

The climate of the South Fork area is semi-arid and Huntsville has an annual rainfall of 28 inches. Heavy snow and cold make the area inaccessable for field work from late October to early June.

The foothills in the lower elevations are largely covered by sagebrush. At higher elevations scrub oak

and mountain mahogany are common. Quaking aspen are found in the canyon bottoms, and scattered conifers grow on north facing slopes.

Rock Exposures

The Paleozoic strata are best exposed in strike canyons where the overlying Tertiary conglomerate has been stripped away. Good exposures are found in the canyon of the South Fork near Magpie Canyon and further east in the "South Fork Narrows". Two main tributaries to the South Fork, Dry Bread Hollow and Camp Kiesel Canyon, also afford good exposures. The Precambrian strata are well exposed in a wide belt from the mouth of the South Fork to Magpie Canyon.

STRATIGRAPHY

Rocks exposed in the South Fork of the Ogden River area range in age from Precambrian to Quaternary. The Precambrian and Paleozoic strata crop out only where major streams have cut through the Eocene Knight formation which blankets the area. The rocks exposed are entirely sedimentary; however, the Proterozoic (?) has been slightly metamorphosed and is classed as a metasediment.

The Proterozoic (?) and Cambrian strata crop out in a wide north-trending belt from Ogden Valley to Magpie Creek. Ordovician and Silurian rocks crop out in the "Narrows" of the South Fork. Devonian, Mississippian, and Pennsylvanian rocks comprise the remainder of the Paleozoic section and crop out in Camp Kiesel Canyon and Dry Bread Hallow. The tops of the Cambrian and Pennsylvanian systems are not exposed. Quaternary deposits consists of sediments deposited in Lake Bonneville, and alluvium. No igneous rocks are exposed in the area.

Precambrian System

Proterozoic (?) Rocks

The oldest rock exposed in the area is a thick sequence of Proterozoic (?) quartzite and phyllite. These strata form the north trending mountain mass from the mouth of the South Fork to Magpie Canyon.

Eardley (1944) recognizes two divisions within the Proterozoic (?) sequence: a lower 3000 foot unit of interbedded quartzite, arkosite and phyllite and an upper 7000 foot unit of rust-weathering quartzitic sandstone. The quartzites and quartzitic sandstones are buff, pink, purple and maroon. Sand particles range from medium to coarse grained and pebbles to 2 inches in diameter are occasionally found. The phyllites constitute a minor amount of the section and are dark gray and green.

No evidence of an unconformity was detected between the Proterozoic (?) strata and the overlying Brigham quartzite. The upper Precambrian quartzites and lower Brigham are remarkably homogeneous, and although small lenses of conglomerate were found, no widespread basal conglomerate was noted.

Eardley (1944) in discussing the Proterozoic (?) rocks of the north-central Wasatch states:

> "The sediments were probably deposited in a deep trough in late Proterozoic and early Cambrian times and overlap the Archeozoic rocks of the northern Utah highland. They are probably separated from the overlying Cambrian strata by an unconformity, but in the trough area the unconformity was not found except in the Cottonwood uplift of the central Wasatch".

The thickness of the Proterozoic Section is estimated to be 10,000 feet. The base of the section is not exposed in the South Fork area, and the underlying Archeozoic Farmington

Canyon Complex does not crop out.

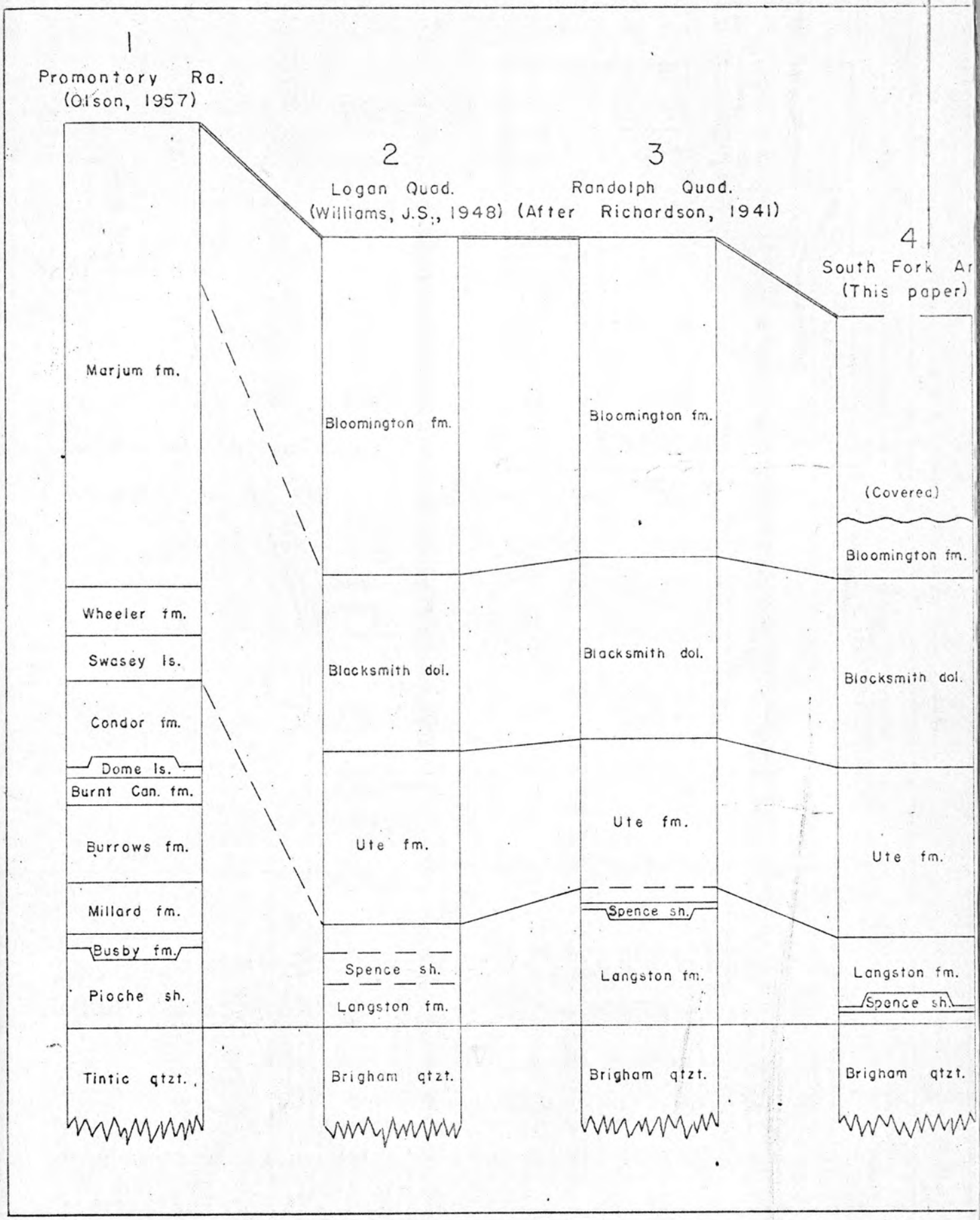
Cambrian System

General Statement

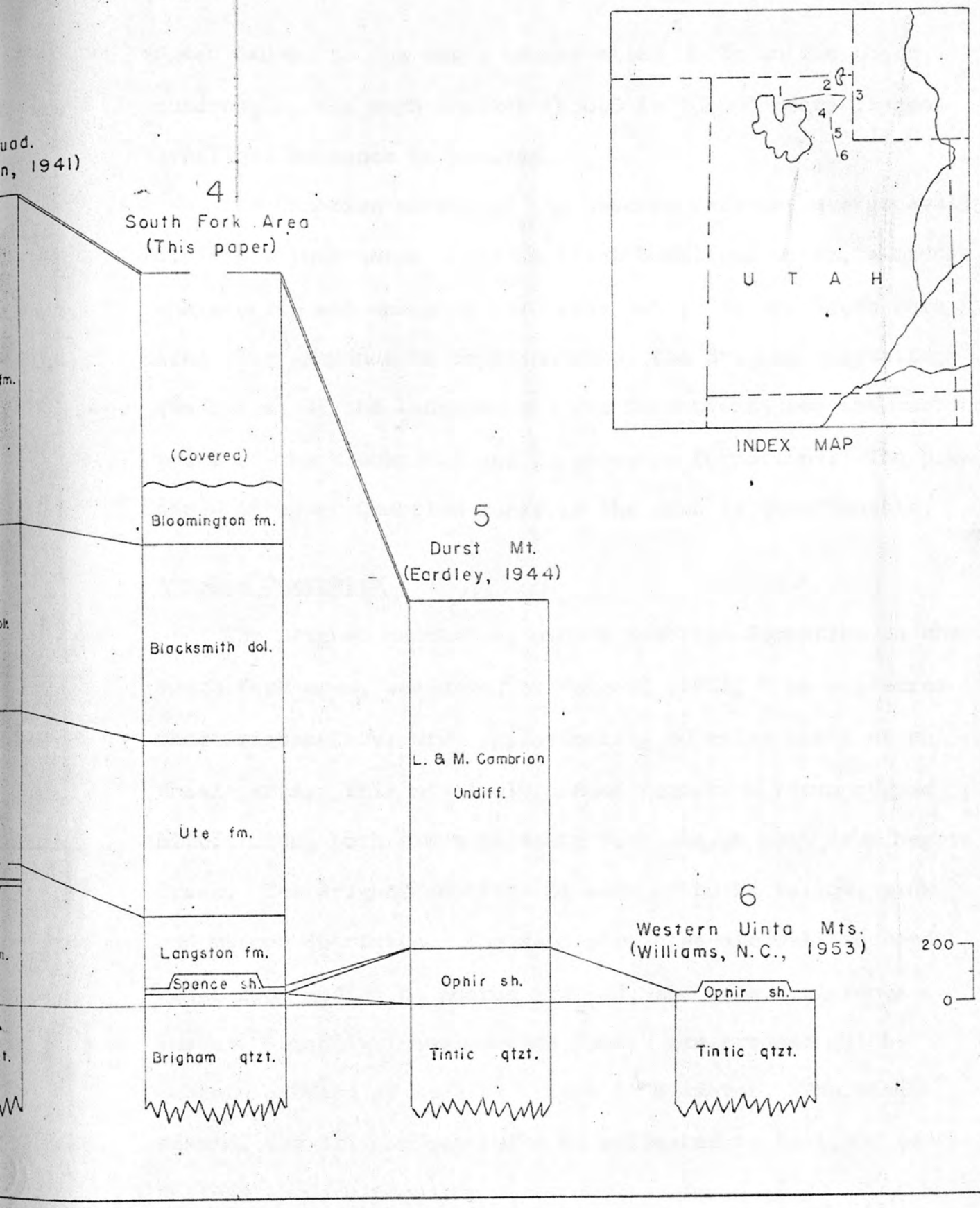
The Cambrian rocks of the South Fork area outcrop on both sides of the South Fork River from Magpie Canyon to Cobble Creek. Approximately 3000 feet of strata are exposed.

