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The Hyrum and Beirdneau Formations of North-Central Utah and Southeastern Idaho

James F. Eliason
Utah State University

THE HYRUM AND BEIRDNEAU FORMATIONS

OF NORTH-CENTRAL UTAH AND SOUTHEASTERN IDAHO

by

James F. Eliason

A thesis submitted in partial fulfillment
of the requirements for the degree

of

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Approved:

Major Professor

Committee Member

Committee Member

Dean of Graduate Studies

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James F. Eliason

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ABSTRACT

The Hyrum and Beirdneau Formations

of North-Central Utah and Southeastern Idaho

by

James F. Eliason, Master of Science

Utah State University, 1969

Major Professor: Dr. J. Stewart Williams
Department: Geology

The Hyrum and Beirdneau Formations of North-central Utah and Southeastern Idaho represent rocks of late Middle Devonian (Givetian) to upper Upper Devonian (Famennian) age. They are disconformably underlain by the Early Devonian Water Canyon Formation in most cases and disconformably overlain by the Devonian-Mississippian Leatham Formation or the Mississippian Lodgepole Formation.

The Hyrum Formation is divided into five members based on lithology and color changes. The five members are: (1) Samaria, (2) Lower Dolomite, (3) Lower Carbonate-detritus, (4) Upper Dolomite, and (5) Upper Carbonate-detritus Members. The Samaria Member is the only fossiliferous unit within the Hyrum Formation.

The Beirdneau Formation is divided into three members based on lithology and color changes. These three members are: (1) Lower Carbonate, (2) Sandstone, and (3) Upper Carbonate Members. This Formation represents deposition in a shallow water and a restricted sea environment.

(92 pages)

INTRODUCTION

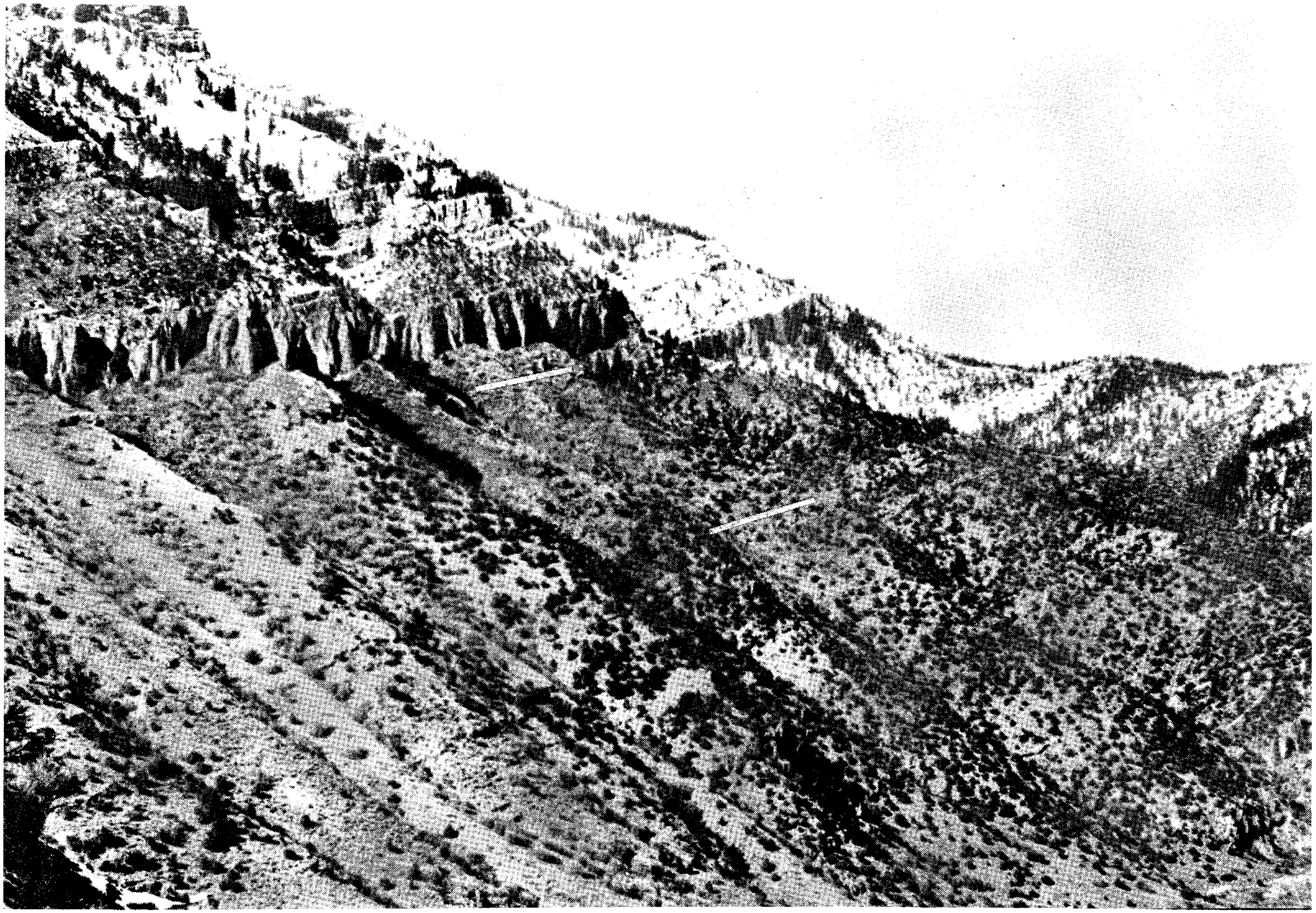
General Statement

In North-Central Utah and Southeastern Idaho, excellent exposures of the Devonian System are present. Recent regional studies of the Devonian, such as those of Benson (1966), Poole *et al.* (1967), and Sandberg and Mapel (1967), have pointed out the importance of the local Devonian section. In view of this increased interest, it seemed desirable to undertake more detailed studies of the Jefferson Formation of Williams' 1948 report (Williams, 1948, p. 1138-1141). Such a detailed study of the Water Canyon Formation of Lower Devonian age has recently been made (Williams and Taylor, 1964).

This project was suggested by J. Stewart Williams with the understanding that the details of the best exposed section, that in Blacksmith Fork Canyon, would be published by him; whereas, the details of other sections in the study area would be recorded in this paper. Williams and I measured part of the Logan Canyon section and the Old Laketown Canyon section, the Portage Canyon section and the Gardner Canyon section. The upper part of the Logan Canyon section, the lower part of the Old Laketown Canyon section, and the Mahogany Canyon section were measured by me with the assistance of my wife, Lynette, and Clinton Davis. Member contacts were agreed on in the field. Field notes were taken independently, and the laboratory examination was made independently.

Figure 1. Hyrum and Beirdneau Formations on the north side of the Left Fork of Blacksmith Fork Canyon, looking northeast.

Located approximately one mile up the Left Fork of Blacksmith Fork Canyon. The Beirdneau Formation is between the markers with the Leatham Formation just above and the Hyrum Formation below (base of Hyrum not shown).



J. Stewart Williams supervised the fossil identification and obtained assistance from G. Arthur Cooper of the Smithsonian Institution, Robert H. Denison of the Field Museum of Natural History, and Gilbert Klapper, then of the Pan American Petroleum Corporation. Analyses of the rock chips for calcium, magnesium, and insoluble residue were made at the Soils and Meteorology Department, Utah State University. Both Dr. Williams and the writer profited by a three-day visit to the study area by F. G. Poole and Charles A. Sandberg of the U.S. Geological Survey. In their company, we visited the sections in Blacksmith Fork Canyon, Logan Canyon, Portage Canyon, Gardner Canyon, and Wide Hollow.

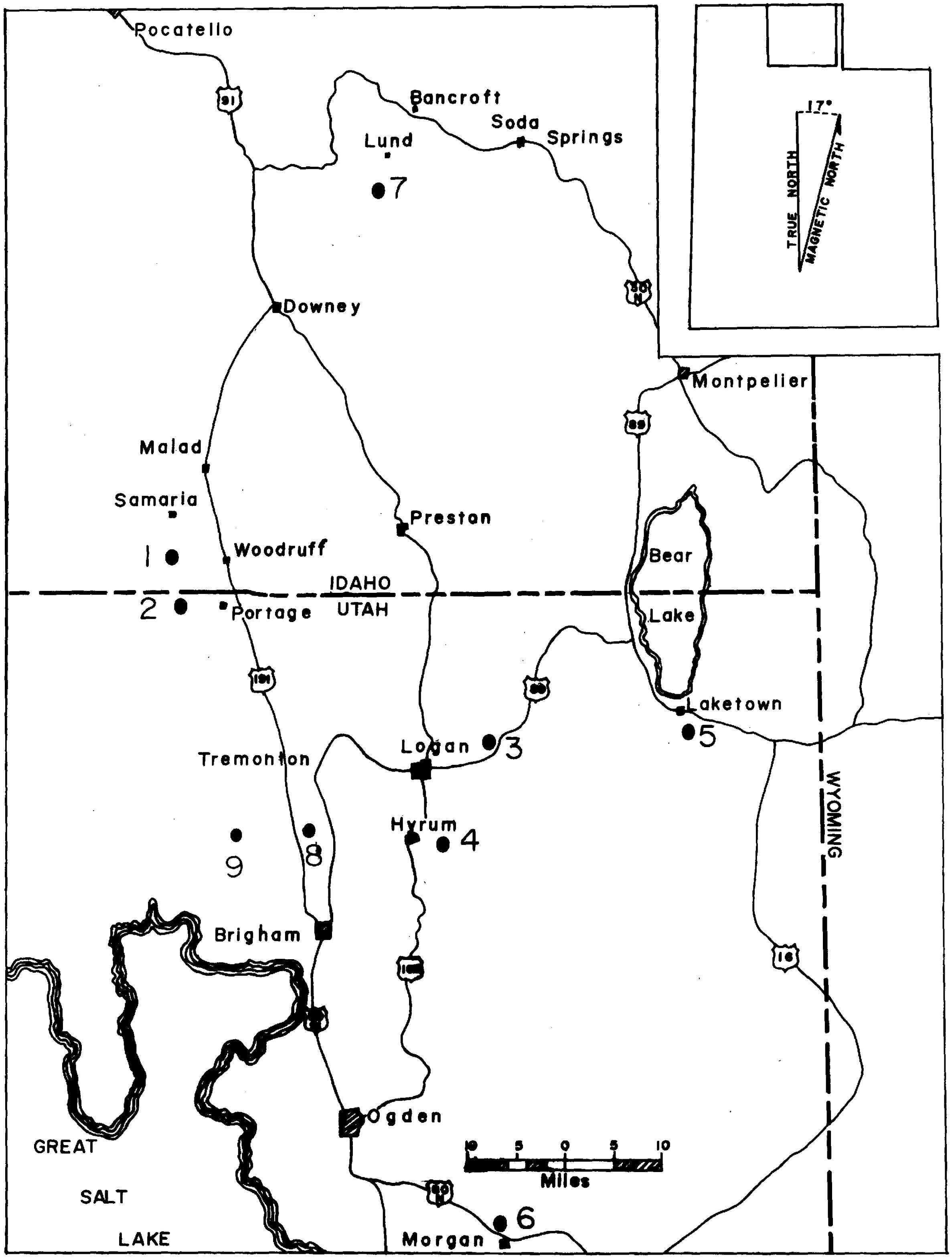
Areal Extent of Investigation

The study area was planned to include those sections of the Hyrum and Beirdneau Formations that are within such distance of the Blacksmith Fork section that their study could be completed in one summer and that an attempt to describe and interpret them would not exceed the scope of a reasonable project. The areal extent of the study area is approximately 50 miles wide and 110 miles long or 5,500 square miles.

The location of the sections can be found on Fig. 2. The Portage Canyon section (No. 2) met the above criteria and is also within a few miles of sections studied by Beus (1963, p. 30-46). The Wide Hollow section (No. 7), to the north in the Portneuf Range, had been described by Benson (1966, p. 2569) as had the section to

Figure 2. Index map of north-central Utah and southeastern Idaho showing location of sections.

1. Gardner Canyon
2. Portage Canyon
3. Logan Canyon
4. Blacksmith Fork Canyon (type locality)
5. Old Laketown Canyon
6. Mahogany Canyon
7. Wide Hollow
8. Wellsville Mountain (Beus, 1958)
9. Little Mountain (Beus, 1963)


Pocatello
Bancroft
Soda
Springs
Lund
7
Downey
Montpelier
Malad
Samaria
Preston
1
Woodruff
Bear
IDAHO
UTAH
2
Portage
Lake
Laketown
5
3
Logan
Tremonton
WYOMING
Hyrum
4
9
8
Brigham
Ogden
GREAT
SALT
LAKE
6
Morgan
10 5 0 5 10
Miles
17°
TRUE NORTH
MAGNETIC NORTH

the east in Old Laketown Canyon (No. 5). The section at Morgan (No. 6) is a reasonable distance to the south and was known to be complete, accessible, and well exposed. The Devonian section to the west in Wellsville Mountain (No. 8) was visited for one day but not included in the study because the bottom is obscure where it can be reached near the mountain base, and because the Beirdneau Formation is not present (Gelnett, 1958, p. 38-41). The section farther west at Little Mountain (No. 9), described by Beus was visited for a day but not measured or sampled (Beus, 1963, p. 37). Measured sections can be found in Appendixes B and C.

