Upper Paleozoic Rocks in The Oquirrh Mountains and Bingham Mining District, Utah

GEOLOGICAL SURVEY PROFESSIONAL PAPER 629-A

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By E. W. TOOKER *and* RALPH J. ROBERTS

with a section on

BIOSTRATIGRAPHY AND CORRELATION

By MACKENZIE GORDON, JR. *and* HELEN M. DUNCAN

GEOLOGIC STUDIES OF THE BINGHAM MINING DISTRICT, UTAH

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A study of the structures, the lithologic successions, and the fossils of two sequences of rocks of the same age that are juxtaposed by thrust faults

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UPPER PALEOZOIC ROCKS IN THE OQUIRRH MOUNTAINS AND BINGHAM MINING DISTRICT, UTAH

By E. W. TOOKER and RALPH J. ROBERTS

ABSTRACT

Recent studies in the Oquirrh Mountains indicate that the rocks of late Paleozoic age may be divided into two main sedimentary sequences, one north of the North Oquirrh thrust fault and the other south of the Midas thrust fault. Upper Paleozoic stratigraphic sections, which make up most of the rocks in the range and in the Bingham mining district, are in the Bingham sequence, on the upper plate of the Midas thrust; a much thinner section of comparable age occurs in the Rogers Canyon sequence, on the upper plate of the North Oquirrh thrust. Underlying both the North Oquirrh and Midas thrusts is an areally small, stratigraphically incomplete, complexly folded, faulted, and altered sequence, which seems stratigraphically and structurally more akin to the Rogers Canyon sequence than to the Bingham sequence.

The main stratigraphic unit of the Rogers Canyon and Bingham sequences, the Oquirrh Group, is composed of three mappable lithologic units: a lower clastic limestone; a middle unit consisting of cyclically repeated limestone, shale, and sandstone; and an upper unit of interlayered thick beds of quartz sandstone and thin beds of carbonate sandstone. Formal names are here proposed for the units in the Rogers Canyon sequence, and previous terminology is examined for comparable units in the Bingham sequence because of the distinctive sedimentary and faunal characteristics in each. In addition, some member units and marker beds of local significance are recognized. These lithologic units have been useful in the preparation of new geologic maps of the Oquirrh Mountains and in making regional correlations with comparable rocks elsewhere in the Great Basin.

The Rogers Canyon sequence consists of the following formational units, in ascending order: the Green Ravine Formation (new) of Late Mississippian age; the Oquirrh Group comprising the Lake Point Limestone (new) of Late Mississippian and Early Pennsylvanian age[1], the Erda Formation (new) of Middle Pennsylvanian age, and the Keesler Canyon Formation (new) of Late Pennsylvanian and Early Permian(?) age; and the Grandeur Member of the Park City Formation of Early Permian age.

The part of the Bingham sequence overlying the Manning Canyon Shale of Late Mississippian and Early Pennsylvanian age consists of the following formational units in the Oquirrh Group: the West Canyon Limestone (redefined) of Early Pennsylvania age; the Butterfield Peaks Formation (new), of Middle Pennsylvanian age; and the Bingham Mine Formation (redefined) of Late Pennsylvanian age, which is divided into the Clipper Ridge and overlying Markham Peak Members (new).

The Carboniferous and Early Permian rocks of the Oquirrh Mountains are very fossiliferous locally and provide a reasonable basis for dating these rocks. They also provide a faunal and biostratigraphic framework for correlating the formations of the Rogers Canyon and Bingham sequences with each other and with similar rock sequences elsewhere in the Great Basin and border areas to the east.

INTRODUCTION

The stratigraphy of sedimentary rocks in different parts of the Oquirrh Mountains, Utah, has been the subject of many reports during the past 70 years (Spurr, 1895; Keith, 1905; Gilluly, 1932; Nygreen, 1958; Bissell, 1959; Welsh and James, 1961; Tooker and Roberts, 1961, 1963). Several systems of stratigraphic nomenclature have been proposed in these reports for rocks in specific areas within the range, but no comprehensive definitive stratigraphic terminology for the whole range has been published. The investigations by Welsh and James (1961) in the central and southern parts of the range, particularly near the Bingham ore deposits, and the studies by Tooker and Roberts (1961; 1963) throughout the range are updated in the present report and new stratigraphic and faunal data are included. The revised stratigraphic data provide standard units for geologic quadrangle maps of the Oquirrh Mountains.

The stratigraphic nomenclature used in this report is largely based on the measured sections and maps of Welsh and James (1961, pls. 2 and 5), the measured sections and map by Tooker and Roberts (1961) and Roberts and Tooker (1961), our unpublished maps, and the stratigraphic sections and faunal data in this report. A section listing and describ-

[1] Since the preparation of this report, it has been determined that paleontologic evidence shows a slight difference in the boundary of the Lower and Middle Pennsylvanian Series as used in the midcontinent when correlated with the type Pennsylvanian in the Appalachian region. Indications are that part of the Morrow is Middle Pennsylvanian in age.

ing the characteristic fauna present and the biostratigraphy and correlation of Oquirrh Mountains rocks is by Mackenzie Gordon, Jr., and Helen M. Duncan. The topography of the northern part of the Oquirrh Mountains is shown on the following 7½-minute quadrangle maps: Mills Junction, Garfield, Magna, Tooele, Bingham Canyon, and Lark. The southern part of the range is shown on the Stockton and Fairfield 15-minute quadrangles.

ACKNOWLEDGMENTS

We deeply appreciate the assistance of colleagues who helped provide and assemble the data for this report: Rudolph W. Kopf, William J. Moore, and Mackenzie Gordon, Jr., helped measure stratigraphic sections; Helen M. Duncan, Mackenzie Gordon, Jr., Raymond C. Douglass, and Ellis L. Yochelson collected many of the fossils and made all of the fossil determinations; and comments by Norman J. Silberling and Ralph L. Miller have materially helped to improve the presentation of these data. We gratefully acknowledge also the helpful criticisms of Allen H. James and John E. Welsh of the Kennecott Copper Corporation and the use of Welsh's extensive stratigraphic and paleontologic data (Welsh and James, 1961). Their interpretations, however, do not fully agree with all of our interpretations.

GEOLOGIC SETTING

The Oquirrh Mountains are in north-central Utah (fig. 1) in the eastern part of the Great Basin. The range is chiefly made up of folded and thrust-faulted sedimentary rocks of Paleozoic age that have been intruded by rocks of Tertiary age and later uplifted and tilted eastward by basin and range faulting. Of lesser extent are volcanic rocks of Tertiary age that crop out along the central part of the east side of the range.

Most of the 12,000–18,000 feet of upper Paleozoic strata exposed in the northern and central parts of the Oquirrh Mountains consist of varying combinations of carbonate- and quartz-rich clastic sediments ranging in age from Late Mississippian through Permian. These in large measure constitute the Oquirrh Formation of Gilluly (1932) or the Oquirrh Group of Welsh and James (1961). The lithology of the Oquirrh Group in the range (as well as in many other places in the Oquirrh basin of deposition) can generally be divided into three distinct units: (1) a lower clastic limestone, (2) a medial unit consisting of cyclical beds of limestone, shale, and sandstone, and (3) an upper unit consisting predominantly of interbedded quartzite and sandstone (Tooker and

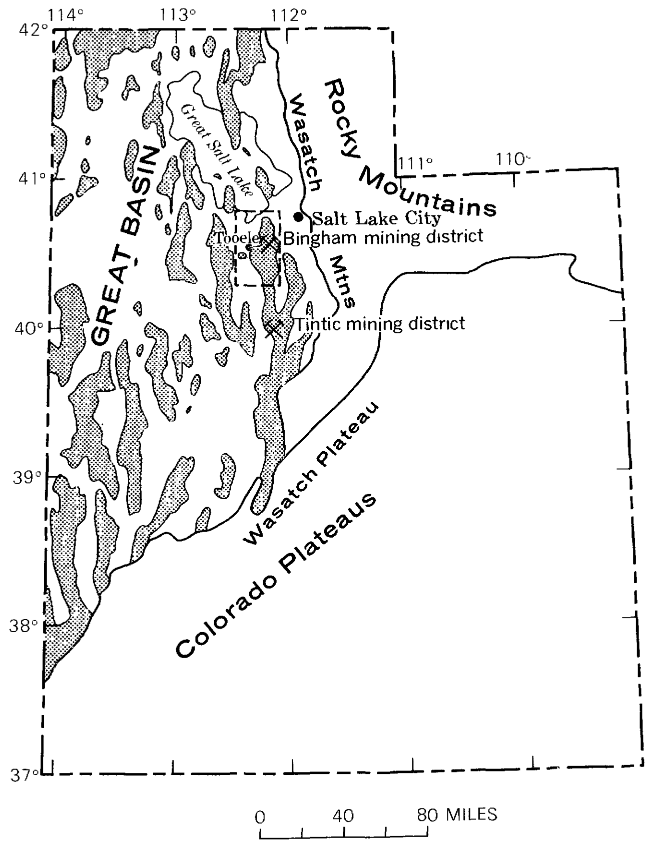

FIGURE 1.—Principal mountain ranges in the Great Basin region in northwestern Utah. The area covered by the dashed rectangle (area of figs. 2 and 4) includes the Oquirrh Mountains and South Mountain.

Roberts, 1963). However, the thickness and age of these units vary from place to place, and the sedimentary characteristics of key beds cannot be traced with certainty across thrust faults in the Oquirrh Mountains or from range to range elsewhere in the Great Basin.

The authors are convinced that structurally the Oquirrh Mountains make up a part of the imbricated upper plate of the Charleston-Nebo thrust plate, which is exposed in the southern part of the adjacent Wasatch Mountains (Crittenden, 1961; Roberts and others, 1965). Near Bingham two thrust faults, the North Oquirrh and Midas,[2] separate three struc-

[2] The North Oquirrh thrust was mapped independently by James, Smith, and Welsh (1961, p. 58) and by Roberts and Tooker (1961, p. 40) and jointly named. A second fault, the Midas thrust, was first mapped in the Lark mine by geologists of the United States Smelting, Refining, and Mining Co., where it was called the North fault. In 1951 C. L. Thornburg recognized it as a thrust fault, but his information was not published (oral commun., 1965; Hewitt, 1966). In 1956 this fault was mapped independently by Allan James and was named the Midas thrust (James, Smith, and Welsh, 1961, p. 62). To avoid confusion of a North thrust fault with the similarly named North Oquirrh thrust, the name Midas is retained in this report.

