Geology of the Southwestern Quarter of the Scipio North (15-Minute) Quadrangle, Millard and Juab Counties, Utah*

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ABSTRACT.–The southern Canyon Range, which occupies most of the quadrangle, is composed of an older Canyon Range allochthon, thrust over a younger Pavant allochthon, which is in turn thrust over autochthonous Precambrian through Paleozoic rocks. This thrust-on-thrust relationship best explains the development of the Canyon Range syncline. Only the Canyon Range thrust is exposed at the surface in this area. Stratigraphic and cross-sectional analyses have reaffirmed the thrust relationship of the western exposure of the Canyon Range thrust.

Northwest- and northeast-trending normal faults in the area suggest a transitional episode of faulting between the Sevier orogeny and later basin-and-range faulting.

Stratigraphic units mapped include Precambrian Upper Pocatello Formation (?), 248 m thick; Blackrock Canyon Limestone (?), 169 m thick; Caddy Canyon Quartzite, 585 m thick; Inkom Formation, 84 m thick; and Mutual Formation, 530 m thick; Cambrian Tintic Quartzite, 835 m thick; and middle and upper carbonate rocks undivided, 855 m thick; Ordovician Pogonip Group, 400 m thick; Kanosh Shale, 113 m thick; Eureka Quartzite, 68 m thick; and Fish Haven Dolomite, 42 m thick; Silurian Laketown Dolomite, 333 m thick; Devonian Sevy Dolomite, 830 m thick; Simonson Dolomite, 236 m thick; and Cove Fort Quartzite, 77 m thick; Upper Cretaceous to Tertiary Canyon Range Formation, 0–500 m thick; Oligocene Goldens Ranch Formation, 40+ m thick; and Fool Creek Conglomerate, 0–1163 m thick; Miocene Oak City Formation, 0–490 m thick; and Quarternary older fanglomerate and younger alluvium and colluvium.

INTRODUCTION

The southwestern quarter of the Scipio North 15-Minute Quadrangle covers a portion of the Canyon Range, which exposes the Canyon Range thrust fault (Christiansen 1952), previously undivided Upper Precambrian rocks, an undescribed lower Paleozoic section more than 2,000 m thick, and thrust-related conglomerates and postthrust sediments (Campbell 1979). Recently Swank (1978) questioned the thrust relationship of the western exposure of the Canyon Range thrust, deeming it more likely a normal fault. Careful investigation of stratigraphic and cross-section relationships of this fault exposure is one emphasis of this thesis. Better delineation of the stratigraphy was needed to clarify these relationships; thus, better definition of the Precambrian and Paleozoic stratigraphy of the Canyon Range is a second emphasis of this thesis.

Location and Accessibility

The edge of the quadrangle is located 2 km northwest of Scipio, Utah, and approximately 30 km east of Delta, Utah. Access is shown in figure 1, and improved dirt roads and trails are shown on figure 4. No road crosses the southern Canyon Range; with 1200 m of relief many areas are accessible only on foot.

PREVIOUS WORK

Loughlin (1914) conducted a brief reconnaissance of the Canyon Range, mistakenly concluding that its stratigraphy consisted almost entirely of Carboniferous limestone and quartzite overlain unconformably by Eocene conglomerate. Christiansen (1952) mapped Canyon Range strata as Precambrian, Cambrian (including Tintic Quartzite, Ophir Formation, and undifferentiated Upper Cambrian dolomite and limestone), Cretaceous Indianola Group, Upper Cretaceous to Paleocene North Horn Formation, Oligocene (?) Fool Creek Conglomerate, Pliocene (?) lava flows and pyroclastic rocks, Pleistocene Lake Bonneville deposits, and Recent alluvium and eolian deposits. He identified a zone of normal faults in the eastern piedmont of the range, a system of folds, and the Canyon Range thrust. Armstrong (1968), in studying the Sevier orogenic belt, challenged earlier assigned ages of the conglomerates in the range. He argued for an age somewhere between the Cretaceous Indianola Group and the Eocene Flagstaff Formation. Stolle (1978) agreed that the conglomerates could not be correlated with the Indianola Group. He informally called them the Canyon Range Formation, showing two

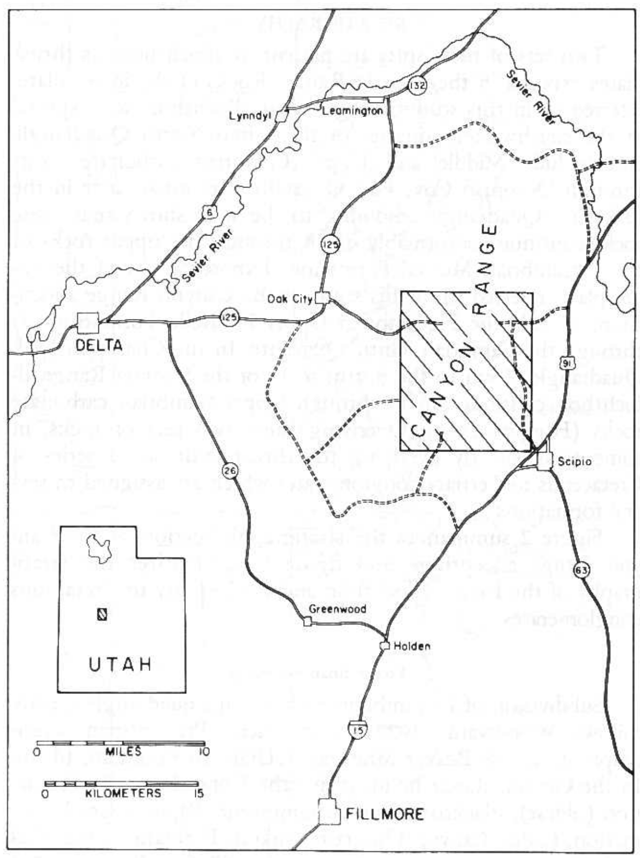

FIGURE 1.–Index map to southwestern quarter of the Scipio North 15-Minute Quadrangle.

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mappable units. Swank (1978), in deciphering the structural history of the Canyon Range, outlined six phases of development. Within this framework he challenged the thrust relationship of the fault on the west side of the Canyon Range allochthon. He cited geometric considerations that led him to consider it as a steeply dipping normal fault. Campbell (1979) described the Cenozoic depositional, structural, and erosional history of the Canyon Range. Higgins (1982) studied the Canyon Range stratigraphy exposed in the Champlin Peak Quadrangle at the north end of the range. She determined that Lower and Middle Cambrian strata of the upper thrust plate best correlated to formations exposed in the House Range, Utah.

GEOLOGIC SETTING

The southwestern quarter of the Scipio North Quadrangle lies in an area of geologic transition in central Utah, along the provincial boundary between the Colorado Plateau, to the east, and the Basin and Range, to the west. Late Precambrian and Paleozoic miogeosynclinal rocks of the Canyon Range have been transported to their present position by thrust faulting associated with the Mesozoic Sevier orogeny. Because the Canyon Range lies along central Utah's thrust belt and between a broad miogeosynclinal belt to the west and Paleozoic platform areas to the east, its geologic setting has been referred to variously as the transition zone, the hingeline, and the overthrust belt.

STRATIGRAPHY

Two sets of rock units are present in allochthonous thrust plates exposed in the Canyon Range. Rocks of the lower plate, referred to in this study as the Pavant allochthon, are exposed in the southwestern quarter of the Scipio North Quadrangle and include Middle and Upper Cambrian carbonate rocks through Devonian Cove Fort Quartzite. Reconnaissance in the Oak City Quadrangle adjoining to the west shows that these rocks continue conformably down through the upper rocks of the Precambrian Mutual Formation. Exposed rocks of the upper plate, referred to in this study as the Canyon Range allochthon, include the Precambrian Upper Pocatello Formation (?) through the Cambrian Tintic Quartzite. In the Champlin Peak Quadrangle, 7 km to the north, rocks of the Canyon Range allochthon continue on up through Upper Cambrian carbonate rocks (Higgins 1982). Overlying these two sets of rocks, in some areas directly overlying the thrust fault, are a series of Cretaceous to Tertiary conglomerates which are assigned to several formations.

Figure 2 summarizes the stratigraphic section of the Canyon Range allochthon, and figure 3 summarizes the stratigraphy of the Pavant allochthon and the Tertiary to Cretaceous conglomerates.

Precambrian System

Subdivision of Precambrian rocks in this quadrangle mostly follows Woodward (1972), who traced Precambrian stratigraphy from the Beaver Mountains, Utah, to Pocatello, Idaho. In the Canyon Range he identified the Upper Pocatello Formation (oldest), Blackrock Canyon Limestone, Papoose Creek Formation, Caddy Canyon Quartzite, Inkom Formation, and Mutual Formation (youngest) (fig. 2). Christie-Blick (1982) challenged Woodward's identification of formations below the Caddy Canyon Quartzite because these units are not continuous across the Sheeprock Mountains, 70 km north of the Canyon Range. He suggested all rocks below the Inkom Formation are equivalent to the Caddy Canyon Quartzite.

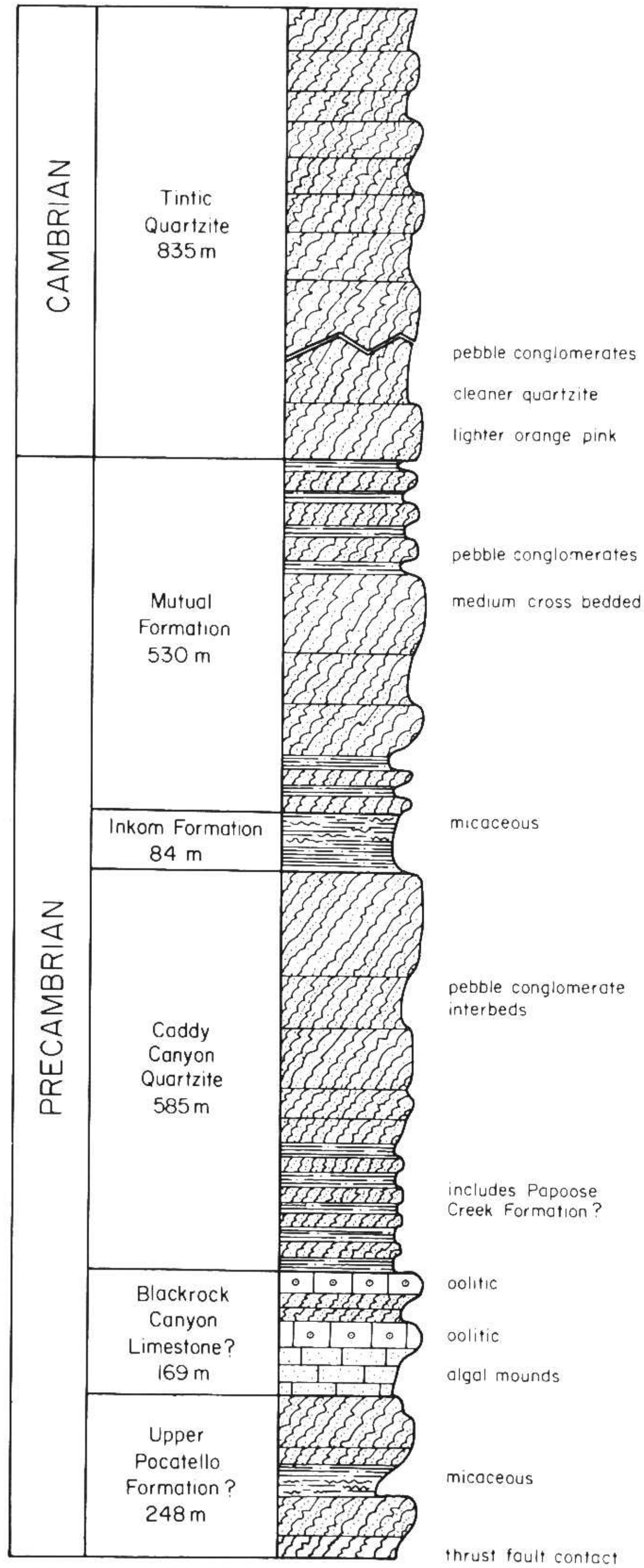

FIGURE 2. Stratigraphic column of the Canyon Range allochthon.

The nearest Precambrian limestones similar to those in the Canyon Range are found in the southern Wah Wah Mountains (Abbott and others 1981). Mapping of these units has followed Woodward's (1972) nomenclature. These limestones, while perhaps correlatable to the Caddy Canyon Quartzite, as suggested by Christie-Blick (1982), have a lithology quite atypical of rocks assigned to the Caddy Canyon Quartzite. My nomenclature follows Woodward (1972) but with a question mark on the lower two units indicating doubt as to exact correlation with rocks near Pocatello, Idaho.