Procedure

The field work for this study was conducted in the spring and summer of 1968. One section was measured with a Jacob's staff and Brunton compass. The remaining sections were measured using the steel tape and Brunton compass. Beds of the measured sections were described in field notes and chips taken at regular intervals or where change of rock type was apparent. Chips taken from the Blacksmith Fork Canyon section were chemically analyzed for calcium, magnesium, and acid-insoluble residue. Some samples from other sections were also analyzed (Appendix A., p.59). The rock-color chart, distributed by the Geological Society of America was the guide for color determination. The nomenclature used for describing the rock types was taken from Guerrero and Kenner (1955, p. 45-50) and

Percentage of Detrital Material \ Mole ratio $\frac{CaO}{MgO}$	1.00–1.20	1.20–2.85	2.85–17.67	17.67–36.19	36.19–100
95–100	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone
50–95	Dolomitic sandstone or siltstone	Calcitic dolomitic sandstone or siltstone	Dolomitic limy sandstone or siltstone	Magnesian sandstone or siltstone	Calcitic sandstone or siltstone
10–50	Arenaceous or silty dolomite	Arenaceous or silty calcitic dolomite	Arenaceous or silty dolomitic limestone	Arenaceous or silty Magnesian limestone	Arenaceous or silty limestone
0–10	Dolomite	Calcitic dolomite	Dolomitic limestone	Magnesian limestone	Limestone

Figure 3. Chart explaining rock nomenclature.

Modified from Guerrero and Kenner (1955, p. 45-50) and Mather (1955, p. 304-305).

Mather (1955, p. 304-305). Further information was obtained from Folk (1959, p. 9-29) and Pettijohn (1949, p. 421, 401-408).

Nomenclature of Rocks

At the present time, carbonate rocks are classified in a wide variety of ways. The limited budget and time available for this study would permit only a simple chemical analysis and no thin sections. It was decided to have the Soils and Meteorology Department at Utah State University determine the mole ratio of CaO/MgO and also the insoluble residue. A classification based on these parameters was needed. We suspected that we would be working primarily with relatively pure carbonate rocks and relatively pure detrital rocks, but on completion of our field work and chemical analyses it was clear that all rocks were mixtures of carbonates and detrital material. A classification was therefore needed that would deal with the mole ratio of CaO/MgO and various sizes and amounts of detrital material.

As no one classification satisfied our needs exactly a combination of two classifications was decided upon. Guerrero and Kenner (1952, p. 45-50) presented a classification of dolomite and limestone based on the mole ratio of CaO/MgO but did not deal with the size range of our detrital material. Mather (1955, p. 304-305) published a classification based on the percentage of detrital material present. A combination of the above two classifications was constructed and is used in this paper (Figure 3).

Previous Investigations

The Jefferson Formation was named by Peale in 1893 for its excellent exposures near Threeforks, Montana, along the Jefferson River (Peale, 1893, p. 27). As early as 1908, Devonian rocks were known to exist in the study area when E. M. Kindle published a section of Green Canyon near Paradise, Utah, as part of his study of the Jefferson Limestone in the northern Rocky Mountains (Kindle, 1908, p. 16). In 1948, J. Stewart Williams separated the Devonian of north-central Utah into two formations: (1) Lower Devonian Water Canyon Formation, and (2) Upper Devonian Jefferson Formation (Williams, 1948, p. 1138). Williams further divided the Jefferson Formation into two members: (1) Hyrum Dolomite for its exposures in Blacksmith Fork Canyon, and (2) Beirdneau Sandstone for its exposures at the base of Beirdneau Peak (Williams, 1948, p. 1139).

Since that time, various studies have been made in the northern Utah region. In 1949, Rigby studied the Devonian in north-central Utah in order to date the major unconformity in the Upper Devonian. He concluded that the uplift that resulted in the erosion of the middle Paleozoic rocks in the Stansbury Mountains must have occurred in Late Devonian. Mullens and Izett (1964, p. 4-5) measured sections of the Hyrum Dolomite and Beirdneau Sandstone Members in Blacksmith Fork Canyon in their study of the Mississippian phosphate beds in the Paradise quadrangle, Utah. Beus (1963, p. 30-46, 1968, p. 785-790), measured and described sections of the Hyrum Dolomite and Beirdneau Sandstone Members in the Blue Spring Hills including sections in both Portage and Gardner Canyons.

Holland (1952, p. 1718), in his work on the Lower Mississippian rocks in northeastern Utah, defined the Leatham Formation in Leatham Hollow of Blacksmith Fork Canyon. He found Devonian fossils in the "Contact Ledge" of J. Stewart Williams (1948, p. 1141), thus placing the Devonian-Mississippian contact above this stratigraphic marker.

Regional studies of the Devonian by Benson (1966), Poole *et al.* (1967), and Sandberg and Mapel (1967), have indicated that the Hyrum Dolomite and Beirdneau Sandstone Members are enough different from time-equivalent rocks in Wyoming and Montana to be accorded formational rank. Therefore, the Hyrum Dolomite and Beirdneau Sandstone Members will be hereafter referred to as the Hyrum and Beirdneau Formations.

HYRUM FORMATION

General Statement

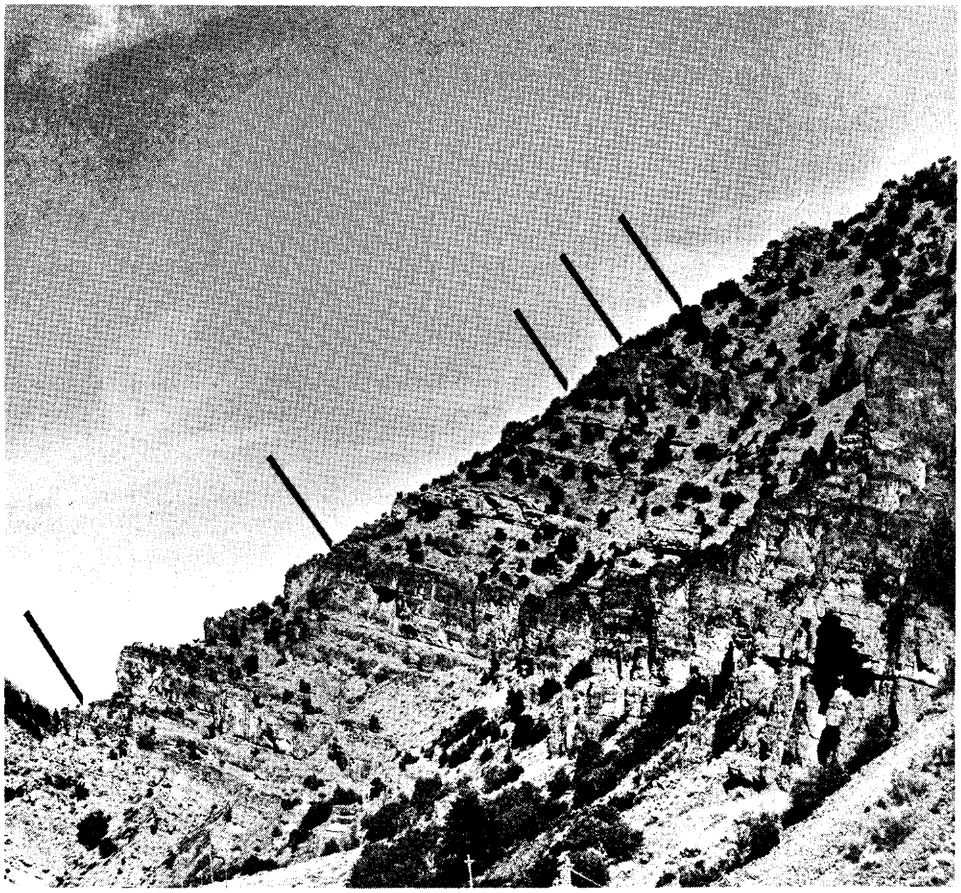
The Hyrum Formation was named and described by Williams in 1948 as a member (Williams, 1948, p. 1139). It has excellent exposures at the mouth of Blacksmith Fork Canyon, east of the town of Hyrum, Utah (Figure 4).

Since the definition of the Hyrum Dolomite Member, sufficient information has been gathered to justify elevating it to formational rank. It has regional extent and mappability and its base and top are readily determined at most localities. The Hyrum Formation, in the Blacksmith Fork Canyon section, exhibits five members which are recognizable in most of the sections studied. The members are as follows: (1) Samaria Member, (2), Lower Dolomite Member, (3) Lower Carbonate-detritus Member, (4) Upper Dolomite Member, and (5) Upper Carbonate-detritus Member.

Blacksmith Fork Canyon was the locality for the original subdivision of the Hyrum Formation into the above members. The rocks are so well exposed in the Blacksmith Fork Canyon section (Figure 4), that it was extremely easy to distinguish each of the five members. In other sections, however, some of the contacts are obscured by cover but a change in lithology, color, weathering characteristics, and percentage of detrital material was apparent above and below

Figure 4. Typical Hyrum Formation on north side of Blacksmith Fork Canyon, looking northwest down the canyon.

Located approximately 1½ miles from the bridge at the mouth of Blacksmith Fork Canyon. The following are between the markers from the bottom to the top: Lower Dolomite Member, Lower Carbonate-detritus Member, Upper Dolomite Member, Upper Carbonate-detritus Member. Part of the Samaria Member is exposed below the bottom marker and part of the Beirdneau Formation is exposed above the top marker.



the covered intervals. In such cases the contacts were identified by a change in float which leaves some error as to the exact contact.

Samaria Member

The name of the Samaria Member, the basal member of the Hyrum Formation, was extended from the Blue Spring Hills where the term Samaria Limestone Member was used by Beus (1963, p. 34) for the lower member of the Jefferson Formation. The best exposure of the member is on the north side of Portage Canyon, approximately 2 miles west of the town of Portage, Utah.

The Samaria Member of the Hyrum Formation is present in only four of the sections measured. Three of these are reproduced in Appendix B.; namely, the Portage Canyon, Logan Canyon, and Blacksmith Fork Canyon sections. A fourth section is the Wide Hollow section. It is not included in the Appendix because it is severely faulted. The Samaria Member is present in all sections on the west side of the Paris and Willard thrust faults. There is no indication of the Samaria Member on the east side.

The basal contact of the Samaria Member is between a basal limestone ledge and a solution breccia that is in the Water Canyon Formation. This breccia under-cuts the basal limestone ledge of the Samaria Member. The upper contact between the Samaria Member and the Lower Dolomite Member was chosen where a marked change in lithology occurred.

The Samaria Member has an average thickness of about 220 feet. It thins toward the southwest from 338 feet at Portage Canyon to about 190 feet 27 miles away at Logan Canyon and to 130 feet at Blacksmith Fork Canyon, 9 miles south of the Logan Canyon section (Figure 8).

The lower part of the Samaria Member consists of a medium-gray limestone or dolomitic limestone. Upward this grades into a light- to medium-gray arenaceous dolomitic limestone or dolomite. The rock is fairly dense and is resistant enough to form small ledges throughout the member. In all sections measured, the member has a 10-foot ledge at its base.

Taking an average percent insoluble residue throughout all sections of the Samaria Member, a figure of 6 per cent insoluble residue was reached. The residue is composed of silt-size light-gray and dark-gray particles. Although a chemical analysis was not run on the particles, I believe the darker ones to be of organic carbon. The lighter silt-size particles appear to be quartz grains.

This member is the only notable fossiliferous unit within either the Hyrum or Beirdneau Formations. A total of 25 different fossil species have been collected in this member.

Lower Dolomite Member

The name Lower Dolomite Member is proposed for the predominantly dolomitic unit just above the Samaria Member. The best exposures of the member are in Blacksmith Fork Canyon where the member was first distinguished and described.

The Lower Dolomite Member is the only member that was recognized in all six of the sections measured. Five of these sections are reproduced in Appendix B. These include: Portage Canyon, Logan Canyon, Blacksmith Fork Canyon, Old Laketown Canyon, and Mahogany Canyon sections.

The Lower contact of the Lower Dolomite Member was chosen where a distinct change in lithology was recorded from that of the member below. The upper contact terminates at the base of a 10-foot bed of pale-orange fine-to-medium-grained sandstone, except in the Old Laketown Canyon section where the lithology is covered, and the Mahogany Canyon section where it is the only member represented.

The Lower Dolomite Member has an average thickness of about 274 feet. It appears to thin toward the center of the study area. The thickness ranges from 308 feet at Portage Canyon, to 266 feet eastward at Logan Canyon, to 296 feet southward at Blacksmith Fork Canyon, to 336 feet eastward at Old Laketown Canyon, and to 136 feet southward at Mahogany Canyon (Figure 8).

This member consists mainly of medium-dark-gray thin-to massive-bedded finely crystalline dolomite. The unit is fairly uniform dolomite with a few interbeds of limestone and arenaceous dolomite. Some breccia was found high in the member in the Logan Canyon section and near the base of the member in the Old Laketown Canyon section. As a unit, the Lower Dolomite Member is fairly resistant to erosion and in places forms small cliffs. A 4-foot bed of arenaceous calcitic dolomite a third of the way up the member contains ripple marks and mud cracks indicating a possible shallow water environment of deposition for this bed.

Fossil fragments are present in the lower part of the member, but the amount is small and the quality of preservation is extremely poor.

Amphipora sp. was found about half way up the member in the Old Laketown Canyon, Mahogany Canyon and Logan Canyon sections.

Lower Carbonate-detritus Member

The Lower Carbonate-detritus Member is the name proposed for the lower detrital unit of the Hyrum Formation. The best exposures of the member are in Blacksmith Fork and Logan Canyons.

The Lower Carbonate-detritus Member is represented in four of the five sections measured. All four of the sections are reproduced in Appendix B., namely: Portage Canyon, Logan Canyon, Blacksmith Fork Canyon, and Old Laketown Canyon sections.

This member has at its base a 10-foot bed of pale-orange sandstone that can be traced through all but the Old Laketown Canyon section. This unit makes a good marker bed for the member. The upper limit of the Lower Carbonate-detritus Member was chosen where the lithology again changes to principally dolomite.

The average thickness of the Lower Carbonate-detritus Member is 292 feet. This member tends to thicken eastward and, in this respect, contrasts with the Lower Dolomite Member which thins toward the center of the study area. The thicknesses are as follows: Portage Canyon, 246 feet; Logan Canyon, 312 feet; Blacksmith Fork Canyon, 284 feet; Old Laketown Canyon, 325 feet (Figure 8).

