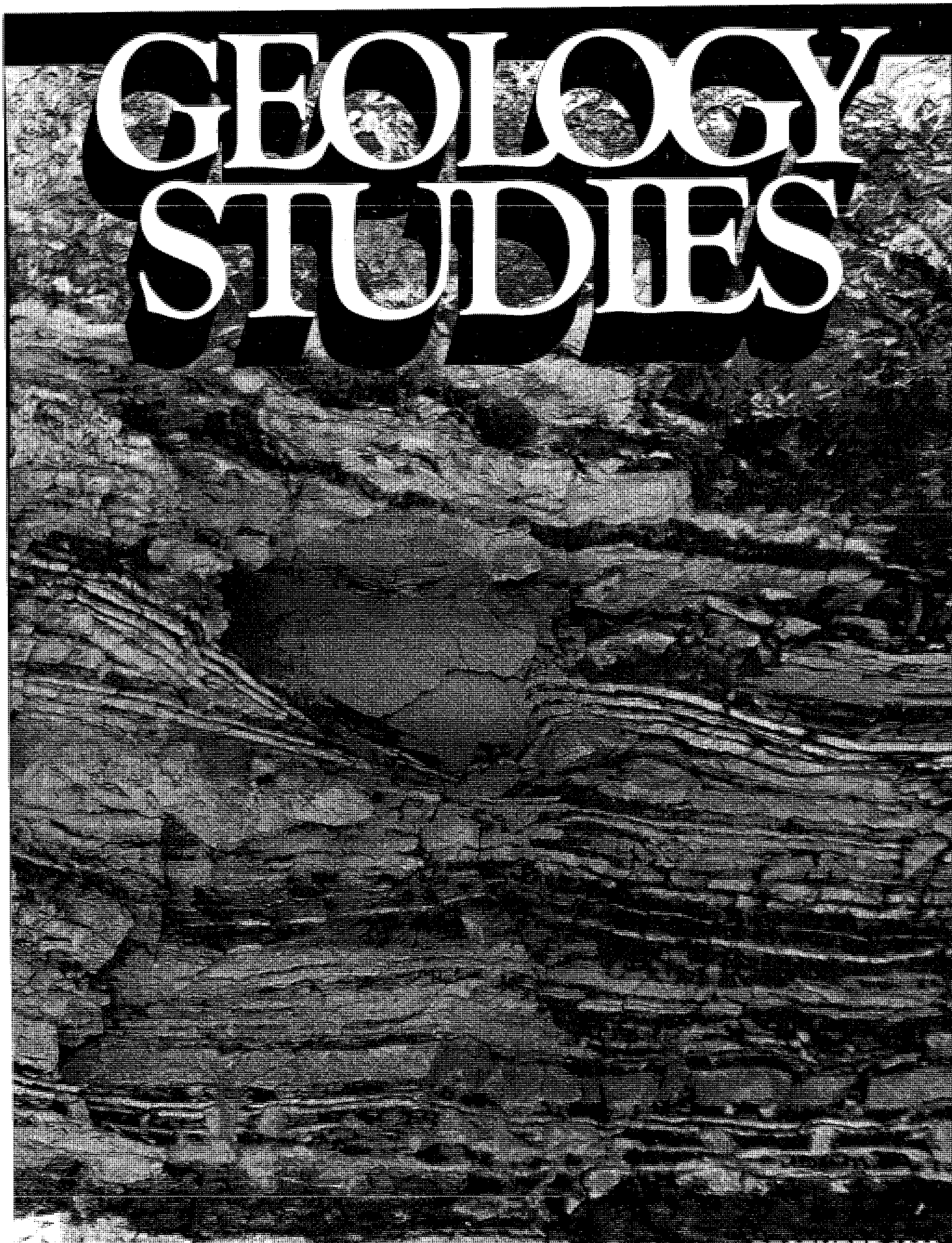
BRIGHAM YOUNG UNIVERSITY

GEOLOGY STUDIES



VOLUME 29, PART 2 DECEMBER 1982

Brigham Young University Geology Studies

Volume 29, Part 2

CONTENTS

Cover: Rafted or foreign cobble that settled into what were soft underlying sediments. From outcrop immediately east of the Sandy Creek Crossing on Blind Trail Wash Road, Garfield County, Utah. Photo courtesy Sidney M. Petersen and Robert T. Pack.

A publication of the
Department of Geology
Brigham Young University
Provo, Utah 84602

Brigham Young University Geology Studies is published by the Department of Geology. This publication consists of graduate student and faculty research within the department as well as papers submitted by outside contributors. Each article submitted by BYU faculty and outside contributors is externally reviewed by at least two qualified persons.

ISSN 0068-1016

Distributed December 1982

12-82 600 58879

CONTENTS

Geology of the Champlin Peak Quadrangle, Juab and Millard Counties, Utah*

JANICE M. HIGGINS
Texaco, Inc., Denver, Colorado

ABSTRACT.—The Gilson Mountains in the northern portion of the Champlin Peak Quadrangle are composed of Late Paleozoic rocks cut by the Tintic Valley Thrust. Overturned Precambrian and Cambrian rocks of the Canyon Range correlate with units adapted from the Sheeprock Mountains and House Range and include a continuous section from Precambrian Caddy Canyon Quartzite to an undifferentiated Cambrian unit above the Wheeler Shale. These allochthonous rocks form the northern edge of the Canyon Range Thrust plate, which terminates at the Leamington Canyon Fault.

The Leamington Canyon Fault dips 50° southeastward, and small-scale folds and slickensides in rocks on the upper plate near the fault suggest northwestward thrusting. This interpretation of the Leamington Canyon Fault reasons that the Nebo Thrust, traced south of Paleozoic outcrops in Long Ridge and westward from Mount Nebo, does not link with the Leamington Canyon Fault. It passes under the Canyon Range Thrust, if it extends that far west, south of the Leamington Canyon Fault. There is also the possibility that the Canyon Range Thrust plate was thrust over the Gilson Mountains-Nebo Thrust plate from the northwest. This could have produced the same southeast attitude on the Leamington Canyon Fault, but have the opposite direction of movement. The Leamington Canyon Fault also terminates the Tintic Valley Thrust from the north on the surface. Detailed study of that thrust and its associated structures is beyond the scope of this thesis.

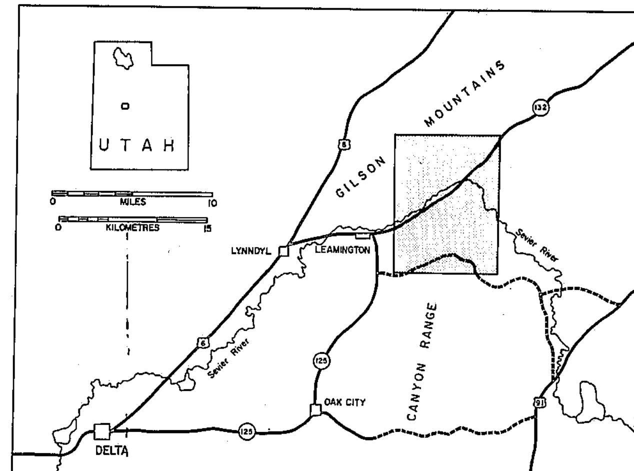


FIGURE 1.—Index map of the Champlin Peak Quadrangle.

INTRODUCTION

The Champlin Peak Quadrangle in central Utah is an area of structural complexity that encompasses parts of both the Gilson Mountains and the Canyon Range where these ranges are separated by the Leamington Canyon portion of the Sevier River Valley. The quadrangle includes the Leamington Canyon Fault (Costain 1960) that serves as a termination for the Tintic Valley Thrust Fault (Morris and Kopf 1969) and also the Canyon Range Thrust Fault (Christiansen 1952), as well as its associated conglomerate.

The nature of the Leamington Canyon Fault has been the subject of much discussion. Close examination of the ministructures along the fault has provided more conclusive evidence of the nature of the fault than that previously available. Also useful in interpreting the Leamington Canyon Fault is an understanding of the significance of the thick sequence of synorogenic conglomerate in the Canyon Range that lies in unconformable contact with Cambrian rocks and has been rotated with them to a nearly vertical attitude.

A second emphasis of this thesis is stratigraphic, providing a correlation of the Cambrian rocks in the Canyon Range with the Cambrian section in the House Range in western Millard Canyon, Utah. Applicable terminology from the House Range and other regional formation names were useful in mapping the Cambrian section in the Champlin Peak Quadrangle.

No detailed examination was made of the Tintic Valley Thrust of Morris and Kopf (1969) (South Gilson Fault of Costain 1960 and Champlin Thrust of Wang 1970) or associated structures north of the Leamington Canyon Fault. That portion of the geologic map (fig. 7) has been adapted after Wang (1970).

Location and Accessibility

The quadrangle, outlined in figure 1, is located approximately 27 km southwest of Nephi, Utah, and 39 km northeast of Delta, Utah. It is divided by Utah 132 through Leamington Canyon. The Gilson Mountains, in the northern part of the quadrangle, are accessible only by a few unimproved dirt roads and jeep trails, while the Canyon Range, on the southern half of the quadrangle, is accessible by several improved dirt roads as well as jeep trails. There is approximately 838 m of relief in the quadrangle, and much of the area is accessible only on foot. The Sevier River also hinders accessibility as there are few bridges across it.

Field Methods

Mapping was recorded in the field on aerial photographs at a scale of 1:27,600 and then transferred to a topographic base map. In some areas where a more detailed study was necessary, photo enlargements, scale 1:6,700, were utilized. Stratigraphic descriptions include color determinations from the Geological Society of America (1975) Rock-Color Chart.

PREVIOUS WORK

Several studies have been made that include sections of the Champlin Peak Quadrangle, but no studies have been done on the Champlin Peak Quadrangle per se. Costain (1960) mapped the Gilson Mountains and vicinity, part of which is included in the north half of the quadrangle. He called the Leamington Canyon Fault a thrust fault and postulated that the Canyon Range Thrust Plate overrode what later became the Gilson Mountains. Wang (1970), in a gravity and magnetic study of the same area, concluded that intensive silicification of the Humbug Formation prevented an accurate estimate of the dip of the Leamington Canyon Fault, but he called it a tear fault with right-lateral movement.

*A thesis presented to the Department of Geology, Brigham Young University, in partial fulfillment of the requirements for the degree Master of Science, December 1981. Thesis chairman: Lehi F. Hintze.

Although the stratigraphy and structure of the Canyon Range in the south half of the quadrangle has been briefly treated by several authors, only a few detailed studies have been conducted. Christiansen (1952) divided the stratigraphic section of the range into Precambrian rocks and a Cambrian System that included the Tintic Quartzite, Ophir Formation, and undifferentiated Cambrian limestone and dolomite. He tentatively assigned a thick sequence of conglomerate to the Cretaceous Indianola Group. Christiansen's study also contained a possible sequence of events in the development of the Canyon Range.

Armstrong (1968), in defining the Sevier orogenic belt, discussed the problem of correlating the conglomerate of the Canyon Range with the conglomerates of the surrounding area. He suggested that the conglomerates could be equivalent to Paleocene to early Eocene Flagstaff Limestone, rather than the Indianola Group. His main point was that the age of the conglomerate or "fanglomerate" is not well known because of lack of fossil evidence. Stolle (1978) also worked on the problem of the conglomerates and concluded that two mappable units are present. He suggested that these units, A and B, be called the Canyon Range Formation, which would correspond to the Cretaceous Price River Formation and the Paleocene-Eocene North Horn or Flagstaff Formation.

Swank (1978) outlined a sequence of six major events in the formation of the Canyon Range and suggested that the initial folding of the range was due to flexual-slip folding which was later cut by thrust faulting. He referred to the conglomerates as Indianola and North Horn. Campbell (1979) documented the Cenozoic structural, depositional, and erosional history of the Canyon Range through a careful investigation of Cenozoic deposits.

ACKNOWLEDGMENTS

Sincere thanks and gratitude are extended to Drs. Lehi F. Hintze and James L. Baer for their help and direction throughout the preliminary work and the preparation of this thesis. Appreciation is also expressed to Drs. J. Keith Rigby and Richard A. Robison who willingly helped with fossil identification. Thanks are extended to Dr. Dana T. Griffen as a member of the thesis committee and for his help in describing the petrography of the igneous rocks.

Julie Barrott, Mark D. Bunnell, Robert L. Davis, Brad T Johnson, and Steven P. Knowles served as field assistants and contributed many hours of discussion relative to this thesis. Sincere thanks are given to Brad T Johnson for aid in designing and drafting many of the illustrations. Appreciation is expressed also to Harold D. Mitchell for the hours of flying time and his photographic expertise which greatly aided this project.

Thanks are also given to Douglas Sprinkle of Placid Oil and to Hank W. Allen of Martin-Marietta Cement for their cooperation and assistance. Funding for the project was provided by Amoco Production Company, Gulf Oil Exploration and Production Company, and Marathon Oil Company. Field and lab equipment were provided by the Brigham Young University Department of Geology.