These Late Precambrian rocks occur in this quadrangle on the Canyon Range allochthon, though reconnaissance in the

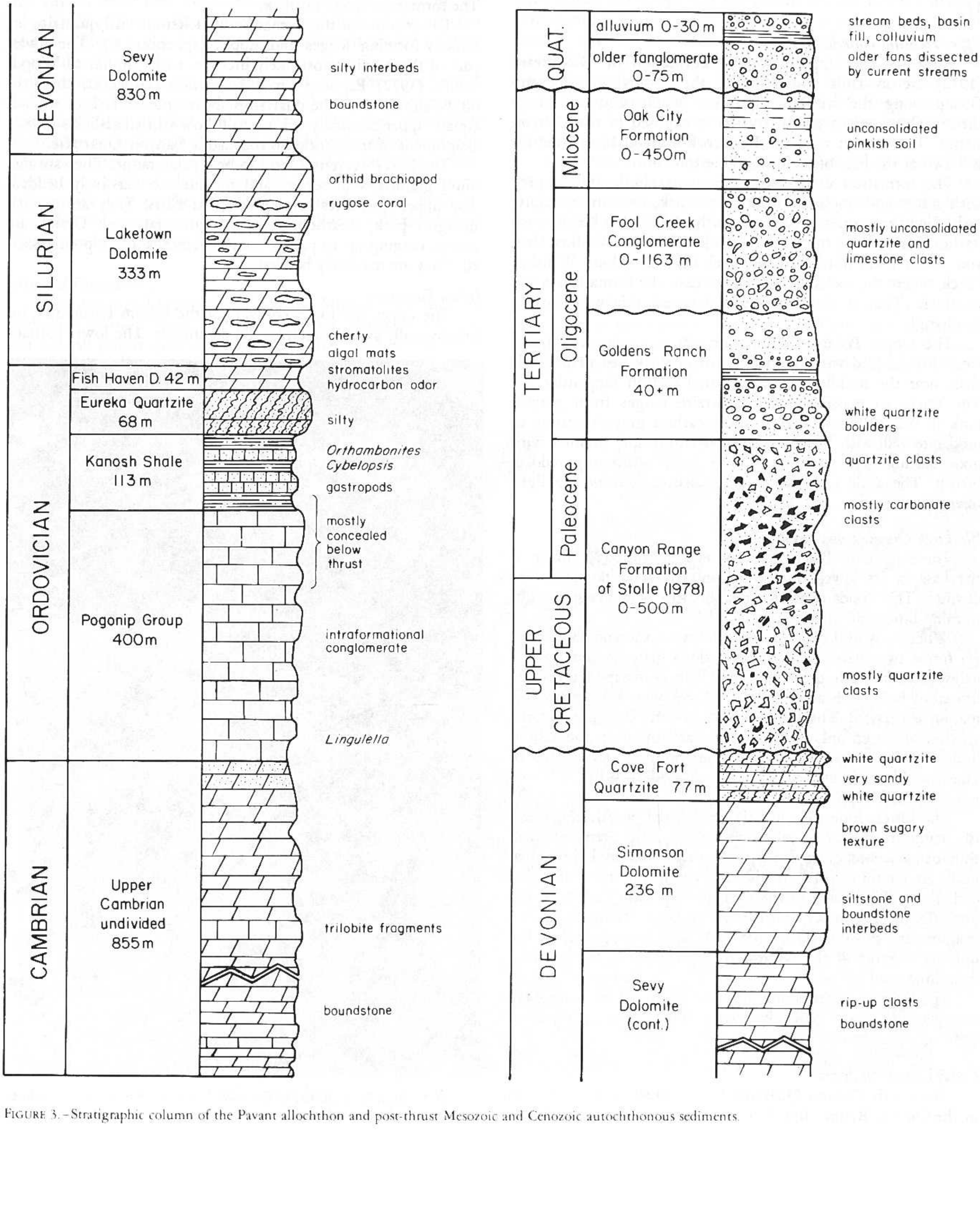

FIGURE 3.–Stratigraphic column of the Pavant allochthon and post-thrust Mesozoic and Cenozoic autochthonous sediments.

Oak City Quadrangle, directly to the west, shows exposures of the Mutual Formation also occur on the Pavant allochthon; any lower units are concealed by Cenozoic deposits. This Late Precambrian sequence is conformable throughout and conformably grades into the Cambrian sequence above. The rocks of the Canyon Range allochthon are folded into a syncline, which ranges from a broad fold along Oak Creek Canyon to a tight, overturned fold along Dry Creek to Bear Hollow (figs. 4, 17).

Upper Pocatello Formation (?)

Rocks of the Upper Pocatello Formation of Woodward (1972) are in fault contact with the Ordovician Pogonip Group along the western exposures of the Canyon Range thrust. Thus, only a partial section is exposed in the Canyon Range. The contact with the Blackrock Canyon Limestone (?) is drawn at the base of its lowest limestone unit.

The formation erodes to valleys and saddles interrupted with ridges and hogbacks formed by thick, resistant quartzite beds. Good exposures occur just north of Whiskey Creek, near its head, and along the western flanks of North Walker Canyon, about 1 km north of Oak Creek Canyon. Along Whiskey Creek, where the rocks dip 60° to the east, the formation is 248 m thick. This is the maximum exposed thickness in the quadrangle.

The Upper Pocatello Formation (?) is a mixture of siltstone interbedded with quartzite, with a thick bed of phyllitic shale near the middle of the measured section (appendix A). The thick- to massive-bedded quartzite ranges from grayish pink to pale yellowish orange and weathers grayish orange to moderate yellowish brown. The quartzite is fine grained with good sorting. The siltstone is olive gray, weathering reddish brown. The shale is moderate olive brown, weathering light olive gray.

Blackrock Canyon Limestone (?)

The base of the Blackrock Canyon Limestone (?), drawn at the base of its lowest limestone unit, is topographically indistinct. The upper contact is at the top of a massive, cliff-forming limestone unit.

Where it is well exposed, the Blackrock Canyon Limestone (?) forms two massive cliffs with a slope between them and a ledgy slope beneath the lower cliff. The best exposure of the limestone is at the head of Whiskey Creek where the entire formation is exposed. The formation occurs on both limbs of the syncline although only partial sections are found on the eastern limb. The best exposure of the eastern limb is at the head of Hardscrabble Canyon. The section measured at Whiskey Creek is 169 m thick (appendix A).

The lowest limestone unit is grayish red, weathering grayish orange to moderate yellowish brown. It is coarse grained, thin bedded, and quite sandy. Structures that look like algal heads are common (fig. 5). The upper two limestone units are darker gray. The lower of the two consists mainly of small oolites (fig. 6). The upper unit is made of larger, complex oolites, pisolites, and possible algae (figs. 7, 8). Calcite crystals form the nucleus of most of the oolites; they most likely recrystallized from lime mud.

The upper two limestone units are separated by a thin-bedded quartzite that is generally grayish orange, weathering moderate yellowish brown.

Caddy Canyon Quartzite

The Caddy Canyon Quartzite forms conspicuous exposures in the Canyon Range (figs. 9, 10). Its upper and lower contacts are well exposed in most areas. The lower contact is drawn at the top of the uppermost cliff-forming limestone unit of the Blackrock Canyon Limestone (?). Its upper contact is a distinct, geomorphically expressed boundary between the uppermost, massive quartzite bed that usually forms a dip-slope and the recessive silty shales of the Inkom Formation above. The Caddy Canyon Quartzite forms large cliffs and broad dip-slopes throughout the range on both limbs of the syncline. The formation is 585 m thick.

Lower units of the formation are siltstone and quartzite interbeds forming ledges and slopes (appendix A). The lower part of these units most likely includes rocks similar to Woodward's (1972) Papoose Creek Formation. However, the lithologic similarity to the quartzites above and the lack of any adequate upper boundary led me to follow Christie-Blick's (1982) assignment of these rocks to the Caddy Canyon Quartzite.

The lower quartzites tend to be a pale orange. They are medium grained, well sorted, and medium to massively bedded. The upper quartzites form prominent cliffs. They are grayish orangish pink, weathering pale to moderate red. Grains are coarse, ranging up to pebbly conglomerate, and are poorly sorted. They are massively bedded.

Inkom Formation

The upper and lower contacts of the Inkom Formation are lithologically and topographically distinctive. The lower contact

FIGURE 5.—Algal head (arrow) in the lower limestone unit of the Precambrian Blackrock Canyon Limestone (?), north of Whiskey Creek.

is placed at the top of the yellowish orange to orangish pink, massive Caddy Canyon Quartzite, commonly above a dip-slope surface. The upper contact is drawn where reddish purple quartzite beds of the Mutual Formation dominate over interbedded shaly units.

The Inkom Formation forms a slope or saddle between resistant quartzite units on both limbs of the syncline. It commonly forms strike valleys filled with alluvium that conceals the Inkom beds. Best exposures of Inkom beds are along the upper half of Lyman Canyon, on the east limb of the syncline (fig. 9). There rocks dip 30° to the west and are 84 m thick (appendix B).

The lower units are more silty and are light olive brown, weathering yellowish gray to medium olive brown. Upper units are much more phyllitic and are light olive gray, weathering light olive to yellowish gray. The middle units are quite fissile. Quartzite interbeds increase near the top. The variation in placing these quartzite beds, either in the top of the Inkom Formation or the base of the Mutual Formation, is most likely responsible for variations in reported thicknesses of the Inkom Formation by various authors.

Mutual Formation

The upper and lower contacts of the Mutual Formation are indistinct in most areas. The lower contact, drawn at the lowest reddish purple quartzite interbed greater than 30 cm thick, is widely obscured by alluvium in stream valleys formed along the Inkom Formation. The upper contact is placed at the upper limits of interbedded shale and quartzite, where colors change from reddish purple to the grayish orangish pink of the Tintic Quartzite.

The Mutual Formation forms cliffs and peaks of the highlands of the Canyon Range. It is commonly the uppermost unit of the Canyon Range allochthon in this area and occurs on both limbs of the syncline. Its lower and upper portions form ledges and slopes, but the middle section forms a massive cliff throughout the range and is well exposed along Lyman Canyon (fig. 9). The measured section of Mutual Formation (appendix C), unfortunately, appears to have a complex fault system cutting through it. Thus, the 690 m measured are most likely thicker than the formation should be. Coarse measurements made in other areas of the quadrangle suggest that the Mutual Formation is about 530 m thick.

The quartzite is mostly a pale to grayish red and is medium grained with good sorting. Cross-bedding is common, with sets ranging up to 30 cm high. Pebbly conglomerate interbeds are interspersed throughout the quartzite. Siltstone and shale interbeds are common in the lower and upper units (appendix C).

Cambrian System

In previous studies it has been common to assign all Paleozoic rocks in the Canyon Range to the Cambrian System (although some have allowed for a possibility of Ordovician rocks). This practice apparently follows the mapping of Chris-

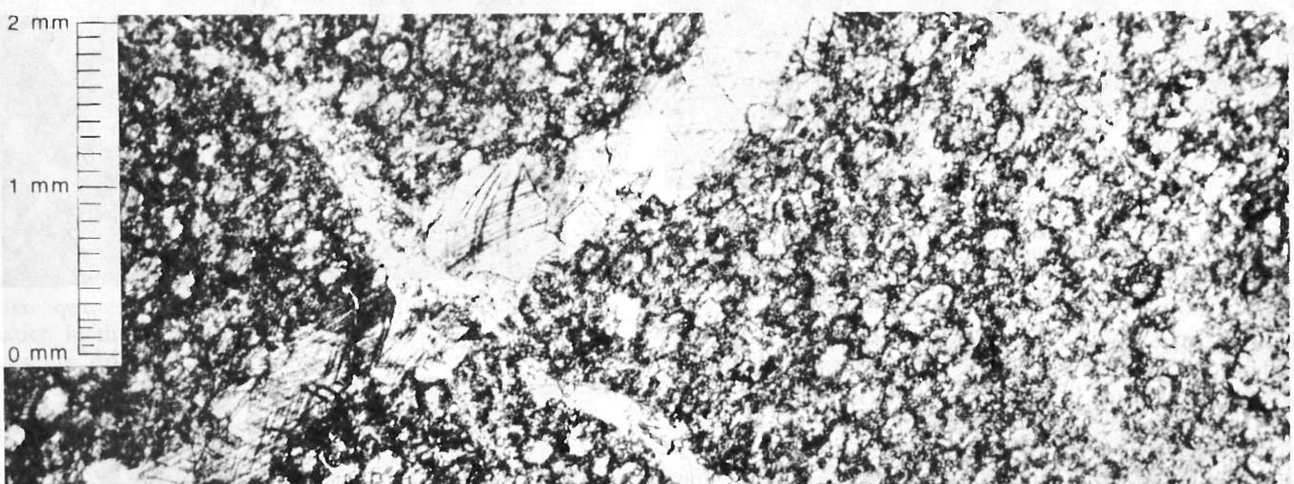

FIGURE 6.—Micrograph of fine-grained oolites making up the middle limestone unit of the Precambrian Blackrock Canyon Limestone (?), north of Whiskey Creek. X10.

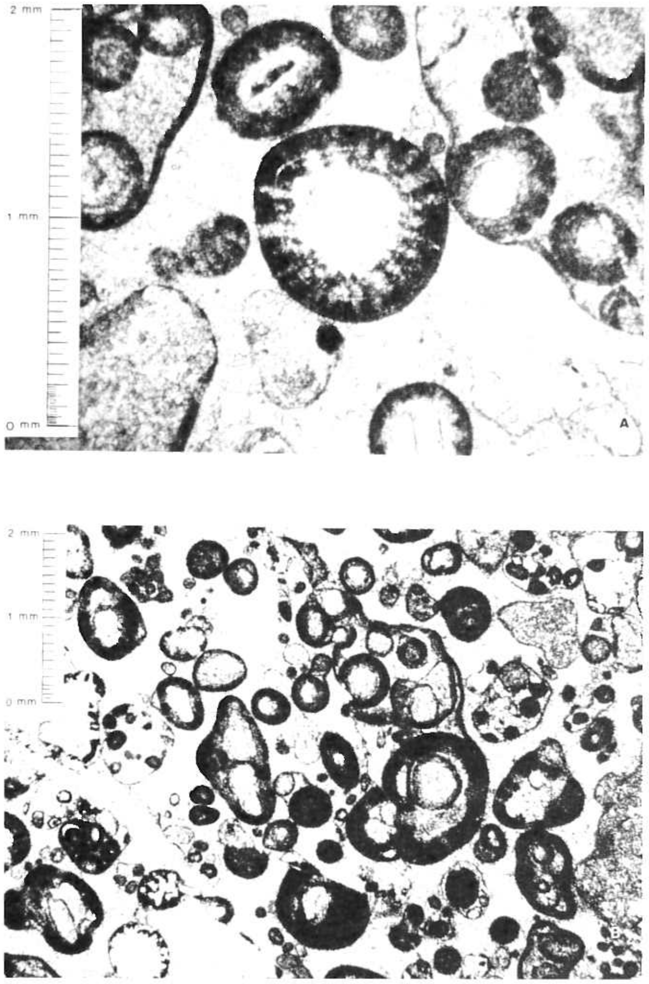

FIGURE 7.–Micrograph of oolites and compound oolites in upper limestone unit of Precambrian Blackrock Canyon Limestone (?), at the head of Hardscrabble Canyon. Calcite recrystallized from lime mud forms nuclei. Top, X12.5; bottom, X5.

tiansen (1952), even though he suggested a younger age for many of the rocks (p. 724). My study has distinguished rocks of Cambrian age from younger Paleozoic rocks (fig. 4).