This member is marked by light-gray arenaceous dolomite which contrasts with the dark-gray beds in the Lower Dolomite Member below and in the Upper Dolomite Member above. In the Logan Canyon and Blacksmith Fork Canyon sections, this member displays contemporaneous folding, including Z-folds (Figure 5 and 6), just above the 10-foot sandstone bed. Contemporaneous deformation is present in different degrees throughout both the Hyrum and Beirdneau Formations, but this member displays it on a much larger scale. The axes of the folds appear to trend approximately north-south. Beds above and below the unit show little or no contortion. The transfer of material to produce these contortions seems to have taken place in the interbedded thin-bedded units of silty limestone and dolomite; whereas, the more resistant thin-to thick-bedded dolomite has conformed to the deformation in the weaker beds. In the other sections measured, the same lithologic type can be found; however, the Mahogany Canyon section is the exception. Contemporaneous deformation is not present or is on a much smaller scale.

Upper Dolomite Member

The Upper Dolomite Member forms the same type of medium-dark-gray blocky cliffs that is typical of the Lower Dolomite Member. The best exposures of the member are on the north side of Blacksmith Fork Canyon (Figure 7).

This member does not have the extent of the Lower Dolomite Member. Only four of the sections measured has the member present. These can be located in Appendix B and include: Portage Canyon, Logan Canyon, Blacksmith Fork Canyon, and Old Laketown Canyon sections.

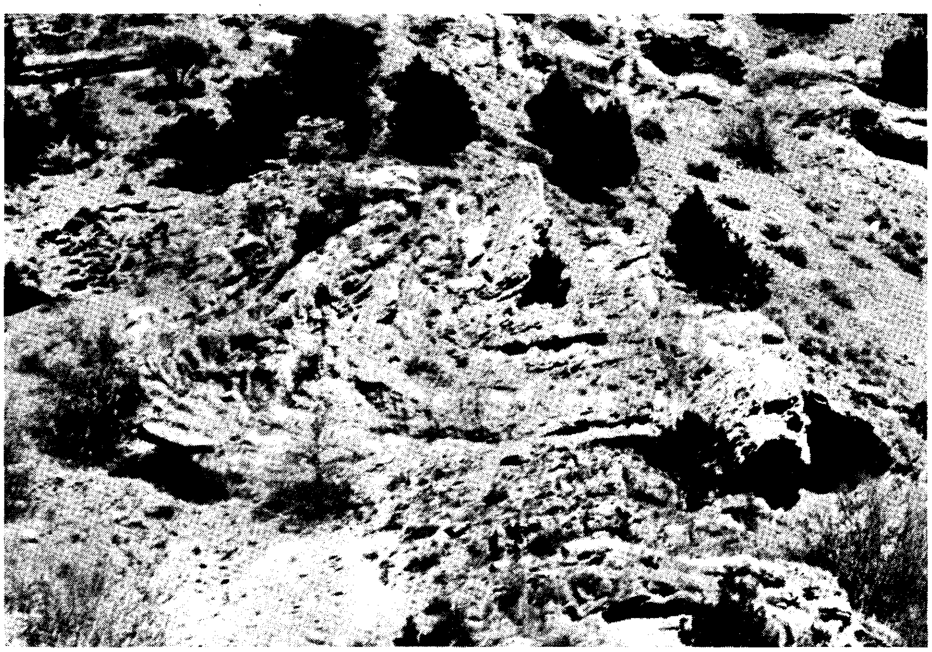
The lower contact of the Upper Dolomite Member was chosen at the point where the principally light-gray arenaceous dolomite of the Lower Carbonate-detritus Member changed to the medium-dark-gray

Figure 5. Contemporaneous Z-fold in the Lower Carbonate-detritus Member of the Hyrum Formation on rht north side of Blacksmith Fork Canyon, looking north.

Located 1 9/10 miles from the bridge at the mouth of Blacksmith Fork Canyon.

Figure 6. Contemporaneous fold in the Lower Carbonate-detritus Member of the Hyrum Formation on the north side of Blacksmith Fork Canyon, looking north.

Located 1 9/10 miles from the bridge at the mouth of Blacksmith Fork Canyon.



principally dolomite of this member. The upper contact was picked where the lithology changed back again to the light-gray arenaceous dolomite.

The Upper Dolomite Member has an average thickness of about 142 feet. Thickness does not range considerably from section to section. The thicknesses are as follows: Portage Canyon, 151 feet; Logan Canyon, 153 feet; Blacksmith Fork Canyon, 84 feet; and Old Laketown Canyon, 180 feet.

The lithology of this member consists principally of medium-dark-gray finely crystalline dolomite. In the Portage Canyon section, breccia is common but southeastward it diminishes until none is present in the Blacksmith Fork Canyon section. In the Logan Canyon section contemporaneous deformation is present but it is on a much smaller scale than in the Lower Carbonate-detritus Member. The contortions are again in the thin-bedded silty dolomite interbeds.

This member correlates with the Birdbear Formation which is the unit above the Jefferson Formation to the north and west of the study area (Sandberg and Hammond, 1958, p. 2320). In some localities the Birdbear Formation is designated as a member of the Jefferson Formation.

Upper Carbonate-detritus Member

The top member in the Hyrum Formation is composed of limestone or dolomite which is interbedded with orthoquartzite or silty dolomitic limestone. For this reason, the name Upper Carbonate-detritus Member is proposed for this unit (Figure 7).

Figure 7. Upper Dolomite and Upper Carbonate-detritus Members of Hyrum Formation on the north side of Blacksmith Fork Canyon, looking northeast.

Located approximately 2.2 miles from the bridge at the mouth of Blacksmith Fork Canyon. The upper Carbonate-detritus Member is between the markers with part of the upper Dolomite Member below and part of the Beirdneau Formation above.

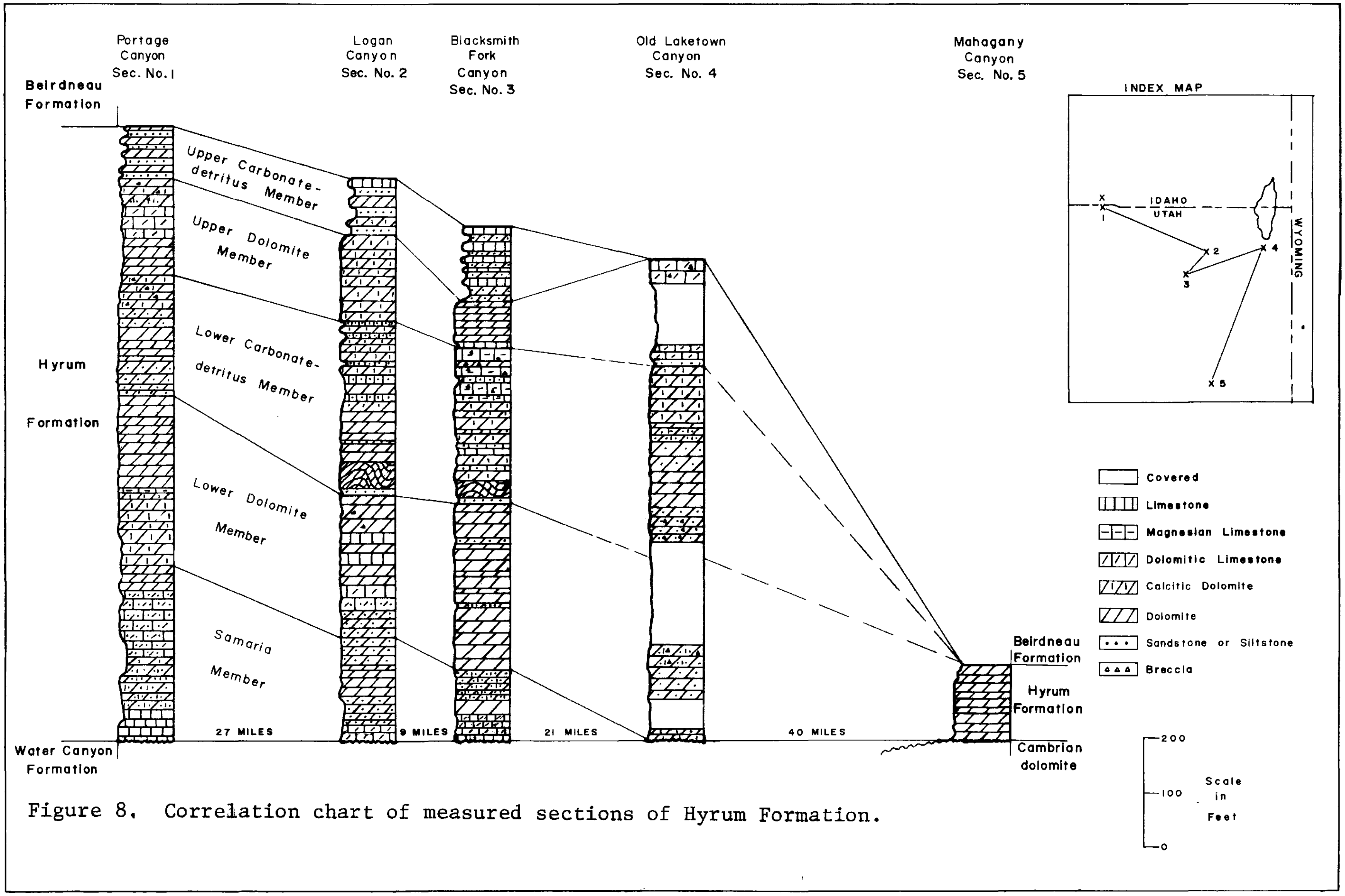


Figure 8. Correlation chart of measured sections of Hyrum Formation.

The Upper Carbonate-detritus Member is the least widespread of any of the members of the Hyrum Formation. Only three sections measured contained this member, these are: Portage Canyon, Logan Canyon, and Blacksmith Fork Canyon (Appendix B.).

Both upper and lower contacts were picked where change in lithology was apparent. The lower contact was chosen where the lithology changed from medium-dark-gray dolomite to a light-gray arenaceous dolomite.

The average thickness of the three sections that contained this member is 107 feet. Thickness increases southeastward from 92 feet at Portage Canyon, 102 feet at Logan Canyon, and 134 feet at Blacksmith Fork Canyon (Figure 8).

This member consists of limestone or dolomite which is interbedded with orthoquarzite or silty dolomite. The member is easily recognized in the field by its step-like appearance due to resistant ledges of carbonate beds and weaker detrital beds which weather back. Contemporaneous deformation is present in the weaker detrital beds, but is not nearly as prominent as it is in the Lower Carbonate-detritus Member. Some ripple marks and halite casts were found in the silty and sandstone beds, particularly in the Blacksmith Fork section, indicating possible shallow-water deposition for at least the weaker detrital interbeds.

Correlation

The Hyrum Formation has various time-equivalent rocks throughout the western United States especially Utah, Nevada, Idaho, Wyoming, and

Montana. An isopach map showing the thickness of the Devonian and related rocks of the southwestern United States was presented by Poole *et al.* (1967, p. 894) and that of the northern Rocky Mountains and Great Plains by Sandberg and Mapel (1967, p. 855) as part of the International Symposium on the Devonian System. These isopach maps show a general thickening of the Devonian strata southwest of the Paris, Willard, Charleston, and Nebo thrust faults. A maximum thickness of over 6,000 feet is finally reached in central western Utah, and then the thickness decreases westward.

Miogeosynclinal time-equivalent rocks in Nevada are largely the Devils Gate Limestone and quartzite interbeds. Together they reach a maximum thickness of over 3,000 feet in a furrow in western Utah (Poole *et al.*, 1967, p. 902, 903).

Cratonic time-equivalent rocks attain a thickness of 1,300 feet in northwestern Arizona. The cratonic rocks of this area compose the Parting Member of the Chaffee Formation, the Elbert Formation, the Temple Butte Limestone, and the Jerome Member of the Martin Formation (Poole *et al.*, 1967, p. 902,903).

Lower Upper Devonian cratonic rocks in Idaho, Montana, and Wyoming have been studied in detail by Sandberg and Mapel (1967, p. 862, 863). These rocks consist of the Souris River Formation in northeastern Montana which ranges in thickness from 0 to 340 feet; the Maywood Formation in western Montana which also ranges in thickness from 0 to 340 feet (Sandberg and Mapel, 1967, p. 862). In northwestern Montana, north-central Montana, and northeastern Montana, the Duperow Formation and Birdbear Formation which comprise the Jefferson

Group in these areas are represented by 0 to 350 feet and 0 to 125 feet of rock respectively (Sandberg and Mapel, 1967, p. 863). The Jefferson Formation represents the miogeosynclinal Upper Givetian and Frasnian rocks in western Montana and east-central Idaho and attains a thickness of about 2,000 feet in these areas (Sandberg and Mapel, 1967, p. 263). An isopach map produced by the writer (Figure 9) shows a general thickening of the Hyrum Formation northwestward.