STRATIGRAPHY

Precambrian and Cambrian rocks in the Canyon Range are unconformably overlain by a Tertiary-Cretaceous conglomerate, as shown in figure 2. Rock units include the Precambrian Caddy Canyon Quartzite through Mutual Formation and basal Cambrian Tintic Quartzite through Middle Cambrian Wheeler Shale and Middle and Upper Cambrian undifferentiated carbo-

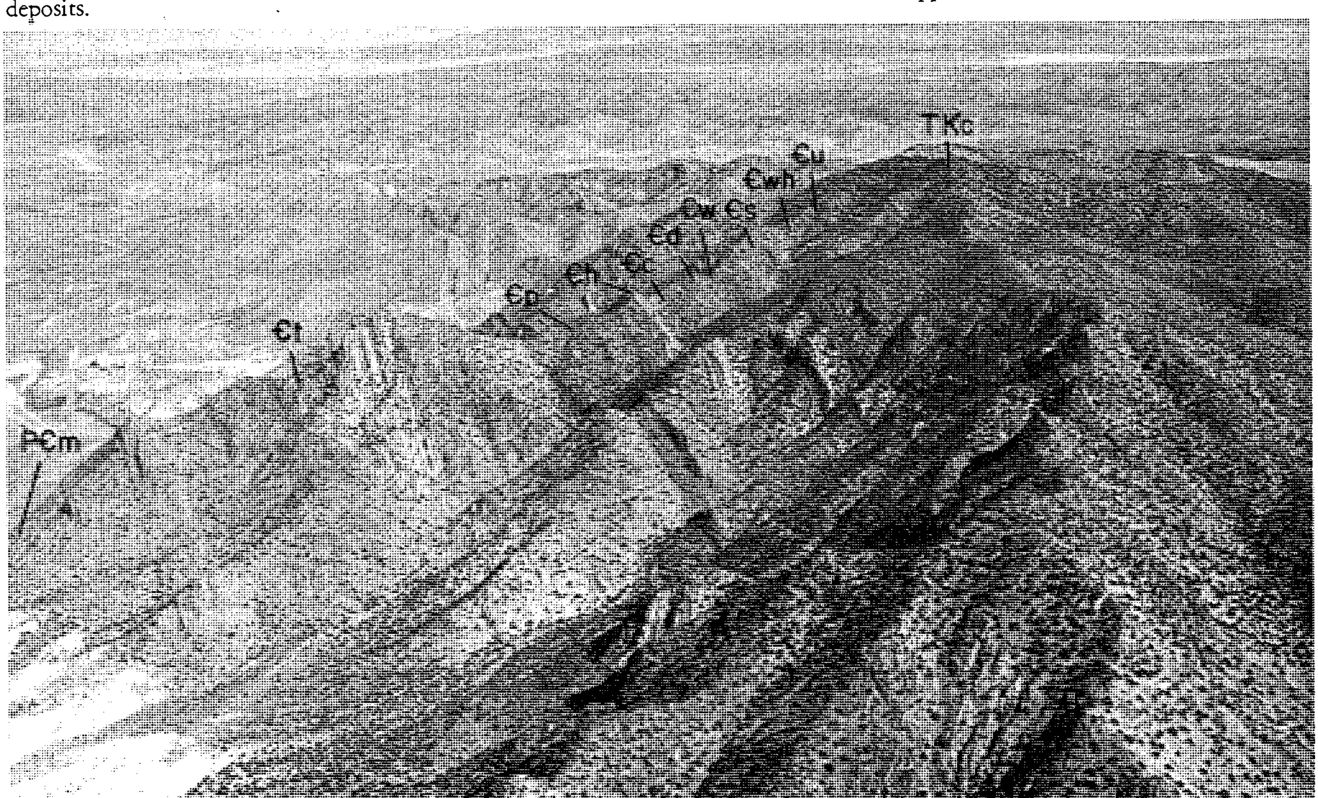


FIGURE 2.—Canyon Range stratigraphy showing overturned Precambrian Mutual Formation through undifferentiated Cambrian carbonate with the Conglomerate of Leamington Pass resting unconformably against the overturned sequence.

nates. This sequence is overturned with a dip ranging from 87° to 34°. The Tertiary-Cretaceous conglomerate is inclined 87° to 50° against the undifferentiated Cambrian unit.

The Precambrian quartzites are believed to be continuous, though not exposed, across Leamington Canyon to the Gilson Mountains on the north half of the quadrangle, where they are juxtaposed against late Paleozoic rocks by the Leamington Canyon Fault. Figure 3 summarizes the stratigraphic section south of the Leamington Canyon Fault, and figure 4 shows that to the north. Paleozoic rocks of the Gilson Mountains, also displaced by the Tintic Valley Thrust Fault, range from the Mississippian Deseret Limestone to the Permian Park City Formation.

The eastern portion of the Champlin Peak Quadrangle includes several Tertiary igneous units and largely unconsolidated Tertiary conglomerates.

Precambrian System

The Precambrian System of the Champlin Peak Quadrangle is divided on the basis of a regional study by Christie-Blick (1981) in which he correlated the Precambrian units of the Canyon Range to those in the Sheeprock Mountains. The formations included in his correlation and those discussed in this thesis include Caddy Canyon Quartzite, Inkom Formation, and Mutual Formation as shown in figure 3.

Caddy Canyon Quartzite

The Caddy Canyon Quartzite is only partially exposed across Leamington Canyon in the Champlin Peak Quadrangle. The upper contact with the Inkom Formation is drawn at the conformable top of the last massive quartzite unit. The base of the formation is not exposed since the formation is in fault contact with the Mississippian Humbug Formation or the Pennsylvanian-Permian Oquirrh Formation along the Leamington Canyon Fault.

The formation was calculated to be approximately 200 m thick from the northwestern edge of the Canyon Range to the southern edge of the Gilson Mountains. Unfortunately, only a few resistant ledges are exposed across Leamington Canyon.

The exposed portion of the Caddy Canyon Quartzite is largely quartzite, with a few interbeds of thinly bedded, mainly grayish red purple siltstone and phyllitic shale exposed near the top of the sequence (see appendix A). The massively bedded quartzite ranges from light brown that weathers medium brown, to pale yellowish orange that weathers very pale orange. It is poorly sorted and includes medium to very coarse grains. Near the base of the exposed interval, a 100-m-thick conglomeratic unit includes quartzite clasts 2–6 cm in diameter within a poorly sorted quartzite matrix.

Inkom Formation

The conformable upper and lower contacts of the Inkom Formation are well exposed in the Champlin Peak Quadrangle. The lower contact is recognized at the top of the light brown to pale yellowish orange, massive Caddy Canyon Quartzite beds. The upper contact is recognized at the base of the reddish purple, massive quartzite of the Mutual Formation.

The Inkom Formation forms a saddle between the more resistant quartzite units and is 93 m thick (see appendix A).

The formation is predominately phyllitic shale with minor quartzite interbeds. The shale is light olive gray, weathering dusky yellow toward the top of the formation and grayish red purple, weathering grayish red at the base. Bedding of the shale has been deformed, and a few prominent slickensides are oriented in a nearly east-west direction and show strike-slip movement. Thin bedded, very dusky red purple to dusky red quartzite interbeds are very fine to fine grained and more common near the base.

Mutual Formation

The basal quartzite bed of the Mutual Formation rests conformably on phyllitic shale of the Inkom Formation, and the upper contact, recognized at the color change from reddish purple to grayish orange pink, is disconformable with the Tintic Quartzite.

The formation is seen as steeply dipping, overturned strata which form prominent ledgy ridges and cliffs. Thickness of the formation in the Champlin Peak Quadrangle is approximately 500 m.

The quartzite is pale red to grayish purple and is massively bedded with well-sorted, medium to very coarse, subangular to rounded grains. Cross-bedding is common and ranges from 1 cm to 10 cm high. Metaconglomerate interbeds occupy approximately 10 percent of the exposed portion of the formation and range from a few centimeters to 3 m thick. They contain poorly sorted, rounded to subangular quartzite pebbles and granules in a medium-grained quartzite matrix (see appendix B).

Cambrian System

In unpublished notes (1972) Richard A. Robison suggested the possibility of applying the terminology of the House Range, Millard County, Utah, to the Cambrian strata of the Canyon Range identified by Christiansen (1952) as the Ophir Formation. The nomenclature for the lower 710 m of Cambrian strata has been determined by correlation of these units with Hintze and Robison's (1975) descriptions of House Range strata. An exception to this nomenclature is the lower Cambrian Prospect Mountain Quartzite that will be referred to as Tintic Quartzite because of its proximity to the Tintic Quartzite type section. Cambrian units included in this correlation are Pioche Formation, Howell Limestone, Chisholm Formation, Dome Limestone, Whirlwind Formation, Swasey Limestone, and Wheeler Shale.

The possibility of applying the nomenclature of Morris and Lovering (1979) from the East Tintic mining district, Utah and Juab Counties, Utah, to the undifferentiated middle and upper Cambrian units of the Champlin Peak Quadrangle has been suggested by Morris. An attempted correlation was aborted because of lack of fossil evidence needed to substantiate the correlation. This sequence of rocks will be referred to as undifferentiated Cambrian carbonates. Appendix B includes a measured section through the Cambrian rocks.

Tintic Quartzite

The Tintic Quartzite forms the basal portion of the Cambrian System and disconformably overlies the Mutual Formation. Because no shale unit similar to the one described by Christiansen (1952) elsewhere in the Canyon Range, was found between the Precambrian and Cambrian quartzites, the division was placed at the obvious color change from the reddish purple Mutual Formation to the grayish orange pink of the Tintic Quartzite. The upper contact with the overlying Pioche Formation, identified by the lowest occurrence of shale, is gradational and conformable.

The Tintic Quartzite, like the Mutual Formation, consists of steeply dipping, overturned strata which form prominent ledgy ridges and cliffs and some of the highest peaks in the area. The formation is 835 m thick in the northern portion of the Canyon Range.

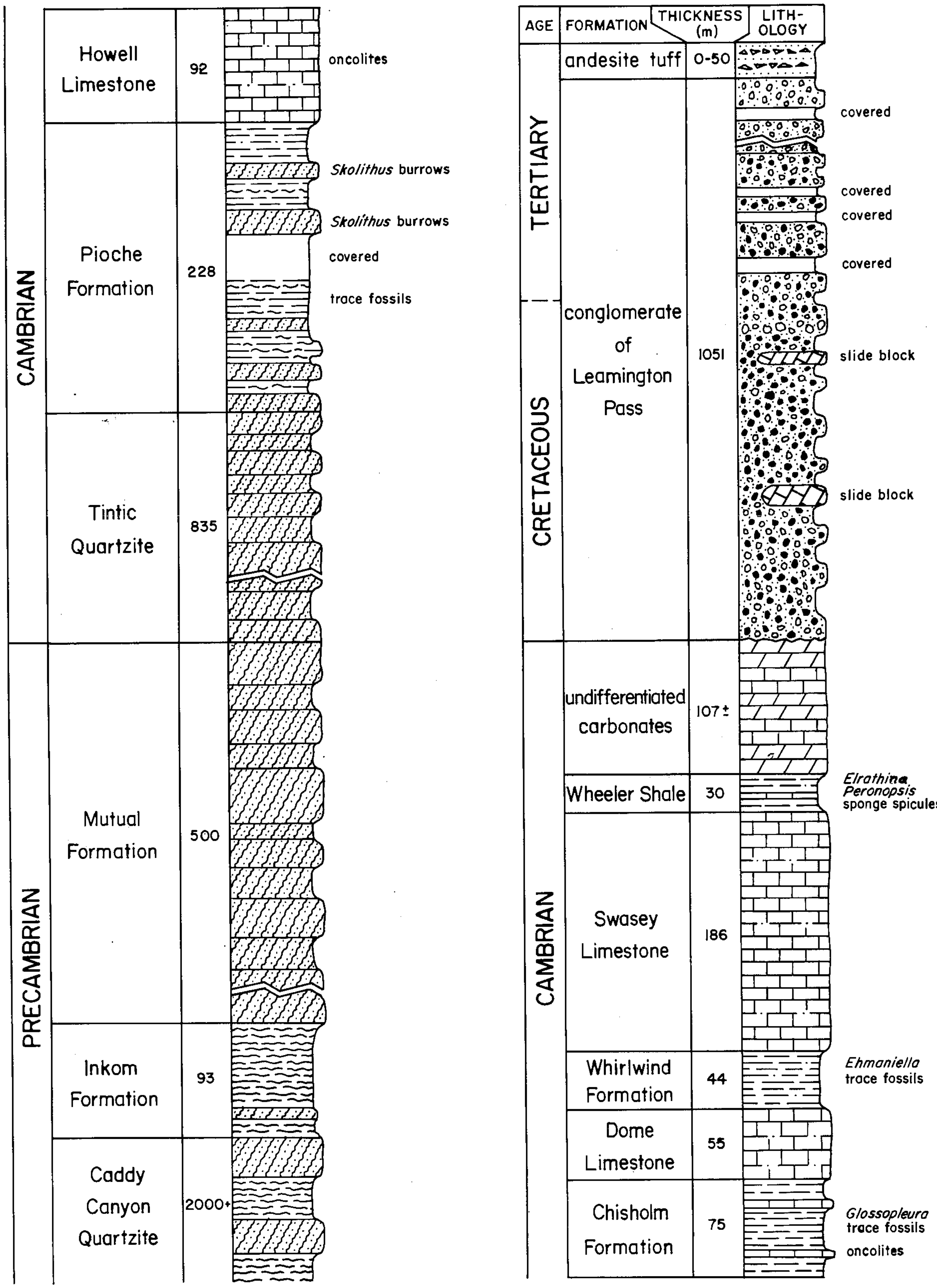


FIGURE 3.—Stratigraphic column of the rock units south of the Leamington Canyon Fault.

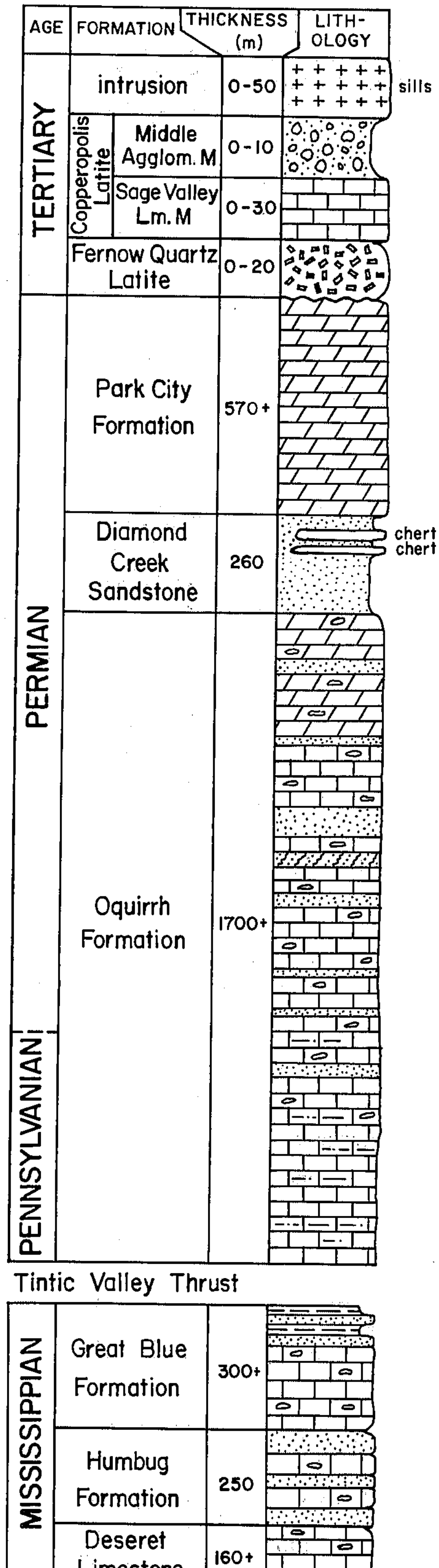


FIGURE 4.—Stratigraphic column of the rock units north of Leamington Canyon Fault.