Cambrian rocks in the southwestern quarter of the Scipio North Quadrangle occur on both the Canyon Range and Pavant allochthons. The Tintic Quartzite occurs conformably above the Precambrian Mutual Formation on the Canyon Range allochthon and is the youngest formation exposed on this slice in the southern Canyon Range (fig. 2). Undivided Middle and Upper Cambrian carbonate units occur on the Pavant allochthon (fig. 3) west of the synclinal axis. Reconnaissance in the Oak City Quadrangle, directly to the west, shows these rocks to be a continuation of a conformable sequence from the Precambrian Mutual Formation through the Upper Cambrian-Ordovician boundary near the Canyon Range thrust. Geologic cross sections suggest that this conformable sequence continues below the thrust, that it is again exposed on the eastern face of the southern Canyon Range, and that it continues up through Devonian rocks.

Tintic Quartzite

The only Tintic Quartzite exposed in the southwestern quarter of the Scipio North Quadrangle lies in the trough of the synclinal axis of the Canyon Range allochthon. Only a partial section is exposed, for upper beds have been eroded away. The lower contact is drawn at the top of the shaly units of the Mutual Formation, at the color change in the quartzites from grayish red to orangish pink.

Tintic Quartzite occurs as a capping band of ledges and cliffs along the spine of the ridge running south from Bear Hollow to West Eightmile Canyon, near the southern border of the quadrangle. A small remnant caps a hill just north and west of Little Creek. Measured thickness of the Tintic Quartzite in this area of the Canyon Range is approximately 396 m (appendix C). About 10 km to the north on the Canyon Range allochthon, Higgins (1982) measured a total thickness of 835 m.

The Tintic Quartzite consists of pale orangish pink, thick- to massive-bedded, coarse to very coarse grained, poorly sorted quartzite. Cross-bedding sets up to 30 cm high are common. About 20 percent of the formation is made up of a pebbly quartzite conglomerate, occurring as interbeds in the sandy quartzite.

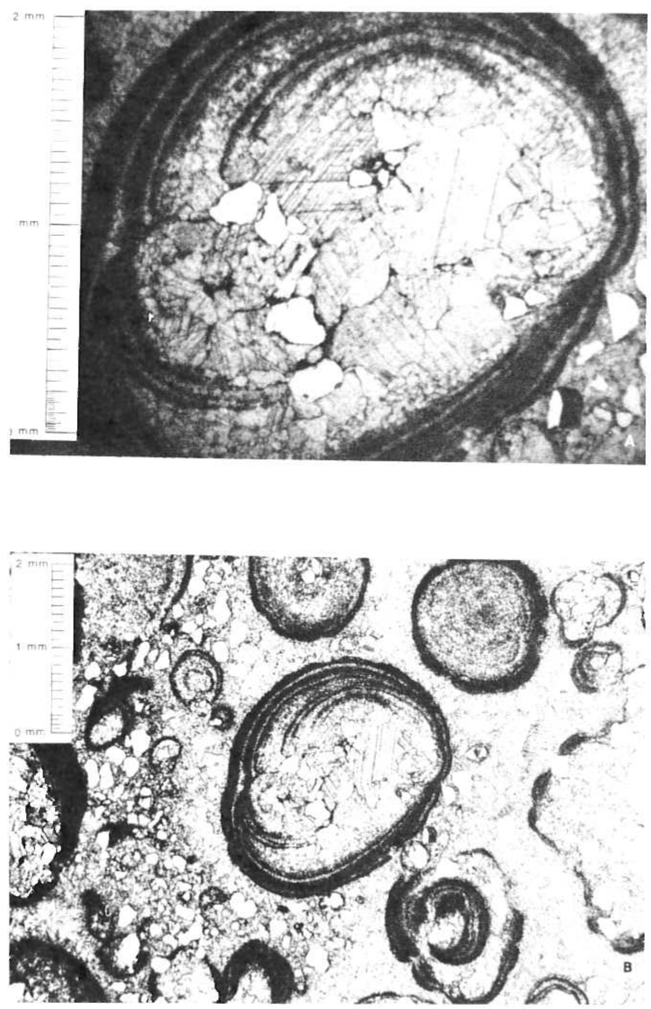

FIGURE 8.–Micrograph of pisolite in upper unit of Precambrian Blackrock Canyon Limestone (?), at the head of Hardscrabble Canyon. Large crystals of calcite recrystallized from lime mud form nucleus. Dense, scalloped structure below and to the right of pisolite may be algal. Note grains of quartz are scattered throughout. Top, X12.5; bottom, X5.

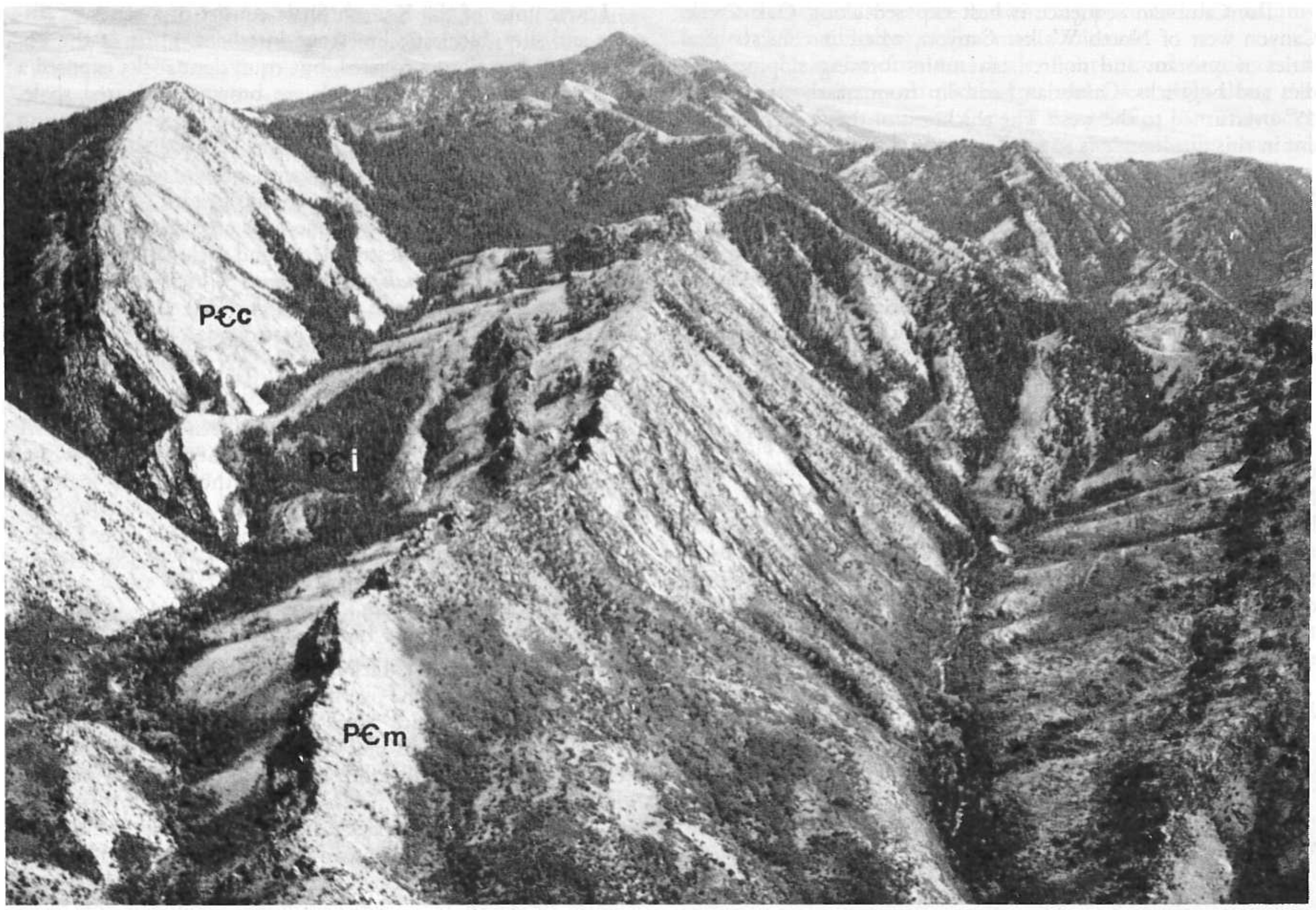

FIGURE 9.–View southward of Precambrian exposure along Lyman Canyon (left). Characteristic dip slopes are formed on the Caddy Canyon Quartzite and to a lesser extent on the Mutual Formation. Inkom Formation forms strike valley. See map legend for formation symbols.

Middle and Upper Cambrian Carbonate Rocks Undivided

The Middle and Upper Cambrian rocks in the southwestern quarter of the Scipio North Quadrangle exhibit little variation in their lithology, making it hard to recognize distinct units. Added to this is a dearth of fossils to substantiate any age assignments of the rocks. Thus, no division of these rocks was made. A shale unit beyond the western border of the quadrangle conformably underlies these carbonate rocks. The upper Cambrian contact is gradational and has been drawn at the change of lithology from primary dolomite, below, to primarily limestone, above. The limestone is assigned to the Ordovician Pogonip Group.

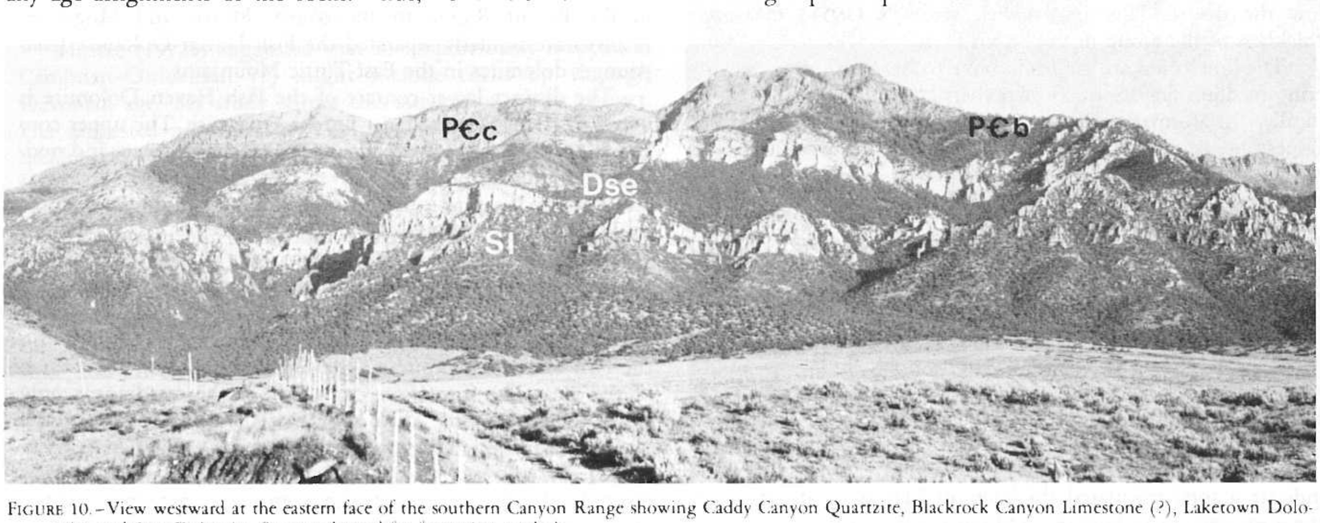

FIGURE 10.–View westward at the eastern face of the southern Canyon Range showing Caddy Canyon Quartzite, Blackrock Canyon Limestone (?), Laketown Dolomite, and Sevy Dolomite. See map legend for formation symbols.

The Cambrian sequence is best exposed along Oak Creek Canyon west of North Walker Canyon, where it consists of a series of resistant and nonresistant units forming sloping saddles and hogbacks. Cambrian beds dip from nearly vertical to 65° overturned to the west. The thickness of the sequence present in this quadrangle is 855 m (appendix D).

The carbonate rocks are almost entirely dolomite with a few thin interbeds of limestone. The dolomites are medium gray, with the lower units weathering to a yellowish gray, whereas the upper units tend toward a medium brownish gray. Most units are thin to very thin bedded, with minor medium- to massive-bedded units being the ridge formers. A few unidentifiable trilobite fragments were found in a limestone unit midway in the sequence.

Ordovician System

Ordovician rocks occur on both the east and west limbs of the syncline on the Pavant allochthon (fig. 4). Nomenclature for these units follows the suggestion of Hintze (1972a) and his description of similar units in the nearby Scipio Pass Quadrangle (Hintze 1951). Contacts are drawn at lithologic changes that correspond to the suggested nomenclature. Formations include the Pogonip Group, Kanosh Shale (separated out from the Pogonip Group), Eureka Quartzite, and Fish Haven Dolomite (fig. 3).

