BRIGHAM YOUNG UNIVERSITY

GEOLOGY STUDIES

Volume 9, Part 1 May, 1962

GEOLOGY OF THE SOUTHERN WASATCH MOUNTAINS AND VICINITY, UTAH

CONTENTS

Brigham Young University Geology Studies

Volume 9, Part 1 — May 1962

Geology of the Southern Wasatch Mountains and Vicinity, Utah

a symposium

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Prepared for the 1962 meetings of the Rocky Mountain Section of the Geological Society of America held on the Brigham Young University Campus, May 10-12, 1962.

A publication of the
Department of Geology
Brigham Young University
Provo, Utah

Part I partially supported by the Rocky Mountain Section.

Price $2.00

Extra copies of map available at $1.00 each.

Contents

Geology of the Southern Wasatch Mountains and Vicinity, Utah

INTRODUCTION

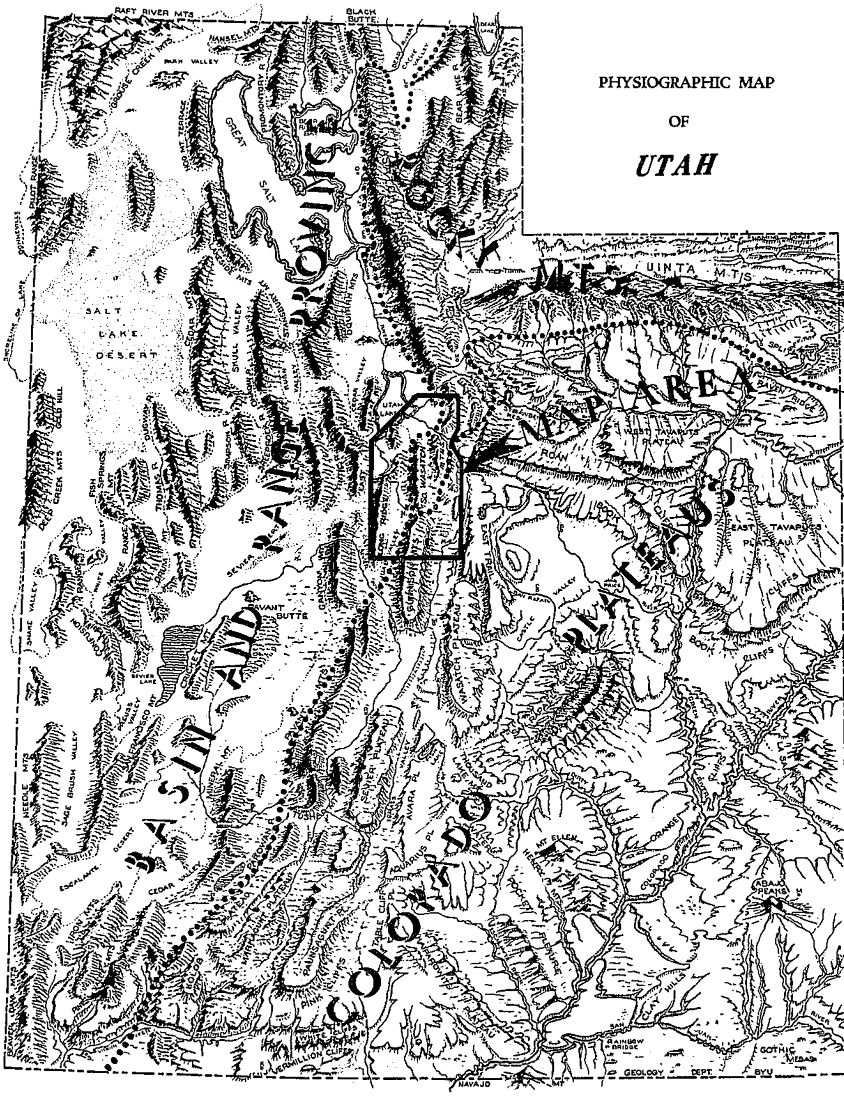
Utah is blessed with geologic features of unusual interest and great variety. The Canyon Lands, the Henry Mountains, the San Rafael Swell, the High Plateaus, the features of Lake Bonneville, the famous mining districts of Tintic, Bingham, and Iron Springs, the magnificent stratigraphic sections exposed in the Book Cliffs and in the Basin Ranges, all have revealed to geologists the tremendous sweep of geologic history and have been made classic through the writings of such pioneer geologists as C. E. Dutton, William M. Davis, C. D. Walcott, and G. K. Gilbert. So complex is Utah's geologic history and so numerous its problems that further detailed work, using improved procedures, continues to increase our understanding of this fascinating area. Each year some aspect is clarified and we wonder why it did not seem more obvious to us before.