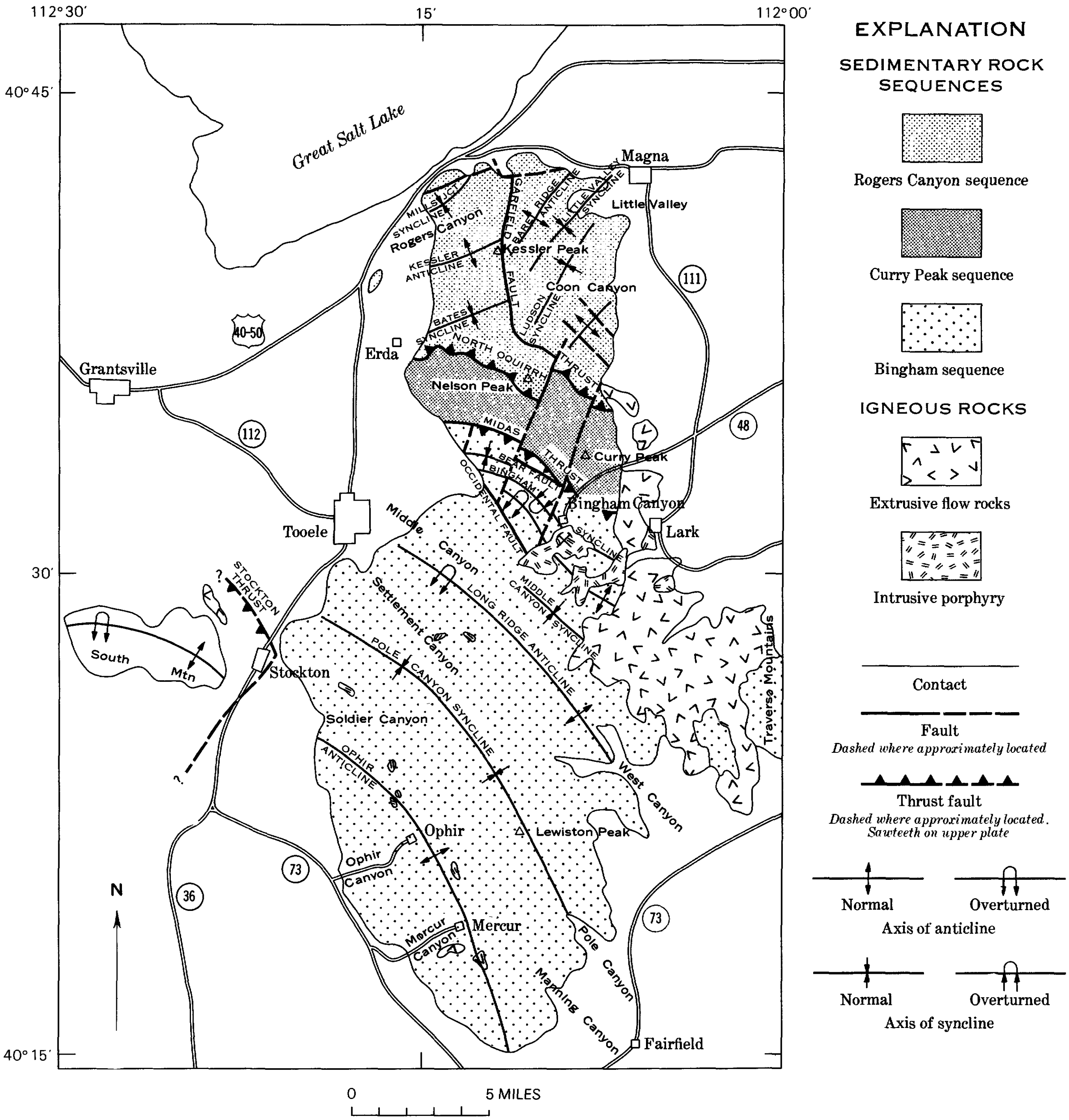

FIGURE 2.—Sketch map of the Oquirrh Mountains and South Mountain showing the locations of the Rogers Canyon, Bingham, and Curry Peak sequences.

tural blocks containing at least two distinct sedimentary sequences[3] (figs. 2, 3). Tooker believes that the rocks on South Mountain, a transverse range adjoining the Oquirrh Mountains on the west, may constitute a separate structural block.

The North Oquirrh thrust, which separates the Rogers Canyon sequence on the upper plate from the more disturbed but possibly related sequence on the lower plate, tentatively called the Curry Peak

[3] The term "sequence" is used here in the sense of Silberling and Roberts (1962, p. 6) as "units of major rank * * * set apart from underlying or overlying sequences by unconformities * * * . Sequences are discrete rock units, some of which, though lithologically distinct, were deposited under much the same environmental conditions."

sequence, strikes nearly southeast across the range, dips northward about 35°, and is offset locally by normal faults. In the upper plate of this thrust, asymmetric folds plunge northeastward and are locally overturned southward; thus, the apparent movement on the thrust was from the northwest or north. The Midas thrust, separating the Bingham and Curry Peak sequences, strikes northwest-southeast and dips about 45° SW. Asymmetric folds in the upper plate plunge northwestward and are locally overturned to the northeast; they indicate, therefore, that movement on the thrust was from the southwest. The complexly folded and faulted, stratigraphically incomplete Curry Peak sequence locally exposes two sets of folds on imbricate thrust fault structures, one striking northwestward and the other northeastward.

Granite, granite porphyry, and monzonite stocks and dikes, which intrude the sedimentary rocks in the central and southern parts of the Oquirrh Mountains, have been described by Boutwell (1905), Gilluly (1932), Schwartz (1947), Stringham (1953), James, Smith, and Welsh (1961), and Peters, James, and Field (1966). The Bingham and Last Chance stocks, the largest intrusive bodies, are exposed in the central part of the Bingham mining district in the east-central part of the range. Other intrusive bodies crop out in and near the Ophir, Stockton,

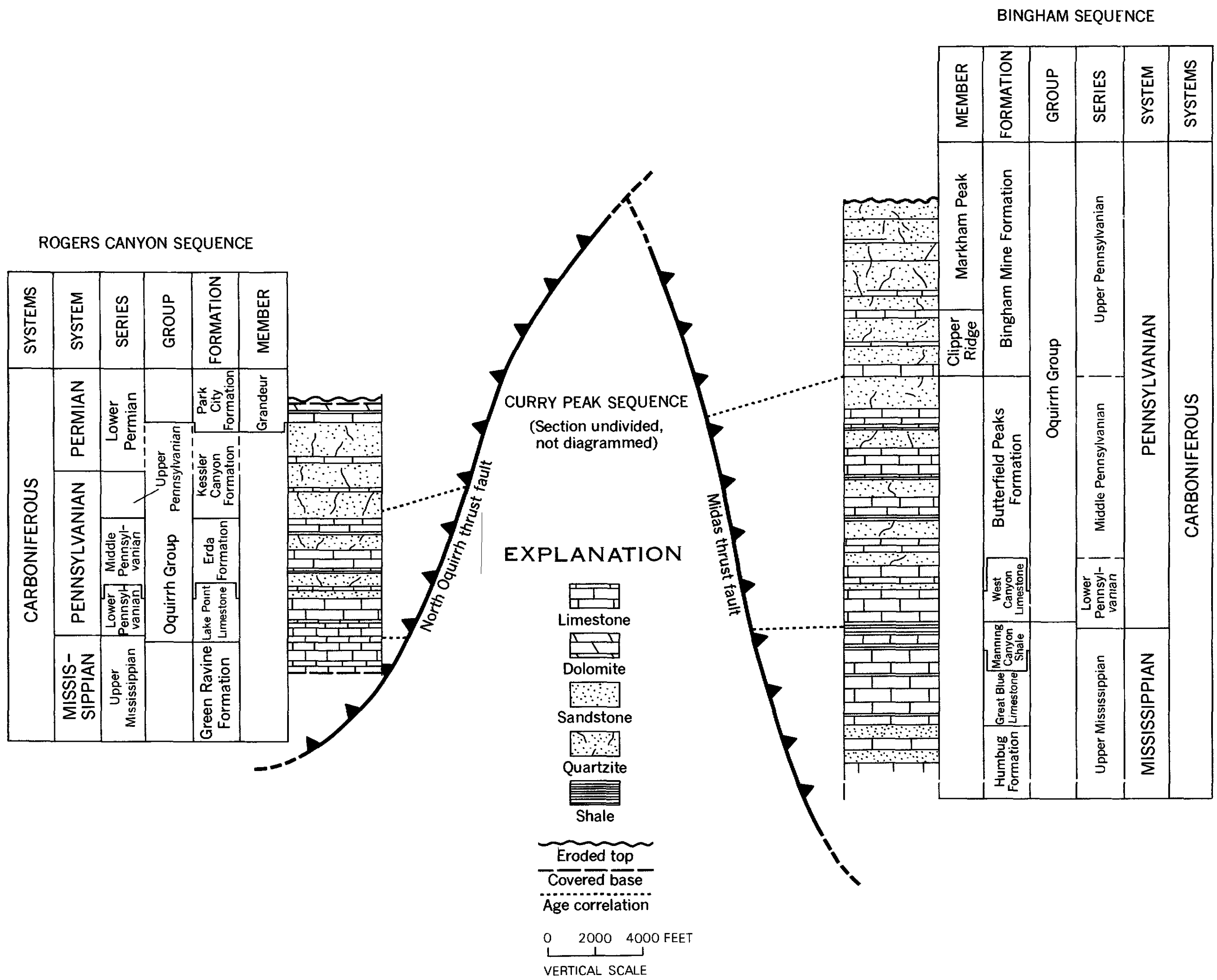

FIGURE 3.—The Rogers Canyon and Bingham sequences in the Oquirrh Mountains showing relative proportions and general character of lithologic units and their structural relationship to the Curry Peak sequence.

and Mercur mining districts in the southwestern part of the range (Gilluly, 1932). Tertiary extrusive flows, breccias, and water-laid tuffaceous rocks, which have been described by Gilluly (1932) and Smith (1961), are found in two distinct areas on the margins of the central part of the Oquirrh Mountains (fig. 2). The smaller of these two areas lies at the northeast base of South Mountain; the larger lies 12 miles to the east along the eastern flanks of the Oquirrh Mountains and extends over much of the adjoining western Traverse Mountains.

PREVIOUS TERMINOLOGY AND RECOMMENDED CHANGES

The Oquirrh Formation has been studied in several localities in the central and southern parts of the Oquirrh Mountains during the past 70 years (fig. 4), but only recently in the northern part.

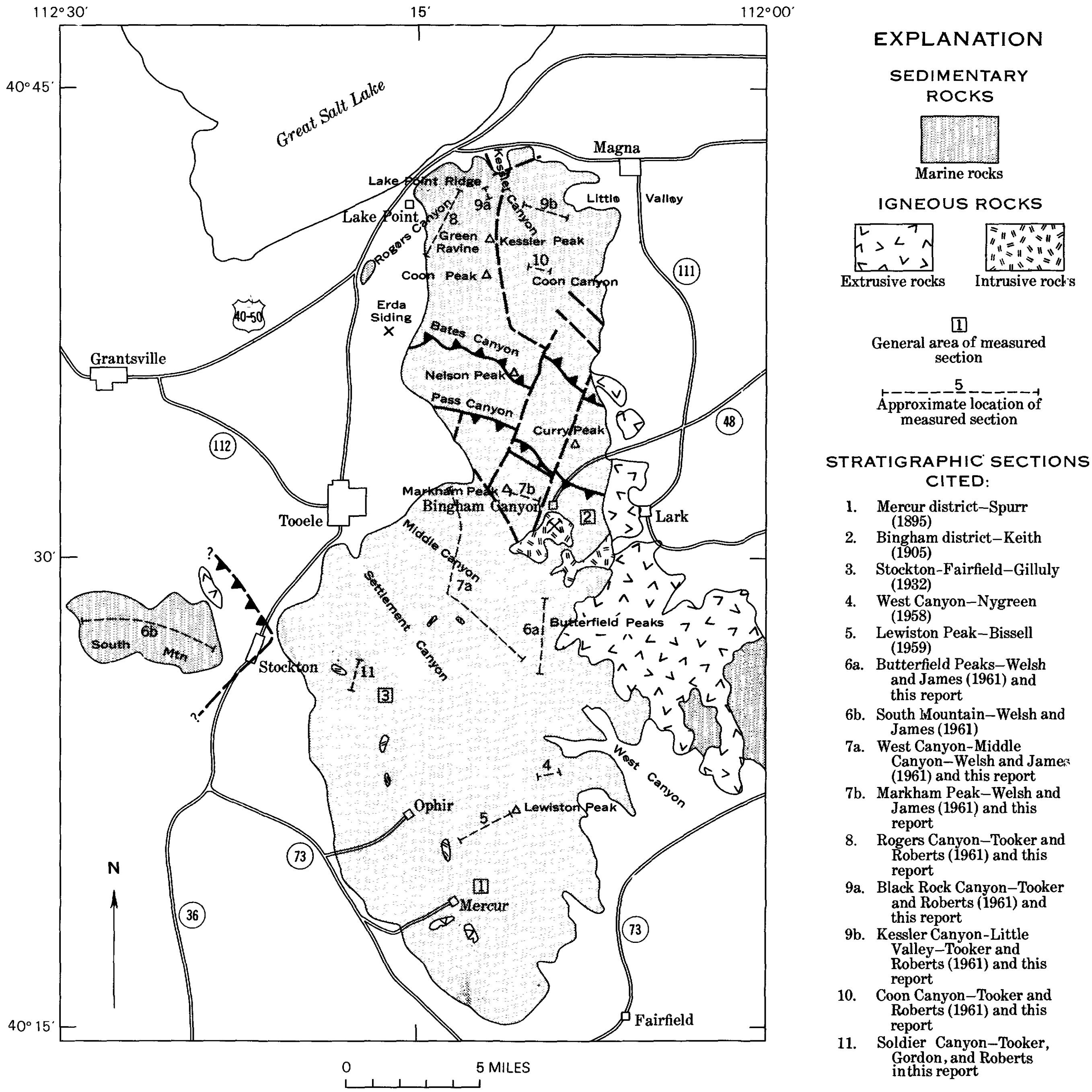

FIGURE 4.—Sketch map of the Oquirrh Mountains showing the location of type and reference sections.