The geographic and stratigraphic relations of the Cambrian rocks of the area pose a problem in Cambrian nomenclature, i.e., should the formation names of the Logan quadrangle to the north, or those of the Great Basin to the south and west, be used? Most workers in the Wasatch Mountains south of the thesis area have used Great Basin formational names (Eardley, 1944, Gilluly, 1932). A careful examination of the units in the area of the present study convinced the writer that they are easily correlated with those of the Logan quadrangle.

Two different but gradational Cambrian sequences are present in the Wasatch Mountains. South of the South Fork area, relatively thin shelf deposits are present whereas to the north the much thicker miogeosynclinal sediments are present. The thesis area was evidently in the transition zone between these two areas of deposition. Shelf sediments are present in the Durst Mountain area 10 miles to the south and in



CORRELATION OF LOWER AND MIDDLE C



AND MIDDLE CAMBRIAN IN NORTHERN UTAH

Ogden Canyon to the west; twenty miles north in the Logan quadrangle, the much thicker (6,000 to 10,000 feet) miogeosynclinal sequence is exposed.

The Cambrian strata of the Western Interior are generally divisible into three units: a thick basal quartzite, a middle shale unit, and an upper carbonate unit. In the South Fork area this sequence is represented by the Brigham quartzite, the shales of the Langston and Ute formations, and the carbonate rocks of the Blacksmith and Bloomington formations. The presence of upper Cambrian rocks in the area is questionable.

Brigham Quartzite

The Brigham quartzite, oldest Cambrian formation in the South Fork area, was named by Walcott (1908) from exposures near Brigham City, Utah approximately 20 miles north of the thesis area. This massively bedded formation forms rugged cliffs along both sides of South Fork Canyon west from Magpie Creek. The Brigham consists of beds of buff, yellow, pink and maroon quartzite. The sand particles are well rounded, range from medium to coarse grained, and have a vitreous luster. Locally, conglomerate "pods" are present which contain pebbles as much as 1 inch in diameter. The thickness of the Brigham quartzite is estimated to be 1,500 feet. No fossils were found.

In the Durst Mountain area a few miles south of the thesis area the Brigham (Tintic) quartzite rests on the older Precambrian Farmington Complex with a coarse conglomerate at the base. No Proterozoic strata are present. In the South Fork area the Brigham quartzite rests with apparent conformity on the Precambrian Proterozoic (?) strata, and no basal conglomerate was found. Most writers (Eardley and Hatch, 1940, Wheeler, 1943, Williams, 1948) believe that sedimentation was continuous from late Precambrian into early Cambrian time.

The upper 200 feet of the Brigham quartzite are interbedded with thin (several inches to 1 foot) olive green, micaeous shale beds. Such interbedding is also seen in the Durst Mountain area to the south and the Logan quadrangle to the north. In the Durst Mountain area the shales grade into the overlying Ophir shale. However, in the South Fork and Logan areas, the Brigham is overlain, with apparent conformity, by approximately 50 feet of dolomite followed by the Spence shale member of the Langston formation.

Several writers (Williams, 1948, Wheeler, 1943) have suggested a correlation between the Spence and Ophir shales. The writer feels such is not the case. The presence of dolomite immediately above the Brigham quartzite, and the somewhat different lithologies of the Ophir and Spence shales seem to indicate they are two distinct units. In

regard to this problem, Wheeler (1943) states:

> "If the Spence and Pioche [Ophir] shales are distinct the northern limit of the latter in north-central Utah is somewhere between Ogden and Blacksmith Fork".

The writer agrees with this interpretation. (See lower and middle Cambrian correlation chart, Plate II)

The uppermost portion of the Brigham quartzite was measured on the east side of Magpie Canyon, where the shale units are well exposed.

	Thickness in feet
Langston formation	
Dolomite: medium crystalline, medium gray, weathers dark gray, medium bedded, slope former	69
Contact conformable	
Brigham quartzite	
11. Quartzite: buff to light red, medium to coarse, well-rounded sand grains, occasional grains to ¼", medium bedded to massive	15
10. Shale: olive-drab to "dirty" yellow, micaceous on bedding planes, friable, slightly arenaceous	½
9. Quartzite, as in No. 11 above	131
8. Interbedded quartzite and shale: shale as in No. 10 above, beds average 1-2" in thickness	5
7. Quartzite: as in No. 11 above	31

Brigham quartzite (continued)	Thickness in feet
6. Shale: as in No. 10, but more fissile, less micaceous	1
5. Quartzite: as in No. 11 above	40
4. Shale: as in No. 10 above	1
3. Quartzite: as in No. 11 above but more red	64
2. Shale: as in No. 10 above	2
1. Quartzite: as in No. 11 above	100

Langston Formation

The Langston formation is well exposed on the cliffs overlooking the South Fork of the Ogden River, just east of Magpie Canyon. It consists of a basal, black arenaceous dolomite, followed successively by a buff weathering, light gray limestone bed, two green shale units separated by a gray limestone, and an overlying sequence of gray limestones.

The Langston formation rests conformably on the Brigham quartzite and the base of the first dolomite unit overlying the quartzite was chosen as the lower contact. The upper contact was placed at the top of the thick bedded limestones under the Ute shale. The Langston formation is 398 feet thick in the South Fork area.

The dark green, very fossiliferous Spence shale member of the Langston is best exposed on the crest of the ridge

above the South Fork where it forms a prominent saddle. The saddle is marked by a lack of vegetation, and by characteristic green Spence shale debris on the surface. Although the shale does not crop out, shallow excavating exposed rocks in place.

Mrs. Christina Lockman-Balk, who examined the fauna collected from the Spence shale, believes it to represent the Glossopleura zone of Middle Cambrian age. Specific forms are listed in the following detailed section.

In the Logan quadrangle, to the north of the thesis area, an extremely fossiliferous black limestone at the base of the Langston formation has been designated the Ptamigania member of the Langston (Resser, 1939). The black dolomite unit at the base of the formation in the South Fork area may correlate with this member although no confirming fossils were found.

The following section was measured on the south side of the South Fork, immediately east of Magpie Canyon:

Ute Formation	Thickness in feet
Shale: light olive green, arenaceous, calcareous, thin bedded to fissile. Interbedded limestone becomes prominent toward top of unit.	137

Langston formation	Thickness in feet
6. Limestone: thin bedded, finely crystalline, very dark gray, weathers medium gray, tan shale partings	69
5. Shale: medium to dark olive green, very fissile to thin bedded, forms depressions. *Glossopleura bion* Walcott, *Westonia ella White*, *Alokistocare idahoense* Resser, A. cf. *natale* Resser	19
4. Limestone: dark gray to black, coarsely crystalline, weathers medium gray, occasional beds of limestone conglomerate, forms ragged cliffs	46
3. Shale: as in No. 5 above. *Alokistocare idahoense* Resser, Ehmaniella sp.	44
2. Dolomite: light gray to tan, medium to coarsely crystalline, weathers light buff, arenaceous, cliff former .	51
1. Dolomite: medium gray, weathers dark gray, medium crystalline, medium bedded, forms slopes	69
Total Langston	398

Contact conformable

Brigham Quartzite

Quartzite: buff to light red, medium to coarse, well-rounded sand grains, occasional grains to ¼", medium bedded to massive. Interbedded olive drab shales.

Ute Formation

The sequence of soft shales and thin bedded limestone lying between the massive limestones of the Langston and Blacksmith formations is correlated with the Ute formation. The Ute is a slope former throughout, and is very poorly exposed in the South Fork area except on the high ridge east of Magpie Canyon. Six hundred fifty nine feet of the Ute formation were measured along this ridge.

The shales of the Ute formation are dark green, gray, and brown. Scraps of float usually indicate their presence in soil areas. The limestones are predominately gray, thin bedded, finely crystalline, and argillaceous. Calcite stringers are common in certain beds. Limestone breccias are common toward the top of the unit.

In the South Fork area, no fossils were found in the Ute formation. However Williams and Maxey (1941) report a Middle Cambrian fauna from the Ute in the Logan quadrangle.

Both the upper and lower contacts of the Ute formation appear to be conformable. The lower contact was placed at the base of the first green shale above the Langston limestones and the upper contact was placed at the top of the last green shale.

The following section was measured on the ridge east

of Magpie Canyon:

	Thickness in feet
Blacksmith formation	
Limestone: dark gray, finely crystalline, weathers dark gray, thin to massively bedded.	27
Contact conformable	
Ute formation	
5. Limestone and limestone breccias, occasional interbedded shale: limestone medium to coarsely crystalline, medium gray, medium bedded. Shale dark green, very fissile, slope former	182
4. Covered: float indicates interbedded limestone and shale. Limestone thin bedded, black, very argillacious. Shale brown, very calcareous, slope former	94
3. Limestone: dark gray, weathers dark gray, finely crystalline, calcite stringers very prominent. Top 7 feet of unit is a conspicuous ledge of limestone	132
2. Limestone: dark gray to black, banded, weathers medium gray, argillaceous partings, finely crystalline to sub-lithographic, thin bedded. Becomes nodular toward top of unit. Probably some thin shale beds	114
1. Shale: light olive green, arenaceous, calcareous, thin bedded to fissile. Interbedded limestone becomes predominate toward top of unit	137
Total Ute formation	658

Contact conformable

Langston formation	Thickness in feet
Limestone: thin bedded, finely crystalline, very dark gray, weathers medium gray, tan shale partings	69

Blacksmith Formation

Overlying the soft, easily eroded Ute formation is the massive, cliff forming Blacksmith formation. It is very well exposed in the high cliff which forms the east bank of Cobble Creek and also along the south side of the South Fork River. The limestones and dolomitic limestones which compose the Blacksmith formation are medium to dark gray, range from medium to finely crystalline, and are commonly oolitic. When viewed from a distance the Blacksmith appears banded in several shades of gray.

The lower contact of the Blacksmith formation was placed at the top of the upper most shale unit of the Ute formation. The upper contact was drawn at the base of a thick, very fissile, green shale unit which is presumably the Hodge shale member of the Bloomington formation. Both contacts appear conformable.

The Blacksmith formation must be of Middle Cambrian age as it lies between beds containing Middle Cambrian fossils. In regard to the fossils found in the Blacksmith

formation by the author, Christina Lockman-Balk states:

> . . . Bathyuriscus-Elrathina zone . . . The Blacksmith lithic unit seems to cover the time of the Bathyuriscus-Elrathina zone although the top of the zone may reach into the Hodges shale - we have never had fossils from this unit reported before. . . The faunas of this zone are several, lower, middle and upper at least, and to date we have not been able to place the division very accurately. The species of Asaphiscus in this material seems to be new, but is most similar to A. wheeleri the type which according to Palmer is to be placed somewhere in the middle part of the zone.