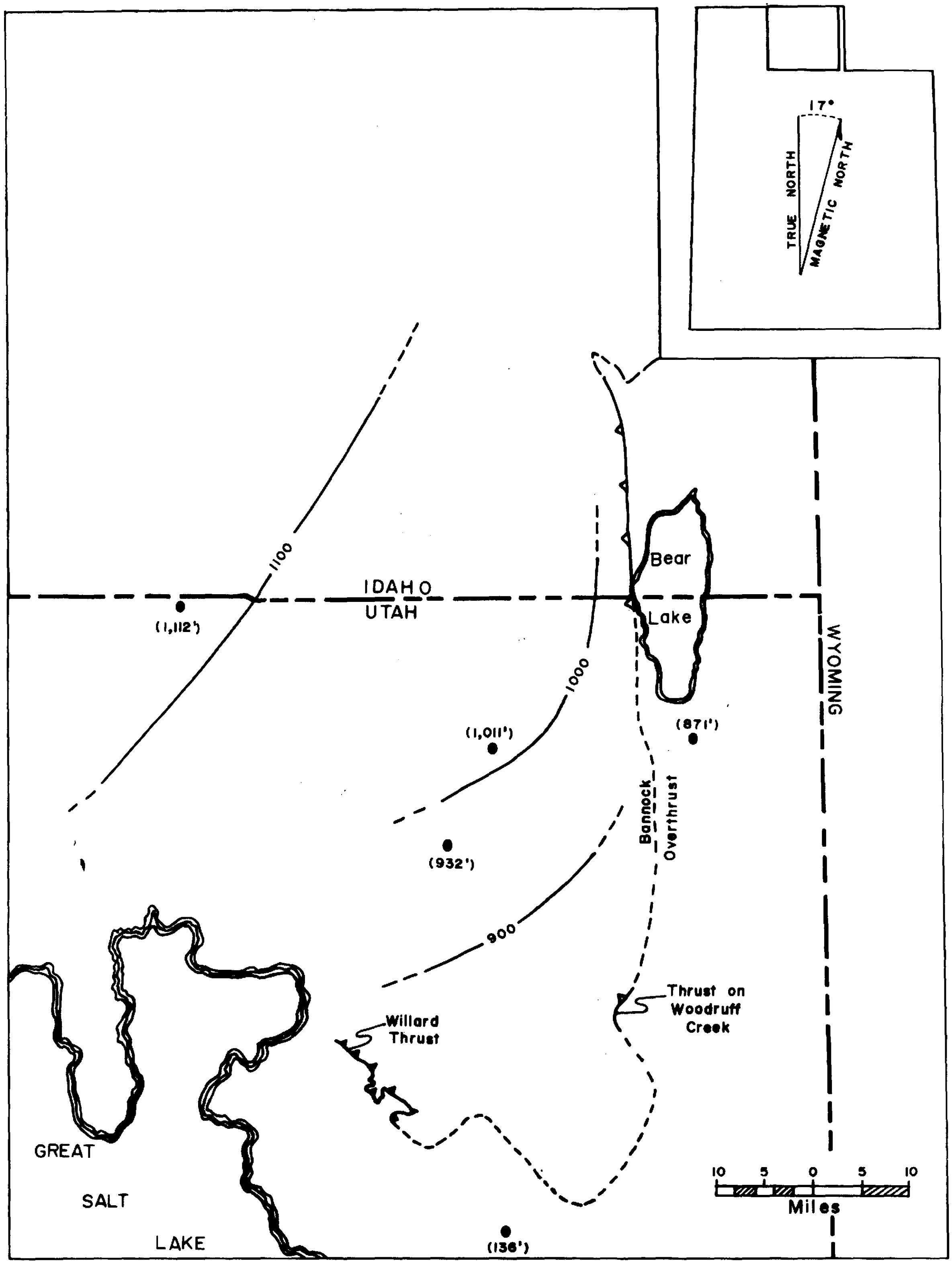


Figure 9. Isopach map of the Hyrum Formation.

BEIRDNEAU FORMATION

General Statement

The Beirdneau Formation was named and described by Williams as a member of the Jefferson Formation (Williams, 1948, p. 1139). The Beirdneau Peak area is the type locality for the unit which consists mostly of sandstone which weathers yellowish gray.

Considerable information has been gathered since Williams described the Beirdneau Sandstone Member. The Beirdneau Sandstone Member has sufficient regional extent in north-central Utah and southeastern Idaho and is sufficiently different from time-equivalent rocks in Montana and Wyoming to be ranked as a formation.

When Williams defined the Beirdneau Sandstone Member, he described it as wholly of sandstone which weathers yellowish gray. Since that time Benson (1966, p. 2596), Mullens and Izett (1964, p. 27), and Williams together with the writer have shown that there is considerable carbonate material in the Beirdneau Formation (Appendix C). Careful examination of the sections of the Beirdneau Formation showed that it has three distinct units based on lithology. The middle unit can be distinguished from the lower and upper units in that it has a weathered surface which is yellowish-orange as compared to their yellowish-gray color, and it typically forms slopes; whereas, the other two form blocky cliffs. These three units are: (1) carbonate unit, (2) sandstone unit (Figure 12), and (3) carbonate unit. The member names are based on their lithology and are as follows: (1) Lower Carbonate Member, (2) Sandstone Member, and (3) Upper Carbonate Member.

Lower Carbonate Member

The Lower Carbonate Member is the name proposed for the basal unit of the Beirdneau Formation. The member was described in Blacksmith Fork Canyon near the first dam. Its maximum thickness of 254 feet (Figure 14) was measured at that location.

The Lower Carbonate Member is represented in all the sections west of the Paris and Willard thrust faults, these include: Gardner Canyon; Portage Canyon; Logan Canyon; and Blacksmith Fork Canyon. Sections measured containing this member can be found in Appendix C.

The basal contact between the Beirdneau Formation and Hyrum Formation was chosen where the lithology changed from the interbedded carbonate and orthoquartzite of the Upper Carbonate-detritus Member of the Hyrum Formation, to the principally calcitic dolomite of the Lower Carbonate Member. The upper contact was recorded where lithology changed to the principally sandstone of the Sandstone Member.

The average thickness of the member in the four sections measured is 162 feet. Thicknesses range from 289 feet at Gardner Canyon, 62 feet at Portage Canyon, 41 feet at Logan Canyon, and 254 feet at Blacksmith Fork Canyon.

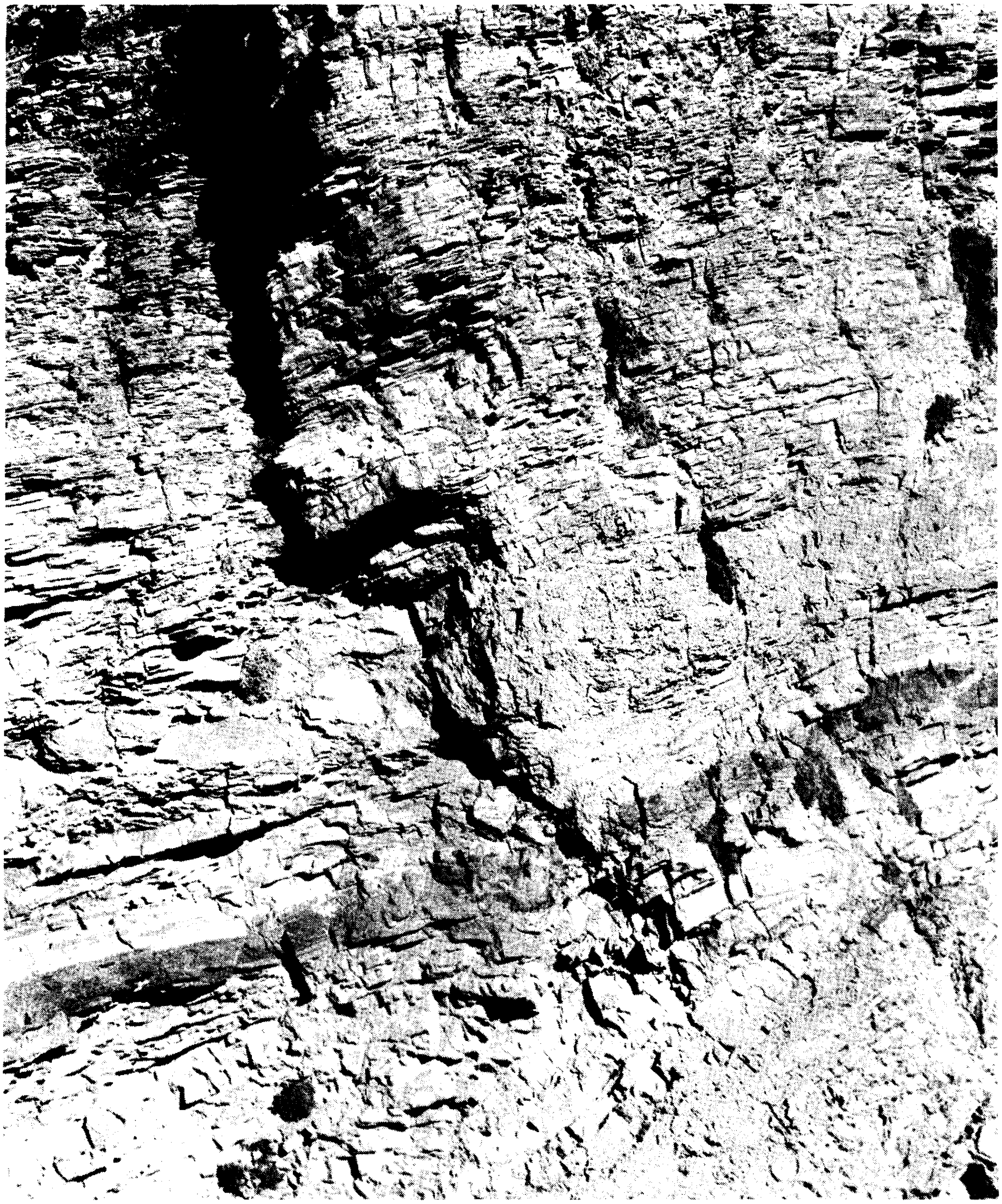
This lower member of the Beirdneau Formation is principally calcitic dolomite with some arenaceous material. The color of a fresh surface ranges from a light olive gray to medium light gray for

Figure 10. Cross-bedding in the Lower Carbonate Member of the Beirdneau Formation on the north side of Blacksmith Fork Canyon.

Located approximately 3 2/10 miles from the bridge at the mouth of Blacksmith Fork Canyon.

Figure 11. Laminated bedding and flowage in the Lower Carbonate Member of the Beirdneau Formation on the north side of Blacksmith Fork Canyon.

Located approximately 2 4/10 miles from the bridge at the mouth of Blacksmith Fork Canyon.



the average of the samples collected. Weathered surfaces of this member are mostly yellowish gray.

Well-developed cross-bedding is present in Unit 21 at Blacksmith Fork Canyon (Appendix C.) and can be seen on Figure 10. The quartz grains, cemented by the calcitic dolomite, are well rounded and are poorly sorted. Cross-bedding is rarely found elsewhere and no regional trend is evident. Mud cracks, ripple marks, and hopper shaped halite casts are fairly common below the unit containing the cross-bedding.

Bed thickness differs throughout the member with thin-bedded and laminated units being present in the lower units (Figure 11). Bed thickness increases upward until thin-bedded units are again represented in Unit 24 at Blacksmith Fork Canyon (Appendix C.).

Sandstone Member

The Sandstone Member is the name proposed for the predominantly sandstone or orthoquartzite unit in the Beirdneau Formation (Figure 12). Blacksmith Fork Canyon is the location of the type section but contains the least sandstone of the sections of the Sandstone Member measured.

This member is present in all the sections measured and six of these are reproduced in Appendix C. The sections recorded in Appendix C are: Gardner Canyon; Portage Canyon; Logan Canyon; Blacksmith Fork Canyon; Old Laketown Canyon; and Mahogany Canyon sections.

Both upper and lower contacts were chosen where the lithology changed to the yellowish-orange principally sandstone of this member. The Lower Carbonate Member below and the Upper Carbonate Member above are principally yellowish-gray calcitic dolomite.

In the type section, the member is made up principally of arenaceous calcitic dolomite or dolomitic sandstone and is predominately thin bedded. Mud cracks, ripple marks, and cross-bedding can be found in almost every unit of this section. Ripple marks are found to truncate cross-bedding surfaces at their tops in several places in Unit 26 at Blacksmith Fork Canyon (Appendix C.).

The Sandstone Member has an average thickness of 230 feet. The Logan Canyon section of the Sandstone Member is 136 feet thick as compared with the Blacksmith Fork section which is 543 feet thick (Figure 14). The rock type, mainly arenaceous calcitic dolomite and sandstone, is the same in both sections. The sandstone in the Logan Canyon section seems to be cleaner and better sorted than in Blacksmith Fork Canyon. Bed thickness differs somewhat from predominately thin beds of Blacksmith Fork Canyon to a few more medium-bedded beds throughout the section. Ripple marks, mud cracks, and halite casts were not observed nearly as frequently as in the previous section and were limited to just a few bedding surfaces. In the Portage Canyon section, the Sandstone Member has reduced in thickness to a little over 60 feet.

Gardner Canyon displays 274 feet of sandstone, orthoquartzite, and dolomite interbedded. This section of the Sandstone Member is mostly covered, but small outcrops of dolomite and sandstone are exposed on the ridges. The sandstone is similar in grain size and color to that found in both Blacksmith Fork and Logan Canyons.

In the Old Laketown Canyon section, only two of the three members were observed (Figure 14). There the Sandstone Member is represented by 181 feet of sandstone with a 12-foot sandstone bed at the base on top of the Upper Dolomite Member of the Hyrum Formation. In the section measured in Mahogany Canyon near Morgan, Utah, the Sandstone Member is the only member representing the Beirdneau Formation. It consists of 186 feet of sandstone and orthoquartzite with one 21-foot unit of dolomitic sandstone. Intraformational breccia and cross-bedding are present in the dolomitic sandstone along with conspicuous folds similar to those present in the Lower Carbonate-detritus Member of the Hyrum Formation, although on a much smaller scale. Since the Beirdneau Formation at Mahogany Canyon section is dominated by sandstone, it probably represents the shore area of the Upper Devonian sea at its maximum transgression on to the Uinta uplift. Although the Sandstone Member differs in thickness locally as does the Lower Carbonate Member, it seems to thin northwestward (Figure 14).

Upper Carbonate Member

The Beirdneau Formation is capped by the same calcitic dolomite expressed in the Lower Carbonate Member. For this reason, the Upper Carbonate Member is the name proposed for this predominantely carbonate unit.