The formation consists of massively bedded, medium to very coarse grained quartzite. The quartz grains are rounded to subangular. Cross-bedding is common in the unfossiliferous quartzite, with cross-bed sets up to 20 cm high that show as alternating gray to grayish red colored laminae. Metaconglomerate interbeds, up to 2 m thick, occupy approximately 10 percent of the total thickness and contain quartz pebbles and granules.

Pioche Formation

Contacts with the underlying Tintic Quartzite and the overlying Howell Limestone are well exposed throughout most of the quadrangle. The lower contact is gradational and is defined at the lowest occurrence of shale. The upper contact is sharp and is located at the base of the overlying limestone unit. In the House Range, the Pioche Formation has been divided into two members with the upper or Tatow member containing numerous limestone interbeds. These interbeds are not apparent in the Champlin Peak Quadrangle.

The Pioche Formation is an olive gray phyllitic shale and siltstone interbedded with grayish red purple to grayish brown quartzite from 2 to 8 m thick. The siltstone and shale weather to slopes covered by micaceous shale and siltstone chips, and quartzite interbeds tend to weather into ledges, giving the entire formation a characteristic ledge-and-slope topography. Two prominent brown quartzite ledges occur within this formation in the northern Canyon Range, but faulting and increased overturning have obscured them to the south. The Pioche Formation is 228 m thick.

Percentage of shale to quartzite increases toward the top of the formation. The phyllitic shales and calcareous siltstones are micaceous and weather light olive gray. Trace fossils are abundant, especially in the siltstones. Tubular worm burrows up to 3 cm are common. The massive quartzites tend to be medium to coarse grained, with the grains being rounded to subangular. A distinctive feature of the quartzite in the Pioche Formation is the occurrence of small, nearly vertical, tubular *Skolithus* burrows up to 0.5 cm in diameter.

Howell Limestone

Middle Cambrian Howell Limestone marks the first appearance of carbonate rocks in the sequence. While the lower contact with the Pioche Formation is sharp, the upper contact with the Chisholm Formation is more gradational but is recognized at the first distinct shale unit above the limestone cliffs. This formation is divided into two members, the Millard Member and the upper member, in the House Range. Although many characteristics of the two members are present in the Canyon Range, they are not definitive enough to allow the formation to be divided.

The Howell Limestone forms a prominent steep ridge throughout the quadrangle, with cliffs ranging from 10 to 30 m high in some areas. It is approximately 92 m thick.

The massively and irregularly bedded limestone varies from medium dark gray to light gray. Oncolites, frequently stained with limonite, are abundant in the lower portion of the limestone and range from 0.5 to 2 cm in diameter. The upper portion of the limestone becomes more shaly and has claystone partings that grade into the shale above. The weathered surface is often solution pitted and hackly with light brown, irregularly shaped markings common.

Chisholm Formation

The Chisholm Formation is bounded below by the Howell Limestone and above by the Dome Limestone. The lower contact is placed where the shale forms a distinct break above the Howell Limestone cliff. The upper contact is placed at the base of the Dome Limestone cliff. While the Chisholm Formation of the House Range is divisible into three distinct units, a lower shale, a middle limestone, and an upper shale, that formation in the Canyon Range is not. Instead of a thick, easily recognized middle limestone, it contains several much thinner limestone interbeds.

The formation is rarely well exposed in the quadrangle but is easily mapped as the ledge- and slope-forming unit between the cliffs of the Howell and Dome Limestones. The Chisholm Formation is approximately 7 m thick.

Rocks of the Chisholm Formation are predominately micaceous shale with approximately 30 percent limestone interbeds. The calcareous shale is olive gray and weathers light olive gray to pale orange. Medium gray limestone forms interbeds up to 3 m thick. They are irregularly bedded and contain limonite-stained oncolites 1–2 cm in diameter. The most distinctive characteristic of the Chisholm Formation is the presence of *Glossopleura* trilobite hash in the thin-bedded limestones. Trace fossils are also abundant in the formation.

Dome Limestone

The Dome Limestone lies between the Chisholm Formation below and the Whirlwind Formation above. The lower contact is gradational and was mapped at the break between the highest slope-forming shale unit and the base of the massive limestone cliff. The upper contact is sharp and lies between the limestone cliff and the shale of the overlying Whirlwind Formation.

The formation forms the second light gray limestone ridge in the quadrangle, is readily mapped between the two slope-forming shales, and is approximately 55 m thick.

The Dome Limestone is medium gray to medium dark gray and weathers light gray. Bedding is massive to irregular and includes brown silty laminae interbeds up to 2 cm thick that occupy approximately 5 percent of the total thickness. A few shale interbeds, up to 3 m thick, make up another 5 percent of the formation. The weathered surface of the Dome Limestone tends to be more rounded than the solution-pitted surface of the Howell Limestone.

Whirlwind Formation

Contacts with the underlying Dome Limestone and the overlying Swasey Limestone are not well exposed throughout most of the quadrangle. The sharp basal contact is drawn above the light gray Dome cliff where the shale unit forms a distinct break in the cliff line. The upper contact, positioned at the base of the lowest prominent limestone ledge of the Swasey Limestone, is gradational.

The Whirlwind Formation erodes to a strike valley between the limestone ridges of adjacent formations in the north Canyon Mountains. To the south, the dip decreases, and this formation forms a slope between the limestone cliffs with shale chips and blocky limestone talus. It is approximately 44 m thick.

The formation is primarily a calcareous, silty shale that is olive gray on the fresh surface and weathers to a yellowish gray or pale orange. Thin limestone interbeds are common, ranging from 10 to 50 cm thick. *Ehmaniella* trilobite hash is common in these limestone interbeds, especially in the upper 30 m of the formation. Trace fossils are common in the lower 20 m.

Swasey Limestone

The Swasey Limestone is bounded below by the Whirlwind Formation and above by the Wheeler Shale. Both contacts are gradational. The lower contact is placed at the base of the cliff-forming limestone, and the upper contact is recognized between the cliff-forming limestone and the lowest appearance of shale above the cliff.

Topographic expression of this formation is similar to that of the other limestone units in the Canyon Mountains, forming a resistant ridge between two slope-forming units. It is generally thicker than the previously mentioned limestone units, being approximately 186 m thick.

The medium dark gray limestone is thick bedded to massively bedded and weathers medium light gray. It contains approximately 5 percent brown silty laminae parallel to the bedding. Fracture fillings by white calcite are also characteristic.

Wheeler Shale

The lower contact of the Wheeler Shale with the Swasey Limestone is gradational, consisting of interbedded limestone and shale, and was mapped at the lowest occurrence of shale. The upper contact is also gradational, progressing from shale to calcareous shale into silty limestone and finally into the limestone of the upper Cambrian undifferentiated carbonate unit. The division is placed between the calcareous shale and silty limestone.

This nonresistant formation forms rounded slopes covered by platy talus between the resistant cliffs of the adjacent limestone units. It is approximately 30 m thick.

The Wheeler Shale is a light olive gray to olive gray, partially calcareous shale that weathers to a pale yellowish brown. It coarsens to a calcareous siltstone in places, with thinly bedded, medium gray limestone interbeds up to 20 cm thick.

The formation is very fossiliferous. A collection from the limestone interbeds just above the Swasey Limestone contact at SE¼ of section 33, T. 14 S, R. 3 W, contains rare specimens of the conodont *Hertzina bisulcata* and the following trilobites: *Bathyuriscus rotundatus, Elrathina* sp., *Kootenia* sp., *Peronopsis segmenta,* and *Ptychagnostus intermedius.* This fauna is representative of the *Ptychagnostus gibbus* Zone, which is found in the lowest one-fifth of the Wheeler Shale or equivalent units throughout the Great Basin (R. A. Robison written communication 1980). A collection from immediately upsection from the previous one contains two different faunas in different lithologies. A dark gray micritic limestone contains poorly preserved and disarticulated sclerites of *Modocia* and *Zacanthoides.* Both genera are long ranging and indicate nothing more precise than that they are from the upper half of the Middle Cambrian. A light brown calcareous siltstone contains abundant, but poorly preserved, specimens of an agnostoid that is probably *Ptychagnostus seminula,* which is common throughout the *Ptychagnostus gibbus* Zone of the Great Basin, northern Greenland, and Australia (R. A. Robison written communication 1980).

Sponge spicules are also abundant in siltstone interbeds. Samples of spicules collected from SW¼, NW¼, section 4, T. 15 S, R. 3 W, were identified by J. Keith Rigby (personal communication 1980) as *Kiwetinokia utahensis.* This is the first reported occurrence of this sponge, common in the lower part of the Wheeler Shale, in the Canyon Range.

Undifferentiated Cambrian Carbonates

The lower contact of the undifferentiated carbonates is sharp and conformable with the Wheeler Shale. Because of its conformable stratigraphic position above rocks of known Middle Cambrian age, the undifferentiated unit probably includes Middle and Upper Cambrian rocks. The limited thickness of these rocks, exposed beneath the angularly unconformable contact with the overlying Tertiary-Cretaceous conglomerate, suggests that no Ordovician rocks are exposed in the Champlin Peak Quadrangle.

The entire exposed sequence ranges from 100 to 300 m thick and forms slopes and hogback ridges. The massive to bedded limestone is pale red, weathering pinkish gray, and includes intervals that have as much as 50 percent calcareous silt interbeds up to 3 cm thick. The limestones are interbedded with medium light gray to grayish orange dolomites, some of which are massive to bedded while others are laminated. Crystalline calcite is common in vertical fractures and irregular laminae. No fossils were found in the undifferentiated limestones and dolomites.

Mississippian System

The Mississippian rocks exposed in the Champlin Peak Quadrangle in the Gilson Mountains include Deseret Limestone, Humbug Formation, and Great Blue Limestone, as shown in figure 4. The map contacts of these formations are adapted from Wang (1970), and the following descriptions are partially condensed from his unpublished dissertation.

Deseret Limestone

The base of the Deseret Limestone is not exposed in the portion of the Gilson Mountains included in the Champlin Peak Quadrangle. North of the quadrangle 1.6 km, however, the Deseret Limestone conformably overlies the Gardison Formation. The upper contact is also conformable and is drawn at the base of the abundant quartzose sandstone interbeds of the Humbug Formation.

Approximately 160 m of the upper portion of the Deseret Limestone is exposed in the Champlin Peak Quadrangle as ledgy slopes. To the north, where the 185-m-thick formation is totally exposed, Wang described two lithologic units. The lower unit consits of light brownish gray, fine-grained, fissile, calcareous siltstone and thin-bedded argillaceous limestone with black chert common in the upper portion. The upper unit is composed of black, fine-grained, thin- to medium-bedded, fissile and argillaceous limestone. Bryozoan fragments, crinoid stems, and brachiopod fragments are common in the upper unit.

Humbug Formation

The Humbug Formation conformably overlies the Deseret Limestone and underlies the Great Blue Formation. Its base is defined as the base of the first sandstone bed, above which the sandstone becomes increasingly predominant. Its upper contact is gradational and is tentatively placed at the base of a 29-m-thick, dark bluish gray, fine-grained, thick-bedded, silty limestone.

The formation is approximately 250 m thick and forms the ledgy cliffs of Champlin Peak in the Gilson Mountains. The Humbug Formation is an alternating sequence of quartzose sandstone and silty limestone. The sandstone that distinguishes it from the other Mississippian formations in the Gilson Mountains comprises approximately 60 percent of the Humbug. Most limestone beds are bioclastic, and those in the lower portion contain crinoid stems, horn corals, and brachiopod fragments. Calcite vug fillings and veinlets are common throughout.

Great Blue Formation

The Great Blue Formation is incompletely exposed in the Gilson Mountains. It is conformably underlain by the Humbug Formation, but the upper portion has been removed by erosion and faulting. The lower contact is drawn at the top of the abundant quartzose sandstone interbeds of the Humbug Formation. Approximately 300 m of the formation are exposed. The beds form ledgy slopes to ledgy cliffs.

The Great Blue Formation in the Gilson Mountains consists chiefly of dark bluish gray to black, fine-grained, thin- to thick-bedded limestone, and subordinate amounts of brownish, fine-grained quartzose sandstone. The formation is very fossiliferous. Horn corals, brachiopods, crinoid stems, productids, and ostracodes are widespread throughout the lower part.

Pennsylvanian and Permian Systems

The Pennsylvanian and Permian age rocks of the Champlin Peak Quadrangle are exposed in the Gilson Mountains between the Tintic Valley Thrust and the Leamington Canyon Fault. These rocks include the upper part of the Oquirrh Formation, the Diamond Creek Sandstone, and the lower portion of the Park City Formation, as shown in figure 4.

Oquirrh Formation

Only the upper portion of the Oquirrh Formation is exposed in the Champlin Peak Quadrangle. The Tintic Valley Thrust cuts off lower beds and places the Pennsylvanian-Permian Oquirrh Formation against the Mississippian Humbug Formation or Great Blue Formation. The upper contact with the Diamond Creek Sandstone is not well exposed. It is presumably unconformable and was mapped at the top of the cherty dolomite ledges beneath the yellowish gray, friable sandstone of the Diamond Creek Sandstone. The 1700 exposed meters of the Oquirrh Formation form the ledges of the rounded knolls along the southeast edge of the Gilson Mountains in Leamington Canyon.

Fusulinids, brachiopods, corals, and bryozoan fragments are common. The lower part of the Oquirrh Formation consists of a medium gray to dark gray, thin- to thick-bedded, somewhat cherty, silty limestone with interbeds of thin- to medium-bedded, fine- to medium-grained, pale reddish brown, calcareous sandstone. The upper part of the exposed Oquirrh Formation is characterized by light olive gray to dark gray, medium-bedded, arenaceous dolomite with interbedded sandstone units similar to those in the lower part. Many of the dolomite beds contain numerous chert stringers and nodules. Some of the more permeable units of the overturned section in the northeastern corner of the quadrangle have been intruded by glassy basaltic sills, and adjacent units have been highly fractured. A complete section of the Oquirrh Formation has been described from an adjacent area by Morris, Douglass, and Kopf (1977).