The following section was measured on the south side of the South Fork River east of Magpie Canyon:

	Thickness in feet
Bloomington formation	
Shale: dark green, very fissile, weathers dark green, slope former	120
Contact conformable	
Blacksmith formation	
6. Covered: probably medium gray limestone.	83
5. Limestone, dolomitic: medium gray, finely crystalline, nodular, thin bedded, hackly surface, oolitic in part, weathers mottled black and brown. Kootenia sp	146
4. Covered: probably limestone as in No. 3 below	174

Blacksmith formation (continued)	Thickness in feet
3. Limestone: banded black and medium gray, finely crystalline, argillaceous, very fossiliferous. Asaphiscus n. sp., Asaphiscus sp., Westonia ella. (White), Ehmaniella cf. Waptaensis Rasetti, Bolaspidella sp., Bathyuriscus sp., Lingulella sp., Micromitra sp., Acrothele sp., sponge spicule.	87
2. Limestone, dolomitic: dark gray to black, finely crystalline, thin bedded to massive, weathers dark gray, Kootenia pectenoides Resser, Mexicella stator (Walcott)	213
1. Limestone: dark gray, finely crystalline, thin to massive bedding, weathers dark gray	27
Total Blacksmith formation	730

Contact conformable

Ute Formation

Limestone and limestone breccias, interbedded shales: Limestone medium to coarsely crystalline, medium gray, medium bedded. Shales dark green, very fissile, slope former	182

Middle and Upper (?) Cambrian Undifferentiated

Overlying the massive Blacksmith formation is a unit of dark green fissile shale. This unit forms the dip slope east of Cobble Creek and probably represents the Hodge shale member of the Bloomington formation. However, exposures east of this area (stratigraphically higher than the shale unit) are

obscured by vegetation and debris from the Knight formation. An outcrop of medium to massively bedded, dark gray, brecciated limestone is exposed along highway 39 east of Cobble Creek. No fossils could be found in the unit however, and its age is unknown. The writer believes that this area is probably underlain, at least in part, by the thick (1200' in Logan quadrangle) Bloomington formation. The presence of upper Cambrian rocks (Nounan and St. Charles formations) is conjectural.

Ordovician System

Garden City Formation

The upper portion of the Garden City formation crops out in the "Narrows" of the South Fork of the Ogden River where it is exposed in the core of a small anticlinal fold. The formation is a slope former and appears as a very distinct buff weathering unit below the massive gray cliffs of the overlying Fish Haven dolomite.

That part of the Garden City formation exposed is composed of thin to medium bedded limestone and intraformational conglomerates with occasional thin beds of buff to yellow calcareous shale. The coarsely crystalline limestone is characterized by a reddish tinge on freshly broken surfaces. Well-rounded disk shaped pebbles are present in the conglomerates. The unit is very fossiliferous, although well

preserved specimens are scarce.

Unfortunately only the top 296 feet of the Garden City formation is exposed in the South Fork area. The trilobite Jeffersonia peltabella, collected near the top of the unit places the strata, at least in part, in zone G(2)e of Ross (1951). In the Logan quadrangle this zone lies 522 feet below the top of the Garden City formation. Therefore it appears that the equivalents of at least 300 feet of Garden City strata are absent in the South Fork area. Owing to the apparently conformable nature of the contact with the overlying Fish Haven dolomite it is believed the absence of part of the Garden City is due to non-deposition rather than erosion. Ross (1951) has described extensive chert beds in the upper one-third of the Garden City formation which are not found in the South Fork area. The absence of the chert also suggests that the upper part of the formation is unrepresented.

The environment of deposition of the Garden City formation was probably one of very shallow seas with alternating periods of submergence and emergence (Ross, 1951). The South Fork area may be very near to the southern limit of Ordovician deposition. No ordovician is reported a few miles southward in the Durst Mountain area (Coody, 1957) or westward in the Ogden Canyon area (Eardley, 1944).

Ross (1951) believes the division between lower (Canadian) and upper Ordovician (Chazyan) lies within 30 to 40 feet of the top of the Garden City formation in the Logan quadrangle. Since this interval is missing in the South Fork area, the formation here must be entirely early Ordovician in age.

The absence of the upper portion of the Garden City and the entire Swan Peak formation indicates that a considerable hiatus must exist at the Garden City-Fish Haven contact. Nevertheless, no physical evidence for an unconformity could be detected, and the contact appears entirely conformable.

The following section was measured in the "Narrows" of the South Fork of the Ogden River. It should be noted that the bottom of the measured section represents the lowest stratigraphic level locally exposed, and not the stratigraphic base of the formation:

	Thickness in feet
Fish Haven dolomite	
Dolomite: medium gray to light tan, finely crystalline, weathers dark to light gray, prominent cliff former	40
Garden City formation	
3. Limestone, becoming dolomitic towards top of unit: medium gray with reddish tinge on freshly broken surfaces, weathers medium to light gray, medium to coarsely crystalline, slope former	37

Garden City formation (continued)	Thickness in feet
2. Limestone, dark to medium gray, reddish tinge on fresh surfaces, interformational conglomerates, arenaceous lens, medium to thin bedding. Jeffersonia peltabella, cf. Lingulepis, Orthis sp., Tentaculites (?) sp., cystoid plate . .	228
1. Limestone, medium to dark gray, fine to medium crystalline, weathers light gray to buff, very thinly bedded, intraformational conglomerates. Dark gray shale 2' thick at bottom of unit. Clonograptus (?) sp., Dictyonema sp. . .	31
Total Garden City formation	296

Base not exposed

Fish Haven Dolomite

The Fish Haven dolomite was named for exposures in Fish Haven Canyon west of Bear Lake in southwestern Idaho. In the thesis area the formation outcrops in the "Narrows" of the South Fork of the Ogden River and forms alternating massive cliffs and smooth slopes above the slope-forming Garden City formation. It consists of medium to dark gray, finely crystalline to sublithographic, arenaceous dolomite. Gray banding can be distinguished when viewed from a distance, but is not discernable on the outcrop.

Although occasional fossil "shadows" are seen in the Fish Haven, identifiable remains are very scarce. A single coral collected by the author was tentatively identified

as Streptelasma (?) sp.

The Fish Haven dolomite is 500 feet thick at the type section in the Randolph quadrangle, (Richardson, 1941) and 140 feet in the Logan Quadrangle (Williams, 1948). The formation is approximately 381 feet thick in the South Fork area, although this figure may be in error as the contact with the overlying Laketown dolomite is very much in doubt. The Fish Haven and Laketown dolomites are shown as one unit on the geologic map of the area, Plate I.

The age of the Fish Haven dolomite has been considered to be Late Ordovician (Richmond) since its original description. Recent evidence however, summarized by Ross (1953) indicates it may be Middle Ordovician (Trenton) or perhaps, as Ross suggests, it spans the Middle-Late Ordovician boundary. He concludes, "At present caution is counseled in regard to the dating of the Fish Haven dolomite and its equivalents in the Cordilleran region".

The following section was measured on the north side of the "Narrows" of the South Fork River:

Laketown dolomite	Thickness in feet
Mostly covered, probably a light gray dolomite becoming very arenaceous at top of unit. Slope former	145

	Thickness in feet
Laketown dolomite (continued)	
Disconformity (?)	
Fish Haven dolomite	
3. Dolomite: medium gray to light tan, very finely crystalline to sub-lithographic, massive, weathers medium-dark gray to light gray. Banding of light and dark gray can be seen from a distance, but cannot be discerned on outcrop, cliff former. . .	117
2. Dolomite: as in No. 3 above, but slightly arenaceous and a slope former	129
1. Dolomite: as in No. 3 above, forms very imposing cliffs	135
Total Fish Haven formation	381
Disconformity	
Garden City formation	
Limestone becoming dolomitic toward top of unit: medium gray with reddish tinge on freshly broken surfaces, weathers medium to light gray, medium to coarsely crystalline, slope former . . .	37

Silurian System

Laketown Dolomite

The Silurian system in the northern Wasatch Mountains is represented by a single formation, the Laketown dolomite. In the South Fork area the light gray, arenaceous Laketown overlies the massive, darker Fish Haven dolomite and underlies the white weathering Water Canyon formation.

As previously noted the poor exposures and uncertain contact necessitated mapping the Fish Haven and Laketown as a single unit (Geologic map, Plate I).

The Laketown dolomite thins rapidly from 1500 feet in the Logan quadrangle to the north (Williams, 1948) to 243 feet in the thesis area. The absence of Silurian strata in the Durst Mountain region to the south (Coody, 1957) indicates that the South Fork area may lie very close to the southern margin of Silurian deposition. Although occasional outlines of fossils were observed in the Laketown of the South Fork area, no identifiable remains could be found. However faunal collections from the formation in other areas indicate a middle Silurian age (Stokes, 1953).

The absence of lower and upper Silurian rocks indicates that a considerable hiatus must exist at both contacts of the middle Silurian Laketown dolomite. The nature of the contacts however, is largely obscured by vegetation and soil.

As noted in the discussion of the Fish Haven dolomite, the contacts chosen in the measured sections may be in error, and perhaps the Laketown is somewhat thicker than indicated. The following section was measured in the "Narrows" of the South Fork River:

Fig. 2 Cliffs of Fish Haven dolomite exposed in the "Narrows" of the South Fork River. Slope forming Garden City formation at lower right.