In this light we embark on a summary of the current knowledge of the geology of the Southern Wasatch Mountains. The area lies at the junction of three major physiographic divisions: the Middle Rocky Mountains, the Colorado Plateaus, and the Basin and Range Province. It includes sedimentary, igneous, and metamorphic rocks ranging in age from Precambrian to Quaternary, and representing dominantly marine deposits of the Early Paleozoic Cordilleran miogeosyncline, the later Paleozoic Madison and Oquirrh Basins, the Cretaceous Rocky Mountain exogeosyncline, and Cenozoic deposits in freshwater lakes. The area has been involved in major structural deformation in Precambrian time, in folding and thrusting in Late Cretaceous (Laramide) time, and in block faulting in later Cenozoic time. In all, a greater variety of geologic features can scarcely be found in so limited an area.

The area is part of what is sometimes referred to as the "transition zone" in Utah. The transition involves more than the change from Basin and Range landforms to those of the Plateaus, it also involves older transitions from Cretaceous orogenic elements on the west to depositional sites on the east, from Paleozoic cratonic deposition on the east to geosynclinal behavior on the west. Two previous guidebooks have discussed the transition zone in Utah: to the north the Intermountain Association of Petroleum Geologists 10th Annual Field Conference in 1959 considered the Wasatch-Uinta Mountains transition area; to the south the Utah Geological Society 4th Annual Field Conference in 1949 traversed the transition between the Colorado Plateaus and the Great Basin in central Utah.

GEOLOGIC MAP

The geologic map accompanying this report was compiled from a great many sources, most of them published and unpublished theses by graduate students of Ohio State University and Brigham Young University (see "Index to sources of data" printed on the map). The original mapping was done on a variety of base maps, some prepared by plane table, some from air photos, and some on U.S.



INDEX MAP.—Shows Southern Wasatch map area in relation to physiographic provinces.

Geological Survey topographic quadrangles. In transferring the mapping from these diverse bases to the common base used innumerable minor adjustments were made in order to fit the original mapping to the new base as well as possible. Air photos aided in making the transfer for it was sometimes necessary to transfer data from the original map to the photos and thence to the final map in case the original map was too distorted to use directly.

In addition, in cases where adjacent mappers disagreed, the compiler has attempted to resolve their differences as best he could in order to eliminate map boundary faults. Many problems, yet to be solved, became apparent during the compilation and it is hoped that the present map may serve as a means of pointing out these problems in their regional setting for the benefit of future students of this complex and interesting area.

ACKNOWLEDGMENTS

Although many famous pioneer geologists such as William M. Davis and G. K. Gilbert had made reconnaissance observations pertaining to the Southern Wasatch Mountains, the first modern areal mapping in the area was done by Armand J. Eardley in the early 1930's. All later workers are indebted to the perspicacity of his observations.

Impetus for further work in the area came from Professor Edmund M. Spieker who extended his earlier interest in the Mesozoic problems of central Utah by directing Ohio State University graduate students in areas surrounding that of his initial work with the U.S. Geological Survey. Under him, S. L. Schoff's work in the Cedar Hills in 1937 was followed by that of many others of whom the following did work in the area of the present report: Dorothy Taylor, H. D. Zeller, R. E. Hunt, S. J. Muessig, R. E. Metter, A. C. Fograscher, J. E. Cooper, M. A. Khin, R. E. Mase, J. D. Hayes, and G. E. Thomas. Professor George E. Moore, Jr., of Ohio State University acted as graduate thesis advisor for some of these students.