Pogonip Group

The lower contact of the Pogonip Group is drawn at the change of lithology from Cambrian dolomites to limestones more typical of the Pogonip Group. Throughout the quadrangle the Canyon Range thrust follows this group along the western exposure of the thrust. Thus, the upper units are cut out in many exposures. The thrust climbs up through the group in the subsurface, under the syncline (fig. 17). The only Pogonip Group rocks exposed on the east face of the Canyon Range are those of the Kanosh Shale, near the top of the group.

The Pogonip Group crops out as a series of vertical to overturned beds in limestone ridges and hogbacks. These rocks are best exposed along a pronounced ridge west of South Walker Canyon. Exposed thickness in the southern Canyon Range was measured at 270 m (appendix D). Cross sections drawn through the range suggest an inferred subsurface thickness of the group (excluding the Kanosh Shale) of 400 m below the thrust. This agrees with Hintze's (1951) measured thickness of the group in the Scipio Pass.

The limestones are generally olive to brownish gray, weathering medium gray. Some brown chert layers and nodules occur locally. Intraformational conglomerate, typical of the Fillmore Limestone, is common along South Walker Canyon. The units are thin bedded. *Lingulella* and trilobite fragments were found near the lower boundary of the group.

Kanosh Shale

The upper contact is a distinct boundary drawn at the base of overlying quartzite ledges and cliffs of the Eureka Quartzite. The lower contact is concealed beneath alluvium (fig. 4).

Kanosh Shale forms a series of rounded hills and slopes along the foot of the ridge southeast of Little Long Canyon on the eastern side of the Canyon Range. The shale is exposed only on the east limb of the syncline on the Pavant allochthon where 98 m of the unit crop out (appendix E). Cross sections indicate a total calculated thickness of 113 m, conforming to the measurement of Hintze (1951) in the Scipio Pass.

Lower units of the Kanosh Shale consist of a series of siltstone and silty, bioclastic limestone interbeds. Most of the upper measured section is covered, but equivalent rocks exposed a few tens of meters to the south are brown, laminated shale. The limestone is olive gray to medium light gray, weathering medium to dark gray to medium brown. The siltstone is pale brown, weathering moderate yellowish brown to grayish red. The limestone and siltstone units are thin bedded.

Fossils collected from limestone beds are typical of the Kanosh Shale throughout western Utah and include *Orthambonites michaelis* (Clark), *Anomalorthis utahensis* Ulrich and Cooper, *Cybelopsis* sp., large pliomerid trilobite, crinoidal debris, small leperditid ostracodes, and planispiral gastropods.

Eureka Quartzite

The name *Swan Peak Quartzite* has been used in several studies of nearby areas, as, for example, Hintze (1972a), where similar rocks are exposed. However, the lithology best matches the description of the Eureka Quartzite by Webb (1956), and the Swan Peak Quartzite may be a member of the Eureka Quartzite in this area. This latter usage is followed by Hintze in subsequent publications (Hintze 1972b).

The upper and lower contacts of the Eureka Quartzite are distinct in this quadrangle. The lower contact is drawn at the top of the shaly units of the Kanosh Shale. The upper contact is drawn at the base of the overlying dark dolomite.

The Eureka Quartzite forms a distinct, light-colored ledgy cliff, which forms a band midway in the slope below the massive cliffs of the ridge southeast of Little Long Canyon. The formation is not exposed north of Little Long Canyon. Measured thickness of the Eureka Quartzite is 68 m (appendix E).

The Eureka Quartzite consists of thin- to medium-bedded, medium-grained quartzite. The lower unit is light gray to orangish brownish pink, weathering the same, but the rocks gradually lighten upward to near white a quarter of the way through the unit. It is siltier than the unit above and exhibits cross-beds up to 20 cm high. The upper unit is a clean, well-sorted white to light gray quartzite that weathers pink to light yellowish gray.

Fish Haven Dolomite

This study follows the usage of Hickcox (1971), who separated the Fish Haven Dolomite from overlying dolomite units in the Pavant Range to the south. Morris and Mogensen (1978) have similarly separated the Fish Haven Dolomite from younger dolomites in the East Tintic Mountains.

The distinct lower contact of the Fish Haven Dolomite is drawn at the top of the light Eureka Quartzite. The upper contact is drawn at the lowest occurrence of cherty layers and nodules in the dolomite units above. This boundary is somewhat arbitrary, but it forms the best basis for a lithologically mappable unit in this area.

The Fish Haven Dolomite crops out as a series of ledges that "stair-step" up from the Eureka Quartzite to the steep cliffs of the overlying Laketown Dolomite. Many of these ledgy steps have been covered by talus from the cliffs above, giving the Fish Haven Dolomite a slope-forming appearance in much of the area. The formation crops out in the quadrangle only along the base of the cliffs southeast of Little Long Canyon (fig. 4). Measured thickness of the formation is 42 m (appendix E). Variation from reported thicknesses in nearby areas is most likely the result of the somewhat arbitrary upper boundary.

The lower part of the Fish Haven Dolomite is medium dark gray dolomite, weathering olive gray to light olive gray. It is medium crystalline, is thick bedded, and has a faint hydrocarbon odor. The middle and upper units are medium- to fine-crystalline limestone. The middle unit is distinctly mottled dark olive gray and light gray and is massively bedded. The upper unit is medium dark gray, weathering olive gray and is very thin bedded. Both middle and upper units appear to have stromatolitic bedding. The entire formation is apparently a healed (recemented) breccia.

Silurian System

Christiansen (1952, p. 24) first suggested that the dark cliffs of the eastern face of the southern Canyon Range appeared lithologically similar to the Silurian Laketown Dolomite. My study reveals that he was right. Laketown Dolomite is the only Silurian unit in this area. It conformably overlies the Ordovician Fish Haven rocks on the Pavant allochthon (fig. 3) and is exposed only east of the synclinal axis (fig. 4).

Laketown Dolomite

The lower contact of the Laketown Dolomite is arbitrarily drawn at the lowest occurrence of extensive chert nodules and layers in dolomite above the upper units of the Fish Haven Dolomite. The upper contact is drawn at the transition from thick-bedded, cherty dolomite to noncherty, thinly laminated dolomite.

Laketown Dolomite constitutes a dark cliff that caps the ridge southeast of Little Long Canyon and forms the dark, massive cliff along the base of the eastern face of the main range south of Hardscrabble Canyon (fig. 10). The formation is 333 m thick (appendix E).

Laketown Dolomite consists of dusky yellowish brown to olive gray dolomite, that weathers light to medium gray to olive gray to pale yellowish orange. The lower and upper units are thick to massively bedded, but the middle section is thin bedded with some boundstone interbeds. Up to 10 percent of the formation consists of moderate brown chert nodules and layers. The nature of the chert layers suggests they were originally algal mats. Some zones of intraformational conglomerate and rip-up clasts occur in the middle units. An orthid brachiopod and a rugose coral were collected near the top of the unit, although most of the formation is unfossiliferous.

Devonian System

Hintze (1972a) suggested that rocks previously mapped as Cambrian-Ordovician (?) might include rocks up through Devonian age. My study shows this suggestion to be correct. His suggested nomenclature (Hintze 1972a) was used in this quadrangle, with contacts drawn on the basis of lithologic characteristics. In addition the Cove Fort Quartzite has been differentiated here for the first time. It is conformable with other Devonian units and lithologically similar to the type section near Cove Fort, Utah.

Devonian rocks crop out along the eastern face of the southern Canyon Range on the Pavant allochthon (fig. 4), and include, from the base up, the Sevy Dolomite, Simonson Dolomite, and Cove Fort Quartzite (fig. 3).

Sevy Dolomite

The lower contact of the Sevy Dolomite is drawn at the transition from the underlying darker, thick-bedded, cherty Laketown Dolomite to the overlying lighter, thinly laminated, noncherty Sevy Dolomite. The top of the Sevy Dolomite was mapped at the base of the brown, sugary-textured, medium-bedded cliffs and ledges of Simonson Dolomite.

Sevy Dolomite forms a thick, light-colored sequence of broad slopes interspersed with ledges and a few cliffs along the eastern face of the southern Canyon Range (fig. 10). The rocks dip gently to the west but shift to a northerly dip eastward through the section. Sevy Dolomite is present only on the east limb of the syncline and makes up most of the eastern face of the range below the thrust. The only good exposure of the complete formation is found along the ridge south of Hardscrabble Canyon (fig. 11).

A thickness of 830 m was measured along this ridge. No other comparably thick section has been reported in the miogeosyncline. The nearest Sevy exposures are in the Pavant Range, to the south, but there the Sevy Dolomite is apparently much thinner. However, there the Sevy Dolomite is cut by a fault (George 1983) and bounded at its lower contact by an unconformity (Davis 1983). Thus, the true thickness there is unknown. In the Canyon Range repetition by faulting was considered as an explanation for the exceptional thickness, but no such fault was detected in mapping. A more plausible explanation is a facies change in Devonian sediments eastward from their well-described sections in western Utah. Figure 12 illustrates such a facies change. Total Devonian rocks of the Canyon Range are 1,143 m thick compared to more than 1,700 m

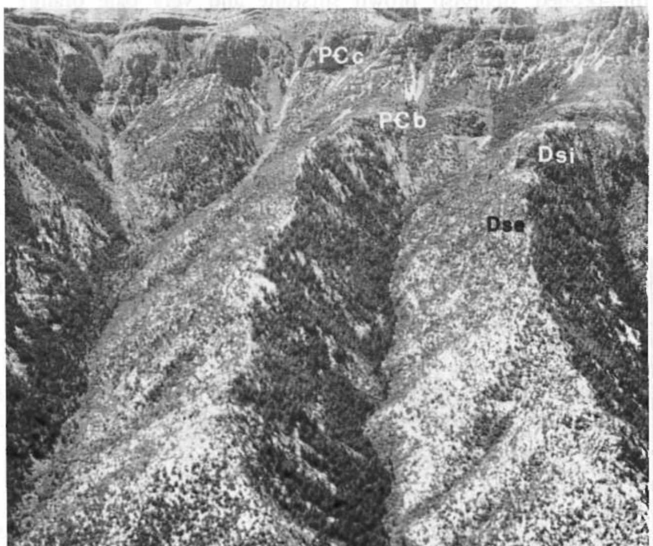

FIGURE 11.–View westward at Hardscrabble Canyon. Note the thick sequence of Sevy Dolomite. See map legend for formation symbols.

in western Utah (Staatz and Carr 1964). Since the Guilmette Formation is not found in this area, it seems possible that in Middle Devonian times Sevy type rock accumulated in the Canyon Range while Guilmette type rocks were being laid down in western Utah.

Sevy Dolomite is monolithologic throughout. It consists of drab, olive gray, thinly laminated dolomite, weathering very pale orange to yellowish gray to grayish orangish pink. Rare moderate red silty interlayers are interspersed throughout (appendix F). Zones of rip-up clasts occur periodically throughout. Sevy beds are unfossiliferous in this quadrangle.

Simonson Dolomite

The lower contact of the Simonson Dolomite is drawn at the base of the brown, sugary-textured, medium-bedded cliffs and ledges above the light-colored, thinly laminated Sevy Dolomite. The upper contact is drawn at the base of the first overlying light-colored quartzite.

Simonson Dolomite crops out as a dark-colored cliff, along the eastern face of the southern Canyon Range just below the thrust contact. The formation first appears near the head of Hardscrabble Canyon and thickens northward to Little Oak Canyon, where it abruptly terminates. It is 236 m thick (appendix G).

Cliffs of Simonson Dolomite consist of a brownish gray dolomite, weathering pale yellowish brown, that has a distinctive sugary texture. It is medium bedded with interlayers of thin-bedded, orangish brown siltstone and very pale orange boundstone. Nodules of calcite are scattered through most of the formation. The upper 20 percent of the formation is thin-bedded, reddish dolomite containing reddish sandy layers alternating with beds of light gray, thin-bedded dolomite that contain sparse sandy interlayers. The formation is unfossiliferous in the Canyon Range.

Cove Fort Quartzite

The lower contact of the Cove Fort Quartzite was mapped at the base of the first light-colored quartzite above the brown Simonson Dolomite. The upper contact is at the thrust.

The formation crops out as near-white ledges and cliffs atop the eastern face of the range. It is exposed at Ox Hollow and thickens from there northward to Little Oak Canyon where it is 77 m thick (appendix G). Total thickness is unknown, inasmuch as the formation is cut by the thrust. However, regional patterns suggest that this thickness is near its original total.

The Cove Fort Quartzite consists of thin-bedded, very pale orange, sandy dolomite and sandstone "sandwiched" between thick-bedded, light grayish orangish pink quartzite, weathering light grayish orange to white. The quartzite has fine, subrounded grains, good sorting, and calcareous cement. The sandstone has medium, subangular grains, fair sorting, and calcareous cement. Interbeds of dolomite are reported in the Pavant Range to the south (Davis 1983) and correlate to the Crystal Pass Limestone (Welsh 1972).

Cretaceous and Tertiary Systems

The Cretaceous and Tertiary Systems include the Upper Cretaceous to Tertiary Canyon Range Formation of Stolle (1978), the Oligocene Goldens Ranch Formation and Fool Creek Conglomerate, and the Miocene Oak City Formation.