Diamond Creek Sandstone

The Permian Diamond Creek Sandstone is not well exposed in the Champlin Peak Quadrangle. The lower contact, although obscure, was drawn at the top of the cherty dolomite ledges of the Oquirrh Formation and is considered unconformable. The upper contact with the Park City Formation is not exposed.

The more resistant units form ledges that crop out from beneath bouldery, elevated alluvial deposits. The exposed thickness of the Diamond Creek Sandstone is approximately 260 m.

The formation is chiefly composed of yellowish gray to grayish orange, medium-grained, friable sandstone. Several lenses of pale blue, highly fractured, bedded chert, up to 2 m thick, occur near the top of the formation. Glassy basaltic sills have also intruded several permeable units, and much of the formation has been intensely altered.

Park City Formation

The lower part of the Park City Formation is well exposed in the Champlin Peak Quadrangle. The lower contact with the Diamond Creek Sandstone is not exposed. The upper contact is formed by the Leamington Canyon Fault that places Permian Park City Formation against Cambrian Tintic Quartzite.

The exposed thickness of the Park City Formation is approximately 570 m. The major outcrop forms a knoll located near the junction of Leamington and Sevier Canyons. The smaller outcrops to the east are so brecciated and altered that identification as Park City Formation is questionable.

The formation is a yellowish light gray to medium gray, fine- to medium-bedded, silty dolomite that is fine to medium grained. It contains many large chert nodules and some bedded chert. The dolomite has a very fetid odor on a fresh surface.

Cretaceous and Tertiary Systems

Cretaceous and Tertiary Systems, shown in figure 3, include conglomerate and igneous units present only in the eastern half of the Champlin Peak Quadrangle. Because of lack of fossil evidence, a more precise age of sedimentary deposits can be determined only by their relationship to the Oligocene volcanic units.

Conglomerate of Leamington Pass

The Cretaceous and Tertiary conglomerate of the Champlin Peak Quadrangle is part of a sequence that occurs throughout the Canyon Range. It rests unconformably against overturned Cambrian rocks and does not extend north of the Leamington Canyon Fault.

The conglomerate typically forms well-rounded hills with the best exposures either on hilltops or in washes and where the dip of the beds is relatively high, as shown in figure 5. Slopes produced by the weathered conglomerate are generally reddish and contain rounded cobbles and pebbles. Approximately 1,050 m of the conglomerate were measured, as described in appendix B.

The conglomerate, usually a pale red gray to grayish orange pink, contains poorly sorted, rounded to subangular clasts (see appendix B). The clasts comprising beds within the conglomerate vary from 100 percent quartzite to 100 percent limestone and from 2 cm to 1 m in diameter. The matrix is composed of poorly sorted, fine- to medium-grained sand. Most of the units have calcareous cement.

Two large limestone blocks are included in the measured section of the conglomerate. The bedding of these slide or fall blocks does not parallel the bedding of the conglomerate. These ledge-forming limestones are characteristic of lower Paleozoic limestones. They are both medium gray, massively bedded, and highly fractured. One block contains iron as limonite stains in fractures, and the other contains abundant limonite-stained pisolites.

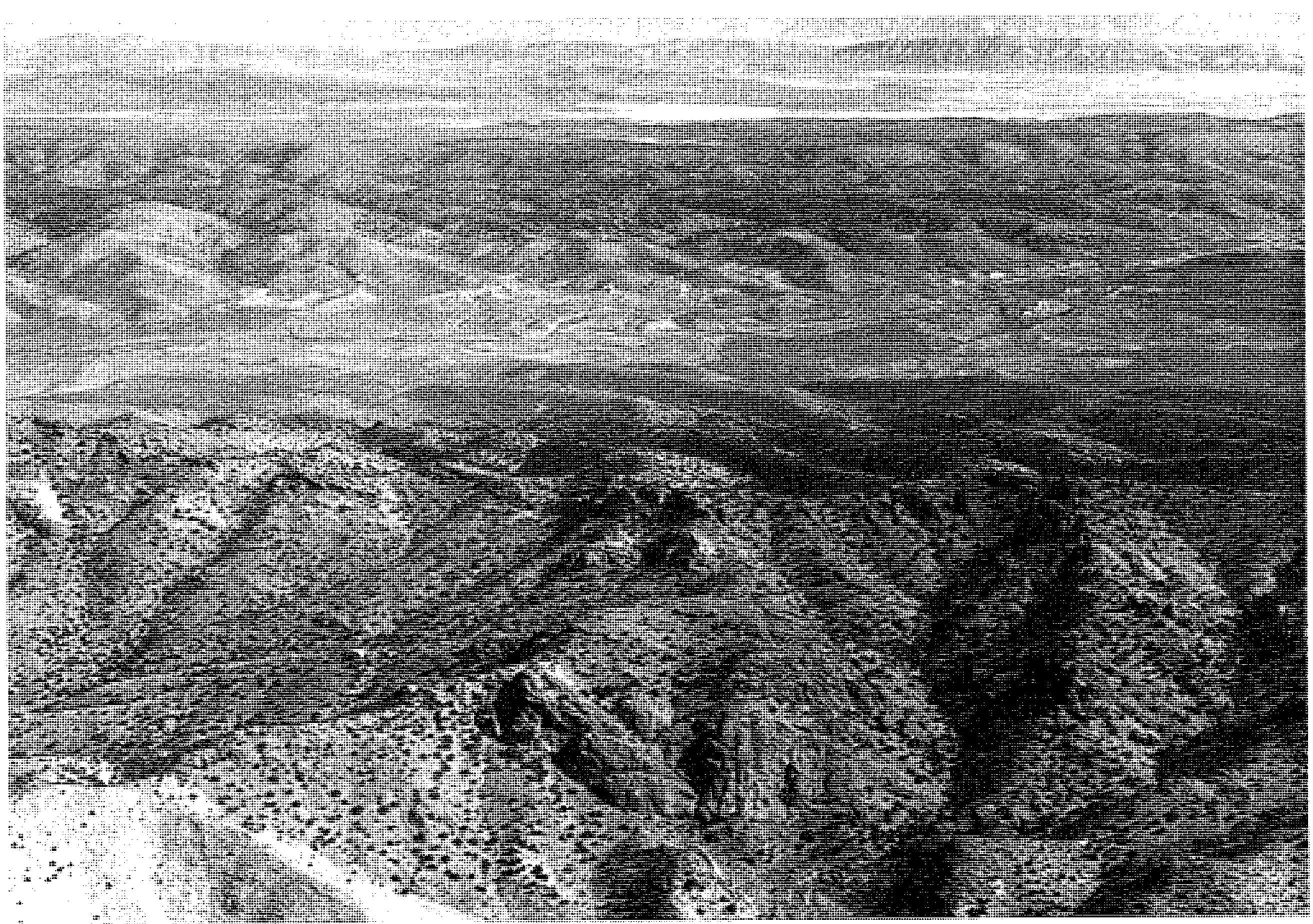


FIGURE 5.–Conglomerate of Leamington Pass. View is southeastward of sections 27 and 34, T. 14 S, R. 3 W.

Dating the conglomerate is difficult because of lack of fossils. Christiansen (1952, p. 725) tentatively correlated the conglomerate with the Indianola Group (Upper Cretaceous), but Armstrong (1968, p. 448) and Stolle (1978, p. 138) place the age later, correlating it with the Price River (Upper Cretaceous) and the North Horn (Paleocene-Eocene) Formations of the Pavant Range. Swank (1978, p. 20) used the Indianola Group and North Horn Formation to define adjacent conglomerates to the south of the Champlin Peak Quadrangle. Campbell (1979) left the Conglomerate of Leamington Pass as one unit and called it Indianola Group-Price River Formation and North Horn Formation undivided. Unfortunately, no new evidence was found to aid in the determination of the age or correlation of the Conglomerate of Leamington Pass.

Fernow Quartz Latite

A small outcrop of Fernow Quartz Latite in the northeast corner of the Champlin Peak Quadrangle reaches a thickness of 20 m and forms rounded hills. Morris (1977) described the Fernow Quartz Latite as a light to medium gray, medium-grained, welded tuff, containing phenocrysts of quartz, sanidine, andesine, and biotite and fiamme of black obsidian in a matrix of partly to wholly welded glass shards.

Copperopolis Latite

The Oligocene Copperopolis Latite, exposed in the northeast portion of the Champlin Peak Quadrangle, consists of two members: the Middle Agglomerate Member and the Sage Valley Limestone Member.

Morris (1977) described the Middle Agglomerate Member as a massive boulder agglomerate composed of rounded clasts of dark gray latite, embedded in a matrix of tuff and volcanic gravel. To the east, the member is both overlain and underlain by thick, dark gray latite flows. In the Champlin Peak Quadrangle, up to 10 m of the member is present but forms a weathered slope beneath the Sage Valley Limestone Member.

In the Champlin Peak Quadrangle the Sage Valley Limestone Member of the Copperopolis Latite has been previously shown on maps by Costain (1960) and Wang (1970) as part of the Permian Park City Formation. Morris (1977) described this member as lenses of light gray, thin-bedded, crystalline, algal limestone within the Middle Agglomerate Member. In the Champlin Peak Quadrangle, these more resistant limestone lenses cap small rounded hills.

Tertiary Tuff

In the Champlin Peak Quadrangle, this Oligocene, pinkish gray, andesite crystal tuff sits directly on the Cretaceous-Tertiary Conglomerate of Leamington Pass. Its exposed thickness in the quadrangle ranges up to 50 m.

It is composed of 40 percent plagioclase, 10 percent biotite, 1 percent pyroxene and amphibole, and 1 percent opaque minerals, as phenocrysts, with the rest of the rock made up of lithic fragments and glass. The composition of the plagioclase is approximately An_{45}. Most of the biotite phenocrysts are bent and broken and show well-developed dehydration rims. Many of the pyroxene and amphibole crystals are not related, but there are some crystals of pyroxene with amphibole cores that are the result of a dehydration reaction.

Intrusive Rocks

The intrusive rocks, related to igneous activity in the Tintic District which is Oligocene, are glass-rich, porphyritic basalt sills in the overturned Permian sequence located in the northeast portion of the Champlin Peak Quadrangle. They are up to 50 m thick.

The rock is composed of 14 percent plagioclase phenocrysts that have a composition of An_{60} and are strongly zoned. Both clinopyroxene and orthopyroxene phenocrysts with pronounced reaction rims make up another 3 percent of the rock. Opaque minerals account for about 1 percent. The matrix of the rock is composed of plagioclase microlites and glass.

Tertiary Conglomerate

The Tertiary conglomerate has not been differentiated from the older Conglomerate of Leamington Pass by previous mappers (Christiansen 1952, Campbell 1978). Except where the two conglomerates are separated by the tuff unit, the Tertiary conglomerate sits directly on the Conglomerate of Leamington Pass. The younger conglomerate is mostly unconsolidated and composed of bouldery material largely derived from the Conglomerate of Leamington Pass. In some areas, this younger conglomerate also contains boulders of Oligocene volcanic rocks, thus dating the deposition of at least part of the conglomerate as post-Oligocene.

Quaternary System

Although the Quaternary System of the Champlin Peak Quadrangle has not been differentiated on the accompanying map, it is easily divisible into three distinct units: older alluvial deposits, Lake Bonneville deposits, and recent alluvial deposits.

The older alluvium is present as bouldery, elevated alluvial fan deposits that are presently being dissected and eroded. Lake Bonneville deposits are found as erosional remnants of horizontally laminated, yellowish gray to very pale orange silts and clays that are somewhat cross-bedded. Recent alluvium consists of bouldery alluvial fan deposits near the mountains, grading to silt in the valley bottom, and includes reworked Lake Bonneville and Sevier River sediments.

STRUCTURE

Figure 6 depicts an overview of the relation of the Champlin Peak Quadrangle to major structures of the region. The Nebo Thrust is extended across Long Ridge shown to the south of allochthonous Paleozoic outcrops but to the north of autochthonous Jurassic rocks. To extend it farther west of this area is conjecture. It may link with the Leamington Canyon Fault, but if that fault is a thrust with northward movement, then the Nebo Thrust should continue beneath the Canyon Range Thrust to the south of Leamington Canyon Fault. There is also the possibility that the Canyon Range Thrust plate was thrust over the Gilson Mountains-Nebo Thrust plate, producing the same attitude on the Leamington Canyon Fault, but having the opposite direction of movement. The relationship of the Nebo Thrust to the Pavant Thrust is uncertain.

The Canyon Range Thrust extends toward the quadrangle from the south as shown by Christiansen (1952). The western thrust contact of Christiansen (1952) is portrayed as a normal fault by Swank (1978). A. W. Millard, Jr. (personal communication) believes that a failure to discuss important relationships that are encountered along this fault leaves the thoroughness of Swank's investigation suspect. In particular, the fault trace has a parallel relationship to the synclinal axis of the allocthonous fold, which should not be the case in a basin-and-range normal fault relationship (A. W. Millard, Jr. written communication 1981). There is not at present enough documented evidence to challenge the thrust relationship mapped by Christiansen (1952).