This member is present in all but the Mahogany Canyon Section, these include: Gardner Canyon; Portage Canyon; Logan Canyon; Blacksmith Fork Canyon; and Old Laketown Canyon sections (Appendix C.). The lithology west of the Willard and Paris thrust faults is fairly homogeneous with dolomite and arenaceous calcitic dolomite being the dominant rock types.

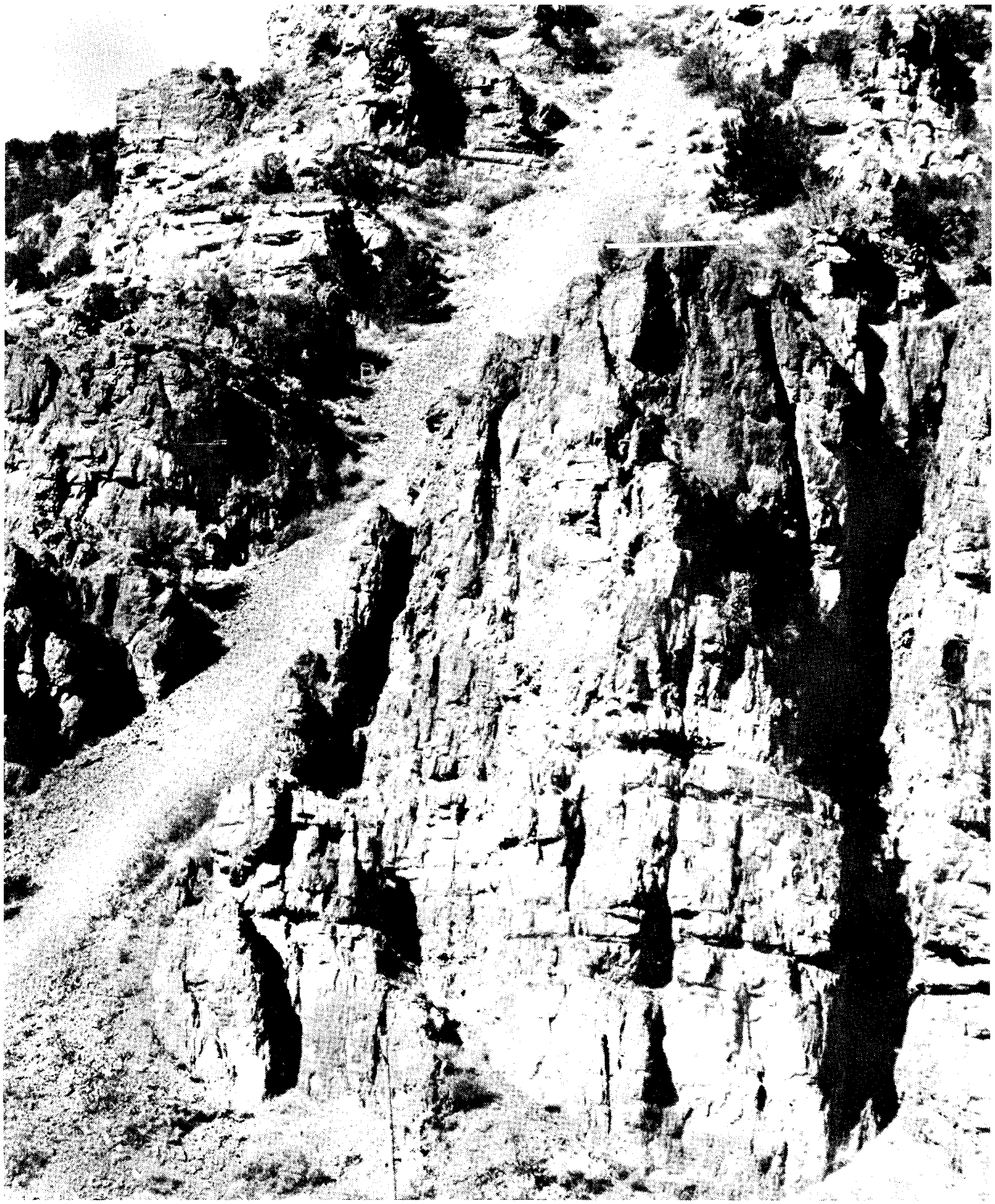
Contacts were chosen where a marked change in lithology occurred from that of the calcitic dolomite of the member. The upper contact was determined at the top of the predominant limestone ledge that marks the boundary between the Beirdneau and Leatham Formations in both Logan and Blacksmith Fork Canyons. In other sections measured the top terminated at the base of the Lodgepole Formation.

Thickness is relatively constant, from 245 feet in Gardner Canyon, 287 feet in Portage Canyon, 297 feet in Logan Canyon, 225 feet in Blacksmith Fork Canyon, and 343 feet in the Old Laketown Canyon section (Figure 14). Thickness of this member differs considerably and there seems to be no general trend.

At the Old Laketown Canyon section, the lithology is considerably different from that in the other four sections. The rock type here is primarily limestone or arenaceous limestone, with one 63-foot unit of magnesian limestone at the base of the member. This 63-foot bed of magnesian limestone is almost completely brecciated. This unit apparently represents the westward limit of the Logan Gulch Member of the Three Forks Formation. Sloss and Laird (1947, p. 1422) attributed the brecciation to the removal of anhydrite by solution causing slumping and brecciation of the beds

Figure 12. Typical outcrop of the Lower Carbonate and Sandstone Members of the Beirdneau Formation on the north side of Blacksmith Fork Canyon, looking northwest.

Located approximately 1 8/10 miles from the bridge at the mouth of Blacksmith Fork Canyon. The marker is the boundary between the Lower Carbonate and Sandstone Members.



above. The units above the magnesian limestone are predominantly light-olive-gray thin-bedded to laminated limestone or arenaceous limestone. Halite casts and ripple marks were observed toward the top of the section. The unit above the brecciated magnesian limestone could possibly represent the westward extent of the Trident Member of the Three Forks Formation because the color and weathering characteristics are more indicative of this formation.

In Logan and Blacksmith Fork Canyons, the Upper Carbonate Member terminates at the top of a limestone bed which has been called the "Contact Ledge." This "Contact Ledge" was originally thought to be Mississippian in age (Williams, 1948 p. 1141), but more recent work by Holland (1952, p. 1718) produced Devonian fossils and thus placed the Devonian-Mississippian contact above the "Contact Ledge" of the Beirdneau Formation. This ledge is not present in the Portage Canyon, Gardner Canyon, or Old Laketown Canyon sections. The contact between the Devonian and Mississippian was drawn at the base of the Mississippian Lodgepole Formation in these localities.

Correlation

Since Williams (1948, p. 1140) first described and named the Beirdneau Sandstone Member of the Jefferson Formation, considerable work has been done in correlating the now Beirdneau Formation with various time-equivalent rocks in Utah, Nevada, Idaho, Wyoming, and Montana. An isopach map of upper Upper Devonian (Famennian) rocks was presented in a paper by Poole *et al.* (1967, p. 904). This isopach map shows a general thickening of upper Upper Devonian rocks northwestward in the study area until a maximum thickness is reached near the Utah-Idaho border of over 750 feet.

Miogeosynclinal time-equivalent rocks include the Stansbury Formation in the Stansbury Mountains, Utah; the Victoria Formation in the East Tintic Mountains, Utah; and the Crystal Pass Limestone in Nevada. These formations are represented by predominantly thin- to thick-bedded limestone or dolomite with some sandy interbeds. A shallow marine environment is postulated for most cases (Poole *et al.*, 1967, p. 903).

The Three Forks Formation of east-central Idaho, western Wyoming, and Montana was first described by Peale (1893, p. 29-32) as the Three Forks Shales and is the time-equivalent unit to the north and west of the study area. The Three Forks Formation is found in both the miogeosyncline and the craton suites. Sandberg (1962, p. 47-50) further divided the Three Forks Formation into three members: (1) lower evaporitic member, (2) middle shale member, and (3) upper sandstone member. These members were formally named: (1) Logan Gulch, (2) Trident, and (3) Sappington (Sandberg, 1965). Benson (1966, p. 2594) described the Logan Gulch Member as brecciated limestone and shale. The writer's lower part of the Upper Carbonate Member in Old Laketown Canyon, Utah, probably represents the westward limit of the Logan Gulch Member of the Three Forks Formation. The upper part of the writer's Upper Carbonate Member could possibly represent the transgression of the late Devonian sea that deposited the Trident Member.

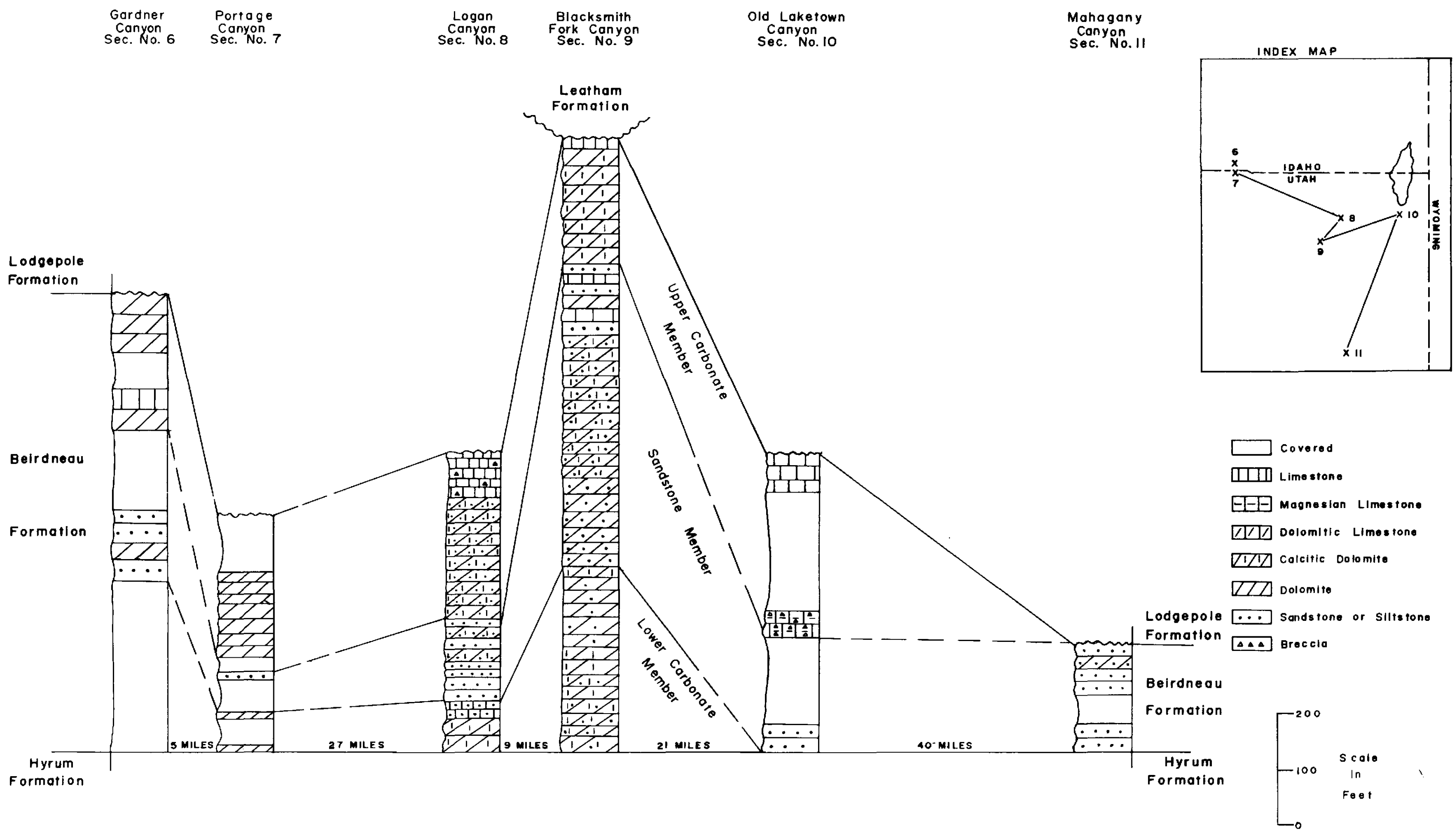


Figure 13. Correlation chart of measured sections of Beirdneau Formation.