Canyon Range Formation of Stolle (1978)

A thick sequence of synorogenic conglomerate occurs along the eastern face of the central and northern Canyon Range. Christiansen (1952) tentatively assigned these rocks to the Indianola Group, and later studies have usually followed his assignment. Armstrong (1968) and Stolle (1978) questioned this nomenclature and concluded that these rocks do not corre-

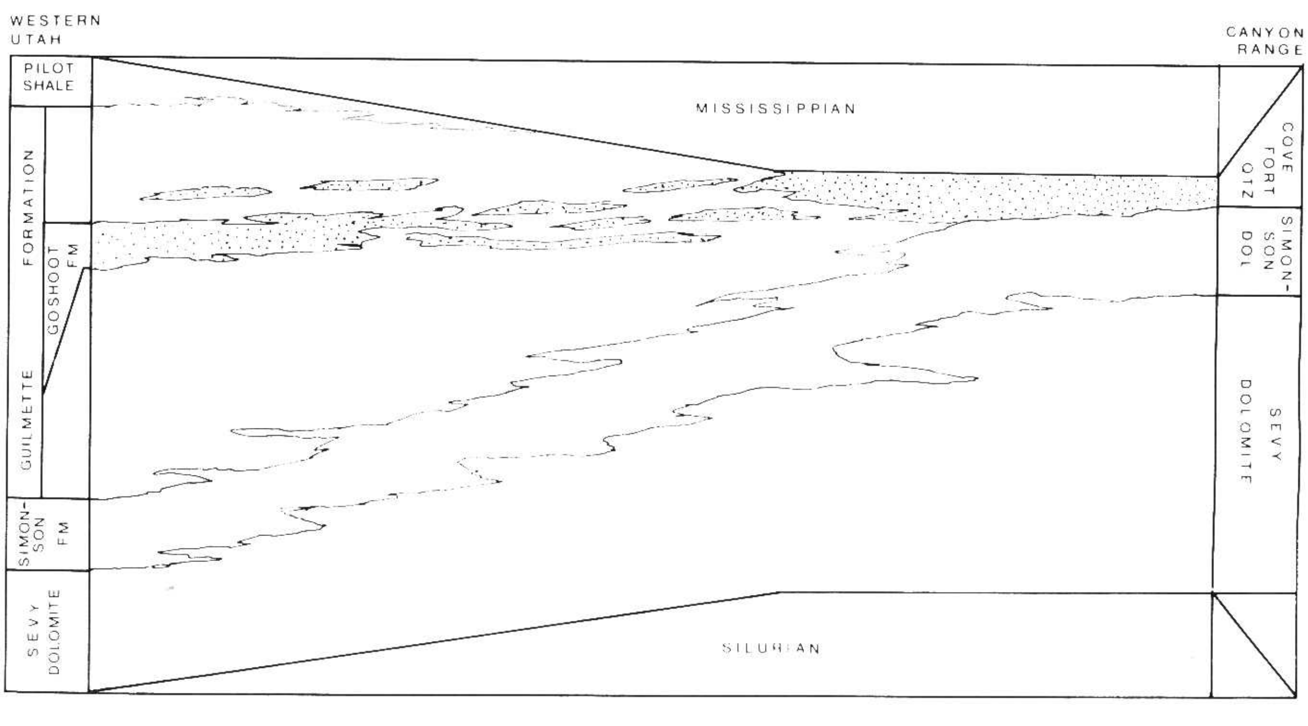

FIGURE 12.—Possible facies change eastward from western Utah to the Canyon Range explaining unusual thickness of Sevy Dolomite in the Canyon Range. Sevy lithology was deposited in the Canyon Range at the same time Guilmette lithology was deposited in western Utah. The Cove Fort Quartzite in the Canyon Range probably correlates with the Goshoot Formation of Staatz and Carr (1964) in the Thomas and Dugway Ranges.

late with the Indianola Group. Stolle (1978) informally assigned the new name *Canyon Range Formation* to these rocks, dividing them into Unit A (older) and Unit B (younger). Higgins (1982) reached a similar conclusion that equivalent rocks in the Champlin Peak Quadrangle were best treated as a local formation, and she informally called them the Conglomerate of Leamington Pass.

These synorogenic conglomerate units occur along the margin of the southwestern quarter of the Scipio North Quadrangle, mostly in T. 17 S, R. 3 W, section 3, T. 17 S, R. 3 W, north of Little Oak Canyon (fig. 4). A small outcrop occurs near the east central border of the quadrangle in low, rolling hills. Clasts I observed showed a high degree of correlation in appearance to the Precambrian and Paleozoic formations of the Canyon Range, confirming their proximal origin. The only additional data provided by my mapping shows that they appear to be conformably overlain by the Oligocene Goldens Ranch Formation near the east central border of the quadrangle. This finding tends to support an early Tertiary rather than a Late Cretaceous age for the formation.

Stolle's (1978) nomenclature is followed in this study. His reference section for Unit A of the Canyon Range Formation lies immediately north of this quadrangle and is similar to the rocks exposed in this quadrangle. An excerpt of his description is included as appendix H. He reported a measured thickness of 500+ m for Unit A (Stolle 1978, p. 123).

The formation occurs north of Little Oak Canyon as distinct, pink cliffs. It is composed almost entirely of conglomerate, with clasts up to large boulder size. Some shale and sandstone are found near the bottom of the formation. Precambrian and Cambrian quartzites comprise most of the clasts in the lower portion of the formation, and the upper part consists primarily of Paleozoic carbonate clasts. At the very top quartzite clasts again predominate.

Goldens Ranch Formation

A limited exposure of tuffaceous sandstone, siltstone, and conglomerate occurs near the east central border of the southwestern quarter of the Scipio North Quadrangle and is here mapped as Goldens Ranch Formation. It appears to conformably overlie a small outcrop of the Canyon Range Formation of Stolle (1978). Meibos (1983) studied the Goldens Ranch Formation in the Nephi Northwest Quadrangle and suggested (personal communication 1981) that these rocks are equivalent.

In this area the Goldens Ranch Formation forms low, rolling hills. Beds are oriented N 15° W, and dip 25° E. The lowest outcrop of conglomerate consists of white, rounded, quartzite boulders in a pebbly matrix of white quartzite, in a bed about 4 m thick. It is overlain by approximately 25 m of a coarse, brown, friable sandstone interspersed with cross-bedded channel fills of coarse, angular quartzite conglomerate. This is capped by a resistant ridge of light orangish brown, pebbly conglomerate that is 3 m thick. The conglomerate clasts are 60 percent light-colored quartzite and 40 percent gray carbonate rocks. A few volcanic fragments appear to be included. They suggest Oligocene age. Clast size ranges from 1.5 cm to 13 cm, most clasts being in the smaller range. The formation continues upsection beyond the eastern border of the quadrangle.

Fool Creek Conglomerate

At the divide between Oak Creek and Little Oak Canyons, a mantle of largely unconsolidated, coarse gravel overlies the older stratigraphic units and structures. Christiansen (1952, p. 727–28) included these rocks with similar rocks along the western foot of the Canyon Range, within the Fool Creek Conglomerate. After careful investigation, Campbell (1979) divided the sequence into two formations: the Fool Creek Conglomerate and the Oak City Formation. He suggested the Oak Creek-Little Oak Canyons divide as a type-section for the Fool Creek Conglomerate and assigned the formation an Oligocene age. Because of its relationship to stratigraphy and structure, this age is important.

The formation contains a variety of Cambrian and Precambrian quartzite clasts ranging in size from granules to 1.2-m boulders. Clasts from the Canyon Range Formation of Stolle (1978) occasionally occur. The matrix is a red, silty sandstone with calcium carbonate cement. A more detailed description from Campbell (1979) is included as appendix I. He reported a maximum thickness of 1,163 m.

Oak City Formation

Along the southern border of the quadrangle, low hills of mostly unconsolidated, poorly exposed conglomerate and fine-grained strata were mapped by Campbell (1979) as the Oak City Formation and assigned a Miocene age. It is recognized by the pink soil that it produces. Campbell's nomenclature and boundaries have been followed in this study. He reported a maximum thickness of 490 m. An excerpt from his description is included as appendix J.

Quaternary System

The Quaternary System has been divided into two mappable units: older fanglomerate and younger alluvium and colluvium (see figs. 3, 4).

Older Fanglomerate

Alluvial fans have coalesced to form a bajada along the eastern foot of the Canyon Range. The fans consist of quartzite and carbonate boulders and sand and pebbles shed from the Canyon Range. About 75 m of older fanglomerate deposits are exposed.

Alluvium and Colluvium

Recent deposits consist of angular talus adjacent to ledges and cliffs, of stream rubble ranging from silt to 5-m boulders, of young alluvial fans, and of fine-grained silts in Scipio Valley.

Regional Stratigraphy

Since this study includes units not previously mapped in the Canyon Range vicinity, a comparison of stratigraphic nomenclature with that in nearby areas has been included as figure 13.

Nomenclature within the Canyon Range allochthon (compare fig. 13a with fig. 2) correlates with that utilized by Higgins (1982), since both sets of strata lie on the same thrust slice. Discrepancies between thicknesses that she gave for the Caddy Canyon Quartzite and that in this study are understandable because she did not attempt to separate units correlated to the Upper Pocatello Formation or Blackrock Canyon Limestone (Higgins personal communication 1981). Her reported thickness for the Caddy Canyon Quartzite probably includes the aforementioned formations.

Thickness variations of the Cambrian through Devonian strata in the southern Pavant Range (Davis 1983) and this study are less significant when the unconformities Davis (1983) mapped are taken into account (fig. 13b).

Marked differences between the stratigraphy of Morris and

Mogensen (1978) in the East Tintic Mountains and this study suggest different depositional environments later brought together by Sevier thrust faults.

STRUCTURE

Thrust Faults

The Canyon Range lies at the intersection of three thrust faults (fig. 14). The complexity which this intersection imposes on the areal geology is most clearly seen at the northern (*see* Higgins 1982) and southern ends of the range. Within this quadrangle, only the Canyon Range thrust is observable, but cross sections indicate that the Pavant thrust fault extends through the quadrangle in the subsurface (fig. 17).

Canyon Range Thrust Fault (eastern exposure)

Precambrian rocks are thrust over Lower to Middle Paleozoic rocks along the southeastern and east central face of the Canyon Range (fig. 15). Farther north along the eastern face

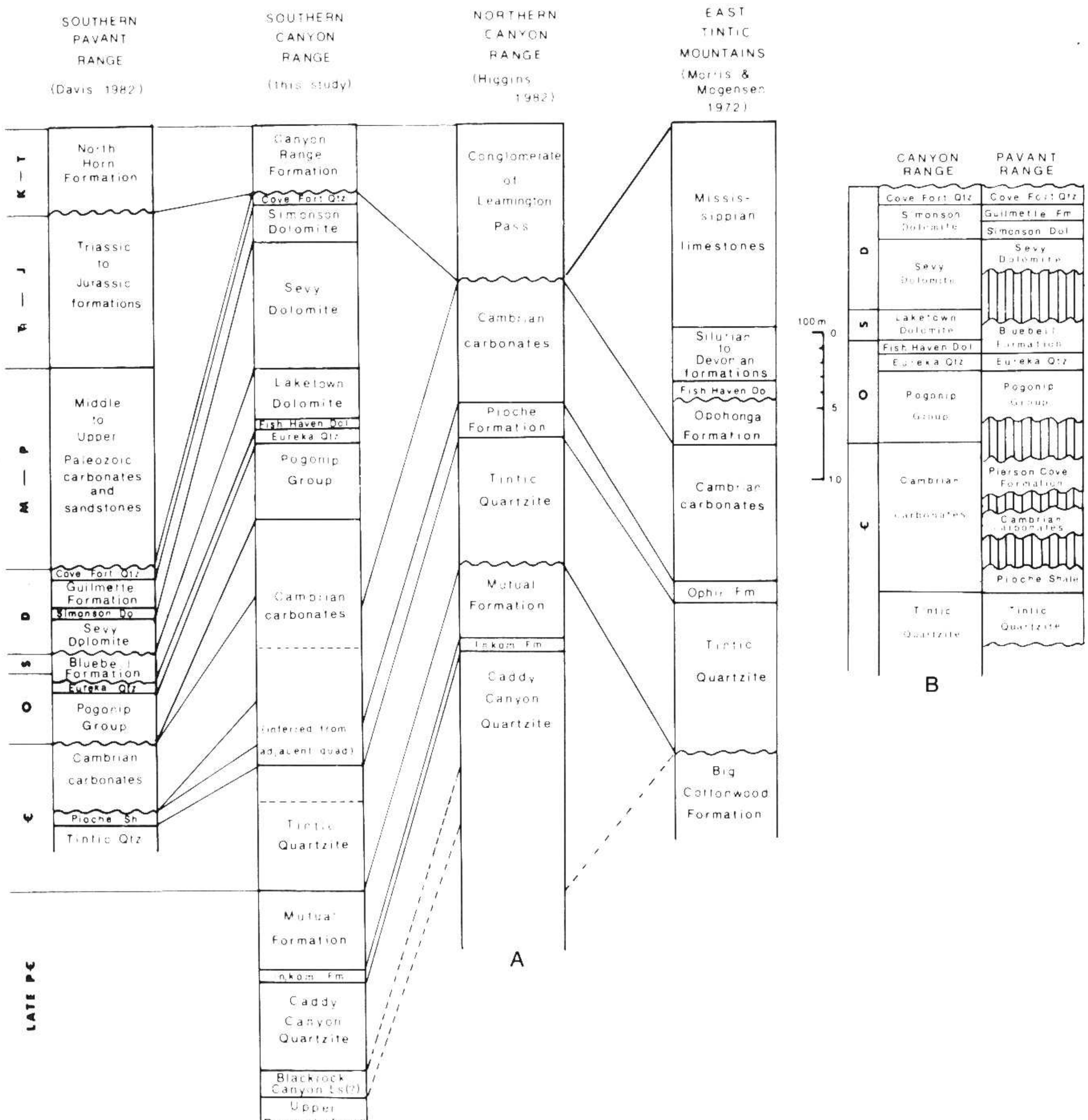

FIGURE 13.—Correlation of regional stratigraphy. A.—Strata thickness compared from the southern Pavant Range northward to the East Tintic Mountains. B.—Cambrian through Devonian correlation table between the southern Canyon Range and the southern Pavant Range.