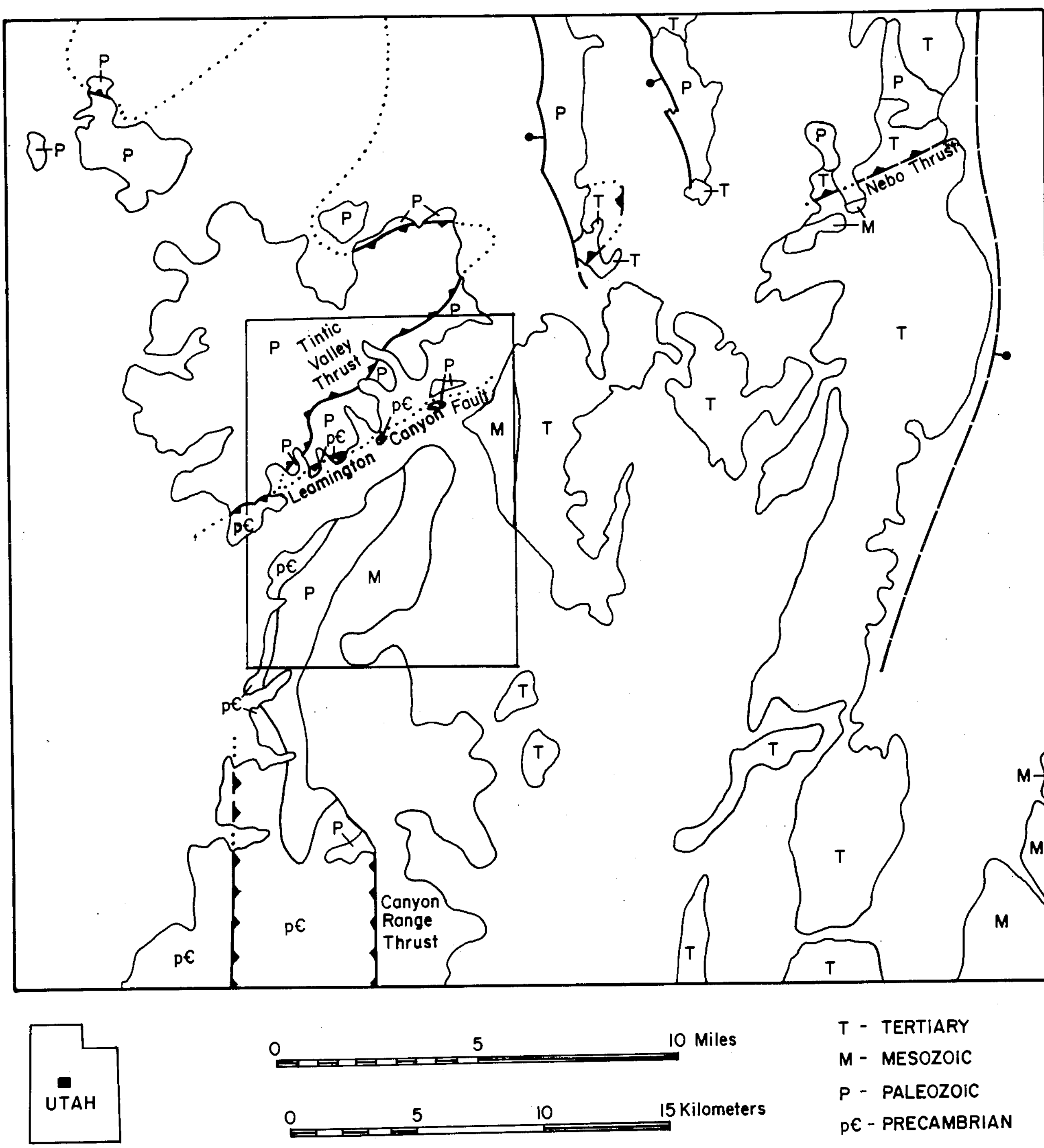


FIGURE 6.—Sketch of the regional structure associated with the Champlin Peak Quadrangle (outlined).

The overturned section in the Champlin Peak Quadrangle is considered to be part of the Canyon Range Thrust plate, with the implication that the Pavant Thrust underlies the rocks exposed in the quadrangle, if the Pavant Thrust actually extends that far north. If the Pavant Thrust does not extend that far north, then the portion of the quadrangle not resting on the Nebo Thrust is in contact with Mesozoic rocks.

The Tintic Valley Thrust, from the north, is also terminated by the Leamington Canyon Fault. However, a discussion of this thrust and related structures north of the Leamington Canyon Fault are not considered further in the following discussion.

Folds

Christiansen (1952) was the first to recognize the general structure of the Canyon Range in the Champlin Peak Quadrangle as an overturned sequence of Precambrian and Cambrian rocks trending north to approximately 35° east of north as shown on figure 7. This overturned sequence is the western limb of an asymmetrical syncline, the axis of which is exposed to the south of the quadrangle. The eastern limb was largely removed by erosion prior to deposition of Conglomerate of Leamington Pass (Christiansen 1952, p. 730).

The overturned limb of the syncline to the east is also the overturned limb of an asymmetrical anticline to the west. Drilling west of the Canyon Range and south of the Champlin Peak Quadrangle, in section 15, T. 18 S, R. 5 W (Placid Oil Company #1 Henley), found the Cambrian section upright and dipping approximately 30° west (Douglas Sprinkle oral communication 1981). This finding helps substantiate the flexural-slip folding described by Swank (1978, p. 17).

The folding of this overturned limb, from a north-south trend along the southern edge of the quadrangle to a 35° northeast trend in Leamington Canyon, produced numerous tear faults and small drag folds along with a gradual change in dip from nearly vertical to 35° west (fig. 7). A horizontal core of the Cambrian sequence spudded in section 4, T. 15 S, R. 3 W, by Martin-Marietta Cement reveals several zones of brecciation along limestone-shale contacts that must have been the result of the bending of the overturned limb. It also helps to account for the variations in thickness of the Cambrian formations, as illustrated in figure 7. Loughlin (1914, p. 58), Christiansen (1952, p. 73), and Costain (1960, p. 112) all recognized a need for northwestward force to account for these folds. Loughlin (1914, p. 58) commented, "The character of the folds shows that in . . . the northern part of the Canyon Range the prevailing force was northwestward."

Loughlin (1914, p. 51) was also the first to recognize the obvious angular unconformity between Cambrian carbonate rocks and the Tertiary-Cretaceous Conglomerate of Leamington Pass. The conglomerate ranges in eastward dip from 87° near the contact with the Cambrian rocks to 10° near the east edge of the Champlin Peak Quadrangle. The lack of evidence on the age of this conglomerate hampers a complete interpretation of the structure. Christiansen (1952, p. 733) concluded that this structural relationship indicated that preconglomerate folding of the rocks in the Canyon Range was not intense, "since in no locality where the unconformity is exposed is the angular discordance . . . greater than 20 degrees." Armstrong (1968, p. 435) argued that bedding-plane thrusting could not develop after such folding and interpreted the folding as either contemporaneous with or subsequent to thrusting. Swank (1978, p. 35) divided the conglomerate into two distinct units and bracketed the time of Canyon Range thrusting as being post-Indianola, resulting in the folding of Indianola Group, and pre-North Horn. Campbell (1979, p. 14) believed the latest pulse of the Sevier orogeny in the Canyon Range occurred subsequent to deposition of the North Horn Formation of Late Cretaceous and Paleocene age. John E. Welsh (oral communication 1981) considers the upending of the conglomerate the result of the thrust simply running into its own debris.

The folding of the conglomerate and subsequent overturning of the lower Paleozoic rocks could possibly be the result of extensive salt movement in Sanpete Valley as compressive forces formed excessive thicknesses of Jurassic salt and shale in front of the eastward-moving thrusts, conceivably including the Canyon Range Thrust. Moulton (1977, p. 6) alluded to this possibility and stated that the overturned beds on the surface could be intrpreted as "erosional remnants of recumbent or mushroom-shaped folds formed by diapiric movement" rather than by large-scale overthrusts.

Thrust Faults

Several small, discontinuous faults with thrust movement are present in the Champlin Peak Quadrangle. They range from 5 to 25 m of nearly horizontal displacement and were possibly caused by simple jostling as the Canyon Range plate moved east. An excellent example is the displacement of the Howell Limestone near the edge of section 8, T. 15 S, R. 3 W (fig. 8), where the upper plate has moved 8 m past the lower plate.

The Leamington Canyon Fault is the only major fault exposed in the area under discussion.

Leamington Canyon Fault

The Leamington Canyon Fault was first mapped and named by Costain (1960, p. 11), who proposed that the fault be interpreted as a thrust fault dipping 30° to the southeast. Morris and Shepard (1964, p. C21), in postulating a concealed tear fault in the central East Tintic Mountains, interpreted the Leamington Canyon Fault as a tear fault with right-lateral movement, which forms the southern edge of the upper plate of the Nebo Charleston Thrust. Wang (1970, p. 94) and Burchfiel and Hickcox (1972, p. 62) agreed with this interpretation. Eardley (1969, plate 1) considered the fault as the northern shear of the Canyon Range Thrust with left-lateral movement and comparatively small displacement.

Differences in opinion are apparently the result of the poor exposure of the Leamington Canyon Fault. Tracing the fault from where it places the Park City Formation against Tintic Quartzite eastward into the conglomerate and volcanic area is aided by numerous outcrops of silicic breccia that seem to follow the trend of the fault. Most areas along the fault give only an estimation of amount of dip as the fault curves over a ridge, as shown in figure 9. Other areas, as in figure 10, provide better control. The best exposure of the fault is found along the western edge of the Champlin Peak Quadrangle (fig. 11), where it appears as a near bedding-plane fault of the Precambrian Caddy Canyon Quartzite on the Mississippian Humbug Formation. At this locality, the fault dips nearly 50° southeastward where the fault line can be traced over the small hills at the back of the canyon. Small folds in the Caddy Canyon Quartzite have axes that trend parallel to the Leamington Canyon Fault (fig. 12b) and suggest a compressive force from the northwest or southeast. Also indicative of this direction of force are the slickenside orientations plotted in figure 12a. In a consideration of the attitude of the fault (see fig. 13) in conjunction with fold axes and slickenside directions, a compressive force from the southeast is most probable. It suggests a thrust of the Caddy Canyon Quartzite over the upper Paleozoic rocks of the Gilson Mountains as shown in the cross section in figure 12.

Morris (written communication November 1981) believes that "small-scale folds and slickensides most commonly record only the last, probably atypical, movement on a fault and usually are more misleading than helpful." However, I suggest that the data presented herein related to direction of movement along this important fault need to be carefully considered by anyone making regional structural syntheses involving this fault.

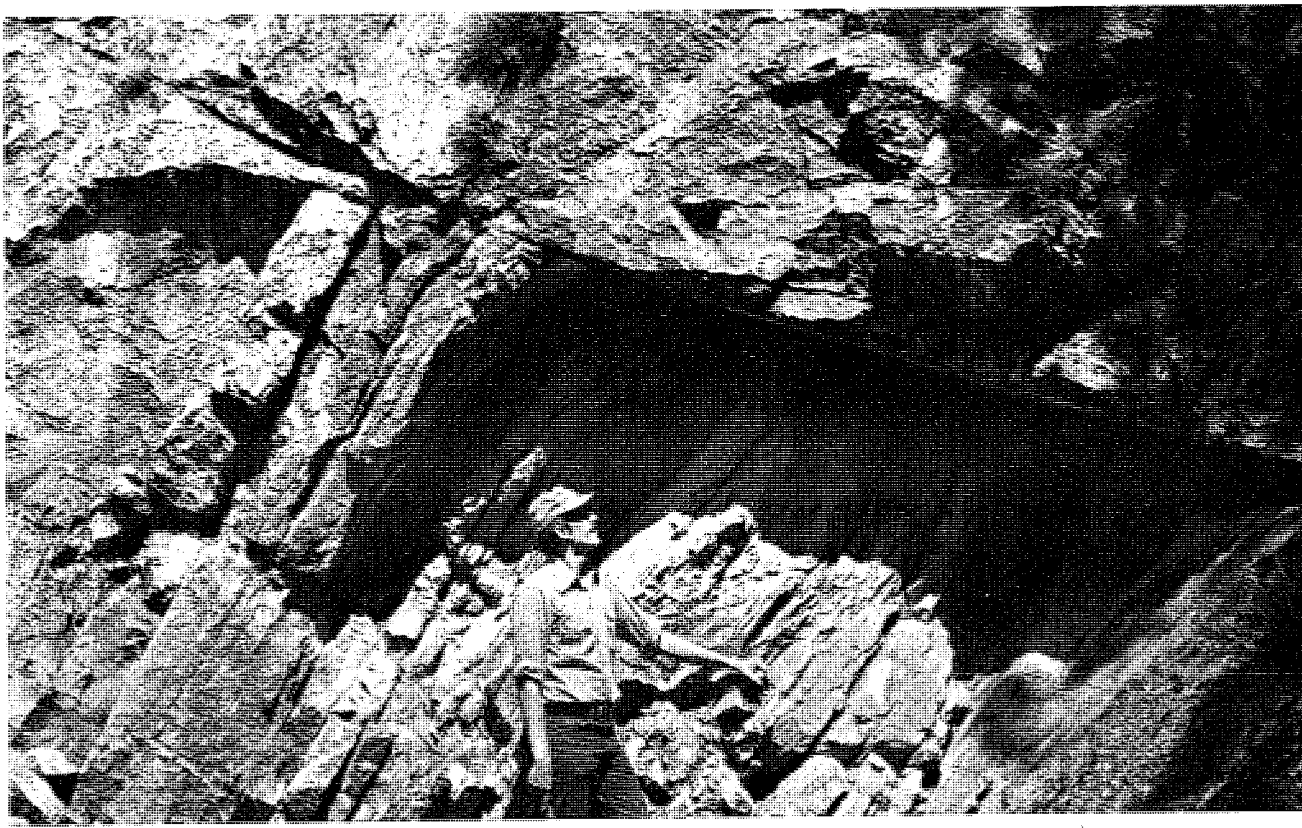


FIGURE 8.–Small thrust fault in Howell Limestone near the edge of section 8, T. 15 S, R. 3 W. The upper plate has moved to the right 8 m past the lower plate.