Many formational and member names have been applied to the formation in the southern part of the range; the complex evolution of stratigraphic terminology shown in figure 5 is summarized chronologically in the following paragraphs.

In 1895 Spurr referred to rocks at the Mercur mining district as the Great Blue Limestone and the overlying upper intercalated series (fig. 5, section 1). Keith (1905) named the rocks in the immediate vicinity of the Bingham mining district the Bingham Quartzite, but he was not able to designate a top or bottom to the formation; part of the Bingham Quartzite is now known to correspond to the upper part of Spurr's upper intercalated series (fig. 5, sections 1 and 2). Because these rocks have subsequently been reassigned by later workers to the Oquirrh Formation as defined by Gilluly (1932), the name Bingham Quartzite is here considered abandoned. Keith also designated several prominent limestones in his Bingham Quartzite as members and lentils. Among these are the Tilden (which he designated the Petro on pls. 1 and 2) and Phoenix Limestone Lentils and the Butterfield, Lenox, Jordan, Commercial, Highland Boy, and Yampa Limestone Members. He suspected that the last four members represented only two units, a fact since substantiated (Hunt, 1924, p. 861). These names and others used in the mines to designate marker beds we

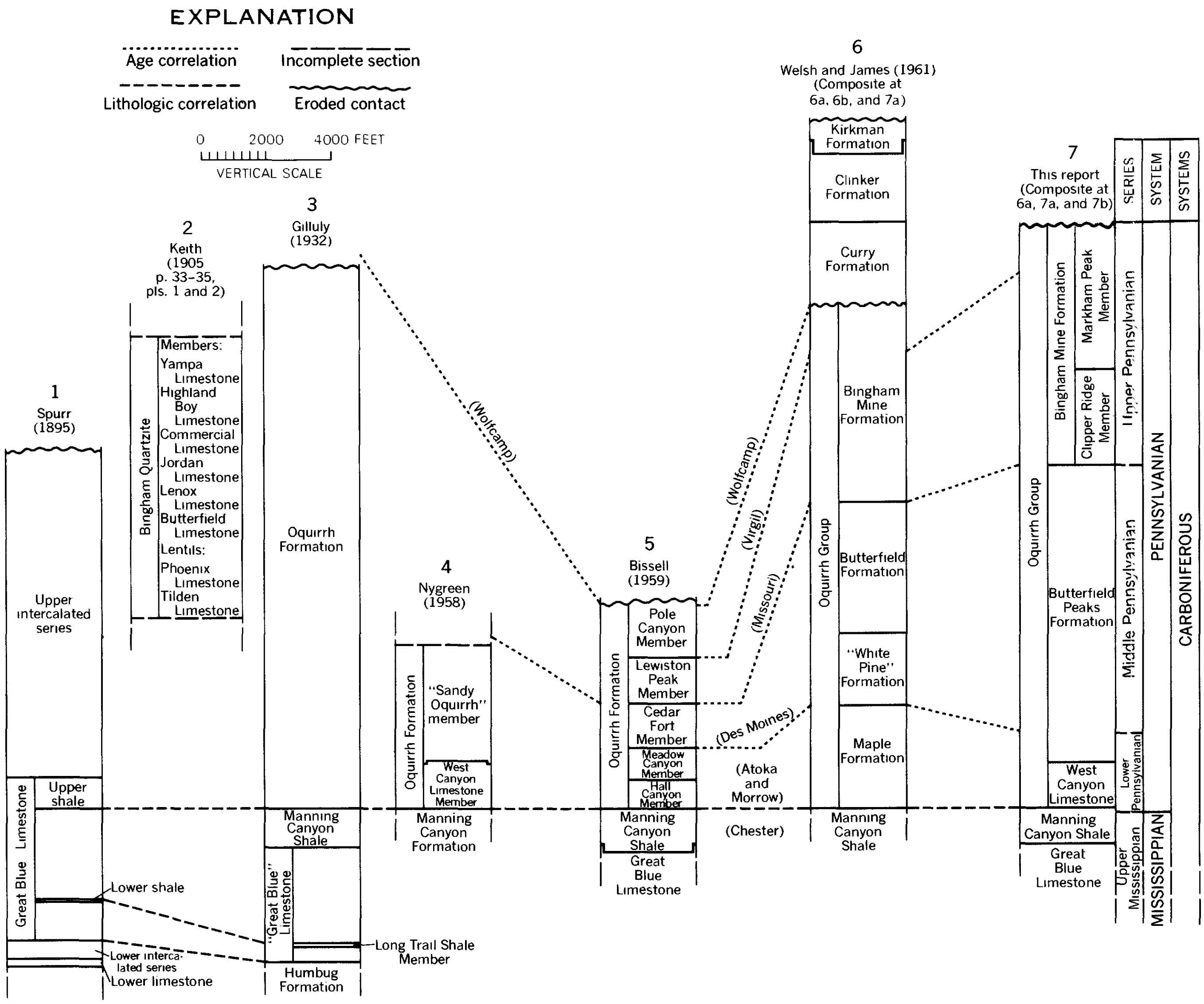

FIGURE 5.—Development of upper Paleozoic rock-stratigraphic divisions in the Bingham sequence. Section numbers indicate locations in figure 4.

herein consider informally named marker beds rather than formally named units of member rank.

Gilluly (1932) formally named the Oquirrh Formation. He placed the base at the top of the Manning Canyon Shale (fig. 5, section 3), a lithologically uncertain transitional boundary, but did not define the top as it is not exposed in the southern part of the Oquirrh Mountains. He estimated the exposed thickness of the formation to be 16,000–18,000 feet, but he did not designate a type section. All faunas collected by him from the southern part of the Oquirrh Mountains proved to be Pennsylvanian, but Bissell (1936), Baker (1947), and Welsh and James (1961) recognized Permian faunas from Oquirrh strata nearby in the Wasatch Mountains and South Mountain.

Nygreen (1958) was the first to study the lower part of the Oquirrh Formation in detail in the southern Oquirrh Mountains area; he named the lower limestone unit the West Canyon Limestone Member (fig. 5, section 4). We retain this name, but raise it to formational rank—the West Canyon Limestone. Nygreen (1958) also used the term "Sandy Oquirrh" for the overlying strata. This term is not considered a formal name.

Bissell (1959) described five time-stratigraphic subdivisions of the Oquirrh Formation in the southern Oquirrh Mountains in the vicinity of Lewiston Peak (fig. 5, section 5); their boundaries coincide with those of the provincial series of the Pennsylvanian. These units are well exposed south of Ophir, where they are broken and offset by numerous faults. As defined by Bissell, these units did not have lithologically recognizable tops and bottoms, which disqualifies them as rock-stratigraphic units (Code of Stratigraphic Nomenclature, Art. 4). Although it is difficult to trace individual beds, generally recognizable lithologic units in the West Canyon Limestone and the lower part of the Butterfield Peaks Formation can be traced northward from the Lewiston Peak area to West Canyon and can be correlated with their stratigraphic and age equivalents. A Morrow to Des Moines age is established for these rocks throughout the lower part of the Bingham sequence on the basis of the fusulinid, brachiopod, coral, and bryozoan assemblages (Mackenzie Gordon, Jr., H. M. Duncan, and R. C. Douglass, this report, and written comm., 1965). This age designation conflicts with the age designation Morrow through Virgil reported by Bissell (1959), an age designation based on fusulinids. Bissell's (1962, p. 37, 40, and 43) suggestion of abnormal thickening of the stratigraphic section in the southern part of the Oquirrh Mountains north of Lewiston Peak is believed to be invalid.

Welsh and James (1961) elevated the Oquirrh Formation of Gilluly (1932) to the Oquirrh Group. We support this designation because the Oquirrh consists of thick but extremely variable lithologic units that can be recognized elsewhere in the Great Basin and Wasatch Mountains. The relationships of the lithologic units require a complex nomenclature. Welsh and James restricted the Oquirrh Group to rocks of Pennsylvanian age and included in it four formational units, from oldest to youngest, the Maple, "White Pine," Butterfield, and Bingham Mine Formations (fig. 5, section 6).

Nomenclatural difficulties and our attempt here to emphasize comparable regionally recognizable lithologic units now prompts us to modify that formational terminology. The lower part of the Maple Formation is a lithologically distinct clastic limestone that Nygreen (1958) named West Canyon Limestone Member; it is herein raised to formation rank. The cyclic limestone, shale, and sandstone of the upper part of the Maple closely resemble comparable beds in the overlying White Pine and Butterfield Formations, which are herein combined into a single formation. (The formational name White Pine is now known to be preempted because of prior usage for an upper Paleozoic formation in Nevada.) Owing to confusion arising from the fact that the Butterfield Limestone of Keith (1905) occurs in the "White Pine" Formation of Welsh and James but not in the Butterfield Formation, the combined unit is here renamed the Butterfield Peaks Formation (fig. 5, section 7). Finally, the Bingham Mine Formation of Welsh and James (1961) is broadened to include all of the comparable predominantly quartzite-sandstone beds of Pennsylvanian age above the Jordan marker bed; as such it includes some beds considered to be of Early Permian age by Welsh and James (1961). The formation is terminated upward by erosion and the Midas thrust fault. Thus, the Oquirrh Group is defined in the Oquirrh Mountains to denote rocks that possess a distinctive three-part lithologic succession that ranges in age from Early to Late Pennsylvanian.

Welsh and James (1961, p. 8), following Keith (1905), suggested names for individual prominent limestone beds in the Bingham mining district but said that, "In a later paper the individual limestones will be formally named." We propose here to designate them informal marker beds; they are locally very important ore-forming horizons in the Bing-

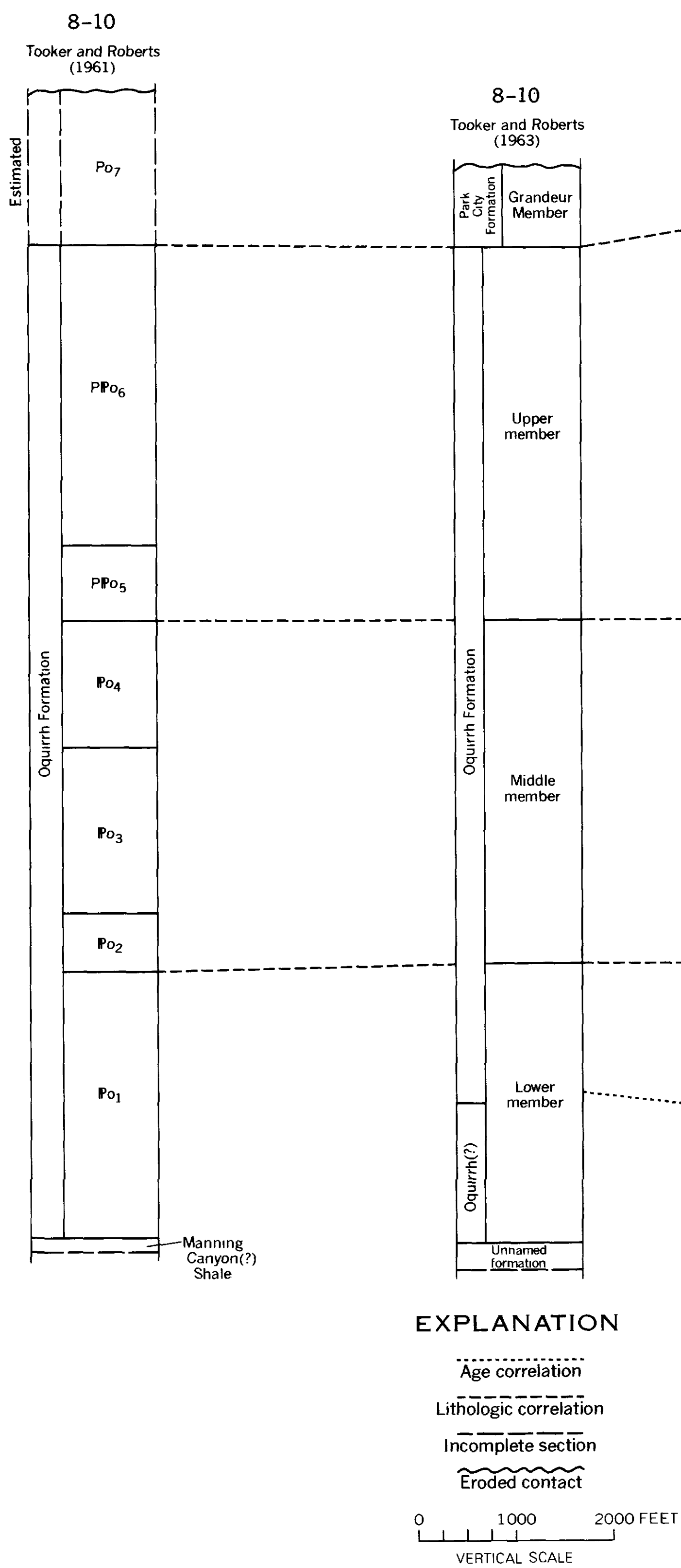

FIGURE 6.—Development of upper Paleozoic rock-stratigraphic divisions in the Rogers Canyon sequence. Composite of sections measured in localities 8, 9a, 9b, and 10 (fig. 4).

ham mining district but are often difficult to trace outside the district.