For the past 25 years Professor Harold J. Bissell has been involved in problems relating to Utah Valley and the adjoining ranges. He has inspired a number of students to work in the West Mountain-Long Ridge-Southern Wasatch area and has served as adviser to most of the following Brigham Young University graduate students who have worked in this area: W. O. Abbott, R. S. Brown, R. S. Clark, L. C. Demars, J. H. Elison, D. R. Foutz, P. W. Gaines, R. W. Gates, T. A. Gwynn, H. D. Harris, R. A. Hodgson, K. D. Johnson, J. W. Madsen, D. F. Mecham, C. H. Peacock, H. N. Petersen, D. J. Peterson, D. O. Peterson, R. P. Peterson, J. R. Price, R. R. Rawson, J. A. Rhodes, S. F. Schindler, G. K. Sirrine, C. V. Smith, J. W. Swanson, and B. O. White.

Arthur A. Baker of the U.S. Geological Survey has mapped in the Wasatch Range from Spanish Fork Canyon northward and his work and advice have served as a guide to many of the above listed workers. In addition to the many people whose field work has made the present compilation possible, I wish to acknowledge the efforts of the authors of the papers in the present volume. I also wish to thank Professors Clyde T. Hardy and J. Keith Rigby for help in preparing the road log, and Mr. Colbeth Killip for drafting the geologic map.

The Editor

Devonian and Mississippian Systems in Central Utah

J. KEITH RIGBY AND DAVID L. CLARK
Brigham Young University

Lindgren & Loughlin (1919, p. 36-42) subdivided the Mississippian and Devonian rocks of the Tintic District. Later Gilluly (1932, p. 20-30) established terminology for equivalent rocks in the southern Oquirrh Mountains and at about the same time Nolan (1935) established a stratigraphic sequence at Gold Hill. Terminology modified from that of these various authors has been applied to the Devonian and Mississippian rocks in central Utah.

In a restudy of the Tintic District, Lovering, *et al.* (1951, p. 1505-1506) modified earlier terminology and McKinney & Peterson (1956, p. 161-164) and Peterson (1956) suggested further refinement in the Ordovician, Silurian, and Devonian terminology by extending formation names described at Gold Hill. Recent authors (Sadlick 1956; Morris 1957; Rigby 1959; Brooks 1959; Crittenden 1959; Beach 1961; Baker & Crittenden 1961; Brooks 1962) have discussed aspects of Devonian and Mississippian stratigraphy in the Wasatch Mountains and adjoining areas (Figure 1). The most recent published work by the U.S. Geological Survey on the stratigraphy of the Tintic District (Morris & Lovering, 1961) is partially outdated because of the time lapse between field work and publication.

DEVONIAN

Sevy Dolomite

Sevy Dolomite (the oldest of the recognized Devonian units) does not occur in the field trip area but does occur in the Tintic District (Bissell, 1959) immediately to the west and within the Great Basin. It is consistently finely crystalline, medium brown-gray to light brown and weathers with a distinctive chalky light gray surface. It thickens from central Utah to approximately 800 feet in regions within the Great Basin. Rare fossil occurrence and stratigraphic position suggest a Medial Devonian age for at least the upper part of the formation (Bissell, 1959, p. 144).

Simonson Dolomite

Simonson Dolomite is exposed in the same general region as the underlying Sevy Dolomite in the Tintic District and westward (Bissell, 1959). Simonsen Dolomite is distinctively banded light and dark gray or gray brown. Light-gray beds are commonly laminated. Thickness increases from an eastern feather edge between the Tintic District and the Wasatch Mountains to approximately one thousand feet in the Great Basin to the west. The Simonson Dolomite is considered to be of Medial Devonian age (Osmond, 1954, p. 1951; Peterson, 1956, p. 12).