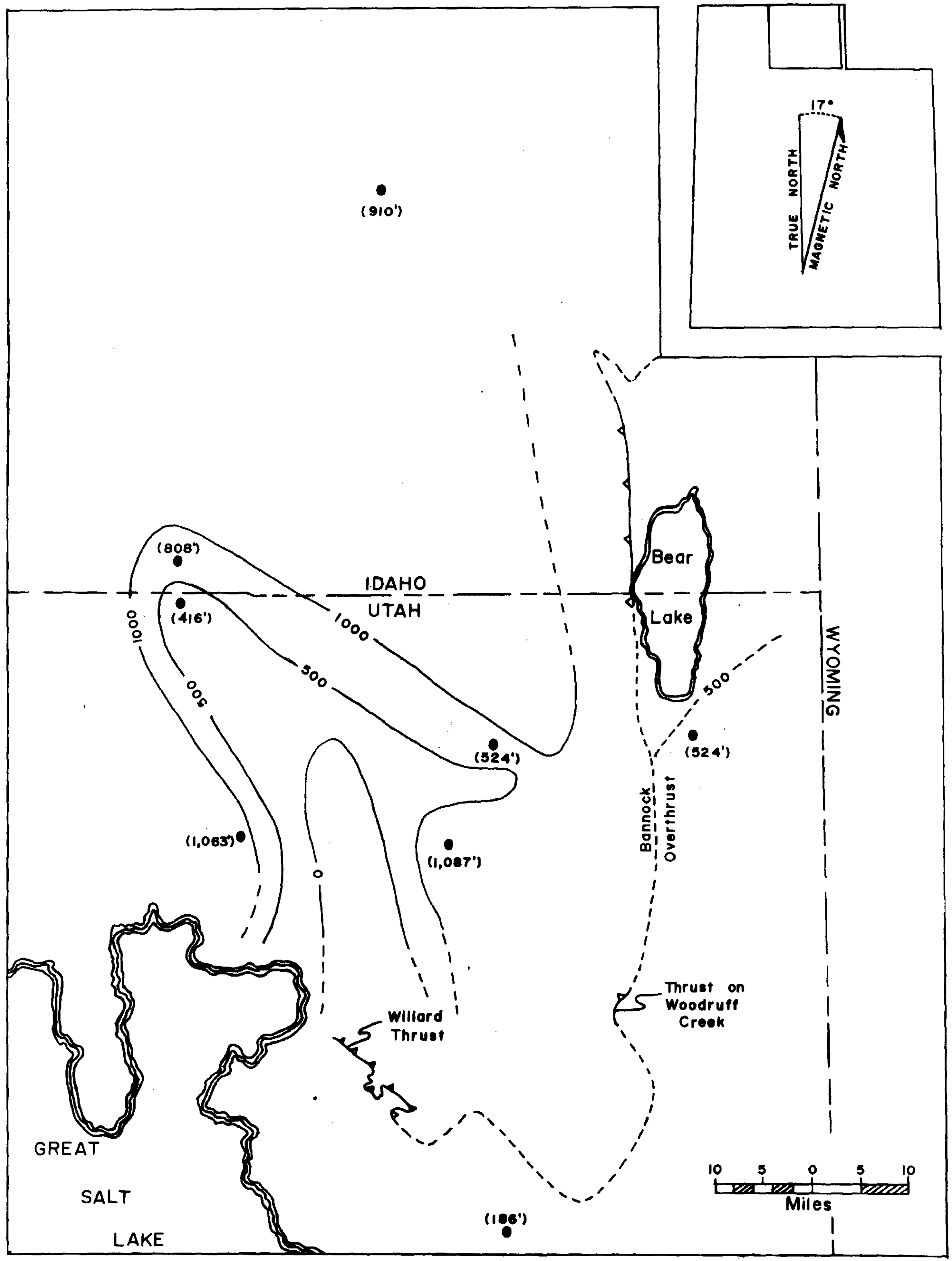


Figure 14. Isopach map of Beirdneau Formation.

PALEONTOLOGY

The Hyrum Formation is generally unfossiliferous. The fossils collected were almost entirely limited to the Samaria Member. Fossils were collected in all sections of the Samaria Member, but the fossils are most abundant in the Portage Canyon section, with the Logan Canyon section being a close second. The following faunal list is the result of arduous collecting by the writer and Dr. J. Stewart Williams:

Amphipora sp.

Thamnopora sp.

Zaphrentid coral

Lingula sp.

Rensselandia cf. *R. missouriensis* (Swallow)

Biconostrophia ? sp.

Atrypa oneidensis Beus

Tenticospirifer utahensis (Meek)

Allanaria engelmanni (Meek)

Ambothyris utahensis Beus

Cyrtina sp.

Reticularia sp.

Raphistomina ? sp.

Hormotomina ? sp.

Bembexia ? sp.

Naticopsis sp.

Aviculopecten cf. *A. cancellatus* (Hall)

Proetus sp.

Icriodus sp.

Icriodus nodosus s.l.

Polygnathus decorosus s.l.

Spathognathodus insitus

Atopacanthus dentatus Hussakof and Bryant

Ptyctodus sp.

Dipterus sp.

Only two of the above list have a geologic range that is valuable in determining the age of the Samaria Member. The species *Rensselandia* cf. *R. missouriensis*, a biconvex brachiopod, is limited to the Middle Devonian (G. Arthur Cooper, letter communication). Also *Spathognathodus insitus*, a conodont, is not known above the upper part of the Coralville Member of the Cedar Valley Limestone, Iowa, and the upper part of the Callaway Formation, Missouri. The age of these occurrences may be uppermost Middle Devonian (Gilbert Klapper, letter communication) (Klapper, 1966). These findings confirm an upper Middle Devonian age for the base of the Hyrum Formation as suggested by Beus (1965, p. 23) Poole *et al.* (1967, p. 884-885), and Sandberg and Mapel (1967, p. 846).

The age of the Hyrum, Beirdneau, and Leatham Formations seems to range from late Middle Devonian (Givetian) to Lower Mississippian (Tournaisian) time. The age of the lower boundary was determined by the Middle Devonian fossils *Rensselandia* and *Spathognathodus*. The age of the upper limit of the Beirdneau Formation was first determined by Holland (1952, p. 1718). Holland found *Cyrtospirifer* cf. *C. Whitneyi* (Hall), which correlates with *Cyrtospirifer monticola*, a brachiopod zone fossil, which is limited to the lower Middle Famennian (Poole *et al.*, 1967, p. 884). Holland also suggested that the Leatham might be a facies equivalent of the upper part of the Three Forks Formation based on finding *Camarotoechia nordeggi* Kindle which is a common fossil of the Three Forks Formation (Holland, 1952, p. 1718). Additional work by Sandberg and Mapel (1967, p. 872) has confirmed Holland's suggestion that the Leatham Formation is a facies of the Three Forks Formation. They have further limited the Leatham Formation to the time-equivalent rocks of the Sappington Member of the Three Forks Formation. In addition to the above, Sandberg and Mapel have determined the Devonian-Mississippian boundary, based on conodont and brachiopod fauna, to be about two-thirds the way up in the Leatham Formation. Regional studies have placed the Devonian-Mississippian boundary in a similar lithology in most cases (Gutschick and Moreman, 1967).

ENVIRONMENTS OF DEPOSITION

The environment of deposition of the Hyrum and Beirdneau Formations is difficult to determine exactly. Fossils are largely restricted to the Samaria Member, the basal member of Hyrum Formation, so the environment of deposition has to be determined mainly from lithology and sedimentary structures.

The late Middle Devonian (Givetian) and Upper Devonian (Frasnian and Famennian) rocks in the study area were deposited in a miogeosynclinal sea that transgressed into the area after having left in Lower Devonian (Coblenzian) time. By early Late Devonian time the sea had extended eastward well onto the craton. This set the stage for the deposition of the Hyrum and Beirdneau Formations (Poole *et al.*, 1967, p. 906).

At the top of the Water Canyon Formation, below the Hyrum Formation, a limestone breccia exists in most localities. The writer believes that it represents a solution breccia which is the result of evaporites having been deposited in the study area as the Coblenzian sea regressed to western Utah and eastern Nevada. When the upper Middle Devonian (Givetian) sea migrated back into the study area, it deposited arenaceous and silty limestone on the evaporites. The evaporites were later dissolved allowing the above beds to collapse forming a solution breccia at the top of the Water Canyon Formation.

The first beds deposited at the study area as the sea migrated onto the craton were probably the predominantly limestone beds of the

Samaria Member. These beds probably record the maximum depth of the Late Devonian seas at any given time as the Hyrum Formation was being deposited. The thickness of the Samaria Member increases westward, along with an increase in the amount of limestone, indicating deeper water for a longer period of time from east to west.

Increased dolomite in the Lower Dolomite Member of the Hyrum Formation apparently represents a time when the sea was somewhat shallower than when the Samaria Member was being deposited. As the Devonian seas became even more shallow, the Lower Carbonate-detritus Member of the Hyrum Formation was deposited. Increased detrital material, mixed with predominantly dolomite, indicates that there was apparently an increase in exposed land area or a shift in river systems of the craton which supplied the detrital material. Sedimentary structures such as ripple marks, mud cracks, and halite casts were found in this member and indicate that some beds were exposed to air.

The deposition of the Upper Dolomite Member of the Hyrum Formation indicates a similar environment as expressed for the Lower Dolomite Member. Thickness of this member increases westward as does the thickness of the limestone which indicates deeper water westward.

Deposition of the Upper Carbonate-detritus Member of the Hyrum Formation indicates a time when the late Frasnian-early Famennian seas in the geosyncline gradually became shallow and locally restricted. Arenaceous or silty dolomite interbedded with sandstone or siltstone was deposited at this time. The sandstone and siltstones display ripple marks, mud cracks, and halite casts in most beds indicating that they were probably deposited in near-shore conditions.

In the latest Devonian (Famennian) time, the time of deposition of the Beirdneau Formation, the seas both in the geosyncline and on the craton were fairly shallow and locally restricted. Uplifted areas such as the Mantua uplift, Stansbury uplift, and ancestral Uinta uplift were supplying detrital material to basins interspersed among these areas of uplift penecontemporaneous in intermittently transgressive and regressive seas (Poole *et al.*, 1967, p. 907).

Rigby (1959, p. 217) suggested that the source of detritus for the Victoria Quartzite and the detrital sand and shale beds of the Three Forks and Beirdneau Formations was the Stansbury uplift which was a western continuation of the Transcontinental arch projecting into the area of northeastern Utah and southwestern Wyoming. The Tintic Quartzite of Cambrian age is exposed in the uplifted area and could have been the source of the sandstone and orthoquartzite in the Beirdneau Formation (Rigby, 1958).

Brooks and Andrichuk (1953, p. 30) constructed an isopach-lithofacies map, showing clastic ratio, of northeastern Utah and parts of Wyoming and Idaho. Clastic material decreases northwestward from the zero isopach near the Wyoming border. This indicates that part of the detritus could have come from the cratonic area to the east as well as from the Stansbury uplift. The Lower Carbonate Member of the Beirdneau Formation is probably the result of a transgressive sea. The large amount of carbonate material mixed with detrital material indicates that depth of the water was sufficient to produce the dolomite but was also receiving detrital material.

Deposition of the Sandstone Member of the Beirdneau Formation probably represents a time of shallow water. The large amount of sandstone and orthoquartzite found within this member along with such sedimentary structures as cross-bedding, ripple marks, mud cracks, and hopper-shaped halite casts indicate that the member was deposited in a near-shore environment.

The Upper Carbonate Member of the Beirdneau Formation is almost the same lithologic type as its lower counterpart. The "Contact Ledge," at the top of this member, probably represents the maximum depth the sea attained. The above strata of latest Devonian age display many local disconformities and gaps as a result of these transgressive and regressive seas (Poole *et al.*, 1961, p. 907).

CONCLUSIONS

The age of the Hyrum and Beirdneau Formations was found to be late Middle Devonian (Givetian) to upper Upper Devonian (Famennian). They are disconformably underlain by the Early Devonian Water Canyon Formation and disconformably overlain by the late Upper Devonian, Early Mississippian Leatham Formation or in some localities the Early Mississippian Lodgepole Formation.

The Hyrum Formation is divided into five members, based on lithology and color: (1) Samaria, (2) Lower Dolomite, (3) Lower Carbonate-detritus, (4) Upper Dolomite, and (5) Upper Carbonate-detritus. The Samaria is the only fossiliferous unit within the formation. The Lower Dolomite Member is characterized by medium-dark-gray thin-to massive-bedded finely crystalline dolomite. The middle, Lower Carbonate-detritus Member, represents a unit with considerable detrital material. It is characterized by light-gray arenaceous dolomite not found in the Lower Dolomite Member. The Upper Dolomite Member has the same lithology and color as the Lower Dolomite Member. It represents the Birdbear Member of the Jefferson Formation to the north and east of the study area (Sandberg and Mapel, 1967, p. 846). The Upper Carbonate-detritus Member is similar to the Lower Carbonate-detritus Member. It represents a transition into the more detrital beds of the Beirdneau Formation.

The Beirdneau Formation has three members: (1) Lower Carbonate Member, (2) Sandstone Member, and (3) Upper Carbonate Member. The Lower Carbonate Member is principally a light-olive-gray calcitic dolomite with some arenaceous material. A yellowish-gray sandstone or orthoquartzite is the rock type of the Sandstone Member. The Upper Carbonate Member is principally a light-olive-gray arenaceous calcitic dolomite.

The environment of deposition of the Hyrum and Beirdneau Formations appears to have occurred in a sequence of deepening and shallowing of the late Middle to upper Upper Devonian sea. The sea apparently became increasingly shallower as the Hyrum Formation was being deposited and even shallower and occasionally restricted when the Beirdneau Formation were being deposited. The source of detritus apparently came from the south and east of the study area.