Above the Oquirrh Group, Welsh and James (1961) also named two younger units, the Permian Curry and Clinker Formations, and designated overlying even younger rocks as the Permian Kirkman, Diamond Creek, and Park City Formations. More recent mapping of the Curry Peak sequence rocks in the structurally complex area north of the mining district by Tooker and Roberts (unpub. data) has shown these rocks to be lithologically similar to rocks of the Rogers Canyon sequence although they are locally highly altered and sheared, and their fossils destroyed. We have not been able to confirm the Early Permian age for these rocks that was reported by Welsh and James (1961), who correlated them with the type Curry and Clinker Formations on South Mountain. There is a similarity of lithology and age between the Kessler Canyon Formation of the Rogers Canyon sequence, the unnamed upper quartzite unit of the Curry Peak sequence, and the Bingham Mine Formation of the Bingham sequence. Their separation is based largely on the structure discontinuities and their separation by the North Oquirrh and Midas thrust faults. The Grandeur Member of the Park City Formation, however, is restricted to the upper plate of the North Oquirrh thrust and is in the Rogers Canyon sequence. We find no rocks equivalent to the Kirkman Limestone or Diamond Creek Sandstone in the Bingham sequence. The formational units that have been correlated with the Kirkman Limestone and Diamond Creek Sandstone [type localities are in the Timpanogos sequence (Tooker and Roberts, 1963) in the Wasatch Mountains] and with the Clinker and Curry Formations of Welsh and James (1961) [type localities are on South Mountain], which Welsh and James (1961) reported in the Curry Peak sequence, are not considered here. Because of as yet incompletely understood internal structural and stratigraphic complexities, the irregular alteration of strata, and the scarcity of well-preserved fossils in Curry Peak sequence rocks and their superficial resemblance to rocks of the Rogers Canyon sequence, we defer further discussion of the stratigraphy of these lower plate rocks.

Tooker and Roberts (1961) mapped and described the stratigraphic units of the Rogers Canyon sequence at the north end of the Oquirrh Mountains. Changes in stratigraphic terminology of these rocks are summarized in figure 6. The informal recognition of seven mappable units of the Oquirrh Formation (Tooker and Roberts, 1961, p. 24) was subsequently revised (Tooker and Roberts, 1963, p. E33) into a lower, middle, and upper series of distinctive mappable units. The lower shale and limestone, tentatively called the Manning Canyon(?) Shale (Tooker and Roberts, 1961), was later designated an unnamed formation when the pre-Manning Canyon age of the shale was confirmed (Tooker and Roberts, 1963, p. E33). An unnamed unit was designated the Grandeur Member of the Park City Formation following the usage of Welsh and James (1961, p. 4).

REVISED UPPER PALEOZOIC STRATIGRAPHY

Revision of the Oquirrh Formation to the rank of Oquirrh Group and its subsequent division into lithologically distinct formational units in the Oquirrh Mountains permits us to make systematic regional stratigraphic correlations. Several correlative lithologic formational units have already been designated elsewhere. The Round Valley Limestone and Weber Quartzite in the Wasatch Mountains (Crittenden, 1959) represent the lower limestone and middle cyclical limestone, shale, and quartzite shelf facies of Pennsylvanian age. The Ely Limestone of eastern Nevada contains a similar lower limestone and overlying cyclic limestone, shale, and quartzite basin unit of Pennsylvanian age; these beds in turn are overlain by the Arcturus Formation containing sandstone of Early Permian age (A. Brokaw, oral commun., 1964). The revision of the stratigraphic division into two main sequences of the Oquirrh Group in the Oquirrh Mountains, the Rogers Canyon and Bingham sequences, is briefly described in the following sections and is shown in figure 3. The type sections of the Rogers Canyon and Bingham sequences are designated, respectively, the Rogers, Black Rock, and Kessler Canyons, at the north end of the range, and the West, Middle, and Bingham Canyons, in the vicinity of the Bingham mining district. The type section of the Oquirrh Group is designated the composite of the type sections of its formations in the Bingham sequence.

ROGERS CANYON SEQUENCE

The Rogers Canyon sequence, named for the area of excellent exposures of these rocks in and adjacent to Rogers Canyon at the northwest end of the range, is divided into four new formations. The Green Ravine Formation at the base is overlain by the Oquirrh Group, consisting of the Lake Point Limestone and the Erda and Kessler Canyon Formations. The Grandeur Member of the Park City Formation (Tooker and Roberts, 1963) overlies the

Oquirrh Group with apparent conformity, but there may have been an erosion interval separating them.

GREEN RAVINE FORMATION

The Green Ravine Formation, here named for exposures near the mouth of Green Ravine (fig. 4, section 8), is composed of a basal 290 feet of interbedded limestone and calcareous shale section overlain by more massive cherty and sandy limestone. The formation, whose previous informal designations are shown in figure 6, is exposed only in the core of the Kessler anticline (Roberts and Tooker, 1961, p. 40). The type section of the formation is on the west side of Kessler Peak at the north end of the Oquirrh Mountains, south of the mouth of Green Ravine in the SE¼ sec. 1, T. 2 S., R. 4 W., and the NW¼ sec. 6, T. 2 S., R. 3 W., Garfield quadrangle, Utah.

The total thickness of the Green Ravine Formation is uncertain because the base is concealed by alluvium at the range front; a thickness of about 1,400 feet was measured in the exposed part of the type section. The formation is conformably overlain by the Oquirrh Group.

The Green Ravine Formation is mostly a limestone and consists of two parts. The lower part is dominantly 1–2-foot-thick limestone beds and shale layers. The limestone is medium and dark gray to light olive gray or yellowish gray and is locally very fossiliferous; the shale is black and dark gray to olive gray. In the lowest part, variegated argillaceous limestone is composed of rounded medium-dark gray crystalline limestone "nodules" that are as much as 3 inches in average diameter; the nodules are embedded in a medium-light-gray silty to sandy carbonate matrix. The lower contacts of individual beds are commonly scoured and may indicate short erosion intervals. Thin beds and partings of shale between thicker limestone layers in the lowest exposed part of the formation locally show well-developed cleavage.

The upper part consists of medium-bedded to massive 2–3 foot-thick medium-gray locally fossiliferous limestone and banded nodular black cherty limestone at the base, and interbedded medium- to thick-bedded fossiliferous limestone and thin- to medium-bedded argillaceous and fossiliferous limestone at the top. The upper contact of the formation is placed above a thick series of argillaceous and fragmented-fossil limestones that underlie a crossbedded limestone that contains quartz sand; this sandy limestone is characterized by brown-weathering wispy sand lenses or streaks in a gray limestone matrix—a characteristic which is common in the cyclically bedded Lake Point Limestone of the Oquirrh Group.

TYPE SECTION OF GREEN RAVINE FORMATION (see fig. 4, section 8)

West side of Kessler Peak from 4,700-ft altitude in unnamed drainage south of KSL-TV television transmitter tramway line northeast across Green Ravine to unnamed drainage north of hill whose altitude is 5,244 ft, SE¼ sec. 1, T. 2 S., R. 4 W., and NW¼ sec. 6, T. 2 S., R. 3 W., Garfield quadrangle, Utah

[Measured by E. W. Tooker and R. J. Roberts]

	Thickness (ft)
Oquirrh Group:	
Lake Point Limestone	
Conformable contact.	
Green Ravine Formation:	
12. Argillaceous limestone, limestone, cherty limestone, and bioclastic limestone, interbedded; medium to dark gray; weather medium gray to tan and buff; locally variegated; thin to medium bedded; clastic limestone is crossbedded; shale partings are found in the limestone; sparse layered chert nodules are present; limestones contain abundant brachiopods, corals, bryozoans, and crinoids (USGS colln. 16333–PC, 21132–PC, 17144–PC, and 20254–PC)	215
11. Limestone, medium-gray; weathers medium light gray to light gray; thin to medium bedded; locally platy; interbedded thin-bedded cherty limestone, crossbedded bioclastic limestone, and argillaceous limestone; shale partings throughout unit; abundant productid brachipods, *Caninia* corals, and chaetetiform bryozoans (USGS colln. 20256–PC, 16331–PC, 17143–PC, 20253–PC, 20257–PC, 16330–PC, 20258–PC, 21131–PC, 21130–PC, 20248–PC, 16329–PC, 20249–PC, 20251–PC, 20250–PC, 20252–PC, and 16332–PC)	331
10. Cherty (banded) limestone, dark-gray; weathers light gray; thin to medium bedded; interlayered bioclastic limestone in basal part; black chert nodules present; abundant *Caninia* corals (USGS colln. 16335–PC)	82
9. Limestone, dark-gray; weathers light gray; medium to thick bedded; interbedded thin arenaceous often bioclastic limestone, argillaceous limestone, shale, and black cherty limestone (nodules in bands and irregular lenses); sparse coral fauna. Lower half of unit is mostly covered slope; section crosses a fault of small but unknown displacement, and a small part of the section may be missing	500
8. Limestone and shale, interbedded; medium dark gray and gray; weather light gray; thin to medium bedded; bioclastic limestone limestone lenses and shale partings in the limestone. Unit is mostly covered	145

	Thickness (ft)
7. Shale, dark-gray to black; weathers medium dark gray; thin bedded and fissile; calcareous.. Unit is mostly covered slope	17
6. Shale and limestone, interbedded; dark gray and black; weather light olive gray; thin to medium bedded; ferruginous stains along bedding; platy. Shale parts of unit are mostly covered slope. Abundant bryozoans, brachiopods, and crinoids in limestone layers (USGS colln. 20247–PC, 20246–PC, 20243–PC, 21129–PC, and 20228–PC)	61
5. Limestone, yellowish-gray; weathers yellowish orange and tan; thick bedded; sparse light-gray chert nodules	8
4. Limestone intraformational conglomerate, medium-gray; matrix weathers dark yellow orange, and rounded limestone fragments weather light gray; medium to thick bedded; shale partings locally	5
3. Limestone and arenaceous and argillaceous limestone, interbedded; light gray and light olive gray; weather grayish orange; thin bedded	34
2. Bedded chert, pale-yellowish-brown; weathers olive gray and grayish orange	2
1. Arenaceous limestone, olive-gray; weathers light olive gray; thin bedded; locally contains brownish-gray chert lenses in upper part	17
Total thickness measured	1,417

Covered at base by alluvium, faults.