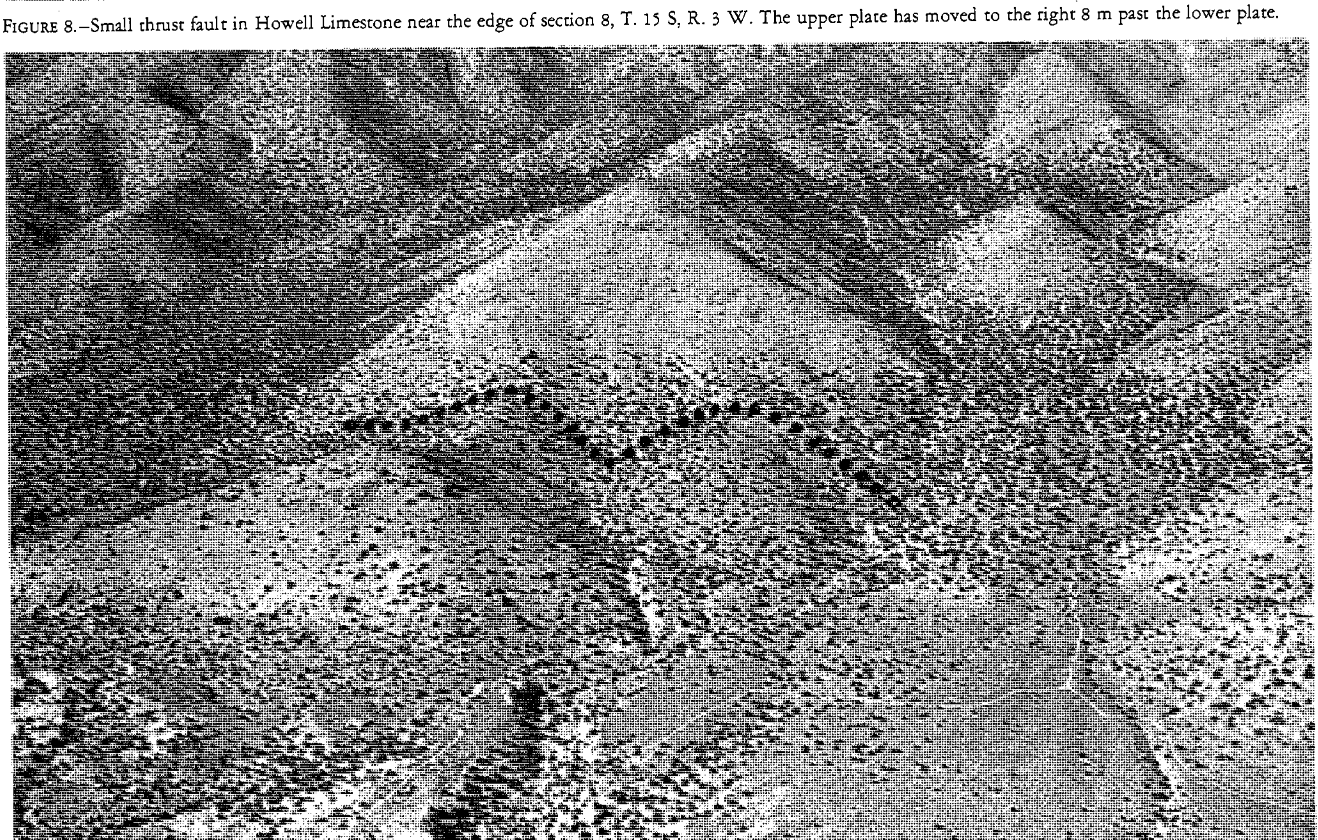


FIGURE 9.–View of Leamington Canyon Fault in W¼, section 29 and SE¼, section 30, T. 14 S, R. 3 W, toward the northwest.

FIGURE 10.–View of Leamington Canyon Fault in N¼, section 29, T. 14 S, R. 3 W, looking north of west.

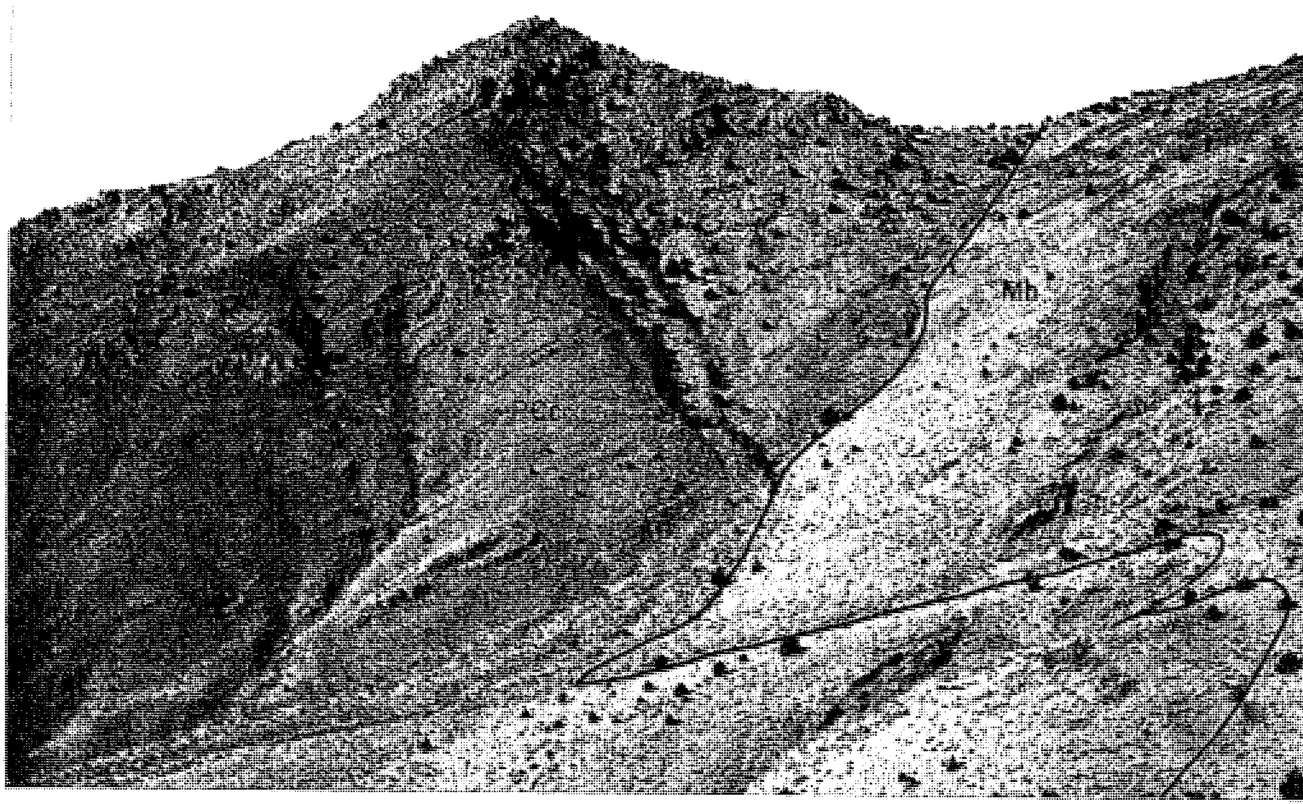


FIGURE 11.–View of Leamington Canyon Fault in section 36, T. 14 S, R. 4 W, toward the west.

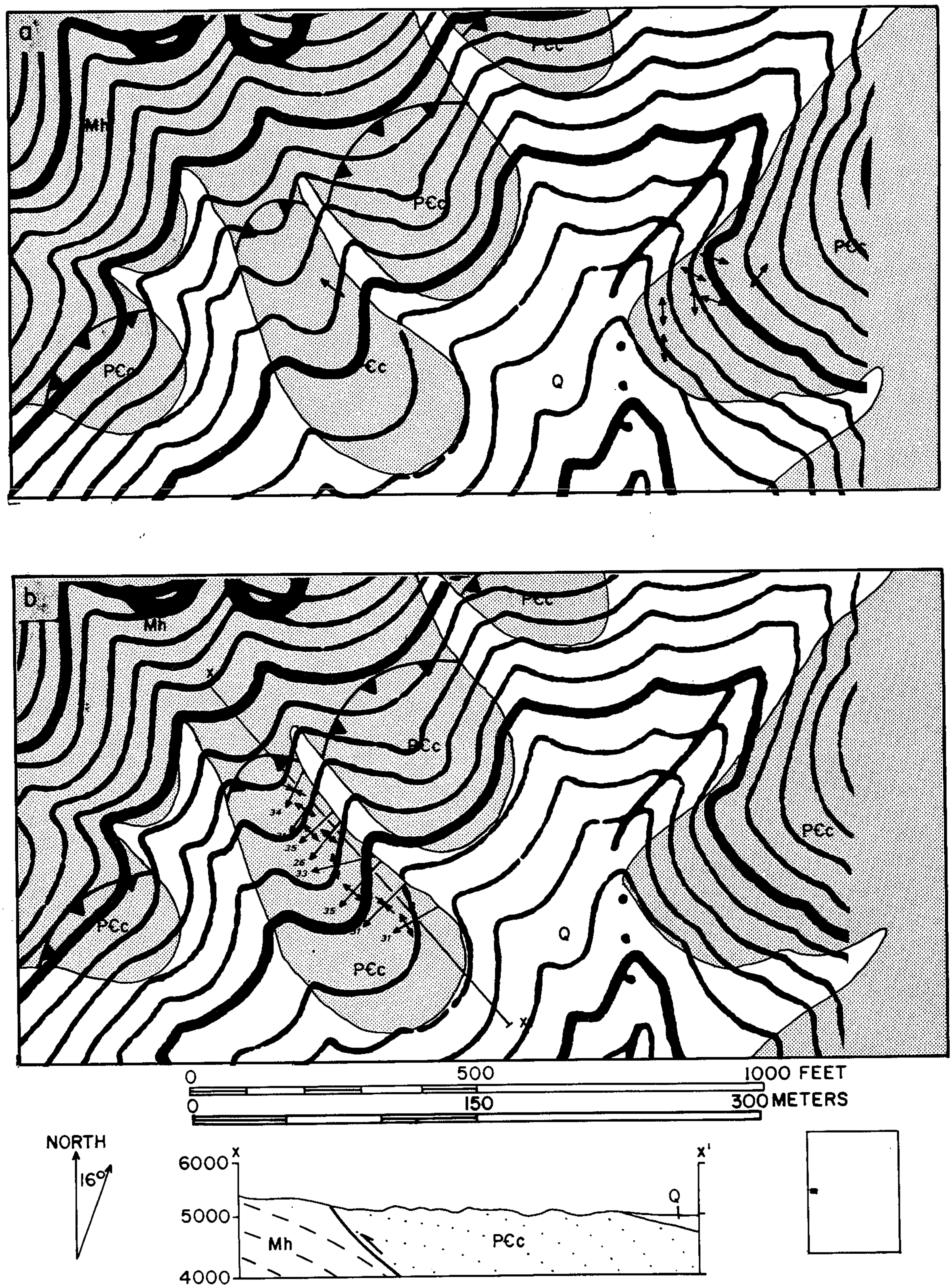


FIGURE 12.–a.–Slickenside directions showing, for the most part, movement in a southeast-northwest direction; b.–Axes of small folds parallel to the Leamington Canyon Fault indicating thrust movement along the fault, as shown in cross section.

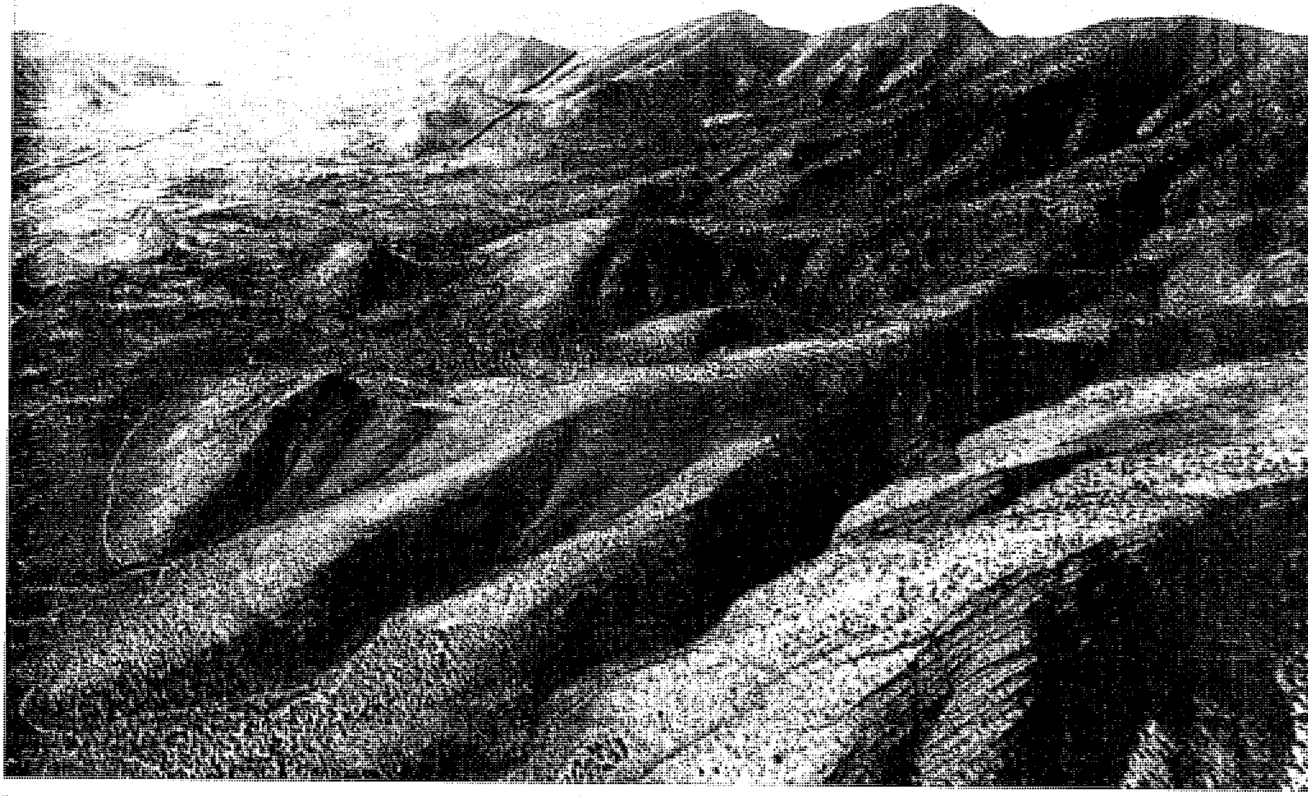


FIGURE 13.—View of Leamington Canyon Fault from section 29, T. 14 S, R. 3 W, to the southwest.

The present attitude of the fault, as related to the rotation of the conglomerate, could also be attributed to recent salt movement in Sanpete Valley causing the northwestward force needed to push the Canyon Range Thrust plate over the Nebo plate—in which case the Nebo plate probably does not extend very far beneath the Canyon Range Thrust plate.

An alternative hypothesis is the possibility that the Canyon Range Thrust plate moved over the Gilson Mountains portion of the Nebo Thrust from the northwest to the southeast, producing similar fault attitudes, slickenside directions, and fold axes to those produced by the previously discussed northwestward force. This type of movement would, in effect, make the Gilson Mountains a klippe. The hypothesis can be supported by a comparison of Cambrian sections. The Cambrian section in the Canyon Range does not correlate with the Cambrian section southwest of Kanosh, Utah, section 5, T. 24 S, R. 6 W (Robert L. Davis personal communication 1981), yet this section is substantially farther west than the Canyon Range section. On the other hand, there is a close correlation of the Cambrian rocks of the Canyon Range with those far to the west in the House Range. This relationship suggests that the Canyon Range Thrust plate was thrust far to the east, possibly over a portion of the Nebo Thrust plate, producing the rock relationships found in Leamington Canyon.