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APPENDIXES

Appendix A

Samples Analyzed for Percent Ca CO_3, Mg CO_3, and Residue

Samples Analyzed for Percent

$CaCO_3$, $MgCO_3$, and Residue

Location	Formation	Member	Unit	$CaCO_3$%	$MgCO_3$%	Residue %
Blacksmith Fork Canyon Section			1	97.4	.9	1.6
			3-1	53.5	48.0	1.5
		Samaria	3-2	56.2	40.4	4.7
			3-3	45.0	39.8	17.7
			4	54.5	33.1	9.8
			5	52.9	47.6	2.5
			6-1	37.5	25.9	34.9
			6-2	50.9	35.9	13.4
			7	53.5	46.8	1.7
		Lower Dolomite	8-1	16.1	7.2	76.5
			8-2	51.1	49.4	7.8
	Hyrum Formation		8-3	42.0	34.5	21.5
			9	56.2	40.2	1.7
			10	29.5	26.0	46.0
			11	53.5	23.5	2.0
			12	1.8	2.2	95.9
			13-1	53.2	43.9	3.5
			13-2	49.6	43.9	8.9
		Lower Carbonate-detritus	14-1	99.1	.9	1.1
			14-2	92.1	2.8	6.1
			15-1	58.1	39.8	1.9
			15-2	55.6	37.0	9.0
			16-1	90.0	8.1	.4
			16-2	56.2	41.6	.9
			16-3	97.4	1.0	1.2
		Upper Dolomite	17	53.8	44.2	2.4
		Upper Carbonate-detritus	18-1	96.4	.8	1.9
			18-2	59.1	9.6	32.3
Blacksmith Fork Canyon Section			19-1	47.1	19.6	33.4
			19-2	53.9	48.8	1.3
		Lower Carbonate	20	37.2	29.3	32.8
			21	13.1	8.3	75.7
			22	62.9	33.3	1.4
			23	43.6	33.3	23.1
			24	61.6	37.2	1.5

Location	Formation	Member	Unit	$CaCO_3$%	$MgCO_3$%	Residue %
Blacksmith Fork Canyon Section (Continued)			25-1	28.4	20.8	50.0
			25-2	39.1	28.1	31.6
		Sandstone Member	26-1	41.2	26.7	30.6
			26-2	9.1	2.2	89.5
			27	62.1	34.1	2.5
	Beirdneau Formation		28-1	98.0	1.6	1.9
			28-2	57.3	41.6	.76
			29-1	72.4	22.7	5.9
		Upper Carbonate	29-2	57.8	39.8	1.3
			30-1	52.2	35.5	10.5
			30-2	95.0	1.5	1.9
Logan Canyon Section			1-1	94.5	5.6	2.3
			1-2	53.5	40.7	7.1
		Samaria	2	51.5	39.1	9.1
	Hyrum Formation		3-1	56.2	44.2	1.1
			3-2	50.7	41.8	8.8
			4	55.1	39.8	5.0
		Upper Dolomite	19	99.1	1.8	2.0
Logan Canyon Section		Lower Carbonate	23	68.0	30.7	1.9
		Sandstone	27	65.3	26.2	6.0
	Beirdneau Formation		29	94.8	1.9	4.0
		Upper Carbonate	30	75.8	24.6	2.0
			31	97.4	1.5	1.2
Portage Canyon Section			1	96.4	2.2	2.4
			1-1	54.5	39.8	2.8
			1-2	53.0	41.2	5.9
			2-1	49.4	29.1	19.4
		Samaria	2-2	98.0	1.4	3.4
			3-1	89.8	7.1	5.9
			3-2	87.8	6.4	6.4
			4	74.2	19.6	6.8
	Hyrum Formation		5-1	67.3	30.9	2.0
			5-2	66.4	27.2	2.9
			6-1	75.5	23.6	0.8
			6-2	95.8	2.9	3.5
		Lower Dolomite	6-3	67.2	28.2	1.9
			7	54.5	45.6	1.0
			9	53.6	45.5	3.0
			10-1	55.4	43.3	1.3
			10-2	41.2	11.1	45.8

Location	Formation	Member	Unit	$CaCO_3$%	$MgCO_3$%	Residue %
Portage Canyon Section (Continued)	Hyrum Formation (Continued)	Lower Carbonate detritus	16-2	76.0	23.2	2.8
			16-3	59.1	32.9	5.3
		Upper Carbonate detritus	20-1	56.7	39.8	4.0
			20-2	54.0	41.2	3.1
Portage Canyon Section	Beirdneau Formation	Lower Carbonate	21	52.1	48.5	2.6
		Sandstone	22	56.2	41.6	0.9
Laketown Canyon Section	Hyrum Formation	Lower Dolomite	1	60.7	31.0	7.1
		Lower Carbonate-detritus	II	57.5	39.0	3.0
Laketown Canyon Section	Beirdneau Formation	Upper Carbonate	20	89.8	2.3	4.6
			21	83.0	1.3	16.8
			22	89.2	1.1	11.7
			23	65.9	23.9	11.6
			24	90.5	1.4	7.1
Gardner Canyon Section	Beirdneau Formation	Lower Carbonate	1-1	53.5	45.0	2.8
			1-2	53.0	44.2	2.8
		Sandstone	6	19.0	14.1	67.7
			8	55.9	42.4	1.4
		Upper Carbonate	9-1	54.0	45.0	2.7
			9-2	54.1	39.8	3.9
			11-1	55.7	39.8	3.1
			11-2	51.7	48.9	2.4

Appendix B

Measured Sections of the Hyrum Formation

Section No. 1. Hyrum Formation (Figure 2, Locality 2).

Section of Hyrum Formation in SE1/4 sec. 11, T. 15 N., R. 4 W., Box Elder County, Utah; measured about 1,000 yards below the crest of divide between Rough and Portage Canyons, in Portage Canyon, 2 miles WSW. of Portage, Utah.

Beirdneau Formation Unit	Thickness (feet)	Cumulative Thickness (feet)
Upper Carbonate-detritus Member		
20. Orthoquartzite and dolomite inter-bedded, medium gray, weathers yellowish gray (5Y 7/2), medium bedded, orthoquartzite medium grained, dolomite finely crystal-line, breccia present, partly covered.	92	92
Upper Dolomite Member		
19. Arenaceous calcitic dolomite, medium dark gray to light olive gray (5Y 6/1), laminated to medium bedded, very finely crys-talline, breccia is common.	51	143
18. Arenaceous dolomitic limestone, inter-bedded limestone, medium dark gray, laminated to medium bedded, finely crystalline, breccia and chert stringers are present.	69	212
17. Arenaceous dolomite, light gray to medium gray (N4), thin bedded to thick bedded, very finely crystalline, ledges weather rounded.	63	245

	Thickness (feet)	Cumulative Thickness (feet)
Lower Carbonate-detritus Member		
16. Calcitic dolomite, light gray (N7), some beds weather grayish orange (10YR 7/4), medium to thick bedded, some breccia, beds weather rounded, contains some stringers of chert.	58	333
15. Arenaceous dolomite; medium light gray (N6), thin bedded to massive bedded, some very finely crystalline beds, breccia.	56	389
14. Dolomite; medium dark gray (N4), thin to medium bedded, finely crystalline, interbedded with grayish-orange (10YR 7/4) sandstone, some beds weather in vugs.	28	417
13. Dolomite; dark gray (N3), weathers medium dark gray; thin to medium bedded, finely crystalline, contains some chert nodules and fossil fragments; partially covered.	12	429
12. Dolomite, medium dark gray (N4), thin to medium bedded, finely crystalline, some chert nodules and fossil fragments.	54	483
11. Sandstone, very pale orange (10YR 8/2), thin bedded, fine to medium grained.	8	491
Lower Dolomite Member		
10. Dolomite, medium dark gray (N4), medium bedded, finely crystalline, outcrops form blocky ridges.	55	546
9. Dolomite, medium dark gray (N4), thin bedded to thick bedded, finely crystalline.	51	597
8. Dolomite, medium dark gray (N4), thin bedded to massive, finely crystalline, forms blocky ledges, laminated beds in places alternating light gray and dark gray.	64	661

	Thickness (feet)	Cumulative Thickness (feet)
7. Calcitic dolomite, medium light gray (N6), weathers light gray (N7), thin bedded to massive, finely crystalline, one massive bed of light-gray magnesian limestone near top of unit.	73	734
6. Calcitic dolomite, medium gray (N5) to medium light gray (N6), thin to medium bedded, finely crystalline, mostly covered.	65	799
Samaria Member		
5. Dolomite, medium gray (N5), weathers light gray (N7), thin to thick bedded, finely crystalline, partially covered.	42	841
4. Arenaceous dolomitic limestone, medium dark gray (N4), finely crystalline, thin to medium bedded, fossiliferous.	30	871
3. Arenaceous dolomitic limestone, medium dark gray (N4), thin bedded to thick bedded, finely crystalline, extremely fossiliferous; weathers in ledges 1-3 feet thick.	85	956
2. Arenaceous calcitic dolomite, medium gray (N5), thin to thick bedded, very finely crystalline, some silty beds, extremely fossiliferous.	90	1,046
1. Limestone, yellowish gray (5Y 8/1) to medium light gray (N6), thin bedded to massive, weathers in 10-foot ledges, contortions in upper part, base is underlain by a sandstone breccia, fossil fragments present.	66	1,112
	TOTAL	1,112

Section No. 2. Hyrum Formation (Figure 2, Locality 3).

Section of Hyrum Formation in NW 1/4 sec. 23, T. 12 N. R. 2 E., Cache County, Utah; measured on the north side of Logan Canyon approximately 7 miles from mouth of canyon.

Beirdneau Formation Unit	Thickness (feet)	Cumulative Thickness (feet)
Upper Carbonate-detritus Member		
22. Sandstone, yellowish gray (5Y 8/1), laminated to massive bedded, fine grained, sun crack, some limestone and dolomite beds, forms small cliffs.	102	102
Upper Dolomite Member		
21. Calcitic dolomite, medium dark gray (N4), weathers yellowish gray (5Y 8/1), laminated to massive, very finely crystalline, chert in places, some pale olive gray (10Y 6/2), calcareous siltstone, cliff forming.	25	127
20. Calcitic dolomite, medium dark gray (N4), weathers light olive gray (5Y 6/1), laminated to massive bedded, finely crystalline, chert in places, some contortions in laminated beds, forms cliffs.	67	194
19. Calcitic dolomite, medium light gray (N6), thin bedded to massive bedded, very finely crystalline, lower 60 feet covered, forms steep slopes.	61	255
Lower Carbonate-detritus Member		
18. Calcitic dolomite and sandstone interbedded, this unit is almost entirely covered.	42	297

	Thickness (feet)	Cumulative Thickness (feet)
17. Dolomitic limestone and sandstone interbedded, almost entirely covered.	57	297
16. Limestone and dolomite, dark gray (N3), thin bedded to medium bedded, very finely crystalline, mostly covered, some thin-bedded sandstone.	58	412
15. Sandstone, very pale orange (10YR 8/2), weathers pale yellowish orange (10YR 8/6), thin bedded to medium bedded, medium grained.	5	417
14. Dolomite, medium gray (N5), weathers medium light gray (N6), thick bedded to thin bedded, finely crystalline, slope forming, öolitic weathering texture on one 2-foot bed.	52	469
13. Sandstone, very pale orange (10YR 8/2), weathers pale yellowish orange (10YR 8/6), thin bedded to medium bedded, very fine grained to fine grained.	5	474
12. Dolomite, medium gray (N5), thin bedded to medium bedded, finely crystalline, fossil fragments present.	33	507
11. Dolomite, medium gray (N5), thin bedded to massive, finely crystalline, forms steep slopes with cliffs, fossil fragments in some beds.	49	556
10. Sandstone, very pale orange (10YR 8/2), laminated to thin bedded, fine to medium grained, quartz crystals are well rounded.	11	567
Lower Dolomite Member		
9. Dolomite, medium dark gray (N4) alternating with medium light gray (N6), thin bedded, very finely crystalline to finely crystalline, forms slopes and cliffs, some fossils.	42	609

	Thickness (feet)	Cumulative Thickness (feet)
8. Dolomite and limestone interbedded, medium gray (N5), laminated to thick bedded, finely crystalline, forms rounded cliffs, brecciated in most areas.	66	675
7. Dolomite and limestone interbedded, medium light gray (N6), alternating with medium dark gray (N4), laminated to medium bedded, finely crystalline to medium crystalline, brecciated zones, some fossils.	58	733
6. Dolomitic limestone, medium light gray (N6), laminated to thick bedded, finely crystalline.	47	780
5. Arenaceous dolomite, medium gray (N5), weathers light olive gray (5Y 6/1), laminated to medium bedded, very finely crystalline, to medium crystalline, forms slopes with some small cliffs, weathers with a saccharoidal texture in places.	53	833
Samaria Member		
4. Silty dolomite, medium gray (N5), weathers light olive gray (5Y 6/1), laminated to medium bedded, finely crystalline, basically slope forming, fossils present.	49	882
3. Dolomite, medium light gray (N6), weathers light olive gray (5Y 6/1), laminated to thick bedded, finely crystalline to medium crystalline, weathers with a saccharoidal texture.	58	940
2. Arenaceous dolomite, medium gray (N5), weathers light olive gray (5Y 6/1), medium bedded to thick bedded, finely crystalline, forms slopes except for 5-foot cliff.	45	985
1. Dolomitic limestone, medium dark gray (N4), weathers light olive gray (5Y 6/1), medium bedded to thick bedded, very finely crystalline, fossils present.	26	1,011
	TOTAL	1,011

Section No. 3. Hyrum Formation (Figure 2, Locality 4)

Section of Hyrum Formation in SE1/4 sec. 1, and NE1/4 sec. 12, T. 10 N., R. 1 E., Cache County, Utah; measured on the north side of Blacksmith Fork Canyon approximately 1 1/4 miles from mouth of canyon.

Beirdneau Formation Unit	Thickness (feet)	Cumulative Thickness (feet)
Upper Carbonate-detritus Member		
18. Limestone, medium dark gray (N4), weathers yellowish gray (5Y 8/1), massive beds interbedded with thin beds, finely crystalline, six massive beds from 1-10 feet thick interbedded with light-gray silty dolomitic limestone, halite casts, ripple marks, sun cracks, and some oölitic texture breccia common.	134	134
Upper Dolomite Member		
17. Dolomite, medium dark gray (N4), weathers medium gray (N5), thin bedded to medium bedded, finely crystalline, thin calcite veins throughout, forms dark gray, cliff above the light-gray rounded cliff.	84	218
Lower Carbonate-detritus Member		
16. Dolomitic limestone, medium dark gray (N4), weathers medium light gray (N6), medium bedded to laminated, finely crystalline, several beds of dark-gray medium-crystalline dolomite, some thin beds of sandy limestone contains considerable breccia throughout, cliffs weathers rounded.	95	313

	Thickness (feet)	Cumulative Thickness (feet)
15. Calcitic dolomite, dark gray to medium dark gray (N4), thin-bedded to medium-bedded, medium crystalline, some thin beds of sandstone.	55	368
14. Calcitic dolomite, some of the carbonate beds are limestone. Some interbeds are silty limestone	92	460
13. Dolomite, medium light gray (N6) to medium gray (N5), thin bedded, very finely crystalline. Interstratal contortions.	30	490
12. Sandstone, very pale orange (10YR 8/2), medium-bedded to subparallel laminations, medium grained, well cemented, sharp contacts bottom and top.	12	502
Lower Dolomite Member		
11. Dolomite, medium gray (N5), thick-bedded, finely crystalline.	10	512
10. Silty or argillaceous dolomite, pale yellowish brown (10YR 6/2), laminated to thinly laminated, finely crystalline, contains breccia.	3	515
9. Dolomite, medium gray (N5), thick bedded, medium crystalline, forms cliffs.	50	565
8. Calcitic dolomitic sandstone, medium gray (N5) to light olive gray (5Y 6/1), thin-bedded to laminated, medium-grained to fine-grained, weathers in vugs.	8	573
7. Dolomite, medium dark gray (N4), thin bedded to laminated, forms small cliffs, weathers in vugs.	110	683

	Thickness (feet)	Cumulative Thickness (feet)
6. Arenaceous calcitic dolomite, grayish orange (10YR 7/4) to a light olive gray (5Y 6/1), very finely crystalline, basal breccia, basal contact gradational, upper contact sharp, ripple marks and sun cracks present.	4	687
5. Dolomite, dark gray to medium dark gray (N4), medium bedded to thick bedded, finely crystalline, forms the predominate cliff of the Hyrum dolomite.	111	798
Samaria Member		
4. Silty calcitic dolomite, medium gray (N5); weathers light gray (N7) thin bedded to medium bedded.	53	851
3. Dolomite, medium light gray (N6) weathers very light gray (N8), laminated, finely crystalline, some microdeformation, some thin bedded beds of silty dolomite.	26	877
2. Dolomitic limestone, thin to medium bedded, dark gray (N3), weathers medium gray (N5), medium crystalline, *Rensselandia* in middle.	45	922
1. Limestone, massive-bedded, medium crystalline.	10	932
	TOTAL	932

Section No. 4. Hyrum Formation (Figure 2, Locality 5)

Section of Hyrum Formation in NE1/3 sec. 17, T. 12 N., R. 6 E., Rich County, Utah; measured about three-fourths of a mile up the east fork of Old Laketown Canyon.