Victoria Quartzite

Victoria Quartzite unconformably overlies the Simonson Dolomite and older formations in the field trip area and westward. It is well exposed in Long Ridge

<table>
<tr><th>LINDGREN and LOUGHLIN 1919
Tintic District</th><th>GILLULY 1932
Oquirrh Range</th><th colspan="2">MORRIS 1957
Tintic District</th><th colspan="2">BISSELL 1959
RIGBY 1959
Oquirrh Range and Fivemile Pass Area</th><th>PRESENT PAPER
Central Utah</th></tr>
<tr><td>Manning Canyon shale</td><td>Manning Canyon shale</td><td colspan="2">Manning Canyon shale</td><td colspan="2">Manning Canyon shale</td><td>Manning Canyon shale</td></tr>
<tr><td>Great Blue limestone</td><td>Great Blue limestone</td><td colspan="2">Great Blue limestone</td><td colspan="2">Great Blue limestone</td><td>Great Blue limestone</td></tr>
<tr><td>Humbug formation</td><td>Humbug formation</td><td colspan="2">Humbug formation</td><td colspan="2">Humbug formation</td><td>Humbug formation</td></tr>
<tr><td>Pine Canyon limestone</td><td>Deseret limestone</td><td colspan="2">Deseret limestone</td><td colspan="2">Deseret limestone
Pine Canyon limestone</td><td>Deseret limestone</td></tr>
<tr><td rowspan="2">Gardner dolomite</td><td>Madison limestone</td><td rowspan="2">Madison limestone</td><td>upper</td><td rowspan="2">Gardner dolomite</td><td>Upper</td><td>Gardison limestone</td></tr>
<tr><td>Jefferson dolomite</td><td>lower</td><td>Lower</td><td>Fitchville dolomite</td></tr>
<tr><td>Pinyon Peak limestone</td><td rowspan="4">Lynch dolomite</td><td colspan="2">Pinyon Peak limestone</td><td colspan="2">Pinyon Peak limestone</td><td>Pinyon Peak limestone</td></tr>
<tr><td>Victoria quartzite</td><td colspan="2">Victoria quartzite</td><td colspan="2">Victoria quartzite</td><td>Victoria quartzite</td></tr>
<tr><td rowspan="2">Bluebell dolomite</td><td colspan="2" rowspan="2">Bluebell dolomite</td><td colspan="2">Simonson dolomite</td><td>Simonson dolomite</td></tr>
<tr><td colspan="2">Sevy dolomite</td><td>Sevy dolomite</td></tr>
</table>

FIG. 1.—Stratigraphic nomenclature compared

and in the mountains west and northwest where it grades into the much thicker and coarser textured Stansbury Formation. It is either very thin or missing within the Wasatch Mountains proper. It is from 200 to 300 feet thick in the Tintic District.

The formation typically consists of interbedded quartzose sandstone and gray dolomite, commonly weathering to a tan, rubble-covered semi-slope. The dolomite comprises most of the formation in the field trip area. On the basis of stratigraphic position, the Victoria Quartzite has been considered of medial Late Devonian age (Morris, 1957, p. 11).

Pinyon Peak Limestone

Pinyon Peak rocks have essentially the same distribution as the underlying Victoria Quartzite, but occur on West Mountain where Victoria rocks are absent. Pinyon Peak-age rocks occur within the Wasatch Mountains but lithologically are difficult to differentiate from the overlying Fitchville Formation. Pinyon Peak Limestone ranges from 70 to 300 feet in its area of outcrop.

The formation consists of argillaceous and silty limestone and dolomite and is transitional from the underlying clastic sandy beds into the more nearly pure overlying dolomites. The U.S. Geological Survey considers the Pinyon Peak to be Late Devonian-Early Mississippian (?) (Morris, 1957, p. 13; Morris & Lovering, 1961) but recent conodont studies (Beach, 1961) indicate this formation is entirely Late Devonian.