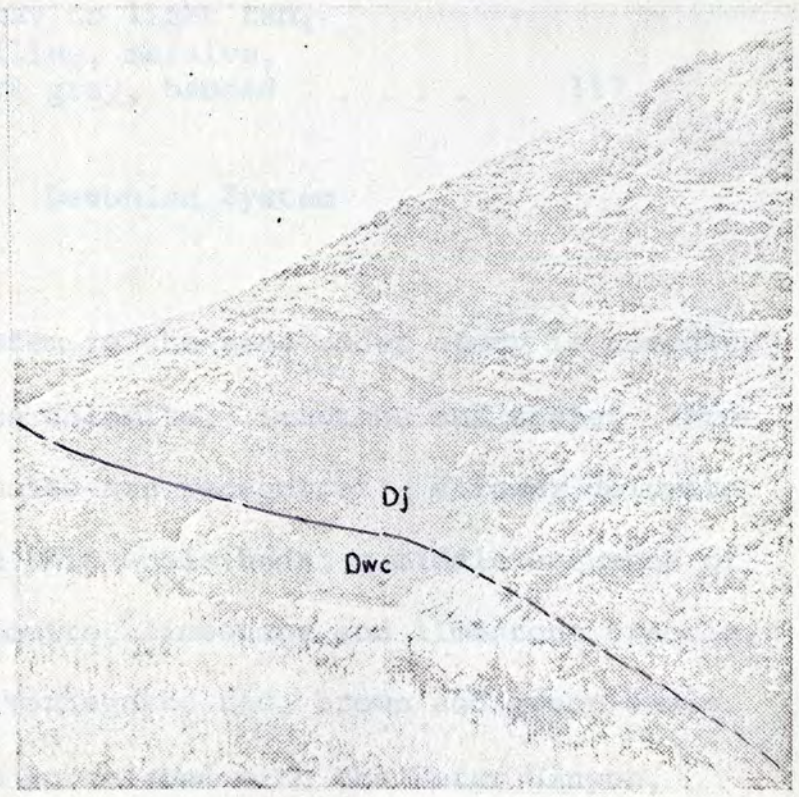


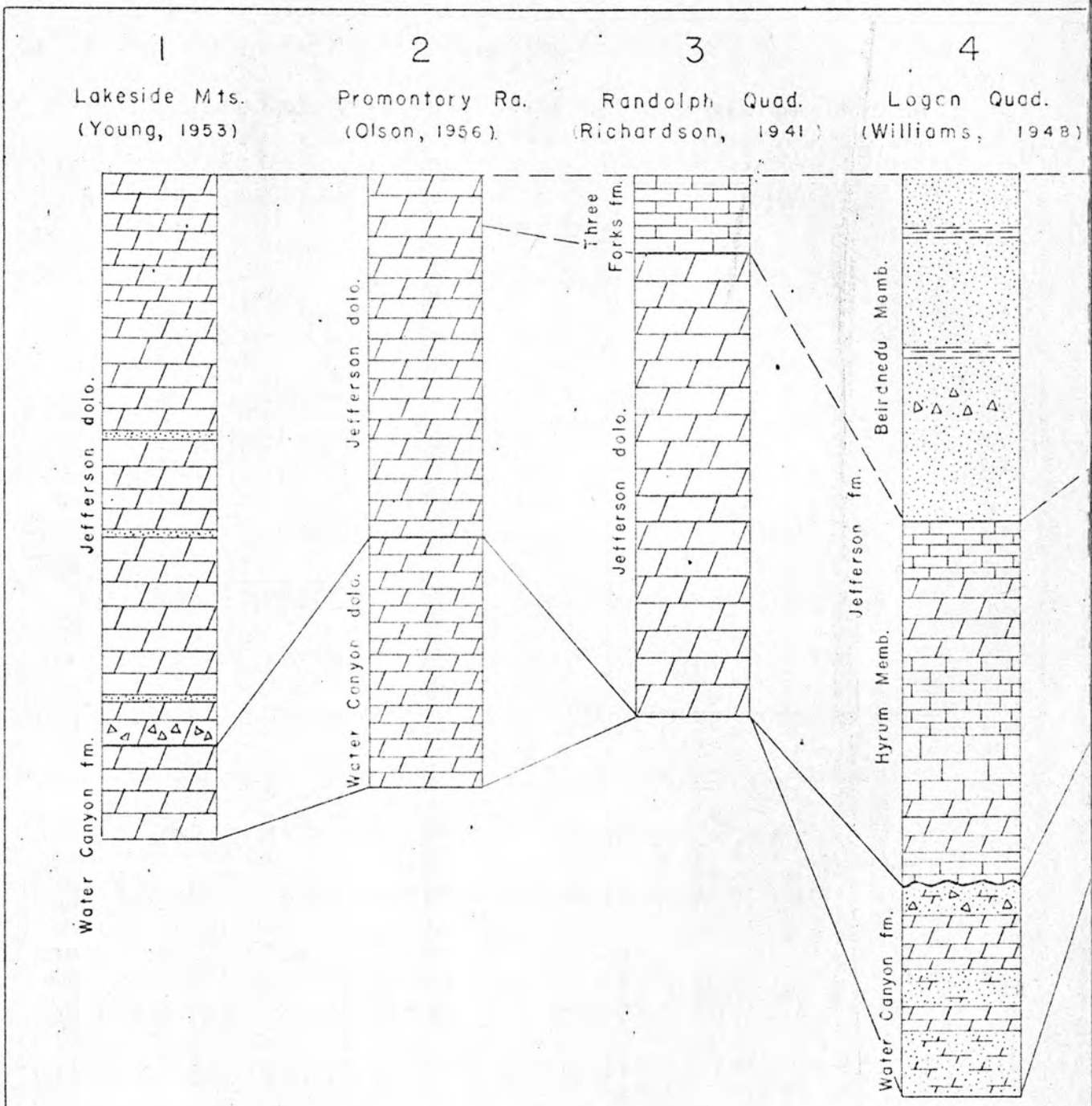
Fig. 3 View at mouth of Camp Kiesel Canyon showing Water Canyon and Jefferson fms.

	Thickness in feet
Water Canyon formation	
Dolomite: light gray to white, coarsely crystalline, oolitic, weathers nearly white, slope former.	54
Laketown dolomite	
2. Dolomite: light gray, medium to coarsely crystalline, fossil "shadows", cliff-former	98
1. Covered: probably a light gray dolomite becoming very arenaceous at top of unit, slope former	145
Total Laketown dolomite formation	243
Disconformity	
Fish Haven dolomite	
Dolomite: medium gray to light tan, very finely crystalline, massive, weathers medium-dark gray, banded	117

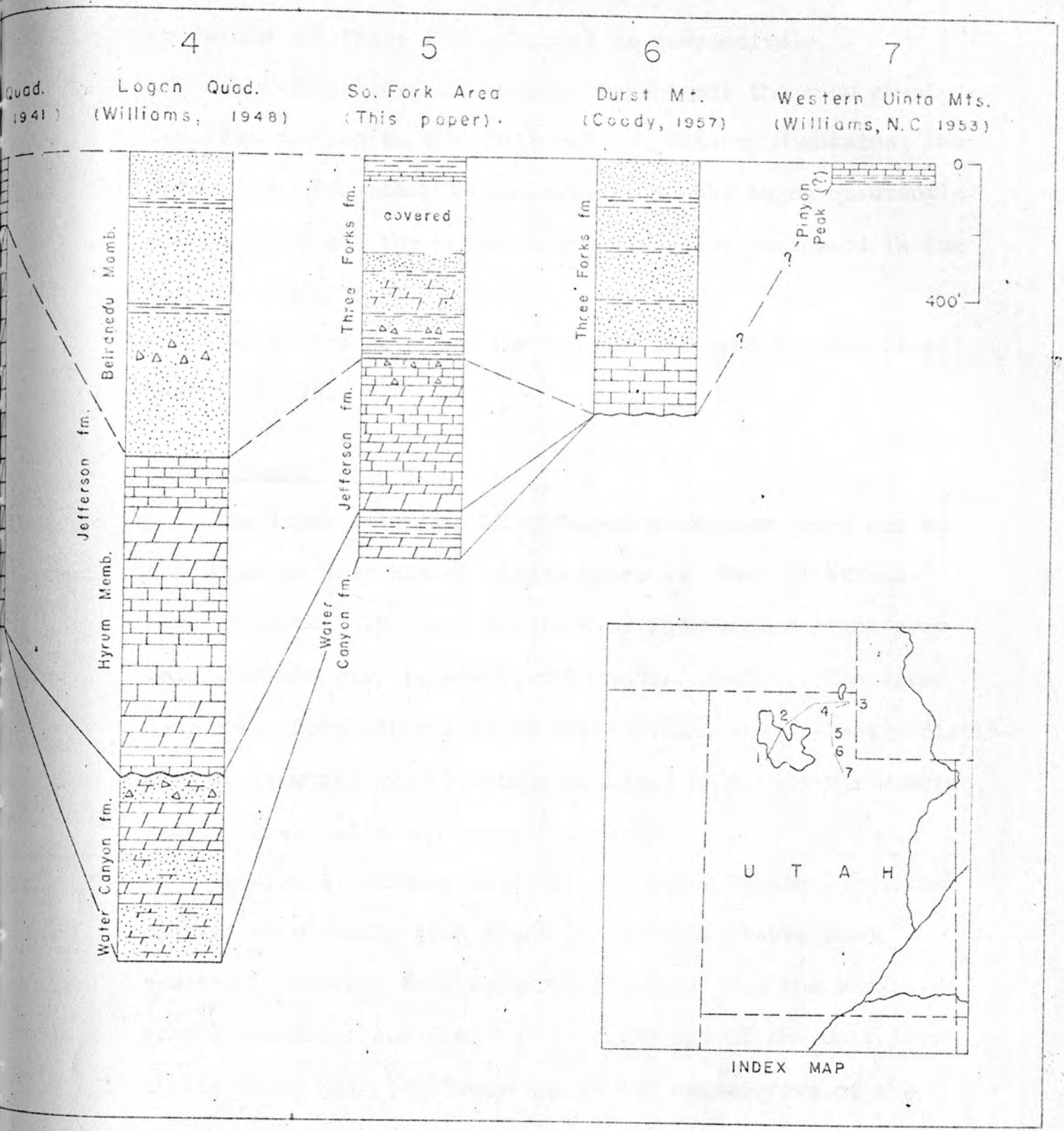
Devonian System

General Statement

The Devonian System in the area under study is composed of 1144 feet of marine dolomite, limestone and shale. Three distinct lithologic units are recognized: a lower dolomite unit interbedded with thin shale beds; a middle sequence of black, arenaceous dolomite, limestone and limestone breccia, and an upper unit of variegated red, brown and green shale. These units have been correlated with the Water Canyon,



CORRELATION OF DEVONIAN SY



DEVONIAN SYSTEM IN NORTHERN UTAH

Jefferson and Three Forks formations respectively.

This stratigraphic sequence represents the most complete Devonian section in the north-central Wasatch Mountains; the Three Forks formation is not present in the Logan quadrangle to the north and the Water Canyon is absent southward in the Morgan-Henefer area.

The entire Devonian section was measured in Camp Kiesel Canyon, T. 7N., R. 3 E.

Water Canyon Formation

The lower Devonian Water Canyon formation crops out at the mouth of Camp Kiesel Canyon where 121 feet of strata were measured. The unit consists of interbedded light gray dolomites and gray to black, thin bedded shales. The Water Canyon weathers light buff to nearly white and is easily distinguished from the gray Laketown dolomite below and the massive, nearly black Jefferson formation above.

The fossil remains found in the Water Canyon formation consist of a single fish plate and unidentifiable plant remains. However, this meager collection plus the stratigraphic position and distinctive lithology of the unit leave little doubt that the formation is the correlative of the type Water Canyon to the north.

Although Williams (1948) noted a marked disconformity

at the top of the Water Canyon, the contact appeared everywhere conformable where it was exposed in the thesis area.

The following section was measured at the mouth of Camp Kiesel Canyon:

	Thickness in feet
Jefferson formation	
Dolomite: medium gray, medium crystalline, slightly arenaceous, bedding medium to massive, weathers dark gray to black	10
Contact conformable (?)	
Water Canyon formation	
8. Dolomite: medium gray, fine to medium crystalline, medium bedded, weathers light buff to nearly white. Fish plate found near top of unit	28
7. Covered: probably black shale as in unit No. 5	18
6. Shale: dark gray to black, fissile, contains poorly preserved plant remains	4
5. Shale: black, dolomitic, medium bedded, with plant remains	5
4. Shale: medium to dark gray, fissile	1
3. Dolomite: as in unit No. 1	10
2. Interbedded shale and dolomite: thin bedded (1"), shale light olive gray, fissile, dolomite light gray	1
1. Dolomite: light gray to white, coarsely crystalline, oolitic, weathers nearly white, slope former	54
Total Water Canyon Formation	121

Water Canyon formation (continued)	Thickness in feet
Contact conformable	
Laketown dolomite	
Dolomite: light gray, medium to coarsely crystalline, cliff former . . .	98

Jefferson Formation

Overlying the nearly white weathering Water Canyon formation is a thick sequence of dark gray to black, dark weathering dolomites and limestones. In the Logan quadrangle north of the thesis area, Williams (1948) has assigned this unit to the Jefferson formation.

In the South Fork area the Jefferson is well exposed on the west side of Camp Kiesel Canyon where it outcrops in massive, dark gray cliffs. The limestones and dolomites are medium to finely crystalline and become increasingly arenaceous toward the top of the formation. Limestone breccias and gray shales are also found in the unit.