The Green Ravine Formation contains an abundant, well-preserved brachiopod, coral, and bryozoan fauna of Late Mississippian (fairly early to late Chester) age. Mackenzie Gordon, Jr., and H. M. Duncan in the section on biostratigraphy and correlation list and discuss details of fossil collections from the type locality, their biostratigraphic relations, and correlation with similar rocks elsewhere. They separate the formation into three parts: a pre-*Caninia* Zone containing a predominantly bryozoan-brachiopod fauna; the *Caninia* Zone with corals and chaetetiform bryozoans predominant; and a post-*Caninia* Zone with brachiopods predominant. These rocks may be correlative with those in the upper part of the Great Blue Limestone in the Bingham sequence near the Ophir mining district and with those in the lower part of the Doughnut Formation in the Mount Raymond sequence (Tooker and Roberts, 1963) in the Wasatch Mountains. The Green Ravine, however, is neither lithologically similar to the Great Blue Limestone nor to the overlying Manning Canyon Shale in the type localities. The lower part may correlate with one of the shaly units of the Great Blue Limestone.

OQUIRRH GROUP

The Oquirrh Group in the Rogers Canyon sequence consists of three new formations: the Lake Point Limestone and the Erda and Kessler Canyon Formations.

LAKE POINT LIMESTONE

The Lake Point Limestone is here named for the small farming community of Lake Point immediately south of the Great Salt Lake; the nearby northwestern ridge of the Oquirrh Mountains in the Mills Junction and Garfield quadrangles is also called Lake Point. These rocks previously were designated an unnamed unit, which subsequently was informally referred to as the lower member of the Oquirrh Formation (fig. 6). The rocks crop out in the core of the Kessler anticline 1 mile east of Lake Point, on the north side of Lake Point Ridge, in the upper part of Bates Canyon, on the upper plate of the North Oquirrh thrust fault at Nelson Peak, and in small downfaulted klippen on the lower plates of the thrust near the mouth of Bates Canyon (Tooker and Roberts, 1961, pl. 6; Welsh and James, 1961, pl. 2).

The type section of the formation is on the west side of Kessler Peak and extends from the bottom of an unnamed ravine at an altitude of 5,200 feet northeastward to near the top of the hill whose altitude is 6,231 feet in the NE¼ sec. 6, T. 2 S., R. 3 W., and SW¼ sec. 31, T. 1 S., R. 3 W., of the Garfield quadrangle, Utah (fig. 4, section 8). The formation is 1,700 feet thick in the core of the Kessler anticline. The Lake Point Limestone conformably(?) overlies the Green Ravine Formation and is conformably overlain by the Erda Formation. The upper contact is at the base of the lowest red-brown-weathering quartzite bed in the Erda Formation.

The rocks are chiefly interbedded medium-gray light-gray- to tan-weathered medium-grained thin- to medium-bedded limestone and massive (thick-bedded) gray limestone; locally the limestone is cherty and contains bioclastic sand material in cross-bedded arenaceous layers, thin-bedded to parting (very thin) argillaceous layers, and carbonaceous shale beds and partings. The lower 350 feet consists mostly of 1–3-foot-thick shale partings and shaly limestone intervals in dense platy medium-bedded limestone and arenaceous limestone that locally are cherty and very fossiliferous. The beds in the upper 1,387 feet contain more-massive detrital cliff-forming limestone and interformational conglomerate with interbedded cherty, argillaceous, bioclastic limestone and calcareous sandstone and sparsely fossiliferous limestone beds (figs. 7, 8). A typical sedimentary cycle consists of a lower predominantly shaly or argillaceous limestone unit that is succeeded by a dominantly clastic calcareous (often bioclastic) sandstone, a calcitic arenaceous limestone, a crossbedded wispy quartz and calcitic arenaceous limestone, and a cherty limestone. The cycle is generally completed by a bedded chert layer.

TYPE SECTION OF LAKE POINT LIMESTONE (see fig. 4, section 8)

Southwest ridge of hill where altitude is 6,231 feet, from 5,200-ft altitude to about the 6,160-ft altitude in NE¼ sec 6, T. 2 S., R. 3 W., and SW¼ sec. 31, T. 1 S., R. 3 W. Garfield quadrangle, Utah

[Measured by E. W. Tooker and R. J. Roberts]

	Thickness (ft)
Oquirrh Group:	
Erda Formation.	
Conformable contact.	
Lake Point Limestone:	
12. Arenaceous limestone, dark-gray; weathers light gray; thin to medium bedded; interlayers of thin argillaceous limestone, black nodular cherty limestone, and bioclastic limestone; sparse brachiopod fauna	71
11. Argillaceous and arenaceous limestone and interbedded shale; dark gray; weather medium gray; thin to medium bedded; local bioclastic limestone and carbonaceous shale partings and lenses; nodular black chert layers; shale layers produce mostly covered slope (USGS colln. 23855–PC)	79
10. Calcareous sandstone, medium-gray; weathers reddish brown to buff; medium bedded; crossbedded; light-tan chert nodules	6
9. Limestone, argillaceous limestone, arenaceous limestone, and cherty limestone, interbedded; medium gray to dark gray; weather tan to light gray; medium bedded; subordinate lenses and thin beds of carbonaceous shale, and banded and crossbedded calcareous sandstone and bioclastic limestone; black chert nodules and lenses. Unit locally forms cliffs; locally is fossiliferous (USGS colln. 23854–PC)	399
8. Chert and interbedded argillaceous limestone partings and layers; medium gray; weather yellowish brown	3

FIGURE 7.—Typical exposures of Rogers Canyon sequence. View eastward between Rogers and Big Canyons, west side of the north end of the Oquirrh Mountains. Included are the basal Green Ravine Formation and the Oquirrh Group, consisting of the Lake Point Limestone and Erda and Kessler Canyon Formations. Also indicated are the Bonneville and Provo shore levels of Lake Bonneville, the Kessler anticline, the Lake Point thrust fault underlain by Erda Formation strata, and points *a*, *b*, and *c* shown in figure 8.

	Thickness (ft)
7. Limestone, arenaceous limestone, and argillaceous limestone, interbedded; medium to dark gray; weather light gray to tan and yellowish brown; thin to medium bedded; locally massive; fossiliferous limestone and carbonaceous shale partings; locally thin crossbedded bioclastic limestone; black chert nodules in layers and lenses; abundant, brachiopods, corals, and bryozoans (USGS colln. 17150–PC, 17148–PC, 17149–PC, and 16324–PC)	426
6. Arenaceous limestone, light-gray; weathers brown to tan; medium bedded; medium grained	11
5. Limestone, dark-gray; weathers light gray; medium bedded; interlayered thin bedded argillaceous limestone, carbonaceous shale, and crossbedded bioclastic limestone; irregular layers of nodular black chert in limestone; abundant, brachiopods, corals, and bryozoans (USGS colln. 16323–PC, 17147–PC, 16322–PC, and 16319–PC)	154
4. Fossiliferous limestone, dark-gray; limestone weathers medium gray, corals weather brown; medium bedded; *Orygmophyllum*? (colonial coral) (USGS colln. 16318–PC, 17146–PC, and 20259–PC)	5
3. Limestone, variegated medium- and dark-gray; weathers light gray and tan; fine grained; thin to medium bedded; arenaceous limestone and shale layers and partings; brachiopods abundant (USGS colln. 21140–PC)	48
2. Limestone, medium-gray; weathers yellowish tan to light gray, locally irregularly variegated light gray and medium gray; medium bedded to massive; cliff former; contains shale partings. Thin green-weathering chert layers at top contain *Rhipidomella nevadensis* (USGS colln. 21139–PC and 21141–PC)	98
1. Limestone, argillaceous limestone, and arenaceous limestone, interbedded; medium gray; limestone and argillaceous limestone weather light to medium gray, and arenaceous limestone weathers tan; thin to medium bedded; locally crossbedded. Upper 85 ft of unit contains medium-bedded limestone intraformational conglomerate that consists of medium-dark-gray limestone clasts in tannish-gray limestone matrix; forms cliffs above *a* in figure 8. Lower beds of unit contain the first appearance of brown-weathered quartz grains set in light-gray carbonate matrix (characteristic of arenaceous limestones above the Green Ravine Formation). Local chert nodules and shale layers and partings occur throughout unit. Brachiopods locally abundant (USGS colln. 16340–PC, 17145–PC, 21134–PC, 21135–PC, 17031–PC, 21139–PC, 21138–PC, and 21137–PC)	437
Total thickness measured	1,737

Conformable contact.

Green Ravine Formation.

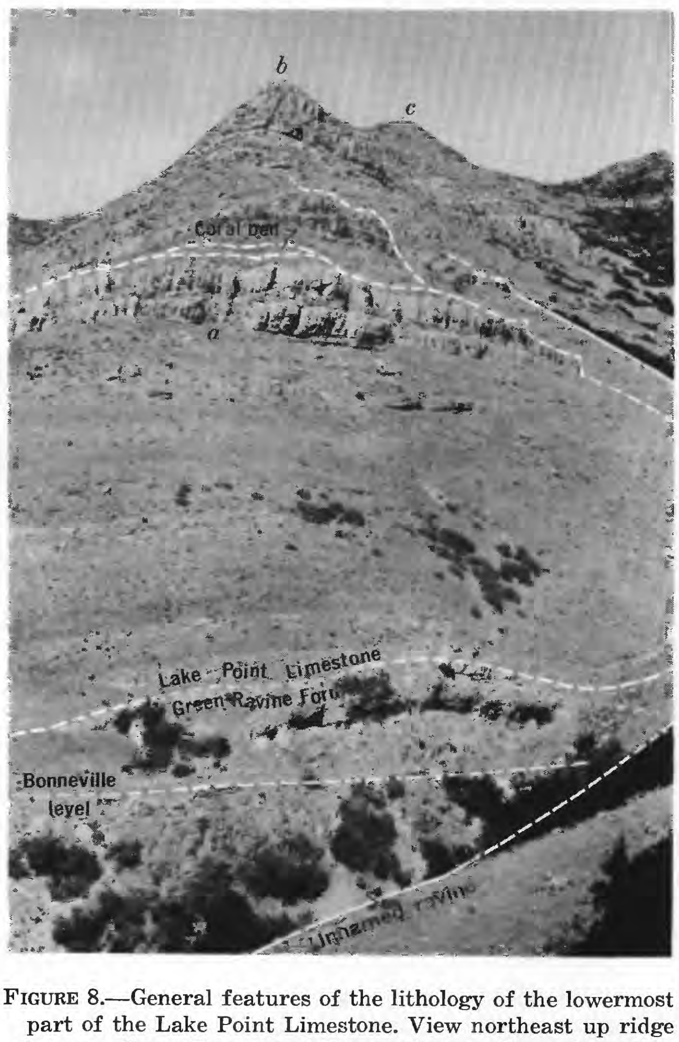

FIGURE 8.—General features of the lithology of the lowermost part of the Lake Point Limestone. View northeast up ridge between Green Ravine and Rogers Canyon. General location of reference points *a*, *b*, and *c* is shown in figure 7.

The Lake Point Limestone locally contains an abundant, generally well-preserved silicified brachiopod, coral, and bryozoan assemblage. The positions of the collections are shown in the stratigraphic section and in table 2. In their detailed discussions, Gordon and Duncan have delineated two faunal zones, the *Rhipidomella nevadensis* Zone in the lower part of Late Mississippian (late Chester) age, and the *Rugoclostus* Zone in the upper two-thirds of Early Pennsylvanian (Morrow) age. An intermediate, poorly fossilized shaly limestone zone within the *Rhipidomella nevadensis* Zone contains specimens of *Archimedes,* which resemble those in the Manning Canyon Shale of the Bingham sequence. Thus Gordon and Duncan correlate the lower part with Upper Mississippian rocks and the upper part with Lower Pennsylvanian strata, the actual boundary lying within unit 3 of the type section.