DEVONIAN - MISSISSIPPIAN

Fitchville Formation

Fitchville rocks occur throughout the field trip area in the Wasatch Mountains and the faulted ranges to the west. The formation rests unconformably upon rocks as old as Cambrian but grades into the underlying Pinyon Peak Limestone where the latter is present. This unit includes what has been previously referred to as Lower Gardner or Jefferson formations by early workers.

Somber gray, massive to thick-bedded dolomite characterizes the formation. Locally a dolomitic sandstone occurs at the base where the lower contact is unconformable. The upper contact is placed immediately above the "curly bed," a local algal limestone.

Thickness ranges within the field trip area from slightly over 100 feet to approximately 300 feet.

Morris & Lovering (1961) indicate that the entire Fitchville is Early Mississippian but rocks of Late Devonian and Early Mississippian age (Kinderhookian) are now known to be included with the Fitchville Formation (Beach, 1961).

MISSISSIPPIAN

Gardison Limestone

Beds formerly termed Madison Limestone within the field trip area are currently included in the Gardison Formation, a unit earlier differentiated in several publications as the upper member of the Gardner Formation.

The formation is a sequence of relatively thin-bedded dark-gray, commonly fossiliferous, limestones and dolomites. The upper beds of the formation are distinctly cherty and usually form a prominent ledge or cliff.

Thickness of the formation ranges from three to six hundred feet. Late Kinderhookian (?) and Osagean faunas have been collected from the formation (Woodland, 1958; Davis, 1956; Zeller, 1957).

Deseret Limestone

Deseret Limestone occurs above the Gardison Limestone in all outcrops and is widely exposed in the Wasatch Mountains and adjacent ranges to the west.

Lenticular chert characterizes the formation which consists of interbedded limestone and dolomite, often silty, in the lower part and massive limestone in the upper part. A thin phosphatic shale marks the base of the formation.

Thickness of the Deseret Limestone ranges from 600 to 900 feet.

Fossils of Osagean and Meramecian age have been reported from the formation (Woodland, 1958, p. 804; Baker & Crittenden, 1961).