Tear Faults

Although Campbell (1979) shows the faults on the north side of Wood Canyon as normal faults, several slickensides, similar to the one shown in figure 14, indicate strike-slip or tear-fault movement of all the small faults shown in figure 7.

Tear faults in the Champlin Peak Quadrangle occur in the overturned Precambrian and Cambrian rocks and are the result of the trend of these rocks changing from due north to 35° northeast. Christiansen (1952, p. 730) observed that the varying degree of rotational movement along the tear faults accounts for the abrupt change in intensity of overturning between contiguous segments of the overturned limb.

Normal Faults

The only normal faults under consideration are early Miocene basin-and-range faults that lie just west of the Champlin Peak Quadrangle. Morris (Campbell 1979, p. 8) believed the Canyon Range has been tilted eastward as much as 5° during basin-and-range deformation.

Sandy Calcite Veins

Numerous sandy calcite veins were found in the Cambrian limestones of the Canyon Range. They vary from 0.5 to 2 m in width and 2 to 5 m in length, and seem to trend approximately perpendicular to the bedding. Thin sections of two veins revealed the same composition but different concentrations. A vein in the Dome Limestone, SW¼ of section 8, T. 15 S, R. 3 W, is calcite supported, being approximately 70 percent calcite, 27 percent quartz grains with an average diameter of 0.25 mm, 2 percent very small rounded grains of clay and chlorite aggre-

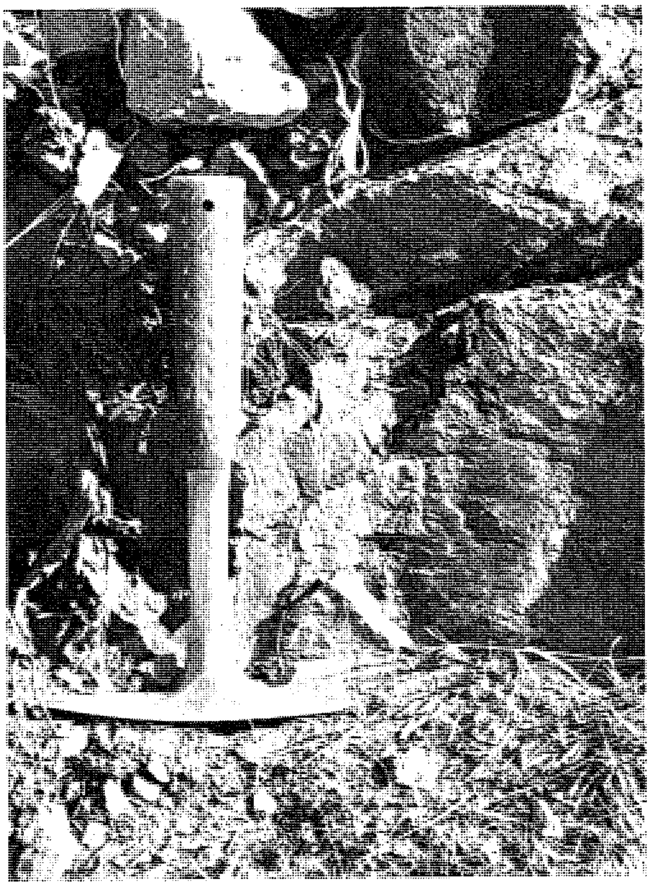


FIGURE 14.–Slickensides on Howell Limestone in Wood Canyon showing tear-fault motion.

gate, and 1 percent opaque minerals. A vein in the Howell Limestone, SE¼ of section 5, T. 15 S, R. 3 W, has the same constituents but is approximately 70 percent quartz grains and 30 percent calcite.

CONCLUSIONS

1. The Cambrian section of the Canyon Range correlates with the Cambrian section of the House Range from Tintic Quartzite to the Wheeler Shale. Above the Wheeler Shale, the carbonate sequence of the Canyon Range does not resemble the Marjum Formation of the House Range.

2. Three Precambrian formations that are known from other areas in western and northern Utah are mappable in the Champlin Peak Quadrangle: Caddy Canyon Quartzite, Inkom Formation, and Mutual Formation.

3. The Leamington Canyon Fault is a thrust fault which placed the Precambrian rocks on Paleozoic rocks as evidenced by the angle of inclination of the fault and the fold axes and slickenside directions.

4. Possible northwestward movement is indicated by the Leamington Canyon Fault and related folds in the northern Canyon Range.

5. The Precambrian and Cambrian rocks are considered as part of the Canyon Range Thrust, not the Pavant Thrust, following Christiansen (1952).

6. The Nebo Thrust, extended west from exposures on Mount Nebo, probably does not connect with the Leamington Canyon Fault, but should pass under the Canyon Range Thrust south of the fault.

APPENDIX

Section measured through the base of the Mutual Formation, Inkom Formation, and the upper portion of the Caddy Canyon Quartzite. Section begins SE¼, NE¼, section 12, T. 15 S, R. 4 W, and ends NE¼, NE¼, section 12, T. 15 S, R. 4 W.

Unit	Description	Meters
	Mutual Formation	
14	Quartzite, pale red, weathers grayish red purple, medium grained, grains subangular to rounded, massively bedded, 5% cross-bedding up to 6 cm thick, forms resistant cliff.	20
	Measured thickness of Mutual Formation	20
	Inkom Formation	
13	Phyllitic shale, light olive gray, weathers dusky gray yellow, quite fissile, forms slope.	82
12	Phyllitic shale with quartzite interbeds; shale, grayish red purple, weathers grayish red, quite fissile, forms slope; quartzite, very dusky red purple, weathers dusky red, thin bedded, very fine grained, grains subrounded to rounded, forms resistant ledges up to 10 cm thick.	5
11	Phyllitic shale, light olive gray, weathers dusky yellow, poor fissility, forms slope.	1
10	Phyllitic shale, grayish red purple, weathers grayish red, quite fissile, forms slope.	3
9	Phyllitic shale and quartzite interbedded; shale, grayish red purple, weathers grayish red, poor fissility, forms slope; quartzite, very dusky red purple, weathers dusky red, thin bedded, well sorted, very fine grained, grains subrounded to rounded, forms resistant ledges up to 20 cm thick.	2
	Total thickness of Inkom Formation	93
	Caddy Canyon Quartzite	
8	Quartzite, light brown, weathers brown, massively bedded, poorly sorted, medium to very coarse grained, grains subangular to rounded, forms cliff.	3
7	Phyllitic shale and siltstone interbedded, grayish red purple, weathers grayish red, thin bedded, well sorted, forms ledgy slope.	2
6	Quartzite, pale yellowish orange, weathers very pale orange, massively bedded, average sorting, medium to coarse grained, grains subrounded to rounded, forms cliff.	4
5	Phyllitic shale, grayish red purple, weathers grayish red, quite fissile, forms slope.	2
4	Phyllitic shale, light olive gray, weathers dusky yellow, quite fissile, forms slope.	1
3	Phyllitic shale, same as unit 5.	1
2	Quartzite, same as unit 6.	3
1	Phyllitic shale and siltstone interbedded, same as unit 7.	3
	Measured thickness of Caddy Canyon Quartizte	19

APPENDIX B

Continuous measured section of the Tertiary-Cretaceous conglomerate through the Cambrian formations to the Precambrian Mutual Formation in the northern Canyon Range within the Champlin Peak Quadrangle. Section begins in the SE¼ of section 10, T. 15 S, R. 3 W, at the alluvial valley fill contact with the conglomerate.

Unit	Description	Meters
	Conglomerate of Leamington Pass	
71	Conglomerate; 30% matrix: sandstone, pale red, weathers dark gray purple, coarse grained, poorly sorted, angular to subangular quartz grains, noncalcareous; 70% clasts: all quartzite, very pale orange clasts are fine grained, well sorted, rounded to subrounded quartz grains, laminated; pale red to dark red clasts are coarse grained to conglomeratic, poorly sorted, angular to subangular quartz grains, laminated; clasts round, up to 40 cm in diameter, outcrop forms ledgy slope.	3

70	Covered slope.	39
69	Conglomerate; same as unit 71.	58
68	Conglomerate; 20% matrix: sandstone, pale red, weathers dark red, medium to coarse grained, poorly sorted, subangular quartz grains, noncalcareous; 80% clasts: all quartzite, very light gray to very pale orange clasts are fine grained, well sorted, rounded to subrounded quartz grains, laminated; gray purple clasts are medium to coarse grained, poorly sorted, subangular to subrounded quartz grains, laminated; clasts are subrounded to rounded, up to 50 cm in diameter, outcrop forms ledgy slope and rounded ledges. Occasional sandstone lenses up to 1 m thick and 3 m wide, contain ing sandstone same as matrix.	14
67	Covered slope.	28
66	Conglomerate, same as unit 68.	52
65	Conglomerate; 10% matrix, 90% clasts, same as unit 68.	144
64	Covered slope.	101
63	Conglomerate; 5% matrix: sandstone, pale red, fine to medium grained, poorly sorted, subangular quartz grains, noncalcareous; 95% clasts: all quartzite, very light gray clasts are fine grained, well sorted; dark gray purple to dark red clasts are coarse grained, poorly sorted, subrounded quartz grains, commonly laminated; clasts are rounded up to 1 m in diameter. Unit forms low-lying ledges and ledgy slope.	55
62	Conglomerate; 60% matrix: sandstone, very pale orange, medium to coarse grained, poorly sorted, noncalcareous, subangular quartz grains, high permeability; 40% clasts: all quartzite, very light gray clasts are fine grained, well sorted, rounded quartz grains; gray red clasts are coarse grained, poorly sorted, subangular quartz grains, laminated; clasts are rounded up to 15 cm in diameter, generally not in contact. Outcrop forms low-lying patches in curved slope.	24
61	Conglomerate; 5% matrix: sandstone, grayish yellow, medium to coarse grained, poorly sorted, subangular quartz grains, noncalcareous, high permeability; 95% clasts: all quartzite, very light gray to very pale yellow clasts are fine grained, well sorted; pale red clasts are coarse grained, poorly sorted, laminated; clasts form round cobbles and boulders up to 2 m in diameter. Outcrop forms rounded ledges, major ridge former in area.	8
60	Covered slope.	9
59	Conglomerate, same as unit 61 with occasional dark red purple quartzite clasts up to 1 m in diameter.	38
58	Conglomerate, same as unit 61.	61
57	Covered slope.	4
56	Conglomerate; 40% matrix: sandstone, pale red, fine to medium grained, poorly sorted, subangular quartz grains, calcareous, high permeability; 60% clasts: all limestone, medium gray to pale red forming round clasts up to 15 cm in diameter. Occasional pale pink quartzite pebbles. Outcrop forms low-lying patches in curved slope.	14
55	Covered slope.	19
54	Conglomerate; 30% matrix: sandstone, pale red, fine to medium grained, poorly sorted, subangular quartz grains, calcareous, high permeability; 70% clasts: 60% quartzite, very light gray to very pale red, forming round clasts up to 20 cm in diameter, fine to medium grained, well sorted with occasional poorly sorted sandstone clasts; 40% limestone, medium gray, forming round clasts up to 30 cm in diameter. Outcrop forms low-lying ledges.	8
53	Covered slope.	8
52	Conglomerate; 30% matrix: sandstone, pale red, fine to medium grained, poorly sorted, subangular to subrounded quartz grains, calcareous; 70% clasts: 90% limestone, medium light gray, forming subrounded clasts up to 30 cm in diameter; 10% quartzite, very light gray, fine to medium grained, well sorted, form-round clasts up to 1 m in diameter. Outcrop forms low-lying patches in rounded slope.	6
51	Covered slope.	12
50	Conglomerate; 20% matrix: sandstone, pale red, medium to coarse grained, poorly sorted, subangular quartz and limestone grains, calcareous; 80% clasts: 60% quartzite, very light gray to very pale pink, medium grained, well sorted, round quartz grains, forming subrounded clasts up to 2 m in diameter; 40% limestone, medium light gray, forming subrounded clasts up to 50 cm in diameter. Unit forms ledgy slope.	8
49	Conglomerate; 10% matrix: sandstone, very light gray, fine to medium grained, poorly sorted, subangular quartz and limestone grains; calcareous; 90% clasts: all limestone, medium gray, forming subangular to subround clasts up to 20 cm in diameter, occasional sandy laminae. Occasional light pink quartzite granules and pebbles. Outcrop expressed as low-lying ledges in covered slope.	4
48	Covered slope.	13
47	Conglomerate; 5% matrix: sandstone, pale red, medium to coarse grained, poorly sorted, calcareous, subangular quartz and limestone grains, occasional rugose coral fragments; 95% clasts: 80% limestone, medium light gray with occasional sandy laminae, forming subrounded clasts up to 30 cm in diameter; 20% quartzite, very light gray to very pale orange, medium grained, well sorted, subrounded quartz grains, forming rounded to subrounded clasts up to 70 cm in diameter. Unit forms ledgy slopes.	4
46	Conglomerate; 20% matrix: sandstone, light gray, medium gray, poorly sorted, subangular quartz grains, calcareous, high permeability; 80% clasts: 60% quartzite, pale red to very pale orange, medium to coarse grains, well sorted, forming subrounded clasts up to 1 m in diameter; 40% limestone, medium light gray, forming subangular clasts up to 70 cm in diameter. Occasional lenticular sandstone bodies up to 20 cm thick and 2 m wide. Unit forms ledgy slope.	15
45	Conglomerate; 10% matrix: sandstone, light pink, fine grained, poorly sorted, subangular grains, calcareous; 90% clasts: 85% limestone, medium light gray, forming subangular to subrounded clasts up to 40 cm in diameter, rugose coral occasionally found in larger limestone cobbles; 15% sandstone, pale orange, medium grained, well sorted, noncalcareous, forming subangular clasts up to 10 cm in diameter. Outcrop forms ledgy slope.	11
44	Conglomerate; 15% matrix: sandstone, very light gray to very pale orange, medium grained, poorly sorted, subrounded to rounded grains, noncalcareous, high permeability; 85% clasts: all quartzite, very light gray to very pale orange, well sorted, subrounded grains, laminated, forming subangular to subrounded clasts up to 2 m in diameter. Unit forms rounded ledges, laterally extensive.	10
43	Conglomerate; 5% matrix: sandstone, medium orange pink, medium grained, poorly sorted, subangular grains, calcareous; 95% clasts: 90% limestone, light gray, subangular to subrounded clasts up to 30 cm in diameter; 10% sandstone, very light gray, medium grained, poorly sorted, subangular quartz grains, calcareous, forming subrounded clasts up to 5 cm in diameter. Occasional light pink quartzite granules. Unit forms ledgy slope, laterally extensive.	14
42	Limestone block in conglomerate, medium dark gray, weathers light gray to medium light gray, massive, limonite stains and calcite coating in fractures, solution pitted on weathered surface, forms rounded ledge.	8
41	Conglomerate; calcareous cement, 85% medium gray limestone clasts, 10% medium orange pink	95