The faunas indicate, therefore, that the lower 540 feet of the Lake Point Limestone is of Late Mississippian age and that it is equivalent in age to parts of the Manning Canyon Shale in the Bingham and Timpanogos sequences and to the upper part of the Doughnut Formation in the Mount Raymond sequence (Tooker and Roberts, 1963, p. E35). The uppermost 1,200 feet is of Early Pennsylvanian age and is believed to be correlative with the lower part of the Oquirrh Group in the Bingham sequence and with the Round Valley Limestone in the Mount Raymond sequence. No break in the pattern of sedimentation between Mississippian and Pennsylvanian time has been recognized in the Rogers Canyon sequence. This Lake Point Limestone section is a continuous series that includes rocks of both Mississippian and Pennsylvanian age.

ERDA FORMATION

The Erda Formation of the Oquirrh Group is here named for the Erda siding on the Union Pacific Railroad; this siding is west of the mouth of Bates Canyon and immediately southwest of the prominent cliff exposures of these rocks on the west sides of Kessler, Coon, and Nelson Peaks in the Mills Junction and Garfield quadrangles, Utah (fig. 4, section 8). These rocks had previously been included in the middle member of the Oquirrh Formation (fig. 6). The formation is well exposed along the north and west sides of the range and is lithologically similar to altered rocks exposed on the pediment 2 miles west of the range at Adobe Rock near Mills Junction (Tooker and Roberts, 1961, pl. 6). Erda Formation strata are also exposed in the structurally discordant lower plates of the Lake Point thrust fault at the range front (fig. 7) north of Green Ravine (Roberts and Tooker, 1961, p. 45). The rocks dip steeply northward and are locally overturned to the south on the north side of the range (Roberts and Tooker, 1961, p. 39); south of Lake Point, on the western side of the range, the strata are exposed in the Mills Junction syncline, the Kessler anticline, and the Coyote and Bates synclines. The exposures extend southward in a sinuous line as far as Bates Canyon, where they end against the North Oquirrh thrust fault. The Erda Formation is cut off east of the crest of the range by the Garfield fault.

The type section of the Erda Formation is on the west side of Kessler Peak and extends from the hill that is 6,231 feet in altitude northward across the center of sec. 31, T. 1 S., R. 3 W., Garfield quadrangle, Utah, crossing Rogers Canyon, up toward the ridge point that is 7,521 feet in altitude on Lake Point Ridge as far as the 6,800-foot contour. Here the formation is 3,606 feet thick and is conformably overlain by the Kessler Canyon Formation. The upper contact of the Erda is at the base of the first thick tan-brown-weathering, cliff-forming quartzite unit (fig. 6; Tooker and Roberts, 1961, p. 30) below the interbedded calcareous quartzite, orthoquartzite, and ferruginous sandstone beds that characterize the Kessler Canyon Formation.

The Erda Formation is characterized by cyclically repeated layers of medium-gray limestone and medium-dark-gray ledge-forming argillaceous limestone and light-brown slope-forming carbonaceous shale, cinnamon-brown to tan calcareous quartzite, and variegated tan and light-brown crossbedded calcareous sandstone (fig. 9). These rocks stand in marked contrast to the predominantly grayish limestone beds below and massive red-brown-weathered quartzite layers above. The quartzite and limestone beds crop out as prominent ribs along gentle slopes or as cliffs on steep slopes. The shale and argillaceous limestone form intervening covered slopes. Cyclically repeated thin beds that are as much as 1 foot thick occur in the lower part of the section (Tooker, 1962, p. 357), whereas these beds are medium to thick (2–4 ft) in the middle and upper parts of the section. However, in individual beds within each major cycle, minor repetitions are observed. For example, a limestone bed 2 feet thick is often composed of thin repetitive layers of sandy limestone (containing detrital quartz, clastic limestone, and fossil-fragment sands), cherty limestone, and argillaceous limestone. A comparable shale bed commonly contains thin dense arenaceous limestone, bedded chert, and calcareous quartzite layers and lenses; and a similar quartzite bed commonly contains limestone and shale partings separating individual quartz laminae. A complete major cycle may be 60–100 feet thick.

Silica-cemented quartzite (quartzose sandstone or orthoquartzite) is not abundant and commonly

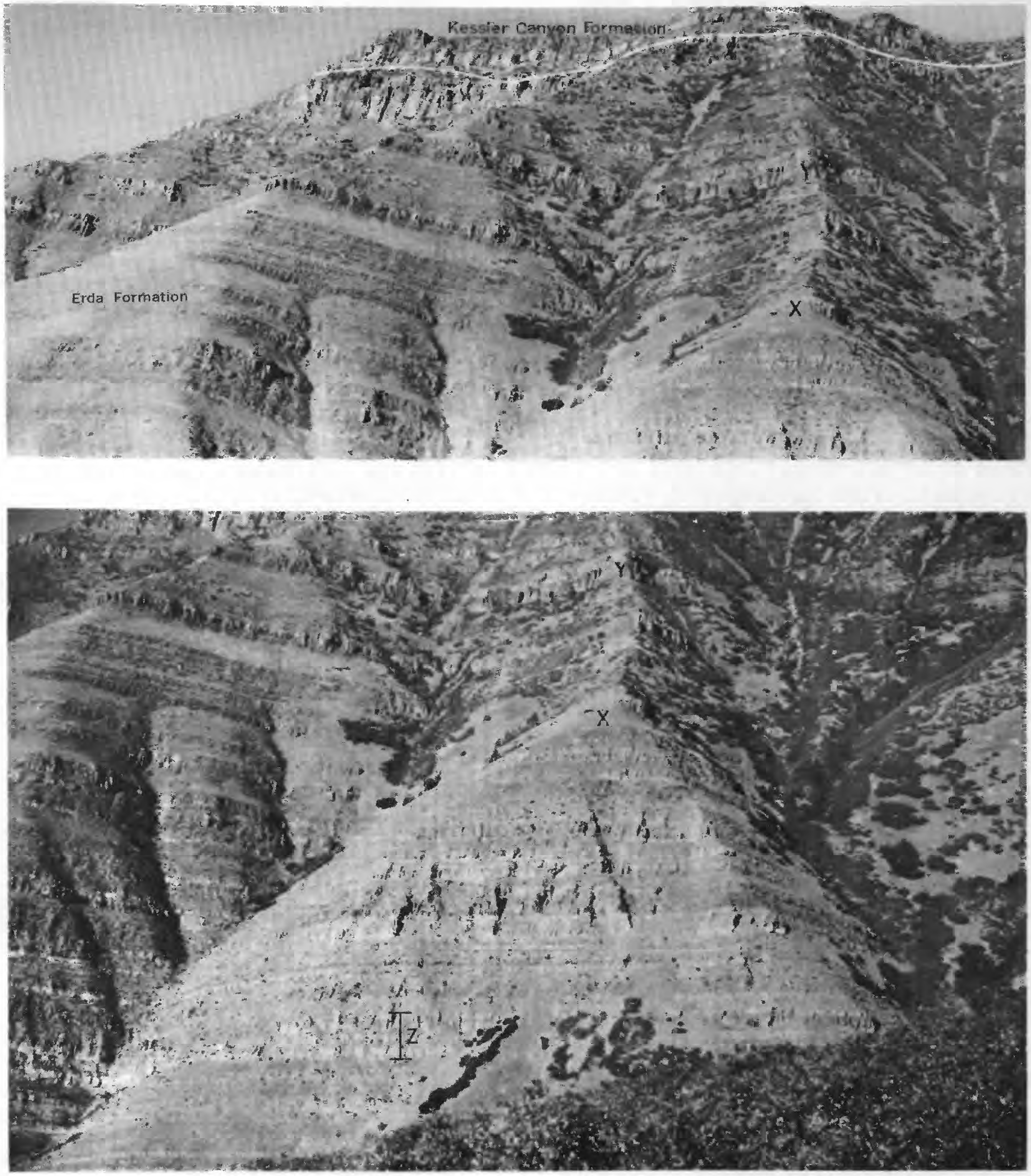

FIGURE 9.—Upper two-thirds of the Erda Formation and the basal part of the Kessler Canyon Formation. Views north of Rogers Canyon; point X is common to both photographs. The cyclic lithology of the Erda Formation can be seen. The massive quartzite beds (dark gray) at the base of the Kessler Canyon Formation are exposed at the top of the ridge. Z indicates three-layer limestone marker unit 4. Point Y locates unit 25, light-gray crinoid marker bed at the top of prominent cliff-forming cherty limestone.

grades into calcareous sandstone. This calcareous sandstone contains detrital limestone and calcite grains in addition to quartz and feldspar and is cemented by calcite and silica cement. The rock is hard and fractures conchoidally. It effervesces in weak acid and weathers to a sandy, locally punklike surface as much as half an inch thick.

Limestone ranges from a dense fine-grained apparently precipitated rock to a crossbedded, coarse-grained, clastic rock. Irregular layers and lenses of chert nodules are common, and shale partings are abundant. Most of the interbedded shale is carbonaceous and generally grades vertically into argillaceous limestone.

Argillaceous and cherty limestones in the Erda Formation are abundantly fossiliferous; the fossils consist of brachiopods, bryozoans, corals, fusulinids, gastropods, and crinoids. In general fossils are less abundant and less well silicified in the Erda Formation than they were in the Lake Point Limestone.

TYPE SECTION OF ERDA FORMATION (see fig. 4, section 8)

Traverse south to north across the center of sec. 31, T. 1 S., R. 3 W., Garfield quadrangle, Utah

[Measured by E. W. Tooker and R. J. Roberts]

Thickness (ft)

Oquirrh Group:

Kessler Canyon Formation.

Conformable contact.

Erda Formation.

35. Cherty limestone, dark-gray; weathers medium gray; thin to medium bedded in lower part, medium to thick bedded in upper part; black chert nodules and lenses; carbonaceous shale partings. Middle part of unit is medium-gray platy argillaceous limestone ---- 147
34. Calcareous quartzite, quartzose sandstone, and limestone, interbedded; gray brown and medium gray; weather brownish tan and light gray; banded; medium bedded to massive; locally crossbedded. Quartzite and sandstone contain thin argillaceous limestone and carbonaceous shale layers and partings ---- 267
33. Cherty limestone, dark-brownish-gray; weathers light gray to tan; thin to medium bedded; black chert nodules and layers. Middle part of unit contains argillaceous platy limestone 2–6 in. thick ---- 93
32. Calcareous quartzite, light-brownish-gray; weathers light grayish brown; medium bedded to massive ---- 48
31. Argillaceous limestone, dark-gray; weathers light grayish brown and tan; thin to medium bedded; in many places, platy ---- 39

Thickness (ft)

30. Calcareous sandstone, brown-gray; weathers medium grayish tan to red brown; occurs as massive beds ---- 82
29. Limestone and argillaceous limestone, interbedded; light to dark gray; weather to tan- and gray-striped beds; thin bedded to massive; locally black chert nodules; chert, fissile shale, and quartz sandstone partings ---- 122
28. Calcareous quartzite, light-grayish-brown; weathers tan brown; medium bedded. Unit contains a thin-bedded 4-ft gray limestone at 16 ft ---- 111
27. Limestone and cherty limestone, interbedded; dark gray; weather medium light gray; medium to thick bedded; locally black chert nodules in the upper limestone layers; locally fossiliferous (USGS colln. 20232–PC, 20235–PC, 20236–PC, and f22568) ---- 160
26. Calcareous sandstone, brownish-gray; weathers tan to rusty brown; thick bedded; well jointed; sparsely crossbedded ---- 18
25. Crinoidal limestone, medium-light-gray; weathers light gray; thin bedded; interlaminated thin sandstone and chert layers and lenses; bryozoans at base (USGS colln. 16328–PC) ---- 4
24. Cherty limestone and limestone, interbedded; dark gray; weather medium light gray; thin to medium bedded; interlayers of bioclastic limestone and shale; locally fossiliferous (USGS colln. f22570) ---- 38
23. Cherty limestone, limestone, arenaceous limestone, and argillaceous limestone, interbedded; medium gray; weather medium light gray; thin to medium bedded; abundant thin shale partings; local bioclastic limestone layers; bryozoan and fusulinid fauna in upper part ---- 140
22. Argillaceous limestone, arenaceous limestone, and limestone, interbedded; medium gray to brownish gray; weather to light brown gray and gray on fluted crossbedded surfaces; bioclastic limestone and shale layers and partings; sparse black chert nodules at base, increase upward in section ---- 90
21. Carbonaceous shale and argillaceous limestone, interbedded; medium gray; weather dark brownish gray; thin bedded to platy. Unit is poorly exposed on covered slope ---- 13
20. Calcareous quartzite, light-brown; weathers tan to rusty brown; crossbedded ---- 12
19. Cherty limestone, arenaceous limestone, limestone, argillaceous limestone, and fine-grained limestone, in sequence up-