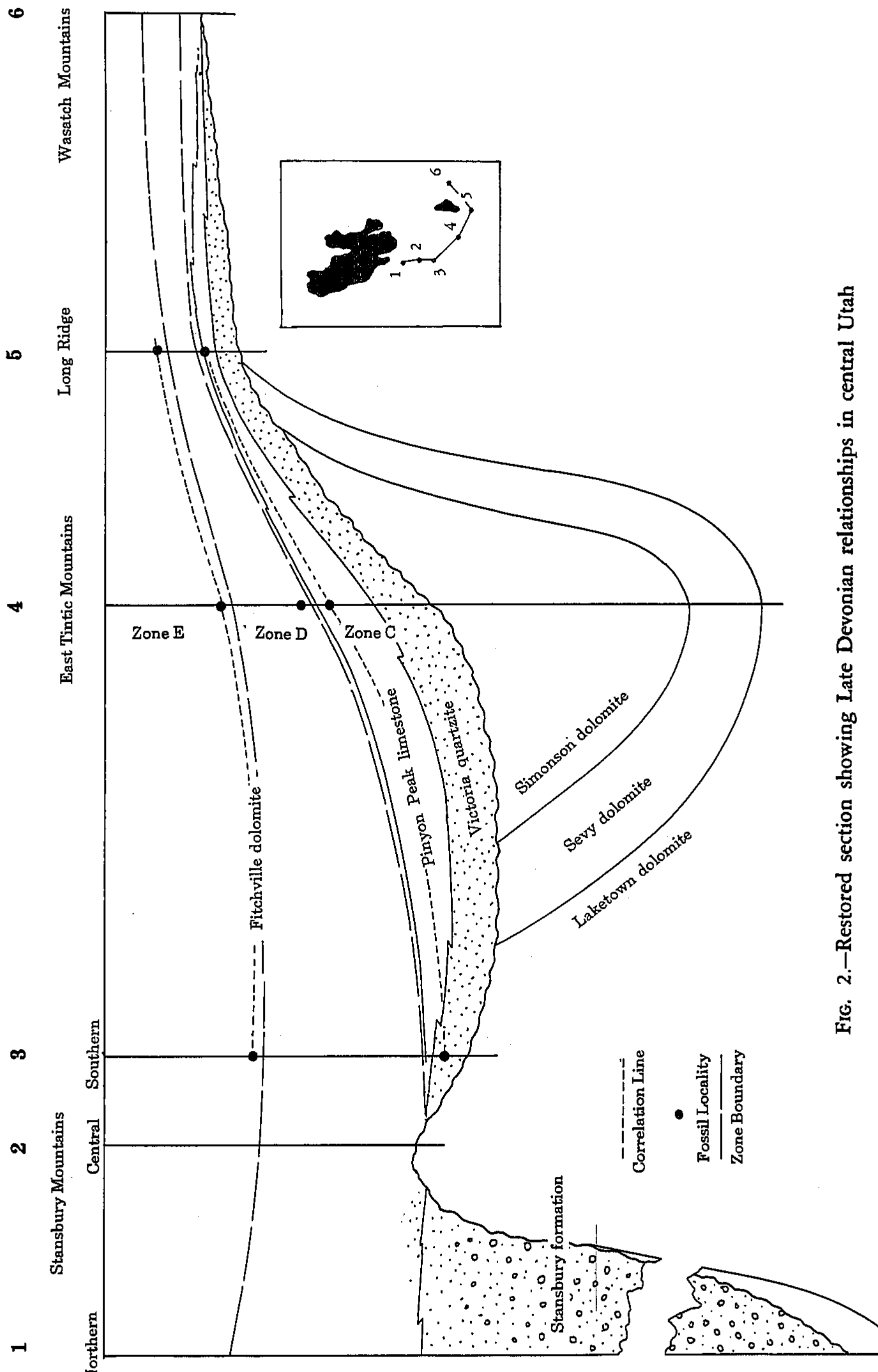


FIG. 2.—Restored section showing Late Devonian relationships in central Utah

Humbug Formation

Humbug rocks have essentially the same distribution as the underlying Deseret and Gardison formations.

Quartzitic sandstone, interbedded with sandy limestone, crinoidal limestone and minor dolomite and shale distinguish the Humbug Formation from units above and below. The contacts are placed at the lowest and highest orthoquartzite beds in the sequence.

Thickness of the formation ranges from 600 to 800 feet.

Most authors indicate a Meramecian age for the Humbug Formation (Woodland, 1958; Davis, 1956).

Great Blue Limestone

The Great Blue Limestone is particularly well exposed in the Southern Wasatch Mountains, at West Mountain, and in the Oquirrh Mountains.

Locally three members of the formation can be recognized, a lower and upper carbonate sequence separated by a medial shale unit. Lower carbonates are relatively pure, but upper member carbonates are often silty or argillaceous.

Thickness of the Great Blue ranges from 2500 to 2800 feet.

Age of the formation is Late Mississippian (Baker & Crittenden, 1961).

MISSISSIPPIAN - PENNSYLVANIAN

Manning Canyon Shale

Manning Canyon Shale gradationally overlies the Great Blue Limestone and is exposed along the Wasatch Front and in many of the ranges to the west.

It consists characteristically of interbedded black shale, quartzitic sandstone and beds and lenses of detrital limestone. A medial limestone member is locally differentiated. The shale forms the most prominent strike valleys along the mountain front.

Thickness varies from 1000 to 1700 feet, of which only the lower part may be Mississippian (Moyle, 1958, p. 33; Gilluly, 1932, p. 32-34).

PROBLEMS IN DEVONIAN AND MISSISSIPPIAN STRATIGRAPHY

Recent work in the field trip and adjacent areas has pointed up interesting aspects and problems of Late Devonian and Early Mississippian stratigraphy (Rigby, 1959; Brooks, 1959; Petersen, 1956; Clark & Beach, 1961; Beach, 1961).