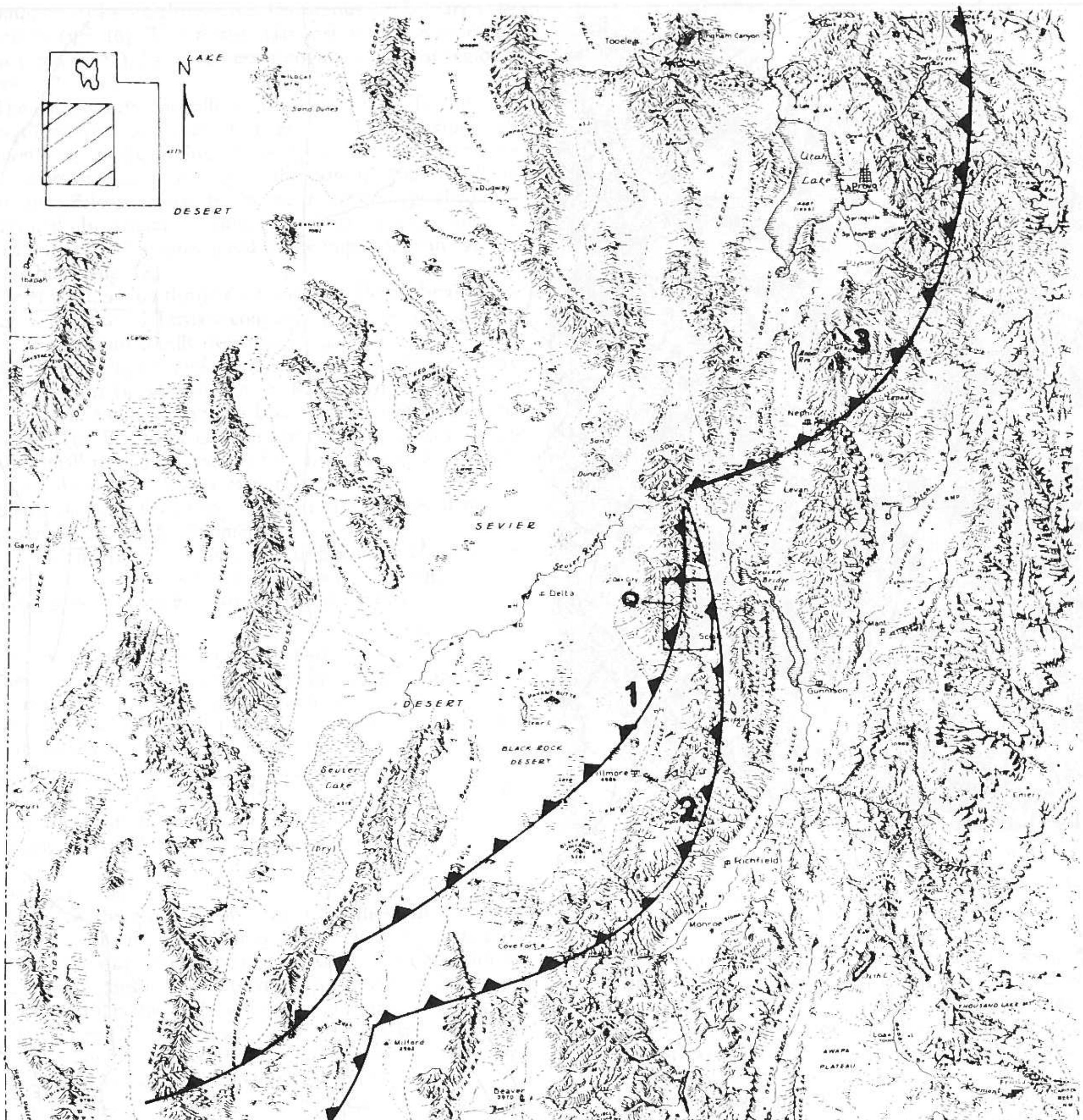

FIGURE 14.–Traces of major thrust faults and their relationships to the southwestern quarter of the Scipio North Quadrangle (Q). (1) Canyon Range–Wah Wah Mountains thrust, (2) Pavant–Blue Mountains thrust, (3) Nebo–Charleston thrust.

FIGURE 15 - Index map to structural features of the southwestern quarter of the Scipio North Quadrangle. Canyon Range thrust fault: 1 = eastern exposure, 2 = western exposure; folds: 3 = Canyon Range syncline, 4 = east-face anticline; normal faults: 5 = Little Long Canyon fault, 6 = Little Oak Canyon fault, 7 = Little Valley scarplets, 8 = Scipio Valley scarplets, 9 = low-hills fault, 10 = eastern-border fault; tear faults: 11 = Dry Creek, 12 = Whiskey Creek, 13 = Partridge Mountain; slide blocks: 14 = Dry Creek, 15 = Oak Creek. No differentiation is indicated for concealment by alluvium.

Precambrian rocks are thrust over Cretaceous to Tertiary conglomerates (fig. 16). This thrust relationship, first mapped by Christiansen (1952), has long been recognized in most regional studies.

The thrust fault generally strikes about N 7° E, and dips westward between 30° and 40° (figs. 4, 17). A pronounced, commonly abrupt steepening of the dip of the fault plane generally occurs in close proximity to the eastern exposure of the thrust fault. Paleozoic rocks below the thrust are typically highly fractured. In several locations the thrust appears to have formed imbricate structures ahead of the upper plate in the underlying block (fig. 18).

Northward, at the thrust contact where Precambrian rocks rest on Cretaceous to Tertiary conglomerates, the latter exhibit drag folding and are locally overturned (fig. 19).

The eastern exposure of the thrust-fault trace occurs along most of the east face of the Canyon Range, with rocks of Devonian below and Precambrian Blackrock Canyon Limestone (?) above. The Blackrock Canyon Limestone (?) occurs in slivers too small to map at a scale of 1:24,000, the scale of figure 4, along the southern third of this trace.

South of Little Oak Canyon the thrust is covered by the Oligocene Fool Creek Conglomerate.

At the northern border, Precambrian Caddy Canyon Quartzite in the upper plate is thrust over the Cretaceous to Tertiary Canyon Range Formation of Stolle (1978).

Canyon Range Thrust Fault (western exposure)

Near the western border of the quadrangle Ordovician rocks lie in fault contact with Precambrian rocks (figs. 4, 15). Christiansen (1952) mapped this contact as an exposure of the same thrust fault exposed on the eastern face of the Canyon Range. The fault trace is along a highly brecciated zone which obscures the trace and makes difficult any attempt to directly examine the fault surface and the fault attitude. The fault is best recognized by the distinct transition from Paleozoic carbonates to Precambrian quartzites, a transition easily detected even in the breccia.

At the northern end of the quadrangle, the fault trace is in Ordovician rocks near the Cambrian-Ordovician boundary on the Pavant allochthon. Just a few hundred meters southward the fault trace rises in the Ordovician rocks and remains at or near that stratigraphic level southward throughout the quadrangle. On the Canyon Range allochthon, the trace is in the upper units of the Upper Pocatello Formation (?) or lower units of the Blackrock Canyon Limestone (?) (fig. 4).

Swank (1978) questioned a thrust relationship for this fault; instead he mapped it as a Tertiary basin-and-range normal fault. He based his conclusions on (1) a presumption that the rocks to the west of the fault are autochthonous (p. 29); (2) observed striation of slickensides (p. 30); (3) local topographic expression of the fault (p. 30); (4) indiscriminate cutting of the stratigraphic section, exposing lower structural levels as the trace runs north to south (p. 30); (5) better support of his proposed model for folding of the Canyon Range allochthon (p. 17, 38).

Swank presumed that rocks west of the fault are autochthonous, but my study indicates that these rocks, while indeed "autochthonous" in relationship to the Canyon Range thrust, are actually part of the Pavant allochthon, which itself has been thrust eastward and strongly folded (*see* sections on Pavant Thrust and Geologic History). My study also shows that slickensides along a thrust fault or normal fault of similar attitudes could be similar. The same could be said about local topographic expression. My mapping shows that the fault does not cut across strata any more drastically (in fact less) than does the fault trace along the eastern face of the Canyon Range. My study also reveals that the eastern exposure of the Canyon Range thrust exposes lower structure from north to south in the same way as does the fault in question.

FIGURE 16.—Aerial view northward of exposures of the Canyon Range thrust (dashed line) along the east face of the Canyon Range. See map legend for formation symbols.

A significant problem in past studies of this fault has been lack of differentiation of stratigraphic units involved. Units simply mapped "Cambrian undivided" or "Precambrian undivided" have left too much room for error in the construction of cross sections. The current mapping of separate Precambrian units on the Canyon Range allochthon and Ordovician through Devonian units on the Pavant allochthon puts constraints on cross sections which have led to the conclusion that this is a thrust fault.

This conclusion is based in part on (1) the tendency of the fault exposure to occur consistently along the Upper Pocatello Formation (?) and Blackrock Canyon Limestone (?) boundary zone in the upper plate (fig. 4); (2) the near-parallel attitudes of the fault and beds both above and below the fault (fig. 17); (3) the tendency for the fault to occur in or near the same upper-plate formations as does the eastern thrust exposure (figs. 4, 17); (4) the near-parallel relationship between the fault and the synclinal axis (fig. 4); (5) the relationship of the eastern and western exposures of the Pavant allochthon in regard to both attitude and stratigraphy (fig. 4, 17); (6) the detection of a northwest-trending, normal fault of pre-basin-and-range age which cuts across the fault under question about 1 km north of the northern border of the quadrangle (*see* fig. 4 and sections on Little Oak Canyon Fault and on Geologic History).

Canyon Range Thrust Fault (general summary)

The Canyon Range thrust fault appears to be a low-angle thrust fault with movement in an easterly direction, on the basis of cross sections and map relationships. The fault cuts up-section from Ordovician through Devonian rocks in this quadrangle. Restoration of both the Canyon Range and Pavant

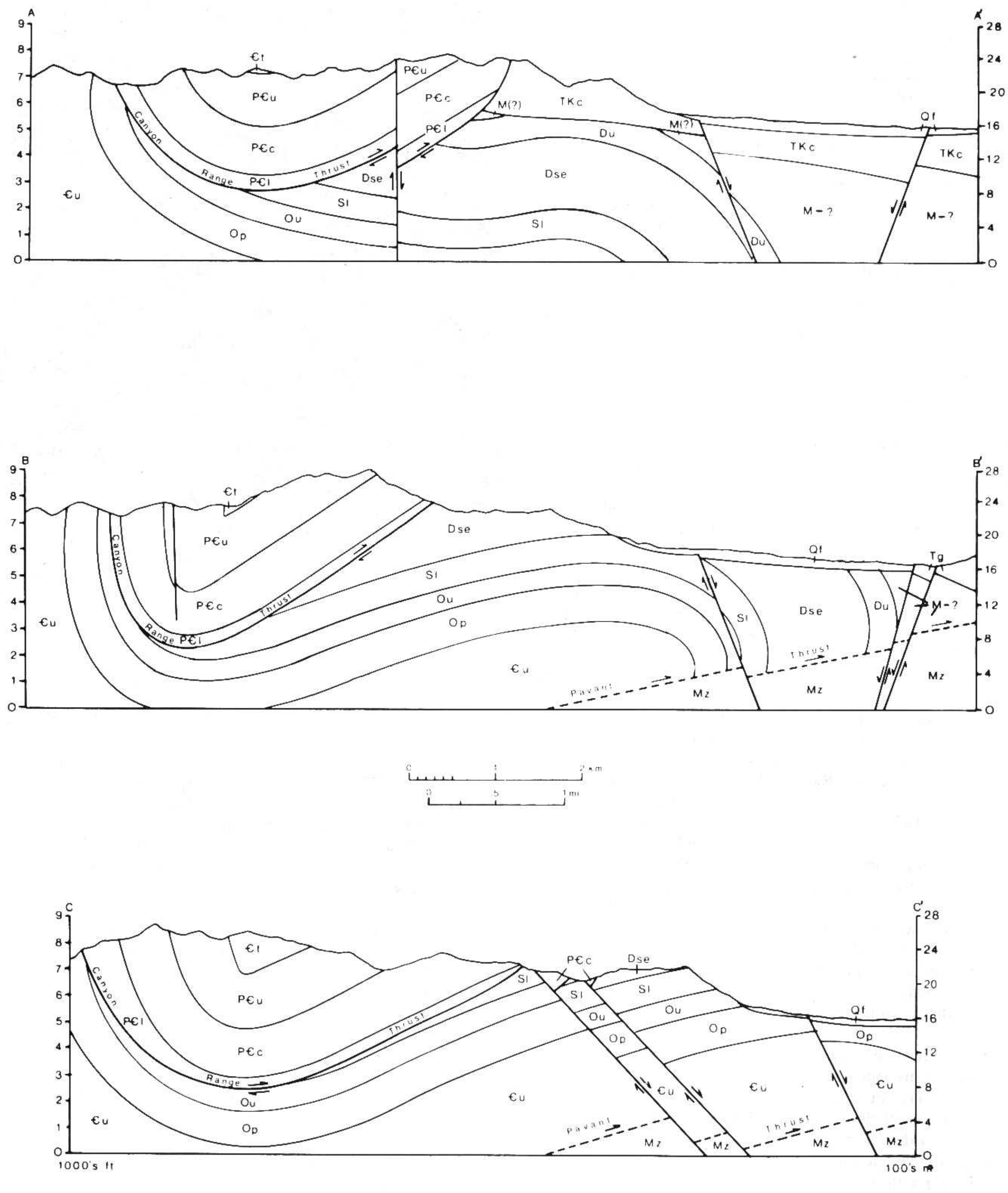

FIGURE 17.–East-west cross sections through the Canyon Range. See figure 4 to correlate locations and to identify formation symbols.

thrusts indicates total movement along the Canyon Range thrust of about 40 km. Apparent high-angle attitudes of the thrust plane, as currently observed, are the result of a folding that followed the main movement on this thrust (*see* fig. 25).