	Thickness (ft)
ward; medium gray; weather brownish gray, slate-gray to light-gray and tan bands; thin to medium bedded; local layers of gnarly black chert nodules; local bioclastic limestone and shale partings; *Prismopora* (bryozoan), corals, brachiopods, and fusulinids abundant (USGS colln. 17165–PC and 17166–PC)	85
18. Calcareous quartzite, light-gray; weathers tan to reddish brown; medium to thick bedded; thin crossbedded calcareous sandstone parting layers; buff and black chert pods 1–6 in. thick	74
17. Limestone, dark-gray; weathers to gray- and tan-striped plates; argillaceous at base, more arenaceous and cherty in upper part	145
16. Calcareous quartzite, light-brown-gray; weathers light brown; thin bedded to laminar; limestone partings; local chert pods	43
15. Cherty limestone and shale, interbedded; dark gray; weather medium light gray and tan; thin bedded; calcareous sandstone and carbonaceous shale partings in limestone; local chert nodule layers; fossiliferous; productid brachiopod zone	136
14. Limestone, shale, and calcareous sandstone, interbedded; dark gray; weather to tan, light-gray, and dark-gray bands; thin to medium bedded; thin layers of gnarly black chert nodules and layers; argillaceous limestone layers and shale partings locally; spiriferid brachiopods in upper part (USGS colln. 16327–PC)	46
13. Limestone, cherty limestone, and carbonaceous limestone, interbedded; dark dark gray and black; weather light to medium bedded; upper 40 ft mainly ar- thin to medium-bedded limestone and finely laminated platy shale; black irregular chert nodule layers and lenses. Shale part of unit forms covered slopes. Fossils occur locally throughout limestone parts, zone of *Desmoinesia muricatina* (USGS colln. 17164–PC, 16325–PC, and 16326–PC)	303
12. Calcareous quartzite, tan; weathers tan to brown; thin to medium bedded; interbed thin argillaceous limestone	71
11. Argillaceous limestone, limestone, and arenaceous limestone, interbedded; dark gray and gray to brown gray; weather light grayish tan and brown; thin to medium bedded; upper 40 ft mainly argillaceous; thin layers and lenses of calcareous sandstone and carbonaceous shale partings spaced irregularly throughout unit; black chert nodules and lenses occur throughout unit; rocks are locally fossiliferous (USGS colln. 17163–PC)	112
10. Limestone, black cherty limestone, and arenaceous limestone, interbedded; medium dark gray; weather light gray and tan; banded; medium to thick bedded; fossiliferous (USGS colln. 17159–PC, and 17161–PC)	140
9. Calcareous quartzite, light-brown-gray; weathers brown to tan; medium bedded at base, massive in upper part; interbedded calcareous sandstone and arenaceous limestone; locally crossbedded; black chert nodules in basal layers	56
8. Limestone, medium-dark-gray; weathers medium light gray; medium to thick bedded; locally platy and argillaceous; carbonaceous shale partings; sparse black chert nodule layers; fossiliferous (USGS colln. 17158–PC)	90
7. Bedded black chert; limestone partings	6
6. Limestone, dark-gray; weathers light gray; thin bedded at base and medium to thick bedded in upper part; black chert nodules; arenaceous and argillaceous limestone layers and partings; sparse fossils (USGS colln. 17157–PC)	193
5. Calcareous quartzite, tan; weathers tan to buff and brown; banded; crossbedded; interlayered thin limestone and chert in lower one-third of unit	71
4. Fossiliferous limestone, arenaceous limestone, cherty limestone, argillaceous limestone, and calcareous quartzite, interbedded; olive gray and medium gray to brownish gray; weather light gray and brown; thin to medium bedded. Unit forms prominent three-layer light-gray-weathering marker unit. Clastic limestone and quartzite are commonly crossbedded. Carbonaceous shale, thin chert, and bioclastic limestone form parting layers within beds. Unit is locally fossiliferous; large horn corals, brachiopods, and crinoids abundant in the top 22 ft and in the middle part (USGS colln. 17155–PC and 17156–PC)	119
3. Limestone, arenaceous limestone, argillaceous limestone, and calcareous sandstone, interbedded; light olive gray and medium dark gray; weather to variegated grayish orange and tan and light gray; thin to medium bedded; thin crossbedded sand layers and shale partings. Thin- to medium-bedded interformational conglomerate in middle part of unit. Fossiliferous at top; fauna includes *Profusulinella* (USGS colln. 17154–PC and f20486)	131

	Thickness (ft)
2. Fossiliferous limestone, argillaceous limestone, and cherty limestone, interbedded; tan and olive gray to dark gray; weather yellowish gray to light gray; thin to medium bedded; crossbedded arenaceous limestone, thin carbonaceous shale, black chert, and calcareous sandstone parting layers and lenses. Fossils include spiriferid and productid brachiopods, bryozoans, and corals	57
1. Quartzite and calcareous quartzite, interbedded; light tan to light gray; weather grayish brown to reddish brown; thin (1–2 in. thick) to medium bedded; locally crossbedded bioclastic limestone layers and argillaceous limestone partings. Unit locally forms cliffs and contains interbedded limestone, black nodular cherty limestone, and arenaceous limestone, which are medium gray to light brown, weather light gray to brown, are thin to medium bedded, and are locally massive (up to 5 ft thick). Fossils locally abundant, include brachiopods and *Chaetetes* (USGS colln. 16334–PC, 17151–PC, 17152–PC, and 17153–PC)	344
Total thickness measured	3,606

Conformable contact.

Oquirrh Group, Lake Point Limestone.

Fossil faunas from the Erda Formation, which are listed in table 3 and are described in detail by Gordon and Duncan, consist of several faunal assemblages that include brachiopods, corals, bryozoans, and fusulinids of Middle Pennsylvanian age. These strata, therefore, are approximate age equivalents of the lower and middle parts of the Oquirrh Group in the thick Bingham and Timpanogos sequences in the Oquirrh and Wasatch Mountains and of the thin Weber Quartzite in the Mount Raymond sequence in the Wasatch Mountains (Tooker and Roberts, 1963).

KESSLER CANYON FORMATION

The Kessler Canyon Formation of the Oquirrh Group is here named for the most prominent north-flowing stream at the north end of the Oquirrh Mountains in the Garfield quadrangle. These rocks previously were designated informal units and subsequently were included in the upper member of the Oquirrh Formation (fig. 6). The formation is exposed on both sides of the Garfield fault (Tooker and Roberts, 1961, pl. 6). West of the fault, the lower part of the formation crops out on north-facing dip slopes on the north flank of the Kessler anticline and as south-dipping beds on the ridge east of the Garfield smelter at the north end of the range. On the upper slopes of Coon Peak in the Coyote and Bates synclines, the lower and middle parts of the Kessler Canyon Formation are exposed. The upper part of the formation is exposed throughout the area east of the Garfield fault and north of the North Oquirrh thrust, where it forms symmetrical low-amplitude folds. Because of interruptions in exposures, the type section is in two parts (fig. 4, sections 9a and 9b). The lower 1,038 feet, section 9a, (Tooker and Roberts, 1961, p. 30) was measured on the west side of Black Rock Canyon in a traverse from the NE¼ SE¼ sec. 30, T. 1 S., R. 3 W., northwest to the ridge at the south edge of NE¼ sec. 30. The upper 3,436 feet, section 9b, (Tooker and Roberts, 1961, p. 30) was measured in Kessler Canyon southeast from the center SE¼ sec. 27, T. 1 S., R. 3 W., at an altitude of 5,400 feet, across the hill whose altitude is 5,984 feet, and across the tributary to Little Valley Wash to the hilltop west of the hill whose altitude is 5,341 feet in the center of the west side NE¼ sec. 35, T. 1 N., R. 3 W. The upper contact is at the base of a prominent light-gray-weathering abundantly fossiliferous limestone containing a well-preserved brachiopod, coral, bryozoan, and crinoid assemblage (Tooker and Roberts, 1961, p. 31).

The lower third of the Kessler Canyon Formation is predominantly interbedded massive orthoquartzite and cherty limestone, and the upper two-thirds is ferruginous and dolomitic sandstone, dolomite, and fusulinid-bearing chert. The orthoquartzite is light gray tan and weathers tan and light brown to orange brown; it is fine grained to sandy, medium bedded to massive, generally well jointed, locally well banded, commonly crossbedded, and often contains interbedded calcareous. ferruginous, or dolomitic sandstone and shale partings. Thin (1 ft or less) chert layers and lenses occur locally in the section. The cherty limestone is light gray, thin bedded, and contains either black or tan chert nodules.

The upper part of the formation is poorly exposed; the beds are thin- to medium-bedded interbedded orthoquartzite, calcareous, ferruginous, and dolomitic sandstone and dolomite, in contrast to thick silica-cemented orthoquartzite and cherty limestone in the lower part of the formation. Some dolomite beds are now sedimentary breccia. Worm trails are common in the ferruginous sandstone, and poorly preserved fusulinids occur both in dolomite and in bedded chert layers.

The true thickness of the formation is uncertain because the upper part of the measured section crosses the Arthur fault (Roberts and Tooker, 1961, p. 44). Although the relative displacement on the fault initially did not appear to be large, subsequent geologic mapping suggests that as much as 1,500 feet of section may be cut out at this point. Thus the total thickness of the Kessler Canyon Formation is probably in excess of 4,300 feet.

TYPE SECTION OF KESSLER CANYON FORMATION
(see fig. 4, section 9b)

Center SE¼ sec. 27, T. 1 S., R. 3 W., southeast to center west side NE¼ sec. 35, T. 1 S., R. 3 W., Garfield quadrangle, Utah

[Measured by E. W. Tooker and R. J. Roberts]

	Thickness (ft)
Park City Formation:	
Grandeur Member.	
Conformable contact.	
Oquirrh Group:	
Kessler Canyon Formation (upper part):	
37. Dolomitic limestone and interbedded sandstone, calcareous quartzite, and shale; light gray and tan; weather dark brown and orange; thin to medium bedded; limestone brecciated locally. Unit is poorly exposed. Fusulinids collected in sandstone from the same unit nearby (USGS colln. f21018)	260
36. Calcareous quartzite and ferruginous sandstone, interbedded; tan and medium brown; weather brown and dark brown; medium bedded; locally crossbedded; sparse bedded chert; worm trails in sandstone; locally chert contains poorly preserved fusulinids)	250
35. Calcareous sandstone and calcareous quartzite, dolomitic limestone and ferruginous sandstone, interbedded. Unit is covered slope	270
34. Calcareous quartzite, arenaceous dolomitic limestone, and ferruginous sandstone, interbedded; tan to buff and gray; weather light to dark brown and light gray; medium bedded; dolomitic limestone is locally brecciated; worm trails occur in sandstone; brachiopods in thin dolomitic limestone layers. Unit is mostly covered. Normal fault of unknown displacement at 565 ft may cut out as much as 1,500 ft of section	568
33. Fusulinid chert; interbedded dolomitic limestone and calcareous sandstone	12
32. Calcareous quartzite, tan; weathers olive brown. Unit is covered slope	29
31. Fusulinid chert, poorly exposed	10
30. Dolomitic sandstone, light-gray, platy to thin-bedded; interbedded calcareous quartzite; sparse, poorly preserved fusulinids; exposures poor	36
29. Fusulinid chert, light-gray; weathers light to dark brown; weathered surface is pitted; fusulinids collected from unit 1 mile north (USGS colln. f20479)	13
28. Calcareous quartzite, dolomite, arenaceous dolomite, dolomite breccia, interbedded; tan gray and light gray; weather tan to buff and light brown; locally variegated pink to gray green; thin bedded. Weathered quartzite is pitted and punky at the rock surface; black chert nodules and lenses occur in arenaceous dolomite. Unit is poorly exposed on covered slopes	253
27. Arenaceous dolomitic limestone, dolomite breccia, ferruginous sandstone, and calcareous quartzite, interbedded; very poorly exposed	94
26. Ferruginous sandstone and brecciated arenaceous dolomitic limestone, interbedded; tan and light gray; weather light brown and buff; locally cherty; pitted weathered surface on thin interbedded calcareous quartzite; poorly preserved bryozoans and brachiopods in limestone, and worm trails in sandstone. Unit is poorly exposed	63
25. Calcareous quartzite, tan to buff; weathers dark red brown; thin to medium bedded; interbedded thin ferruginous sandstone and fusulinid chert layers. Section crosses small normal fault at base with unknown but small displacement	74
24. Arenaceous dolomitic limestone, light-tan; weathers light gray to buff; medium bedded; contains coarse crinoidal sand stringers. Unit contains medial layer of thick calcareous quartzite. Cherty fusulinid layers occur near the base	48
23. Ferruginous sandstone, yellow-brown; weathers to medium dark brown with soft punky surface; interbedded thin hard ribs of orthoquartzite. Unit is poorly exposed on slopes	69
22. Limestone, light-gray; weathers buff; thin bedded; poorly preserved fusulinids	3
21. Calcareous quartzite, ferruginous sandstone, dolomitic sandstone, and orthoquartzite, interbedded; tan and light gray; weather buff and limonite brown; thin to medium bedded; often platy; quartzite is pitted, and sandstone is punky on weathered surfaces. Locally, there are bedded chert layers. At 92 ft unit contains poorly preserved fusulinids. Unit is most covered (USGS colln. f22588)	288