(a) The structural and stratigraphic pattern is different prior to and following deposition of the Late Devonian clastic unit. (b) Nomenclatural problems thus introduced have not been adequately studied nor is present terminology suitable to describe the facies relationships now evident. (c) Lack of adequate biostratigraphic information in all but a restricted part of the section makes precise local correlation difficult and regional correlation impossible.

Devonian-Mississippian Structural Behavior

The sedimentary pattern established during the Early Paleozoic persisted in Central Utah until disturbed by the Late Devonian uplifts. Sequences deposited

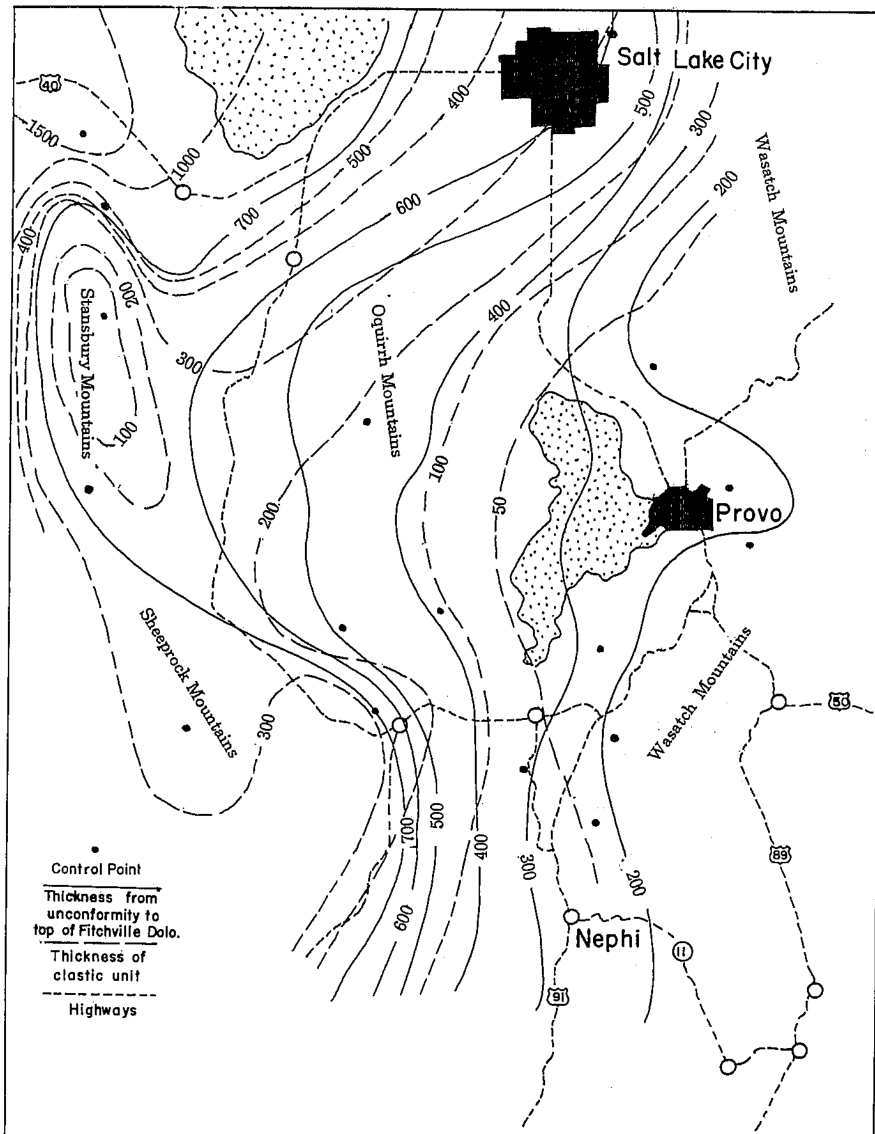


FIG. 3.—Isopach map of Late Devonian rocks in central Utah

prior to the disturbance generally thicken westward into the miogeosyncline (Hintze, 1951; Cohenour, 1959, p. 58; McFarlane, 1955, Pl. 1). Following the Late Devonian disturbance, local basins developed during the Mississippian and Pennsylvanian and maximum thicknesses are along the eastern margin of the miogeosyncline. During the Mississippian the Madison and Brazer Basins differentiated from those of Central Utah. This ultimately led to development of the Pennsylvanian and Permian Oquirrh Basin in the Central Utah region (Bissell, this report).