The contact of the Jefferson formation with the underlying Water Canyon formation was placed at the bottom of the first dark gray dolomite bed. The upper contact was placed at the base of the first red shale of the overlying Three Forks formation. The Jefferson formation is 435 feet thick in the South Fork area; no fossils were found.

Williams (1948) has named two members within the Jefferson formation of the Logan quadrangle. The lower member (Hyrum dolomite) is predominately dark gray dolomites and limestones. The upper member (Beirdneau sandstone) is entirely a buff weathering sandstone. In regard to the Beirdneau sandstone member, Williams states:

> "The Beirdneau sandstone member may be the taxonomic equivalent of the Three Forks shales and limestones, but the possibility of finding fossils in these upper beds in the Logan quadrangle is remote. . . it seems undesirable to divide the Devonian rocks of the region into two formations, and introduce a new formation name, particularly since they are an intergrading lithologic unit."

Also in regard to this nomenclature problem, Brooks and Andrichuk (1953) states:

> "The Beirdneau member of the Jefferson formation may be chronologically a close correlative of the Three Forks, recognized elsewhere in the region. However the lithologies are similar only in that both represent a change in late Devonian time from purely carbonate deposition to that of a more clastic."

The stratigraphic sequence of the South Fork area seems to support this suggestion. The thickness (435 feet) of the Jefferson in the area is substantially less than the combined thickness (2120 feet) of the Hyrum and Beirdneau members (Williams, 1948). However it should be noted that

in the Logan quadrangle the Jefferson formation is absent in several localities and the Madison limestone of Mississippian age rests on Silurian rocks. This pronounced unconformity may represent erosion or non-deposition during Three Forks time.

The following section was measured on the west side of Camp Kiesel Canyon:

	Thickness in feet
Three Forks formation	
Shale and interbedded sandstone: shale red, fissile, calcareous, sandstone buff, medium to coarse grain	11
Jefferson formation	
20. Limestone breccia: medium to coarsely crystalline, light gray, weathers dark gray, arenaceous, medium bedded to massive, forms prominent cliff below Three Forks formation	31
19. Covered: probably interbedded sandstone and shale, forms slope	29
18. Limestone: medium gray, finely crystalline, thin bedded, abundant calcite stringers	16
17. Limestone and limestone breccia: medium gray, weathers dark gray, medium crystalline, very arenaceous	29
16. Covered:	18
15. Limestone and limestone breccia: as in No. 20 above	8

Jefferson formation (continued)	Thickness in feet
14. Covered: probably arenaceous dolomite	52
13. Dolomite: medium gray, very finely crystalline, massive	22
12. Covered: probably a dark gray shale .	18
11. Dolomite: dark gray, finely crystalline, slightly arenaceous, slightly calcareous, medium bedded . .	25
10. Sandstone: very light buff, fine grain, well-rounded, non-calcareous, crossbedded	2
9. Dolomite: gray, medium crystalline, arenaceous, medium bedded to massive	31
8. Dolomite: dark gray to black, fine to medium crystalline, weathers dark gray, slightly arenaceous, medium bedded to massive	24
7. Dolomite: as in No. 16, but thin bedded (2"-4")	21
6. Dolomite: as in No. 16 above	24
5. Covered: probably arenaceous shale buff	27
4. Limestone and shale breccia: medium gray and buff, limestone finely crystalline to sublithographic, bedding indistinct to very thin . . .	6
3. Dolomite: light gray to white, very arenaceous, finely crystalline, weathers to gray, sandy surface, medium bedded, cliff former	20
2. Dolomite: medium gray, weathers gray to buff, thin to medium bedded, thin beds show fine laminations	22

Jefferson formation (continued)	Thickness in feet
1. Dolomite: medium gray, weathers dark gray to black, medium crystalline, medium bedded	10
Total Jefferson formation	435

Contact conformable

Water Canyon formation

Dolomite: medium gray, fine to medium crystalline, weathers white, medium bedded	28

Three Forks Formation

The Devonian Three Forks formation is well exposed on the west side of Camp Kiesel Canyon where it forms a distinct slope below the very imposing cliffs of Madison limestone. Interbedded shale and limestone comprise the lower portion of the unit; the shales are red, green and chocolate brown. Two thin conglomeratic beds composed of red shale fragments interbedded in a calcareous matrix are conspicuous. Casts of halite crystals are also common in the lower unit. The upper portion of the formation, generally poorly exposed, is predominately interbedded reddish sandstone and gray, calcareous shale.

The lower contact of the Three Forks formation was placed at the base of the first red shale bed above the black weathering Jefferson limestone. The upper contact, usually covered

by debris from the overlying Madison limestone, was placed immediately below the first massive Madison cliff.

No fossils were found in the Three Forks formation and its assignment to the Devonian system is based on lithology and stratigraphic position. In the Randolph quadrangle Richardson (1941) describes the Three Forks as

> ". . . thin bedded impure earthy gray limestone, which weathers to yellowish and reddish tints. This narrow debris-covered reddish zone lying between the more resistant beds of Jefferson and Madison limestones is an excellent horizon marker."

Edvalson (1947) believes a positive area of low relief existed between Salt Lake City and Ogden during most of Paleozoic time. He attributes the clastic nature of upper Devonian strata to this highland. He states further that an upper Devonian seaway existed between the Randolph quadrangle southward to central Utah. If such is the case, the Three Forks formation of the South Fork area is surely a direct correlative of the exposures to the north.

At the base of the Three Forks formation the red and brown shale beds are interbedded with dark gray dolomites like those of the underlying Jefferson formation, and both units appear entirely conformable. The upper contact with the Madison limestone is not exposed in the area; however no angular discordance could be detected above or below the boundary, and

the author believes that it also is conformable.

The following section was measured on the west side of Camp Kiesel Canyon:

	Thickness in feet
Madison limestone	
Limestone: dark gray to black, finely crystalline, thin bedded (3"-6"), occasional gray shale stringers at bottom of unit, forms vertical cliff. . . .	53
Contact conformable	
Three Forks formation	
15. Interbedded shale and limestone: shale is dark gray, thin bedded, calcareous; limestone medium gray, finely crystalline; unit is slope former. The top of this unit probably represents the Leatham formation of the Logan quadrangle . . .	35
14. Covered, probably interbedded limestone and shale	209
13. Sandstone, occasional thin shale stringers: sandstone is white and purple, weathers gray and maroon, thin bedded, flaggy, calcareous	80
12. Interbedded sandstone and shale, flaggy, shale very calcareous	34
11. Sandstone, thin stringers of calcareous shale: sandstone fine to coarse grain, poorly sorted, white to buff, weathers medium red, calcareous	27

Three Forks formation (continued)	Thickness in feet
10. Interbedded sandstone and calcareous shale breccia: shale gray, very brecciated and locally disturbed. Sandstone is very light red to pink, coarse grain, well-rounded, well sorted, thin bedded, weathers salmon to nearly white, calcareous	57
9. Sandstone as in unit 10, but cross-bedded. Two white weathering bands approximately 6' thick in middle of unit are excellent markers	53
8. Shale: gray, flaggy, calcareous, grades into unit 7	2
7. Sandstone as in unit 10	33
6. Interbedded shale and sandstone, predominately shale: shales red, mottled red and green, maroon, and chocolate brown, fissile, noncal-careous. Sandstone buff and green, medium to coarse grain. Halite casts in shale	15
5. Sandstone: gray to buff, weathers deep red, massive	3
4. Interbedded shale and sandstone: as in No. 6, halite casts	15
3. Shale conglomerate, red shale pieces in sandy, calcareous matrix	4
2. Dolomite, dark gray, medium bedded, finely crystalline	8
1. Shale and interbedded sandstone: shale is red, fine grain, fissile, calcar-eous. Sandstone medium to coarse grain, buff	11
Total Three Forks formation	586

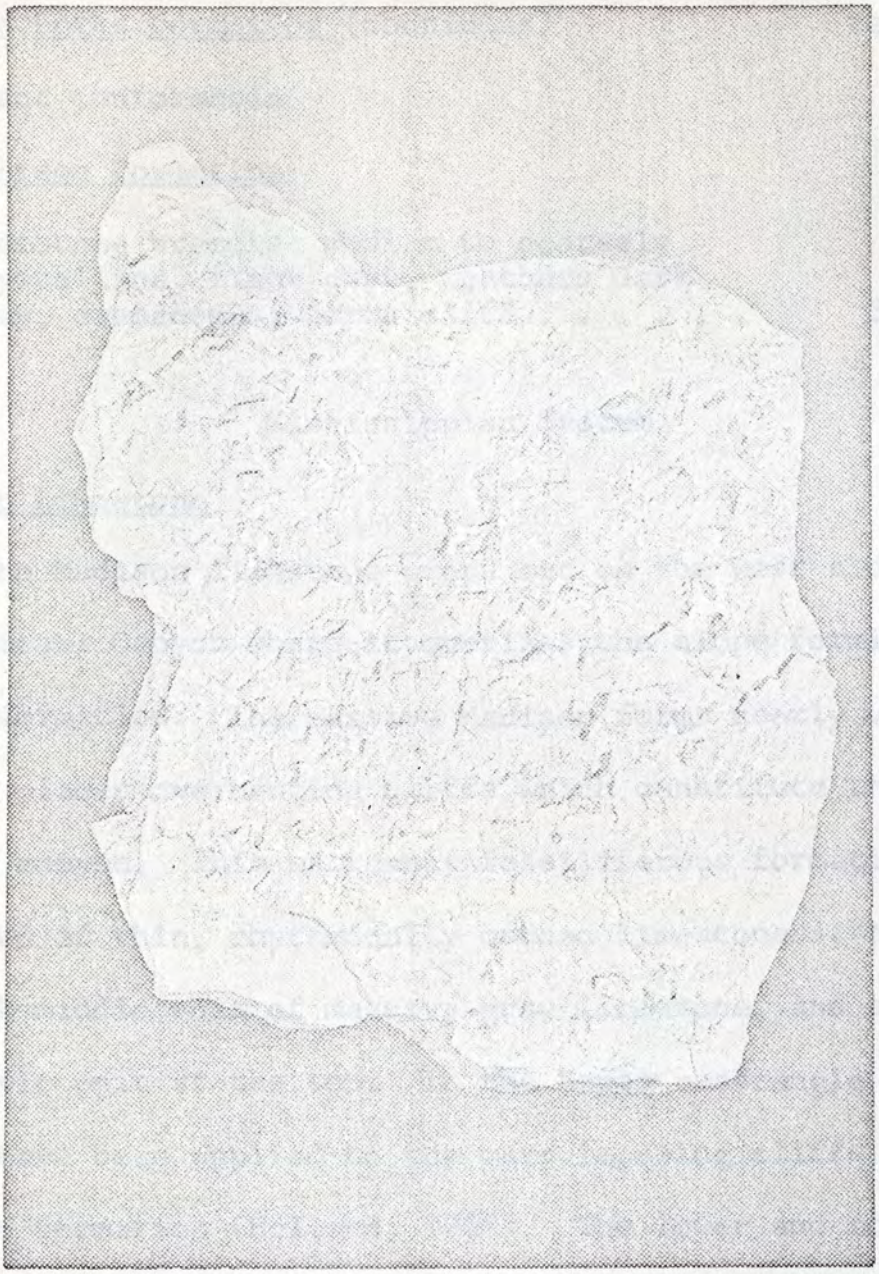


Fig. 4 Hand specimen of Three Forks formation showing casts of halite crystals.