Pavant Thrust Fault

Overturned folds occur in the lower Paleozoic and Late Precambrian rocks of the lower plate west of the Canyon Range thrust (western exposure), indicating that these rocks are not autochthonous. Overturned anticlines and synclines are consistent with a thrust fault in this area. Because similar stratigraphic units occur in the Pavant allochthon in the Pavant Range to the south, it is concluded that these same formations in the Canyon Range represent the Pavant allochthon. However, nowhere in the Canyon Range is the Pavant thrust fault exposed.

Folds

Canyon Range Syncline

The most readily observed structure of the Canyon Range is a syncline that trends northerly throughout the length of the range (referred to in this study as the Canyon Range syncline (fig. 15). In the present map area, the plunge of the axis of the syncline is about 10° to the south at the northern border of the quadrangle. About 1.5 km south of Oak Creek Canyon, the structure levels off and remains near horizontal to a point just south of Whiskey Creek. From there to the southern border of the quadrangle, the plunge is in a northerly direction. Plunge on the structure at southernmost exposures in the Canyon Range is 14° toward N 30° E.

Within the quadrangle, the syncline is a broad, open structure in the northern part, but in the central part is a tight, overturned fold that gradually opens again to the south. Along Oak Creek Canyon, in an easterly cross section, attitudes range from N 2° W, 84° E, in the Caddy Canyon Quartzite along North Walker Canyon, to N 22° E, 10° SE, in the Mutual Formation near the axis, to N 85° W, 10° S, in the Mutual Formation on the axis just south of Oak Creek Canyon, and to N 25° E, 30° NW, in the Caddy Canyon Quartzite near the eastern thrust-boundary (fig. 17). From Dry Creek Canyon east to Hardscrabble Canyon, the syncline is a tight fold (fig. 17). Dips in the west limb are approximately 80° to the east, but near the axis the west limb is overturned (fig. 20). Dips in the east limb are approximately 30° to the west. In some areas the transition from east to west dips is sudden and dramatic. This is seen clearly near the head of Bowens Canyon, where an eastward dip of 81° changes to a westward dip of 13° in less than 2 m (figs. 21, 22). In the southern end of the range, the syncline is folded less intensely (fig. 17). Dips in the west limb range from 60° to 70° to the east near the axis, and those in the east

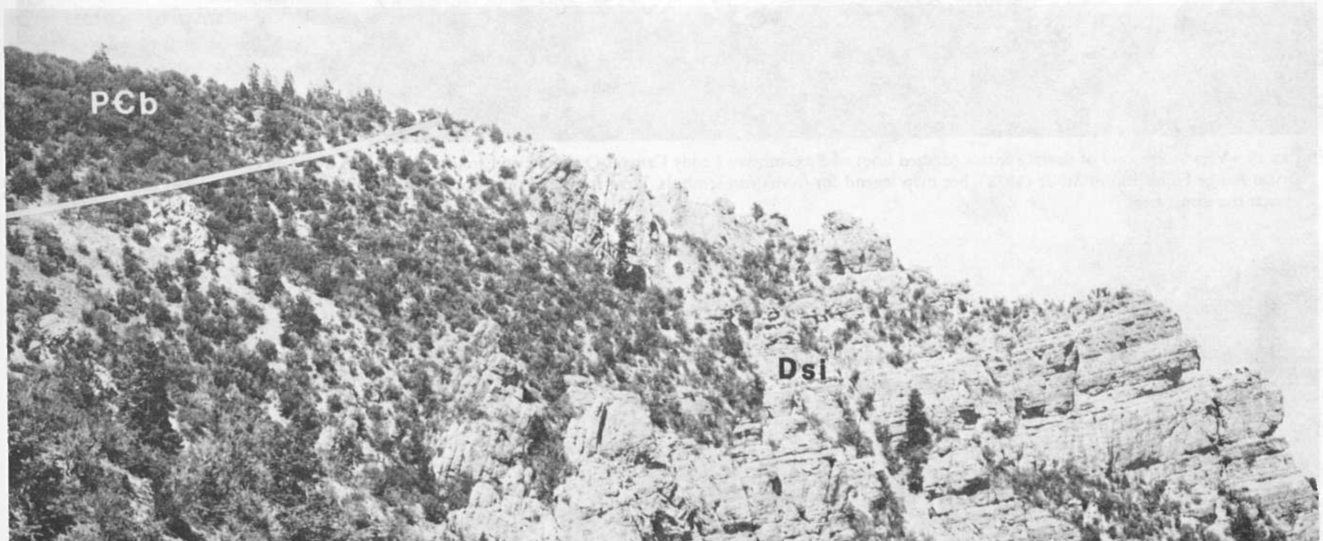

FIGURE 18.–Thrust contact of Precambrian Blackrock Limestone (?) with Devonian Simonson Dolomite in the eastern exposures of the Canyon Range thrust at the head of Hardscrabble Canyon. Note high-angle imbricate structures formed in the Simonson Dolomite. See map legend for formation symbols.

FIGURE 19.—View northward of thrust contact (dashed line) of Precambrian Caddy Canyon Quartzite and Inkom Formation over Upper Cretaceous to Tertiary Canyon Range Formation of Stolle (1978). See map legend for formation symbols. Drag folds and overturned beds (arrow) have been produced in conglomerates near the thrust fault.

FIGURE 20.—View southward of overturned beds (arrow) in the Precambrian Mutual Formation on the west limb of the syncline in Dry Creek Canyon.

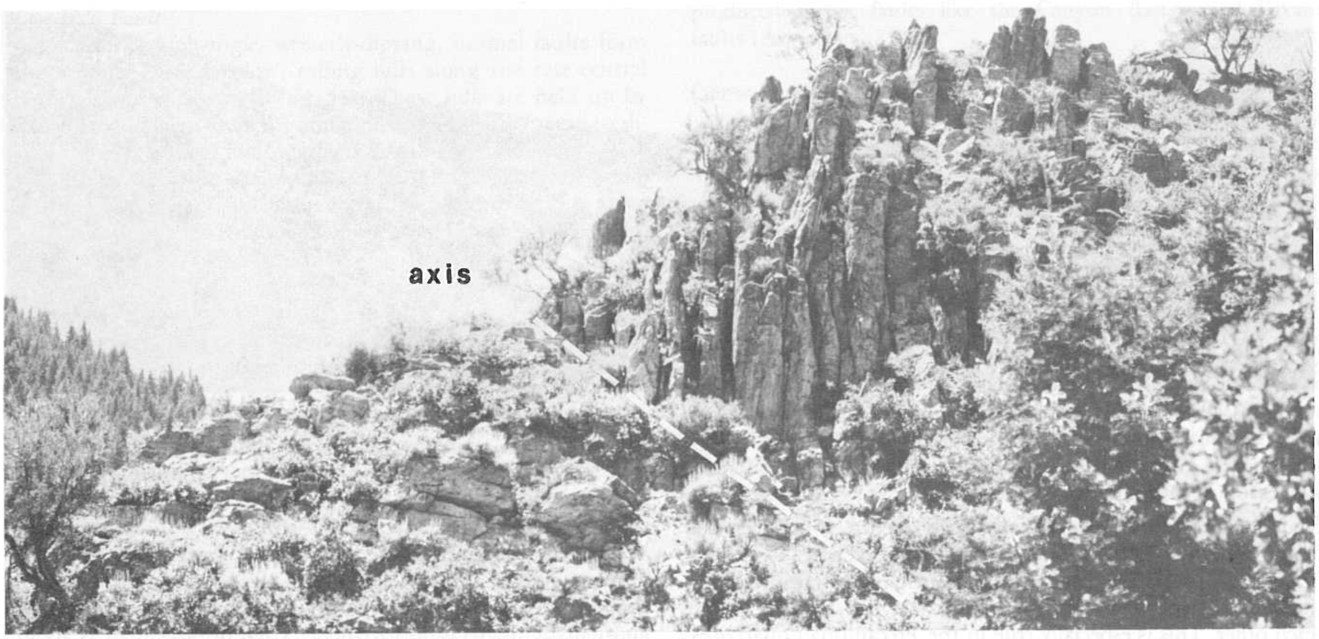

FIGURE 21.—View southward of asymmetrical syncline in Bowens Canyon. Eastern beds (left) dip 13° to the west; western beds (right) dip 81° to the east.

limb are approximately 9° to the west right across the axis, quickly steepening to around 32° to the west, remaining at that angle eastward to the thrust contact. Abundant bedding-plane slickensides occur in the Precambrian and Cambrian quartzites, indicating the syncline is a flexural-slippage fold.

Drag Folds

Strata of the lower plate adjacent to the thrust exhibit drag folds with locally overturned limbs. Such folds occur in the Devonian units of the lower slice but are best developed (fig. 19) in conglomerates of the Canyon Range Formation of Stolle (1978), where beds are overturned and dip up to 80° to the west.

Anticline

Devonian rocks are folded into an eastward asymmetrical anticline just south of Little Oak Canyon. As indicated by cross sections, the axis of the anticline strikes N 10° E and forms a continuous north-south trend throughout the area mapped (fig. 15). This asymmetrical anticline is quite typical of similar anticlines reported by Hickcox (1971) and Davis (1983) near the easternmost edge of the Pavant thrust, suggesting not only that the Pavant thrust is present in this quadrangle below the Canyon Range thrust, but that its leading edge may be no further east than the border of the quadrangle.

Normal Faults

Several normal faults occur within the map area and are named by this study to correspond with local topographic features (fig. 15).

Little Long Canyon Fault

A fault-trace extends along Little Long Canyon, striking about N 35° E, as two, main, more-or-less parallel fractures (figs. 4, 5). The fault zone dips approximately 40° to the southeast, with the southeastern block being down (fig. 23). Displacement along the more northerly fault is between 300

FIGURE 22.—Closeup view of the synclinal axis observed in Bowens Canyon. Note short distance in which the change from west to east dips occurs.

FIGURE 23.–View westward of Little Long Canyon fault near the head of Little Long Canyon. Precambrian Caddy Canyon Quartzite is down against Silurian Laketown Dolomite and Devonian Sevy Dolomite. See map legend for formation symbols.

and 450 m, and on the more southerly fracture is between 200 and 250 m. These faults offset outcrop bands across Little Long Canyon (fig. 24). The fault zone is intensely brecciated, making it hard to trace when two formations are not faulted against each other. This is especially true in the Precambrian quartzites.

Little Oak Canyon Fault

The Mutual Formation is faulted against the Caddy Canyon Quartzite and Inkom Formation at the head of Oak Creek Canyon, and the Inkom Formation is faulted against the Caddy Canyon Quartzite. This same fault cuts the Caddy Canyon Quartzite and the Canyon Range Formation of Stolle (1978). At the divide between Little Oak and Oak Creek Canyons, the Caddy Canyon Quartzite is in fault contact with the Fool Creek Conglomerate, indicating at least some displacement since the deposition of the Oligocene Fool Creek Conglomerate.

The Little Oak Canyon fault strikes N 55° W, is nearly vertical, and cuts across the eastern and western traces of the Canyon Range thrust (fig. 15). The northeastern block is dropped along the normal fault, but dipping-down beds give apparent right-lateral displacement. Total displacement is about 250 m, the northeastern block being down.

Little and Scipio Valleys Faults

Several small normal faults with up to 12 m displacement have produced scarplets within alluvium and older Quaternary fanglomerate in Little and Scipio Valleys (fig. 15). Christiansen (1952) observed that such faults near the Canyon Range trend north-south, but those in the valleys to the east strike more northeasterly-southwesterly. Bucknam and Anderson (1979a,b) concluded that two phases of faulting were involved. The Little Valley and older Scipio Valley faults are pre-Holocene. Younger Scipio Valley faults appear to be Holocene, with possible current activity.