Beirdneau Formation Unit	Thickness (feet)	Cumulative Thickness (feet)
Upper Dolomite Member		
16. Silty dolomitic limestone, medium light gray (N6), weathers light brown (5YR 5/6), laminated to thin-bedded, finely crystalline, contains some breccia.	40	40
15. Covered interval, light-gray (N7) to medium-light-gray float (N6) silty limestone.	114	154
14. Dolomitic limestone, medium light gray (N6) to medium dark gray (N4), laminated to thin bedded, finely crystalline.	26	180
Lower Carbonate-detritus Member		
13. Sandstone, very pale orange (10YR 8/2), laminated to thin bedded, fine grained.	10	190
12. Calcitic dolomite, medium dark gray (N4) to medium light gray (N6), thin to medium bedded, very finely crystalline, unit contains 5-foot sandstone bed.	59	249
11. Calcitic dolomite, medium dark gray (N4), medium bedded to massive, finely crystalline, weathers in vugs.	42	291
10. Covered interval; calcitic dolomite float.	9	300

	Thickness (feet)	Cumulative Thickness (feet)
9. Arenaceous calcitic dolomite, medium dark gray (N4), medium to thick bedded, medium crystalline.	24	324
8. Arenaceous dolomite, medium dark gray (N4), weathers light gray (N7), thin bedded to thick bedded, medium crystalline contains a medium bedded unit of dolomitic sandstone, weathers in vugs.	57	381
7. Dolomite, medium light gray (N6), interbedded with medium-dark-gray (N4) beds, thin to medium bedded, finely crystalline to medium crystalline.	62	443
6. Arenaceous dolomite, olive gray (5Y 4/1), thin to medium bedded, finely crystalline, contains some fossils.	62	505
Lower Dolomite Member		
5. Covered interval, dolomite float.	189	694
4. Arenaceous calcitic dolomite, grayish orange (10YR 7/4) to light olive gray (5Y 6/1), thin to medium bedded, finely crystalline, fossil fragments and breccia.	40	734
3. Arenaceous dolomite, medium light gray (N6) to light olive gray (5Y 6/1), laminated to medium bedded, fine to medium crystalline.	59	793
2. Covered interval, dolomite float.	53	846
1. Arenaceous calcitic dolomite, medium-dark-gray (N4) to grayish orange (10YR 7/4), laminated to medium bedded, finely crystalline, partly covered.	25	871
	TOTAL	871

Section No. 5. Hyrum Formation (Figure 2, Locality 6)

Section of Hyrum Formation in NE1/4 sec. 24, T. 4 N., R. 2 E., Morgan County, Utah; measured on the south ridge at the mouth of Mahogany Canyon.

Beirdneau Formation Unit	Thickness (feet)	Cumulative Thickness (feet)
Lower Dolomite Member		
4. Dolomite, dark gray (N3) to medium dark gray (N4), thin bedded to massive, finely crystalline, overlain by sandstone.	10	10
3. Dolomite, light gray (N7), laminated to thin bedded, finely crystalline, contains some chert.	6	16
2. Dolomite, medium dark gray (N4), thin bedded to massive, finely crystalline, forms small cliffs, fossil fragments.	60	76
1. Dolomite, medium dark gray (N4), thin to thick bedded, finely crystalline, contact at erosion surface, fossils present, forms small cliffs.	60	136
	TOTAL	136

Appendix C

Measured Sections of the Beirdneau Formation

Section No. 6. Beirdneau Formation (Figure 2, Locality 1)

Section of Beirdneau Formation in sec. 12, T. 16 S., R. 35 E., Oneida County, Idaho, measured on the south side of the road in Gardner Canyon, at the first major turn to the right, just below the massive-bedded limestone cliffs of the Lodgepole Formation, 2 miles from the mouth of Gardner Canyon.

Lodgepole Formation Disconformity Unit	Thickness (feet)	Cumulative Thickness (feet)
Upper Carbonate Member		
9. Dolomite, medium gray (N5), laminated to medium bedded, very finely crystalline, fossil fragments, contact with the Lodgepole formation is sharp.	92	92
8. Covered interval, dolomite and limestone float.	76	168
7. Dolomite and limestone interbedded, medium gray (N5), weathering light olive gray (5Y 6/1), thin to medium bedded, finely crystalline.	77	245
Sandstone Member		
6. Covered interval, dolomite and sandstone float.	77	322
5. Covered interval, dolomite and sandstone float.	70	392
4. Covered interval, sandstone float, one medium bedded bed of orthoquartzite, pinish gray (5YR 8/1).	63	455
3. Sandstone and dolomite interbedded, medium gray (N5) to light olive gray, thin to medium bedded, finely crystalline, sandstone medium grained, dolomite finely crystalline.	64	519

	Thickness (feet)	Cumulative Thickness (feet)
Lower Carbonate Member		
2. Covered interval, dolomite and sandstone float.	232	751
1. Covered interval, float mostly dolomite, contact with the Hyrum Formation uncertain.	57	808
	TOTAL	808

Section No. 7. Beirdneau Formation (Figure 2, Locality 2)

Section of Beirdneau Formation in SW1/4 and SE1/4 sec. 11, T. 15 N., R. 4 W., Box Elder County, Utah; measured on the north side of Portage Canyon, below the crest of the divide between Portage and Rough Canyons, 2 miles WSW of Portage Utah.

Lodgepole Formation Disconformity Unit	Thickness (feet)	Cumulative Thickness (feet)
Upper Carbonate Member		
28. Covered interval, dolomite float.	110	110
27. Dolomite, light gray (N7), laminated medium bedded, mostly covered.	56	166
26. Dolomite, light gray (N7), laminated to medium bedded, finely crystalline, contains chert nodules.	53	219
25. Dolomite, light gray (N7), laminated to medium bedded, finely crystalline, mostly covered.	42	261
24. Covered interval, dolomite float.	26	287
Sandstone Member		
23. Covered interval, orthoquartzite float, yellowish gray (5Y 8/1), fine to medium grained.	39	326
22. Covered interval, orthoquartzite float.	28	354
Lower Carbonate Member		
21. Covered interval, orthoquartzite and dolomite float, this covered unit has two thick beds of dolomite exposed.	62	416
	TOTAL	416

26. Sandstone; pale yellowish orange (10YR 8/6), to a very pale orange (10YR 8/2), thin bedded to medium bedded, very fine grained to medium grained, mostly covered.	34	409
25. Sandstone, very pale orange (10YR 8/2), thin bedded, medium grained, mostly covered.	34	443
Lower Carbonate Member		
24. Silty limestone; pale yellowish brown (10YR 6/2), to a medium gray, laminated to thin bedded, few outcrops, mostly covered.	33	476
23. Calcitic dolomite, light gray, weathers yellowish gray (5Y 8/1), laminated to thick bedded, finely crystalline, breccia and throughout, forms small cliff at top of unit.	48	524
	TOTAL	524

Section No. 9. Beirdneau Formation (Figure 2, Locality 4)

Section of Beirdneau Formation in NE1/4 sec. 7, and NW1/4 sec. 8, T. 10 N., R. 2 E., Cache County, Utah, measured on the north side of Blacksmith Fork Canyon approximately 2 1/2 miles from mouth of canyon.

Leatham Formation	Thickness (feet)	Cumulative Thickness (feet)
Disconformity		
Unit		
Upper Carbonate Member		
30. Limestone, interbedded with with arenaceous calcitic dolomite.	25	25
29. Silty calcitic dolomite and limestone, light gray (N7) to medium light gray (N6), weathers yellowish gray (5Y 7/2), massive bedded to laminated at top.	200	225
Sandstone Member		
28. Limestone and dolomite interbedded, light gray (N7), weathers light olive gray (5Y 6/1), medium bedded to thin bedded, finely crystalline, contains stringers of white chert, some laminated beds of siltstone, 10-foot bed of greenish-black (5G 1/1) limestone at top of unit.	135	360
27. Calcitic dolomite (siltstone), light gray (N7), some yellowish gray (5Y 8/1), thin-bedded, laminated, fine to medium crystalline, ripple marks, sun cracks, cross-bedding.	160	520

	Thickness (feet)	Cumulative Thickness (feet)
26. Arenaceous calcitic dolomite, medium light gray (N6) to yellowish gray (5Y 8/1), thin bedded, medium to finely crystalline, dominant cross-bedded units up to a foot thick, some cross-bedding truncated at top by ripple marks and tangential at bottom.	93	613
25. Dolomitic sandstone, medium light gray (N6), weathers yellowish gray (5Y 7/12), thin bedded, fine grained, contains wavy beds, ripple marks.	155	768
Lower Carbonate Member		
24. Calcitic dolomite, medium light gray (N6), weathers yellowish gray (5Y 7/2), thin wavy beds, finely crystalline.	10	778
23. Arenaceous dolomite, light olive gray (5Y 6/1) weathers yellowish gray (5Y 7/2), uniformly thin bedded, grades into medium beds to medium bedded beds, flowage, finely crystalline blocky cliffs.	105	883
22. Calcitic dolomite, medium gray (N5), weathers light olive gray (5Y 6/1) in places, medium bedded to thin bedded, finely crystalline, flowage in central sandy beds.	18	901
21. Calcitic dolomitic sandstone, light gray (N7), weathers yellowish gray (5Y 7/2), thick bedded to medium bedded, coarse grained, shows marked cross-bedding on small and large scale.	56	957
20. Areanceous calcitic dolomite (siltstone), medium light gray (N6), weathers yellowish gray (5Y 7/2), thin bedded, finely crystalline, contain ripple marks and sun cracks.	65	1,022

	Thickness (feet)	Cumulative Thickness (feet)
19. Arenaceous calcitic dolomite, yellowish gray (5Y 7/2), thin wavy bedded, finely crystalline, contains 2-foot bed of medium-gray finely crystalline dolomite at top, sun cracks and ripple marks.	65	1,087
	TOTAL	1,087

Section No. 10. Beirdneau Formation (Figure 2, Locality 5)

Section of Beirdneau Formation in NE 1/4 sec. 17, T. 12 N., R. 6 E., Rich County, Utah; measured about half a mile up the east fork of Old Laketown Canyon.

	Thickness (feet)	Cumulative Thickness (feet)
Lodgepole Formation		
Disconformity		
Unit		
Upper Carbonate Member		
24. Limestone, very light olive gray (5Y 6/1), laminated to thin bedded, very finely crystalline, ripple marks and halite casts present.	73	73
23. Covered interval, arenaceous calcitic dolomite float.	71	144
22. Covered interval, limestone float.	69	213
21. Covered interval, arenaceous limestone float.	67	280
20. Magnesian limestone, light olive gray, (5Y 6/1), thick bedded to massive, unit is completely brecciated.	63	343
Sandstone Member		
19. Covered interval, limestone and sandstone float.	151	494
18. Sandstone, pale yellowish orange (10YR 8/0), laminated to thin bedded, fine grained.	18	512
17. Sandstone, pale yellowish orange (10YR 8/0), laminated to medium bedded, fine grained, unit terminates at massive bed of dolomite the top of the Hyrum Formation.	12	524
	TOTAL	524

Section No. 11. Beirdneau Formation (Figure 2, Locality 6)

Section of Beirdneau Formation in NE1/4 sec. 24, T. 4 N., R. 2 E., Morgan County, Utah, measured on the south ridge at the mouth of Mahogany Canyon.

Lodgepole Formation Disconformity Unit Sandstone Member	Thickness (feet)	Cumulative Thickness (feet)
9. Sandstone, light brown (5YR 6/4), laminated to thin bedded, medium grained, forms slopes, some breccia.	23	23
8. Dolomitic sandstone, light brown (5YR 6/4) to grayish orange pink (5YR 1/2), laminated to thin bedded, medium grained, forms massive cliffs, contortions in central cliff, contains cross-bedding and breccia.	21	44
7. Sandstone light brown (5YR 6/4), laminated to massive bedded, fine grained, forms dominant sandstone cliff of section.	28	72
6. Covered interval, sandstone float.	62	134
5. Sandstone, light brown (5YR 6/4), laminated to medium bedded, fine to medium grained, forms slopes, some breccia, contact sharp with the Hyrum Formation.	52	186
	TOTAL	186