Three Forks formation (continued)	Thickness in feet
Contact conformable	
Jefferson formation	
Limestone breccia: medium to coarsely crystalline, light gray, weathers dark gray, arenaceous, forms cliff	31

Mississippian System

Madison Limestone

The Madison limestone crops out on the west side of Camp Kiesel Canyon where it overlies the slope forming Three Forks formation. The massive Madison forms nearly vertical, and in places overhanging cliffs which constitute the rim of the canyon. This extremely fossiliferous formation is composed of thin, rhythmically bedded limestone at the base, a thick middle unit of massive gray limestone, and a thin dolomitic unit at the top. In the Logan quadrangle local names have been applied to the very imposing cliffs of the Madison formation (Holland, 1952). The lower and most conspicuous cliff has been designated the "Chinese Wall". This is separated from the "Upper Chinese Wall" by a distinct slope. Similar cliffs and intervening slope are well represented in Camp Kiesel Canyon.

In Leatham Hollow, approximately 25 miles north of the thesis area, Holland (1952 has designated and named a

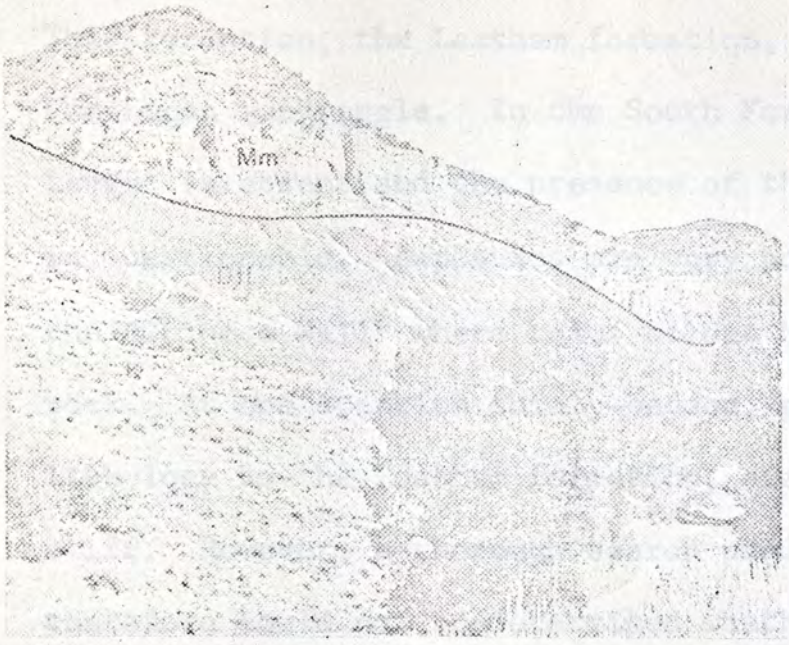


Fig. 5 View looking north in Camp Kiesel Canyon showing Madison limestone cliffs and the slope forming Three Forks formation below.

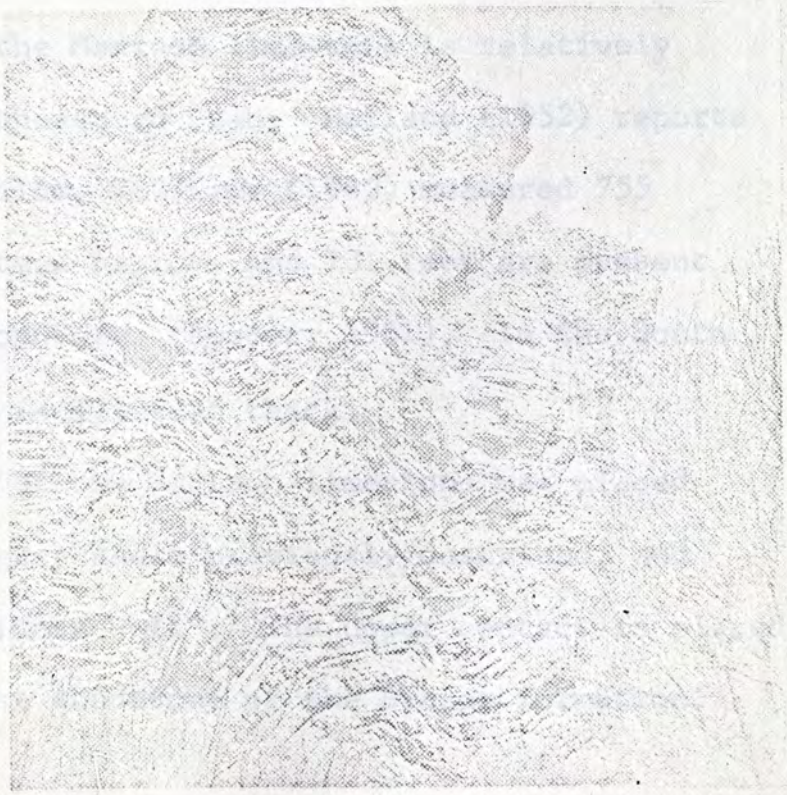


Fig. 6 Locally contorted strata of the Madison limestone in Camp Kiesel Canyon.

Mississippian formation below the first Madison cliff and above the "Contact Ledge", a conspicuous, massive limestone unit. This formation, the Leatham formation, is 76 feet thick in the Logan quadrangle. In the South Fork area the "Contact Ledge" is absent and the presence of the Leatham formation is questionable. Exposures are very poor immediately below the "Chinese Wall" where talus slides have obscured the bedrock. At one location thinly-bedded, gray shales, similar in lithology to the Leatham formation, are exposed below the cliff. However, a thorough search produced no fossils and it therefore could not be determined whether these shales represented the Leatham or the upper part of the Three Forks formation.

The thickness of the Madison limestone is relatively uniform throughout northeastern Utah. Holland (1952) reports 803 feet in Leatham Hollow, Williams (1943) measured 755 feet in the Durst Mountain region, and 731 feet are present in the western Uinta Mountains (Hooper, 1951). In the South Fork area, the Madison is 825 feet thick.

The lower contact of the Madison limestone was placed immediately above the gray shale previously described, and at the base of the "Chinese Wall". The upper contact is placed at the base of the first sandstone of the Brazer formation.

Holland (1952) believes the entire Madison to be of Kinderhookian age.

The following fossils were collected from the Madison limestone and identified by the writer:

Fenestellid bryozoan	Chonetes cf. logani
Girtyella sp.	Productus gallatinensis
Dictyoclostus sp.	Composita humilis
Spirifer centronatus	Dielasma (?) sp.
S. sp.	Euomphalus sp.
Productus of. P. parviformis	Productus cf. P. peroccidens
Loxonema sp.	Crinoid fragments
Camarotoechia metallica	Unidentified crinoid clax

The following section was measured in Camp Kiesel Canyon:

		Thickness in feet
Brazer formation		
	Sandstone: light buff to reddish brown, medium grain, subangular sand grains, calcareous, slope former	200
	Contact conformable (?)	
Madison limestone		
11.	Dolomite: slightly calcareous, medium gray, medium to finely crystalline, abundant light gray to white chert. This unit marks the top of "Upper Chinese Wall"	32
10.	Limestone, becoming dolomitic toward top of unit: dark gray arenaceous, medium to coarsely crystalline, thin (3") shale beds	39
9.	Covered slope:	32
8.	Limestone: as in No. 10, but more arenaceous	20

Madison limestone (continued)	Thickness in feet
7. Limestone: dark gray, medium to coarsely crystalline, arenaceous, shale partings, cliff former	31
6. Limestone: as in No. 7, prominent cliff former. The bottom of this unit marks the bottom of the "Upper Chinese Wall"	44
5. Covered: probably medium bedded, gray limestone, forms slope between "Chinese Walls"	362
4. Limestone: dark gray, weathers medium to light gray, medium crystalline, medium bedded to massive, slightly arenaceous at top of unit. Top of lower "Chinese Wall".	47
3. Limestone: as in No. 4	33
2. Limestone: dark gray to black, finely crystalline, weathers medium gray, thin bedded (3"-6"), occasional gray shale stringers at bottom, forms vertical cliff	102
1. Limestone: as in No. 2, remarkable even, thin bedding	53
Total Madison limestone	825

Contact conformable

Three Forks formation

Interbedded shale and limestone: shale is dark gray, thin bedded, calcareous, limestone medium gray, finely crystalline, unit is slope former. The top of this unit probably represents the Leatham formation of the Logan quadrangle	35

Brazer Formation

The Mississippian Brazer formation is exposed in Dry Bread Hollow where it crops out as high cliffs which form the canyon walls. The lower portion of the formation near the mouth of the canyon is well exposed. However the upper units and the contact with the overlying Round Valley formation are heavily vegetated and exposures are poor.

The lower contact of the Brazer formation was placed at the base of the first sandstone overlying the gray, cherty Madison limestone. The lowermost portion of the Brazer formation is composed of red, tan, and gray, slightly calcareous, medium grain sandstone. Argillaceous bands are not uncommon. This lower sandstone unit is 579 feet thick in Dry Bread Hollow. Above this a thick series of interbedded cherty limestone and sandstone is exposed. The limestones are fine to medium crystalline, extremely arenaceous and medium to thick-bedded. Black and white banded chert occurs in gently undulating beds. The sandstones are lithologically similar to those of the lower unit. The upper portion of the formation is also interbedded cherty limestone and sandstone but is a distinct slope former. Blackwelder (1910b) describes two phosphatic beds of 20 and 100 feet thickness in the Brazer formation which he measured in Dry

Bread Hollow. The 20 foot bed was located, but the thicker bed described as "Phosphatic beds, black limestone with chert, brown shale, and shaly phosphate", was not found.

In the Durst Mountain region south of the thesis area the Brazer formation is 700 feet thick, (Schick, 1955) and thickens to 3700 feet in the Logan quadrangle (Williams, 1948). The writer estimates the formation to be 2500 feet thick in the South Fork area.

Although a few fossils were found in the Brazer formation, it appears to be much less fossiliferous than other locations, particularly the Dry Lake section near the Logan quadrangle which was described by Williams and Yolton (1945). The following fauna, collected from the Brazer in Dry Bread Hollow and Beaver Creek, was identified by the author.

cf. Striatifera brazerianus
Productus cf. richardsi
Camarotoechia sp.
"Zaphrentoid" corals
Archimedes sp.
Fenestella bryozoan
Crinoid fragments

Pennsylvanian System

General Statement

In the South Fork area, the Pennsylvanian system is represented by two formations, the Round Valley formation and the Durst group. Both are poorly exposed in Dry Bread Hollow where heavy vegetation and debris from the overlying

Knight conglomerate has obscured the outcrops. The writer had hoped to measure and describe the Pennsylvanian rocks in detail, particularly the Round Valley, but the poor exposures made this impracticable.