	quartzite clasts, 5% poorly sorted quartzose sandstone clasts; clasts are 10% 20 cm–1 m, 10% 5–20 cm, and 70% 2–5 cm in diameter; clasts are rounded to subangular. Highly fractured around clasts, forms ledgy slope.	
40	Conglomerate; calcareous cement, 90% medium gray limestone clasts, 10% calcareous sandstone clasts; clasts are 10% 5–20 cm, 90% 2–5 cm in diameter; clasts are rounded to subangular. Highly fractured around clasts, forms ledgy slope.	30
39	Limestone block in conglomerate, medium dark gray, weathers medium light gray, bedded to massively bedded, forms ledge, abundant pisolitic bodies.	15
38	Conglomerate; calcareous cement, 60% medium gray limestone clasts, 35% pale red quartzose sandstone clasts, 5% grayish orange pink quartzite clasts, clasts are 5% 10–40 cm, 10% 5–10 cm, 85% 2–5 cm in diameter. Limonite stains common in fractures, forms rounded ledges and ledgy slopes. Contact with Cambrian undifferentiated limestone and dolomite is angularly unconformable.	120
	Total thickness of Tertiary-Cretaceous conglomerate	1051
	Undifferentiated Cambrian carbonate rocks	
37	Dolomite, pale red purple, weathers grayish orange pink, massive, calcite nodules and lenses throughout, forms ledgy slope with blocky dolomite and limestone talus. Upper contact with conglomerates is angularly unconformable.	28
36	Limestone, pale red, weathers pinkish gray, massive, crystalline calcite fills vertical fractures, hematite and limonite stains throughout; 40% dolomite interbeds up to 12 m thick, medium light gray, weathers grayish orange, entire unit forms slope with blocky limestone and dolomite talus, crystalline calcite forms irregular laminae in places, sharp lower contact.	79
	Total thickness of undifferentiated Cambrian carbonate rocks	107
	Wheeler Shale	
35	Shale, light olive gray to olive gray, weathers pale yellow brown, slightly calcareous in places, 10% calcareous siltstone interbeds are up to 1 m thick, 20% medium gray limestone interbeds up to 2 m thick, forms slope covered by platy talus, *Elrathina, Peronopsis,* and sponge spicules abundant.	30
	Total thickness of Wheeler Shale	30
	Swasey Limestone	
34	Limestone, medium dark gray, weathers medium light gray, massive bedded to bedded, forms ledge, 5% light brown silty laminae parallel to bedding, some calcite filling fractures, sharp lower contact.	59
33	Limestone, dark gray, weathers medium gray, massive bedded to bedded, forms ledge, 5% light brown silty laminae parallel to bedding, some calcite filling fractures. Upper 5 m consist of very thin bedded light gray silty limestone.	26
32	Limestone, medium dark gray, weathers medium light gray, massive bedded to bedded, forms ledge, 5% light brown silty laminae parallel to bedding, some calcite filling fractures, sharp lower contact.	101
	Total thickness of Swasey Limestone	186
	Whirlwind Formation	
31	Shale, olive gray, weathers yellow gray, slightly silty, calcareous, 5% *Ehmaniella* trilobite hash common in limestone interbeds of upper 30 m, trace fossils common in lower 20 m, forms slope with platy shale and blocky limestone talus, sharp lower contact.	44
	Total thickness of Whirlwind Formation	44
	Dome Limestone	
30	Limestone, medium dark gray to medium gray, weathers light gray, massive bedded to irregularly bedded, 5% light brown silty laminae parallel to bedding, forms ledgy slope to ledge, ridge former, 5% shale interbeds up to 3 m thick in upper portion, gradational lower contact.	55
	Total thickness of Dome Limestone	55
	Chisholm Formation	
29	Shale, olive gray, weathers light olive gray, micaceous, 35% limestone interbeds up to 3 m thick, medium gray, weathers light gray, irregularly bedded, abundant onkolites, 1–2 cm in diameter, stained with hematite and limonite, trace fossils and *Glossopleura* trilobite hash abundant, forms ledgy slope.	75
	Total thickness of Chisholm Formation	75
	Howell Limestone	
28	Limestone, medium dark gray, weathers medium gray, massively bedded, 5% interbedded siltstone partings, forms cliff, weathered surface solution pitted, hackly, with light brown, irregularly shaped, silty markings common, forms cliff.	39
27	Limestone, medium light gray, weathers light gray, massive to irregularly bedded, some siltstone partings, abundant onkolites, 0.5–2 cm in diameter, frequently stained with limonite, weathered surface solution pitted, forms cliff.	53
	Total thickness of Howell Limestone	92
	Pioche Formation	
26	Shale, olive gray, weathers light olive gray, calcareous, very micaceous, some phyllitic siltstone interbeds up to 20 cm thick, trace fossils abundant, forms slope.	25
25	Quartzite, grayish orange, weathers dusky yellowish brown, fine to medium grained, massively bedded, tubular *Skolithus* burrows up to 0.5 cm in diameter common, forms ridge.	14
24	Shale, olive gray, weathers light olive gray, calcareous, very micaceous to phyllitic, with 10% phyllitic siltstone interbeds up to 40 m thick and 5% grayish orange quartzite interbeds up to 80 cm thick, trace fossils abundant, forms slope.	35
23	Quartzite, grayish orange, weathers dusky yellowish brown, fine to medium grained, massively bedded, common tubular *Skolithus* burrows up to 0.5 cm in diameter, forms ridge.	20
22	Covered slope, blocky quartzite talus on gray clay colluvium.	44
21	Shale, olive gray, weathers light olive gray, calcareous, very micaceous to phyllitic, with 10% siltstone interbeds up to 40 cm thick, trace fossils abundant, forms slope.	9
20	Shale, olive gray, weathers light olive gray, calcareous, very micaceous to phyllitic, with 35% grayish orange quartzite interbeds up to 1 m thick, trace fossils abundant, forms slope.	29
19	Quartzite, grayish orange, weathers grayish brown, medium to coarse grained, massive, forms ledgy slope, rounded to subangular grains, horizontal and vertical fracturing, 30% micaceous shale interbeds, pale olive, weathers grayish yellow green, up to 25 cm thick, 5% phyllitic siltstone, trace fossils common.	20
18	Quartzite, grayish red purple, weathers moderate yellowish brown, medium grained, massive, alternating gray and grayish red laminae, forms ledgy slope with blocky quartzite talus, 10% moderate to light olive gray phyllitic shale interbeds up to 5 cm thick, shale interbeds increase to base of unit, gradational lower contact.	21
17	Quartzite, pale reddish purple, weathers dark yellowish orange, medium to coarse grained, massive, 10% alternating gray and pale reddish purple laminae, some cross-bedding up to 3 cm thick, horizontal and vertical fracturing, forms ledgy slope,	11

	dark gray shale chips in talus, very micaceous.	
	Total thickness of Pioche Formation	228
	Tintic Quartzite	
16	Quartzite, pale reddish purple, weathers dark yellowish orange, medium to coarse grained, massive, 10% alternating gray and pale reddish purple laminae, some cross-bedding up to 3 cm thick, horizontal and vertical fracturing, forms ledgy slope, micaceous shale chips not present in talus.	62
15	Quartzite, pale reddish purple, weathers dark yellowish orange, medium grained, rounded to subangular grains, massive, 10% alternating gray and pale reddish purple laminae, some cross-bedding up to 3 cm thick, horizontal and vertical fracturing, forms ledgy slope.	7
14	Quartzite, pale reddish purple, weathers dark yellowish orange, medium to coarse grained, subrounded to subangular grains, some cross-bedding up to 5 cm thick, horizontal and vertical fracturing, forms ledge.	63
13	Quartzite, moderate orange pink, weathers dark yellowish orange, fine to medium grained, massive, 5% alternating gray and moderate orange pink laminae, rounded to subangular grains, forms ledgy slope with blocky quartzite talus.	149
12	Quartzite, grayish red purple, massive, 10% alternating gray and grayish red purple laminae, 20% cross-bedding up to 4 cm thick, horizontal and vertical fracturing, rounded to subangular grains, forms ledgy slope with blocky quartzite talus.	264
11	Quartzite, grayish orange pink weathers dark yellow orange, medium to very coarse grained, massive, 40% cross-bedding up to 10 cm thick, 20% alternating gray and grayish orange laminae, 5% pebble conglomerate interbeds up to 2 m thick, forms ledgy slope. Lower 30 cm consist of pale pink, medium grained quartzite.	60
10	Quartzite, same as unit 11.	173
9	Quartzite, grayish pink, weathers grayish orange pink, medium to very coarse grained, 5% cross-bedding up to 5 cm thick, 5% alternating color laminae, 10% conglomerate interbeds up to 2 m thick, forms ledgy slope with block quartzite talus.	57
	Total thickness of Tintic Quartzite	835
	Mutual Formation	
8	Quartzite, pale reddish purple to grayish red purple, medium to coarse grained, massive, rounded grains, vertical fracturing, 5% cross-bedding up to 5 cm thick, 10% conglomerate interbeds up to 3 m thick.	12
7	Conglomerate, medium red, 50% rounded to subangular quartz granules, 5% quartz grains, pebbles fractured, 5% cross-bedding up to 6 cm thick, forms ledgy slope.	5
6	Quartzite, pale red to grayish red purple, medium to very coarse grained, massive, highly fractured and jointed, 20% conglomerate interbeds up to 1 m thick with 1% rounded quartz pebbles, 80% rounded to subangular granules, fractures pass through grains, forms ledgy slope.	5
5	Covered slope, blocky quartzite talus on grayish red colluvium.	15
4	Quartzite, grayish red purple, weathers light brown, medium grained, massive, highly fractured and jointed, conglomerate interbed in upper 2 m with 1% rounded quartz pebbles and 80% rounded quartz granules, fractures pass through grains, forms ledge.	15
3	Covered slope, blocky quartzite talus on pale red colluvium.	180
2	Covered slope, Lake Bonneville deposits, very light gray to yellowish gray, laminated silt and clay.	10
1	Quartzite, grayish red purple, weathers dusky red, fine grained, thin to thick bedded, 5% cross-bedding up to 6 cm thick, forms ledge. Lower contact is with Sevier River alluvium. SE¼, section 31, T. 14 S, R. 3 W.	125
	Measured thickness of Mutual Formation	367

REFERENCES CITED

Armstrong, R. L., 1968, Sevier orogenic belt in Nevada and Utah: Geological Society of America Bulletin, v. 79, p. 429–58.

Burchfiel, B. C., and Hickcox, C. W., 1972, Structural development of central Utah: Utah Geological Association Publication 2, p. 55–67.

Campbell, J. A., 1979, Middle to Late Cenozoic stratigraphy and structural development of the Canyon Range, central Utah: Utah Geology, v. 6, no. 1, p. 1–16.

Christiansen, F. W., 1952, Structure and stratigraphy of the Canyon Range, central Utah: Geological Society of America Bulletin, v. 63, no. 7, p. 717–40.

Christie-Blick, N., 1982, Upper Proterozoic and Lower Cambrian rocks of the Sheeprock Mountains, Utah: regional correlation and significance: Geological Society of America Bulletin, in press.

Costain, J. K., 1960, Geology of the Gilson Mountains and vicinity, Juab County, Utah: Ph.D. dissertation, University of Utah, Salt Lake City, 178p.

Eardley, A. J., 1969, Charting the Laramide structures of western Utah: Utah Geological and Mineralogical Survey Bulletin, v. 82, p. 51–70.

Hintze, L. F., 1972, Lower Paleozoic strata in central Utah: Utah Geological Association Publication 2, p. 7–13.

Hintze, L. F., and Robison, R. A., 1975, Middle Cambrian stratigraphy of the House, Wah Wah, and adjacent ranges in western Utah: Geological Society of America Bulletin, v. 86, p. 881–91.

Loughlin, G. F., 1914, A reconnaissance in the Canyon Range, west-central Utah: U.S. Geological Survey Professional Paper 90-F, p. 51–60.

Morris, H. T., 1977, Geologic map and sections of the Furner Ridge Quadrangle, Juab County, Utah: U.S. Geological Survey Miscellaneous Investigation Series Map I-1045.

Morris, H. T., Douglass, R. C., and Kopf, R. W., 1977, Stratigraphy and microfaunas of the Oquirrh Group in the southern East Tintic Mountains, Utah: U.S. Geological Survey Professional Paper 1025, 22p.

Morris, H. T., and Kopf, R. W., 1969, Tintic Valley thrust and associated low-angle faults, central Utah (abs.): Abstracts with Programs for 1969, Geological Society of America, Rocky Mountain Section, 22nd Annual Meeting, p. 55–56.

Morris, H. T., and Lovering, T. S., 1979, General geology and mines of the East Tintic mining district, Utah and Juab Counties, Utah: U.S. Geological Survey Professional Paper 1024, 203p.

Morris, H. T., and Shepard, W. M., 1964, Evidences for a concealed tear fault with large displacement in the central East Tintic Mountains, Utah: U.S. Geological Survey Professional Paper 501-C, p. 19–21.

Moulton, F. C., 1977, Lower Mesozoic and Upper Paleozoic petroleum potential of the Hingeline Area, central Utah: Brigham Young University Geology Studies, v. 24, pt. 1, p. 1–11.

Stolle, J. M., 1978, Stratigraphy of the Lower Tertiary and Upper Cretaceous(?) continental strata in the Canyon Range, Juab County, Utah: Brigham Young University Geology Studies, v. 25, pt. 3, p. 117–39.

Swank, W. J., Jr., 1978, Structural history of the Canyon Range Thrust, central Utah: Master's thesis, The Ohio State University, Columbus.

Wang, Y. F., 1970, Geological and geophysical studies of the Gilson Mountains and vicinity, Juab County, Utah: Ph.D. dissertation, University of Utah, Salt Lake City, 196p.