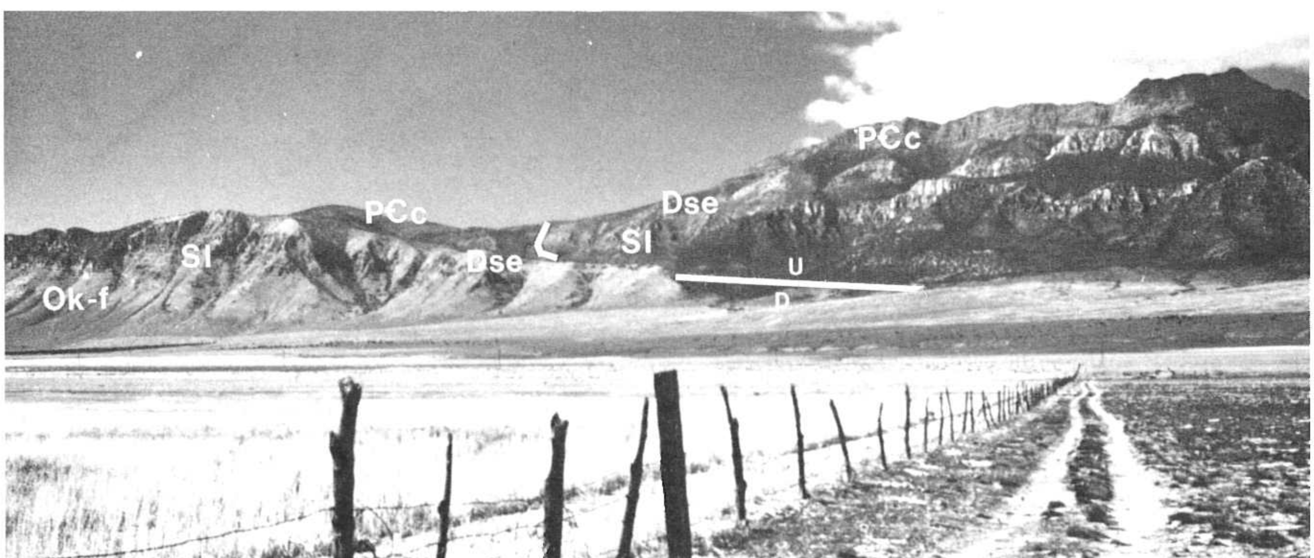

FIGURE 24.–View westward from Scipio Valley of large, downdropped block along Little Long Canyon fault (solid line). See map legend for formation symbols.

Low Hills Fault

A pair of high-angle, westerly-dipping, normal faults form the western border of low, rolling hills along the east central border of the quadrangle (fig. 15). These hills are held up by Oligocene Goldens Ranch Formation (fig. 4) and appear to divide the two areas of fault scarplets in the Little and Scipio Valleys. Rocks from the upper Canyon Range Formation of Stolle (1978) occur along the southern end of the scarps and in cross section appear offset from similar rocks across the fault by less than 150 m.

Border Fault

The topographic configuration and abrupt eastern edge of the Canyon Range indicate that the range is bordered on the east by a normal fault (fig. 15). For the most part, this fault is concealed beneath fanglomerate (fig. 4). In the south, near Fishers Spring, a possible scarp is suggested by changes in the alluvial-fan pattern. Displacement on the fault appears to be relatively small, perhaps 200 m or less, with the eastern block being down.

Tear Faults

Small tear faults occur in the Precambrian and Cambrian rocks of the Canyon Range allochthon in several areas along the western limb of the Canyon Range Syncline. The most readily observed examples are at the head of Dry Creek Canyon (figs. 4, 15), where near-vertical beds of Caddy Canyon Quartzite exhibit internal displacement, and Caddy Canyon Quartzite is faulted against the Inkom Formation, which is in turn faulted against the Mutual Formation. Net displacement within this series is in a left-lateral direction. There are, however, some right-lateral tears within the series. This tear zone may be the result of the folding and overturning of beds during the formation of the Canyon Range syncline. Similar faults occur on a smaller scale at the head of Whiskey Creek Canyon (figs. 4, 15). Christiansen (1952, p. 730) and Higgins (1982) report similar tear faults farther north along the west limb of the Canyon Range syncline in rocks of the Canyon Range allochthon. Another small tear fault displaces beds within the Pogonip Group just north of Partridge Mountain (figs. 4, 15).

Slide Blocks

Blocks of Precambrian rocks have slid downhill at the head of Dry Creek Canyon and at the intersection of Oak Creek and South Walker Canyons (fig. 15). They range in size from about 120 m across to elongate blocks more than 1,200 m long. In both areas faults have broken the blocks. Displacement is only a few tens of meters along slide surfaces that dip northwestward at 40–60°. These blocks are not major structures but do confuse formation outcrop bands.

GEOLOGIC HISTORY

Miogeosyncline

Late Precambrian Upper Pocatello Formation (?) through Devonian Cove Fort Quartzite strata, exposed on the Canyon Range and Pavant allochthons, are typical miogeosynclinal deposits of western Utah, described by Armstrong (1968), Hintze (1972b), and others. Most of that part of the geologic history of this area was characterized by quiet deposition.

Thrusting

During Mesozoic time, geosynclinal development in western North America was terminated by the Sevier orogeny that produced thrust faults like the Canyon Range and Pavant faults (Armstrong 1968).

Canyon Range Thrusting

At least three groups of thrusts developed in the Sevier orogenic belt. The oldest faults placed Precambrian rocks over Paleozoic rocks; intermediate faults put Paleozoic rocks over Mesozoic rocks; and the youngest thrust faults placed Mesozoic rocks over Mesozoic and possibly Tertiary rocks (Burchfiel and Hickcox 1972).

The Canyon Range fault thrust Precambrian rocks over Paleozoic rocks and is older than the Pavant thrust, which put Paleozoic over Mesozoic rocks. The Canyon Range thrust fault has been correlated by Armstrong (1968) to Precambrian-over-Paleozoic faults in the southern Wah Wah Mountains, in southwestern Utah, and southwestward into Nevada. They are "thin-skinned" thrusts, similar to those observed in the Canadian Rocky Mountains. Movement of the upper plate in the Canyon Range area was easterly. Estimates of total displacement along this thrust range from 50 to nearly 100 km (Armstrong 1968). Restorations based on the present study indicate that 40 km is approximately the correct distance (fig. 25).

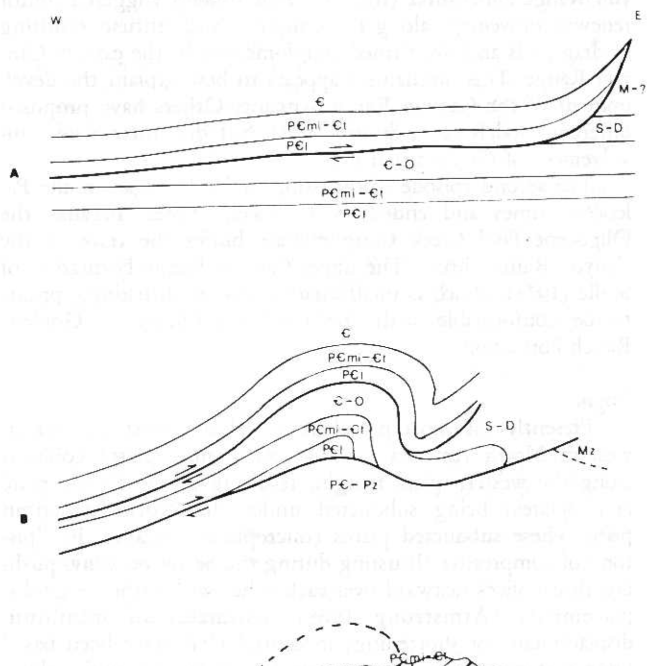

FIGURE 25.—East-west cross sections illustrating development of the Canyon Range and Pavant thrusts and the Canyon Range syncline. A.—First stage shows development of the Canyon Range thrust. To restore lower Precambrian units requires about 50 km of movement. B.—A second thrust, the Pavant thrust, broke below the Canyon Range thrust. Folding during movement on the Pavant thrust produced the Canyon Range syncline. C.—Present topography shown. Later block-faulting and erosion have removed most of the Canyon Range allochthon. See map legend for formation symbols.

Dating of the thrust event is difficult. The synorogenic conglomerate of the Canyon Range Formation of Stolle (1978), formed at least in part during thrusting, provides the best data. However, little unanimity exists as to its exact age. The conglomerates in this quadrangle have been dated as Price River–North Horn age (Late Cretaceous–early Tertiary) by Stolle (1978). Latest units of these conglomerates cover the thrust, but earlier ones are overridden by the fault, suggesting a Late Cretaceous age for the main movement along the Canyon Range thrust.

Pavant Thrusting

Drag folds in the Canyon Range Formation of Stolle (1978) indicate a second period of thrusting and development of a lower fault. This thrust (fig. 14) is part of a belt characterized by Paleozoic rocks over Mesozoic rocks (Hickcox 1971).

The Pavant allochthon carried the Canyon Range slice "piggyback" during this thrust episode. Baer (personal communication 1982) postulates that the Pavant thrust moved more southeasterly than did the Canyon Range thrust, with considerably less displacement. No more than 4 km are needed to restore the Pavant slice to its original position (fig. 25). Folds near the leading edge of the Pavant thrust formed by the same compressional forces that caused synclinal folding of the Canyon Range allochthon (fig. 25). This folding triggered minor renewed movement along the Canyon Range thrust, resulting in drag folds and overturned conglomerates in the eastern Canyon Range. This mechanism appears to best explain the development of the Canyon Range syncline. Others have proposed different models (e.g., Swank 1978), but did not consider involvement of the Pavant thrust.

The second episode of thrusting probably began in the Paleocene times and ended by Oligocene times, because the Oligocene Fool Creek Conglomerate buries the trace of the Canyon Range thrust. The upper Canyon Range Formation of Stolle (1978), which is unaffected by Pavant thrusting, appears to be conformable with the overlying Oligocene Goldens Ranch Formation.

Origin

Presently the most prevalent model of thrust faulting in western North America involves plate (microplate) collision along the western plate margin, resulting in the Pacific plate (microplates) being subducted under the North American plate. These subducted plates (microplates) became the "piston" of compressive thrusting during the Sevier orogeny, pushing thrust slices eastward over each other with rather large displacements (Armstrong 1968). Estimates of minimum displacement (or shortening) in central Utah have been based upon distances from salient crests to reentrant troughs along the thrust front. Davis (1983) described a model which explains these features by a series of buttresses. If his model is correct, then these salient-reentrant distances are not necessarily displacement distances.

The "thin-skinned" nature of the thrust plates suggests that gravity sliding may be just as reasonable a mechanism. Crosby (1976) detailed a model involving arching in eastern Nevada which might have triggered such slides. However, displacements of 40 km appear too large to be compatible.

Transitional Faulting

The orientation of the stress regime appears to have changed following the close of the thrust episodes, as suggested by the northwest-trending Little Oak Canyon fault and the northeast-trending Little Long Canyon fault (fig. 15). These normal faults are not typical of Tertiary to Recent basin-and-range normal faults in this area. Cross-cutting relationships provide the best data for determining the age of these faults.

The Little Oak Canyon Fault places Precambrian Caddy Canyon Quartzite against Oligocene Fool Creek Conglomerate at the divide between Little Oak and Oak Creek Canyons. The eastward trace of this fault has been cut by the border fault (a basin-and-range fault) along the eastern border of the Canyon Range. This relationship indicates a post-Oligocene to pre-basin-and-range age for the Little Oak Canyon fault.

The Little Long Canyon fault displaces the trace of the Canyon Range thrust fault near the head of Little Long Canyon and in turn has been cut by the border fault along the eastern edge of the range. These relationships suggest similar ages for the Little Long Canyon and Little Oak Canyon faults. Because their development occurred sometime between the Sevier orogeny and basin-and-range faulting, these northeast- and northwest-trending faults may represent a transitional episode of faulting.

An intriguing lineament is observed northeastward along strike of the Little Long Canyon fault. An extension of a straight line along strike from the head of Little Long Canyon cuts across the following features as it moves northeastward: the northerly, abrupt termination of the low, rolling hills on the east central border of the quadrangle; the southerly termination of Long Ridge near Mills, Utah; the southeasterly termination or break of Mt. Nebo in Salt Creek Canyon, near Nephi, Utah. This same line carried southwestward is in near-perfect alignment with the sudden cutoff of the southern end of the Canyon Range. This lineament was observed both in the field and on regional topographic maps and may suggest a larger fault system of which the Little Long Canyon fault is only a part. However, it is beyond the scope of this study to do more than suggest this possibility as a basis for further study.

Basin-and-Range Faulting

Subsequent to the development of northwest- and northeast-trending faults, north-south-oriented normal faults developed across the quadrangle. The Canyon Range horst and the Scipio Valley graben developed during this time, as well as the scarplets in the Little and Scipio Valleys (fig. 15). Some of these scarplets indicate current activity. The orientation of these extensional features is typical of basin-and-range faults in this area.

SUMMARY AND CONCLUSIONS

1. The fault mapped by Christiansen (1952) as a western exposure of the Canyon Range thrust in the center of the Canyon Range, later considered by Swank (1978) to be a normal fault, is best considered a thrust fault, as originally mapped by Christiansen.

2. Strata previously mapped as "Cambrian to Ordovician (?) undivided" are mapped as differentiated Cambrian through Devonian formations.

3. Precambrian rocks can be subdivided in the Canyon Range following a modification of the nomenclature suggested by Woodward (1972).

4. The rocks of the Canyon Range represent two allochthonous plates that faulted during the Sevier orogeny.

5. The Pavant thrust slice is present beneath the Canyon Range slice, representing a younger thrust which developed below and in front of the Canyon Range fault during a second period of thrusting. The leading edge of the Pavant thrust may

lie beneath the eastern border of the southwestern quarter of the Scipio North Quadrangle.

6. The Canyon Range syncline is a result of folding of the Pavant thrust.

7. Synorogenic conglomerates, mapped by Stolle (1978) as the Canyon Range Formation, are best interpreted as a local formation and are conformably overlain by the Oligocene Goldens Ranch Formation, suggesting an early Tertiary age for the Canyon Range Formation.

8. Age relationships suggest northwest- and northeast-trending normal faults in the area mapped may represent a transitional episode of faulting between the Sevier orogeny and basin-and-range-style faulting.

9. Basin-and-range faulting produced the Canyon Range block and is still active in the formation of small scarplets in the valley alluvium.

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Appendixes for this paper, 25 manuscript pages, are on open file in the Geology Department, Brigham Young University, Provo, Utah 84602, where a Xerox copy may be obtained.

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