Round Valley Limestone

The Round Valley limestone was named by Sadlick (1955) for exposures in Round Valley, 3 miles east of Morgan, Utah. The Round Valley strata had previously been included in the Mississippian Brazer formation by Eardley (1944), and as the lower member of the Morgan sandstone in the Uinta Mountains. On the basis of its fauna Sadlick believes the Round Valley to be lower Pennsylvanian (Morrowan) in age.

In the South Fork area, the Round Valley limestone is exposed in Dry Bread Hollow where it overlies the Brazer formation. It is essentially a light gray, slightly dolomitic, cherty, medium bedded limestone. Outcrops at the bottom of Dry Bread Hollow have weathered nearly white. Brown and white chert nodules are common. The fossils of the Round Valley are commonly silicified and good specimens can be obtained by acid etching.

At the type section as reported by Sadlick the Round Valley is 389 feet thick. In the South Fork area it thins to approximately 150 feet and is probably absent to the north.

Neither the upper nor lower contact of the formation is exposed. Sadlick (1955) believes the lower contact to be disconformable with the underlying Brazer formation.

Durst Group

Sadlick (1957) has proposed the name Durst group to include the Morgan, Weber, and Hells Canyon formations of northeastern Utah. He believes these three formations, particularly the Weber and Morgan, to be characterized by rapid facies changes and interfingering relationships. He notes further that the typical red color of the Morgan is replaced by the gray sandstone of the Weber in many localities.

The Durst group outcrops near the head of Dry Bread Hollow where it overlies the Round Valley limestone. It consists of gray to reddish, medium to coarse grain, reddish weathering, non-calcareous sandstone. The outcrop is limited to only a few hundred yards in extent before it is covered by the overlying Knight formation. In regard to this outcrop Sadlick (1957) states:

> ". . . at Dry Bread Hollow. . . gray Weber-like unfossiliferous sandstone overlies the Round Valley limestone. It is not known whether the gray sandstone is a time correlative of the type Morgan or of some portion of the type Weber formation, or if any significant hiatus is present."

The writer agrees that the term Durst group is very appropriate here.

No fossils were found in the strata of the Durst group, however Sadlick considers it to be entirely Des Moines in age.

Tertiary System

Knight (?) Formation

Unconformably overlying all the older rocks in the South Fork area is the Knight (?) formation. It is absent where the major streams have cut through it to the underlying Precambrian and Paleozoic strata.

The Knight is the youngest of the three members (Almy, Fowkes, Knight) of the Wasatch group. North of lower Echo Canyon, southeast of the thesis area, the Fowkes formation is absent (James Madsen, personal communication) and the Knight rests unconformably on the Almy. However in the South Fork area no unconformity could be detected within the conglomerates and is not known if they represent the lithologically similar Almy or Knight formation. Eardley (personal communication) believes that in the tracing of these beds southward they will prove to be part of the Knight.

The Knight (?) formation is a deep red weathering pebble and boulder conglomerate with interbedded lenses of coarse sandstone. The phenoclasts of the conglomerate range in

Fig. 7 Looking south at nearly horizontal Knight (?) formation; the South Fork of the Ogden River flows at base of cliff.

size from 1" to 6' in diameter. They are derived predominately from the Proterozoic and Brigham quartzites; limestone pebbles are rare. The pebbles and boulders are easily eroded from their sandstone matrix and exposures are rare except on the walls of the steeper canyons. The Knight (?) was deposited on a surface of moderate relief, and channels of large boulders are common.

The Knight formation thins rapidly to the east and the coarse conglomerate is replaced by finer sandstones. This suggests that the source for this flood of material was to the west. No fossils were found in the Knight (?) formation of the thesis area. However studies by Gazin (1952) in western Wyoming indicate an early Eocene (Wasatchian) age for the formation.

Quaternary System

Deposits related to Lake Bonneville

During the highest stages of ancient Lake Bonneville, an embayment through Ogden Canyon connected the lake with Ogden Valley. Sediments and structures related to Lake Bonneville are present in Ogden Valley and at the mouth of the South Fork River. Lake terraces are especially well preserved immediately south of the canyon mouth near the Monastery (Figure 9). Lofgran (1950) correlates these terraces, located at an elevation

of 5150 feet, with the highest, or Bonneville, stage of the lake. The sediments deposited in Ogden Valley were not investigated by the author. Lofgren (1955) has made a detailed study of these deposits through the use of well logs.

Alluvial deposits

Alluvial deposits of gravel, sand, and silt are found in Ogden Valley and along the narrow flood plain of the South Fork River. Recent material consists of talus material, particularly below the Madison limestone, and fanglomerate material derived from the easily eroded Knight formation.

No evidence of glaciation was noted in the area.

STRUCTURE

General Statement

The most important structural features of the South Fork area are an east dipping homocline, a north trending syncline, and a north trending low angle thrust (?) fault. Unconformities attest to several periods of mild diastrophism during the Paleozoic. The widespread erosion surface which truncates all of the tilted Paleozoic formations is evidence of a major orogeny.

The absence of Mesozoic and middle Tertiary strata make it impossible to date many of the episodes of diastrophism and relationships observed in adjacent areas must be relied upon.

Willard (?) Thrust

At the mouth of the South Fork of the Ogden River immediately north of the Monastery a small "nose" of Paleozoic limestone is exposed. These strata are probably middle Cambrian in age appear and to dip beneath the Precambrian Proterozoic (?) rocks to the east (See geologic map, Plate I). Blackwelder (1910a) believed this relationship to be due to a transverse fault which extends from Ogden Peak on the east, beneath Ogden Valley and thence to the north of the Cambrian outcrop. Blackwelder (1910a) in discussing this fault states:

> "Presumably the direction of displacement along this plane had a large vertical component, but the precise direction has not been ascertained. The greatest shifting of outcrops amounts to about 3½ miles in the hills east of Huntsville. A horizontal displacement of such dimensions would involve changes of volume on one side or the other on a scale which seems impossible. With the observed dips, a vertical displacement of about 12,000 feet would seem to be required to explain the shifting of the outcrops. If the movement was diagonal, the amount of displacement would be still different, but in any case the facts indicate a fault of large dimensions."

The writer has found it very difficult to resolve the structural relations of this small area with a transverse fault as suggested by Blackwelder. No displacement could be detected to the east in either the Proterozoic (?) strata or the Knight formation (as was anticipated by Blackwelder).

Another possible explanation for this structure is a north-south trending normal fault along the eastern margin of Ogden Valley. In order to place the Cambrian strata in its present position a fault of approximately 10,000 feet displacement is required. A recent gravity survey of Ogden Valley (Stewart, 1957) has shown that although a normal fault does exist along the eastern margin of the valley, the displacement is too small to account for this structure. Stewart states, ". . . one fault is postulated along the east margin of the valley. This fault is buried beneath

approximately 1800 feet of valley fill, and has a total vertical displacement varying from 2000 to 3000 feet." The position of the fault indicated by Stewart is approximately three fourths of a mile west of the eastern margin of the valley.

Eardley (1944) has attributed the relationships at the mouth of the South Fork River to thrust faulting and believes this exposure to be the eastward trace of the Willard thrust. He believes the structure across Ogden Valley to be a broad syncline in the thrust sheet and has proposed the name Huntsville sag for this structure.

South of the thesis area and to the east of Durst Mountain, the western edge of the Wasatch conglomerates is in a distinct alignment. Eardley believes the eastern trace of the Willard thrust to lie just east of this edge, buried beneath the conglomerates.

The writer believes that Eardley's interpretation is the most feasible and that it accounts for the structure at the mouth of the South Fork River. It is difficult to envision a normal fault of the magnitude required being present but undetected in the adjacent rocks. The structure of Ogden Valley is probably due to a combination of down-warping of the thrust sheet (the Huntsville Sag) and normal faulting along its margins.

Folds

Beaver Creek Syncline

A shallow syncline, striking slightly east of north, occupies the divide between Beaver Creek and Dry Bread Hollow. First noted by Blackwelder (1910b) the structure has been termed the Beaver Creek syncline. The westwardly dipping Mississippian and Pennsylvanian strata in Dry Bread Hollow comprise the east limb of the structure. A narrow band of Brazer limestone dipping east below the Knight formation defines the western limb. Although the structure is poorly exposed, especially on the west, it appears to be nearly symmetrical, with little or no plunge within the exposed area.

Unconformities

During most of Paleozoic time the South Fork area was very close to the boundary between the thick geosynclinal deposition on the west and the thin shelf deposits on the east. Numerous advances and retreats of the Paleozoic seas over the area resulted in many minor disconformities within the section. The majority of these were undoubtably due to non-deposition rather than uplift and erosion.

The oldest recognizable unconformity in the area under study occurs at the top of the Ordovician Garden City formation. The equivalents of approximately 300 feet of the upper Garden City is absent, and the Swan Peak formation which

normally overlies it is not present. Although this time lapse represents part of the lower and all of middle Ordovician time, no physical evidence for a long time lapse could be detected at the upper contact of the Garden City formation; its presence is based on faunal zones and comparison of the section with adjacent areas.

Stokes (1953) believes the Laketown dolomite to be entirely middle Silurian in age. The apparent absence of upper and lower Silurian rocks indicates that a considerable hiatus exists at both the upper and lower contacts of the Laketown. Unfortunately neither contact is well exposed and their nature was not observed. In the Logan quadrangle Williams (1948) describes disconformities, based on faunal evidence, at both the top and bottom of the Jefferson formation. The author is unable to demonstrate their existance in the South Fork area, although they may well be present.

The most pronounced unconformity in the area is at the base of the Knight formation which has lapped over the upturned and truncated edges of all older rocks. The erosion surface upon which the Knight was deposited had only slight relief; however occasional conglomerate filled channels were found within the Paleozoic sediments.

GEOMORPHOLOGY

General Statement

The South Fork of the Ogden River area is in the middle to late youth stage of geomorphic development. Inter-valley areas are small and the uplands are well drained. The entire region is tributary to the South Fork River; the pattern of drainage is denditric and in only a few cases are the tributary streams adjusted to structure. The South Fork is a superimposed stream which cuts at right angles to the Precambrian and Paleozoic structure. Its course was developed on the Knight formation which once blanketed the area. As the Knight was eroded, the river was superimposed on the underlying resistant formations.

The two most prominent geomorphic features of the area are the Herd Mountain and Weber Valley erosion surfaces. Both are well preserved in the South Fork area.