Devonian-Mississippian Stratigraphic Nomenclature

Prior to the recent publication of Morris & Lovering (1961) nomenclature of the Late Devonian and Early Mississippian units of Central Utah was fluid. The Pinyon Peak-Gardner terminology has been widely used in recent years, as modified by Lovering, *et al.* (1951). Morris (1957), however, applied Madison Limestone with an upper and lower member to these same units. Bissell (1959) rejects usage of Madison Limestone, but refers to the upper and lower Gardner Dolomite. Crittenden (1959) and Baker & Crittenden (1961) refer the lower unit to Fitchville Formation and the upper unit to the Gardison Limestone, terms which only recently were formally defined (Morris & Lovering, 1961).

Loughlin (1919, p. 36) defined the Pinyon Peak Limestone from outcrops on Pinyon Peak in the Tintic District. Because of structural complications in the type area, Loughlin unknowingly included the Pinyon Peak sequence within the Gardner Dolomite. Lovering, *et al.* (1951) demonstrated the correct position of the formation above the Victoria Quartzite and below a restricted Gardner Formation. Morris (1957) and Morris & Lovering (1961) report the Pinyon Peak to be Late Devonian and Mississippian (?) and gradational lithologically with the overlying Fitchville. Morris (1957) states that the name Gardner Dolomite is inappropriate (for the rocks above the Pinyon Peak) because the orginal definition included Devonian beds. Beach (1961) has shown that even as presently redefined (Fitchville) these rocks contain Late Devonian conodonts. Thus not only is the lower part of the Fitchville Devonian, but the underlying Pinyon Peak as well. Although differentiation of the upper and lower units of the Gardner Formation as Fitchville and Gardison is valuable, the separation of the argillaceous Pinyon Peak Limestone from the Fitchville is more difficult and has less value on a regional scale.

The writers visualize three stages of Late Devonian and Early Mississippian sedimentation (Fig. 2); (1) coarse clastics deposited as the result of local uplifts, referred to as the Stansbury and Victoria formations; (2) fine clastics and argillaceous carbonates deposited over the coarser clastic units and peripheral to the much reduced uplifts, referred to as the Pinyon Peak Limestone; (3) relatively pure carbonate deposits, of the Fitchville Formation, gradational from the underlying argillaceous limestone sequence. These three facies are not time restricted, but grade laterally and vertically into one another. Pure carbonates were being deposited in Central Utah by Late Devonian time (Fig. 3).

It is practically impossible to draw a constant boundary between the Fitchville and Pinyon Peak formations on a local or regional scale. This fact leads the writers to the opinion that a more logical regional field differentiation would be to include the entire post-Victoria carbonates (Pinyon Peak and Fitchville) in a single stratigraphic unit. Although a Pinyon Peak facies can be differentiated locally, upper and lower boundaries are intimately gradational (Morris & Lovering, 1961) and no uniformity in placing formation or facies boundaries can be achieved.

Biostratigraphy

Published biostratigraphic information does not as yet allow more than gross regional correlation or classification. Conodont studies (Beach, 1961; Clark & Beach, 1961; Clark & Becker, 1960) in a limited part of the Devonian and Mississippian section have achieved precise correlation and classification. Endothyrid studies (Woodland, 1958; Zeller, 1957) indicate possibilities for similar detail in the Mississippian. Coral analyses (Parks, 1951; Davis, 1956) bryozoan studies (Burckle, 1960) and studies of other biologic groups may prove valuable with additional work.

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