Herd Mountain Surface

The highest and oldest preserved erosion surface in the South Fork area is the Herd Mountain surface. This surface was named for Herd Mountain, a low, rolling, plateau-like area which extends from the head of Magpie Canyon to Cottonwood Creek on the south. The entire southeastern portion of

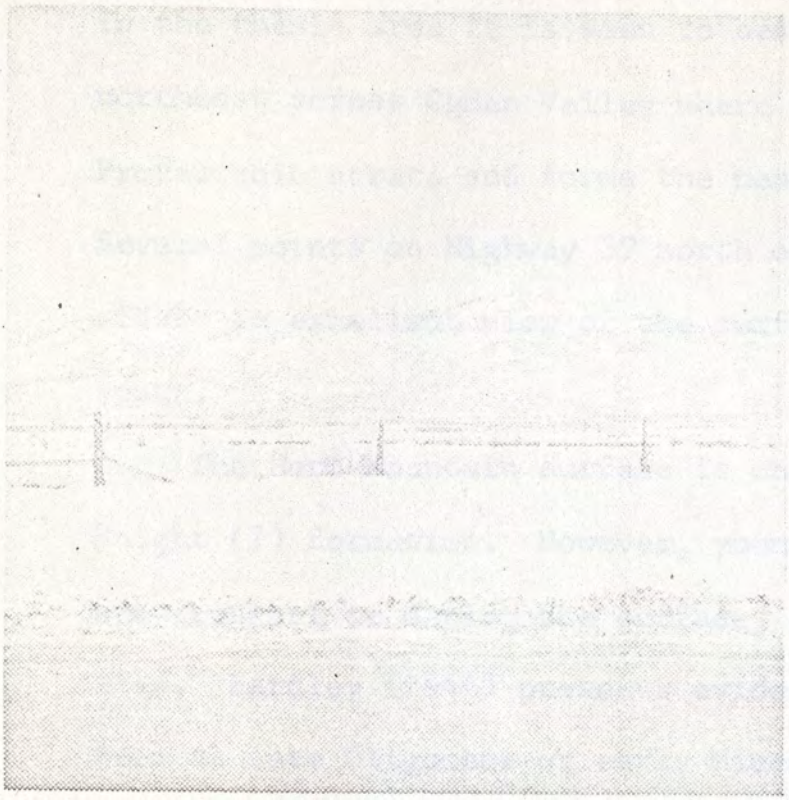


Fig. 8 View eastward in Ogden Valley; Proterozoic(?) strata forms mountain mass. Note Herd Mountain surface on skyline and Weber Valley surface sloping to valley floor.

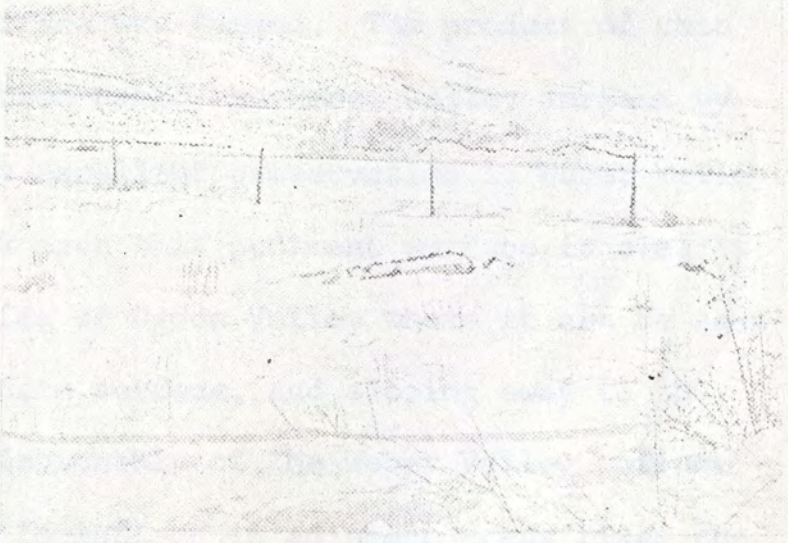


Fig. 9 Lake Bonneville terraces at an elevation of 5150 feet. View eastward from the "Monastery"

the mapped area (Plate I) is a remnant of this ancient surface. In the thesis area it is seen to best advantage by looking northeast across Ogden Valley where the surface truncates the Proterozoic strata and forms the nearly horizontal skyline. Several points on Highway 39 north of the South Fork area afford an excellent view of the surface sloping away to the south.

The Herd Mountain surface is underlain by the Eocene Knight (?) formation. However, younger Tertiary strata, which are critical in dating the surface, are absent in the thesis area. Eardley (1944) presents evidence which dates this surface as late Oligocene or early Miocene, and tentatively correlates it with the Gilbert surface of the Uinta Mountains.

Weber Valley Surface

Following the formation of the Herd Mountain surface the area was uplifted, rejuvenation of the streams commenced and a new pediment surface was formed. The product of this cycle of erosion has been named the Weber Valley surface by Eardley (1944) for its excellent preservation in Weber Valley.

In the South Fork area this pediment surface is clearly visible on the east side of Ogden Valley where it can be seen cutting the Herd Mountain surface, and sloping away to the valley floor. The relationship of the Weber Valley surface to other surfaces and formations in adjacent areas fixes the

age as Pliocene or Pleistocene (Eardley, (1944).

ECONOMIC GEOLOGY

The only mining operation of commercial importance in the South Fork area is a small mine near the mouth of Camp Kiesel Canyon. The mine is not in an organized mining district, and to the writer's knowledge has no official name. In the summer of 1957 manganese ore was mined and hauled to Ogden, Utah and shipped by rail to government stockpiles at Butte, Montana.

The principal manganese ore mineral recovered is pyrolusite (MnO_2). The deposit is found in the basal part of the Knight (?) formation immediately above the unconformable contact with the underlying Jefferson formation. The ore occurs as pod-shaped bodies and as a coating around the boulders of the Knight.

The writer believes the deposit to be of a sedimentary nature. Unusually large quartzite boulders of the Knight conglomerate suggest that channels existed within the formation; pyrolusite was probably precipitated from manganese-bearing ground waters percolating through these channels. In the writer's opinion, the absence of hydrothermal alteration in the South Fork area and vicinity excludes the possibility of a hydrothermal origin.

GEOLOGIC HISTORY

Precambrian Time

The earliest geologic history of the South Fork area is recorded in the thick sequence of Proterozoic (?) and early Cambrian quartzites. Early seas advancing in a northeasterly direction produced the basal quartzite which becomes progressively younger to the east. In northern Utah the sediments were deposited in deep troughs and overlap the northern Utah highland to the west (Eardley, 1944). Sedimentation was probably continuous from late Proterozoic to early Cambrian time. The sediments were derived, at least in part, from the northern Utah highland to the west and from positive areas to the east.

Cambrian Time

During Cambrian time the South Fork area was a part of the rapidly subsiding Cordilleran geosyncline and a variety of clastic and carbonate rocks were deposited. In lower Cambrian and perhaps early middle Cambrian the seas encroached from the southwest and Brigham quartzite was deposited. As middle Cambrian time progressed the finer clastic material of the Langston and Ute formations and eventually the predominately carbonate rocks of the Blacksmith were laid down.

Shallow seas during much of this time are evidenced by abundant oolites.

Although no upper Cambrian is exposed in the South Fork area, the structural relationships indicate that upper Cambrian rocks are buried beneath the Knight formation east of Cobble Creek and shallow seas probably occupied the area until Middle Ordovician time.

Ordovician and Silurian Time

During Early Ordovician time shallow seas extended into the South Fork area and the Garden City formation was deposited. Numerous intraformational conglomerates in the Garden City strata are indicative of a shallow water environment and perhaps even partial desication. The exposures here mark the approximate southern extent of the Ordovician seas in the Wasatch Mountains for Ordovician rocks are absent a few miles south in the Durst Mountain area.

In Middle Ordovician time the seas retreated northward, and the area was slightly emergent. Williams (1948) suggests that the quartzites of the Middle Ordovician Swan Peak formation in the Logan Quadrangle mark the rise of the highlands and draining of the seas. Carbonate sedimentation resumed in Late Ordovician and the Fish Haven dolomite was deposited.

During both Early and Late Silurian time the area was

slightly emergent. However, during Middle Silurian the thick Laketown dolomite was deposited. As was the case with the Ordovician, the exposures in the South Fork area mark approximately the southern extent of Silurian deposition.

Devonian Time

During Devonian time the South Fork area was situated in a geosynclinal embayment which developed between the Wyoming shelf on the north and a smaller shelf area in north-central Utah (Brooks and Andrichuk, 1953). The Lower Devonian Water Canyon formation was deposited in this restricted embayment, and was followed by the increasingly arenaceous Jefferson formation in Middle Devonian time. The Three Forks formation represents a renewed flood of clastic material which was perhaps derived in part from a positive area extending from Salt Lake City to Ogden as suggested by Edvalson (1947). Intraformational conglomerates and halite casts indicate a shallow, tidal flat environment for the Three Forks.

Mississippian and Pennsylvanian

Mississippian and Pennsylvanian time was characterized by extensive seaways and the deposition of a thick sequence of clastic and carbonate sediments. Following the deposition of the Madison limestone, a rejuvenation of the highlands provided the clastic material of the Brazer formation. The

phosphate beds in the upper portion of the Brazer indicate a partial restriction of the seas and perhaps a toxic environment. Sandstone and slightly clastic limestone characterize Late Mississippian time and sedimentation was probably continuous into the early Pennsylvanian (Sadlick, 1956). In middle Pennsylvanian time deposition of rocks of the Durst group commenced and perhaps sedimentation continued into early Permian (Stokes, personal communication).

Permian and Mesozoic Time

No rocks of Permian or Mesozoic age are exposed in the South Fork area. However, thick sections of rock of both ages are present northward in southeastern Idaho (Mansfield, 1927) and southward in the Morgan-Henefer area (Schick, 1955). There is no indication that these strata thin toward the South Fork area as might be expected of sediments lapping against a positive element. The author believes that Permian, Triassic, Jurassic, and perhaps Lower Cretaceous rocks were deposited over the area, and have been removed by subsequent erosion.

The absence of Mesozoic strata in the thesis area precludes the finding of evidence bearing on orogenic events of that Era. Uplift probably occurred during the Cedar Hills orogeny of Early Cretaceous time, or in the initial phase of the Laramide orogeny (Montana time). The Paleozoic rocks were tilted

eastward, and the Beaver Creek syncline was formed. Rapid erosion of the Permian and Mesozoic strata, if present, ensued.

Tertiary

During Tertiary time the north-central Wasatch Mountains were subjected to a complex sequence of geologic events. However the Tertiary deposits related to these events are not preserved in the South Fork area. The following summary of Tertiary geologic history was compiled from Eardley (1944, 1951), Schick (1955), and Coody (1957).

Following the intense thrust faulting of the Ogden Canyon area in early Cretaceous time, the Willard thrust sheet was formed in Late Cretaceous or early Paleocene. In the South Fork area the Willard (?) thrust moved Proterozoic (?) strata westward over Middle Cambrian rocks. In early Eocene time the coarse conglomerates which form the Knight formation covered the area. Following deposition of the Knight (?), Laramide activity subsided. Broad gentle folding ensued and the present relief features began to form. In late Oligocene and Miocene time a long period of erosion formed the Herd Mountain surface. This high surface is well preserved in the South Fork area. In late Miocene and early Pliocene time uplift was renewed, and the Weber Valley surface began to form.

In Pleistocene time the highest stage of Lake Bonneville invaded Ogden Valley through a narrow arm of water extending through Ogden Canyon. Lacustrine deposits related to the lake are found in Ogden Valley and terraces can be seen along its eastern margin.

Alluvial material has been deposited along the course of the South Fork River and talus deposits of recent origin can be seen at many places in the area.

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