	Thickness (ft)
20. Fusulinid chert with crinoid stems; white; pitted; fusulinid molds only	1
19. Calcareous quartzite, calcareous and ferruginous sandstone, and cherty dolomite, interbedded; light gray and tan to light brown; weather light gray to tan, locally reddish brown. Beds are thin to medium bedded and are locally color banded. Locally, weathered surfaces of quartzite are pitted and form a thick punky surface rind. Dolomite breccia beds 1–6 ft thick are interspersed throughout the unit, and two thin fusulinid chert beds occur in the top 40 ft. Unit is poorly exposed and mostly covered	395
18. Orthoquartzite, calcareous quartzite, and calcareous sandstone, interbedded; light gray; weather banded light gray and buff; locally consist of coarse sand; pitted weathered surfaces. Unit poorly exposed	61
17. Orthoquartzite and calcareous quartzite, interbedded; light gray to tan; weather light to medium brown and dark brown in prominent alternating bands; pitted weathered surface that locally appears to have ropy contortions; thin bedded and platy; contain ferruginous and calcareous sandstone and cherty limestone interlayers and partings; worm trails in ferruginous sandstone near top of unit. Lower half of unit is covered slope	639
Total thickness measured	3,436

Oquirrh Group, Kessler Canyon Formation (lower part).

TYPE SECTION OF KESSLER CANYON FORMATION

(see fig. 4, section 9a)

NE¼SE¼ sec. 30, T. 1 S., R. 3 W., to center south edge NE¼ sec. 30, Garfield quadrangle, Utah

[Measured by E. W. Tooker and R. J. Roberts]

	Thickness (ft)
Fault.	
Oquirrh Group:	
Kessler Canyon Formation:	
Upper part:	
17. Calcareous quartzite and orthoquartzite, interbedded; medium brown gray to tan; locally banded; weather brown on pitted surfaces; thin to medium bedded; thin calcareous and ferruginous sandstone layers and partings	224
Total of upper part	224
Lower part:	
16. Limestone, argillaceous limestone, and arenaceous limestone, interbedded; tan gray; weather yellow brown; thin bedded; jointed; locally, chert nodule layers at base	33
15. Cherty limestone and interbedded arenaceous limestone	22
14. Calcareous quartzite, orthoquartzite, ferruginous sandstone, and cherty limestone, interbedded; light gray to gray brown; weather dark brown, gray tan to yellowish and reddish brown; thin to medium bedded; pitted weathered surfaces; cherty limestone contains dense sandstone partings in the middle part of the unit	212
13. Dolomitic sandstone, light-gray; weathers tan to buff; medium bedded	3
12. Dolomitic limestone, light-tan; weathers buff; thin bedded; medium grained; minor chert lenses. Unit contains medial dark-tan arenaceous dolomite marker bed	21
11. Calcareous quartzite and ferruginous sandstone, interbedded; gray brown; weather tan brown and reddish brown; banded; medium bedded; quartzite is well jointed and contains sandstone partings	33
10. Fossiliferous limestone, light-brown-gray; weathers tan to buff; thin to medium bedded; local bioclastic limestone layers; sparse black chert nodules; abundant gastropod, brachiopod, bryozoan, and crinoid stem assemblage (USGS colln. 18486–PC and 18893–PC)	34
9. Cherty limestone, medium-gray; weathers medium light gray; thin bedded, locally laminar; small black chert nodules and lenses	92
8. Ferruginous sandstone and calcareous quartzite, interbedded; orange tan and light gray; weather dark brown and tan to light gray; medium bedded; crossbedded; worm trails in upper sandstone beds	41
7. Cherty limestone, medium-dark-gray; weathers light gray; thin to medium bedded; interbedded arenaceous and cherty limestones. Black chert nodules weather brownish with rought sanded surfaces in the upper part, are black and smooth in the lower part. Arenaceous and cherty limestones are sparsely fossiliferous	125

	Thickness (ft)
6. Calcareous quartzite, tan; weathers dark brown; medium bedded; contorted warped "ropy" layers with tan- and brown-banded layers and pitted weathered surface	75
5. Calcareous quartzite, quartose sandstone, and orthoquartzite, interbedded; tan; weather tan to dark brown and yellowish brown; medium to thick bedded; well jointed; form cliffs and blocky talus slopes; shale partings within the quartzite	97
4. Cherty limestone, medium-dark-gray; weathers medium gray; thin bedded; black chert nodules. Unit is mostly covered slope	28
3. Calcareous quartzite, tan; weathers tan to reddish brown; thin to medium bedded; crossbedded, well jointed; interbedded thin calcareous sandstone	151
2. Ferruginous sandstone, orange-gray-brown; weathers brown; medium bedded; argillaceous limestone partings; carinoid corals, brachiopod fragments	8
1. Orthoquartzite, light-gray-brown; weathers tan to light brown; medium bedded; well jointed; locally crossbedded; black chert layer at base in thin calcareous quartzite layer	58
Total measured thickness of lower part	1,033

Conformable contact.

Oquirrh Group, Erda Formation.

Fossils are sparse and generally poorly preserved in the Kessler Canyon Formation; only one collection (USGS colln. 18486–PC) represents the formation. A 35-foot-thick bed, unit 10, in the lower part (section 9a) contains an unusually fine assemblage of abundant, large, well-preserved specimens of gastropods, brachiopods, bryozoans and long, nearly intact sections of crinoid stems. Most of the upper two-thirds of the section, however, contains only sparse, poorly preserved, silicified fusulinids and occasional crinoid fragments in thin beds of dolomitic limestone and bedded chert.

The lower part of the formation has not provided identifiable fossils, but J. E. Welsh (oral commun., 1961) reported fusulinids of Missouri (Late Pennsylvanian) age from the lower Kessler Canyon Formation in the Coon Canyon syncline south of Coon Peak. Fossils in the middle part are of probable Virgil age according to Gordon and Duncan. The poorly preserved chertified fusulinids found in the upper parts also are of probable Virgil (Late Pennsylvanian) age (section on biostratigraphy and correlation, p. A49). Missouri age strata, so abundant in the Bingham sequence, were not found by us, and, if present, are extraordinarily thinned or were eroded prior to deposition of Virgil strata. Gordon and Duncan suggest that the lack of Missouri age rocks has regional significance and compare it to Steele's (1961) "Regional Middle Pennsylvanian unconformity." This suggests that sediments of the Rogers Canyon sequence have a closer affinity with those in the Confusion Range and eastern Nevada than those of the Timpanogos and Bingham sequences.

Wolfcamp sediments are also missing in this sequence, and the Early Permian Park City strata rest without angular unconformity on Virgil (?) beds of the Kessler Canyon Formation. Similarly these rocks are absent in the Wasatch Mountains in the Mount Raymond sequence (Baker and others, 1949).

Gordon and Duncan suggest that this absence may indicate a period of nondeposition and erosion, a factor that gains some credence in our observation locally of highly altered iron-stained zones in upper Kessler Canyon sediments as at the mouth of Coon Canyon—perhaps evidence of weathering surfaces. The apparently conformable relation between the Kessler Canyon Formation and Grandeur Member of the Park City Formation strata suggests that the area was not undergoing uplift and erosion. It may have been awash, parts of the area emergent at times to permit weathering action.

PARK CITY FORMATION

Rocks equivalent in lithology and age to those in the basal part of the Park City Formation in the Wasatch Mountains, named originally by Boutwell (1907), were recognized in the Oquirrh Mountains by Tooker and Roberts (1961, p. 32) and by Welsh and James (1961, p. 4). These rocks, originally assigned to an informally named unit by Tooker and Roberts (fig. 6), correspond to the Grandeur Member as it was defined in the Wasatch Mountains by Cheney, Swanson, Sheldon, and McKelvey (1959, p. 12).

GRANDEUR MEMBER

The Grandeur Member is exposed in Little Valley syncline in Little Valley at the northeast end of the Oquirrh Mountains and also in the Coon Canyon area (fig. 2). The unit is exposed discontinuously southward along the eastern range front and is cut off by the North Oquirrh thrust fault (Tooker and Roberts, 1961, pl. 6). No outcrops are found west of the Garfield fault. The Grandeur Member appears to lie conformably on the Kessler Canyon Formation of the Oquirrh Group; overlying strata have been eroded. The member is locally unconformably overlain by Tertiary conglomerate and volcanic rocks (for descriptions see Tooker and Roberts, 1961, p. 32–34).

The Grandeur consists of thin- to medium-bedded fine- to coarse-grained arenaceous limestone, dolomite, and dolomitic limestone interspersed with thin shale and argillaceous limestone, phosphorite, chert, orthoquartzite, and calcareous sandstone partings, lenses, and layers. The exposed thickness of the member in section 10 (fig. 4) is about 760 feet. The member can be divided into three parts: a lower limestone 215 feet thick; medial quartzite, dolomite, sandstone, shale, chert, and phosphorite 284 feet thick; and an upper dolomite and quartzite 261 feet thick. These are lithologically comparable to the three parts in the type locality of the Grandeur Member in the Wasatch Range.

REFERENCE SECTION OF GRANDEUR MEMBER OF PARK CITY FORMATION (see fig. 4, section 10)

East of fork in Coon Canyon, north side in NW¼NW¼ sec. 14, T. 2 S., R. 3 W., Garfield quadrangle, Utah

[Measured by E. W. Tooker]

	Thickness (ft)
Unnamed conglomerate.	
Unconformable contact, erosion interval.	
Park City Formation:	
Grandeur Member:	
25. Dolomitic limestone, light-grayish-tan; weathers light tan to buff; medium bedded; tan chert nodules near base	41
24. Calcareous and ferruginous sandstone, interbedded; reddish gray; weather brown to reddish brown; medium bedded; locally, chert nodules. Unit is mostly covered	55
23. Dolomitic limestone, light-grayish tan; weathers light gray; medium bedded. Unit is mostly covered	7
22. Orthoquartzite and limestone, interbedded; tan to light brown and light gray; weather tan; medium bedded; lacy chert laminae in limestone	73
21. Calcareous quartzite, calcareous sandstone, and arenaceous dolomitic limestone, interbedded. Unit is mostly covered	45
20. Dolomite and dolomitic and ferruginous sandstones, interbedded; reddish brown; weather tan; thin to medium bedded; sanded weathered surfaces	24
19. Dolomitic limestone, mottled gray; weathers light grayish-tan; thin to medium bedded; brachiopods abundant	10
18. Dolomite, tannish-gray; weathers light buff gray; thin to medium bedded; banded chert layers and lenses	6
17. Orthoquartzite and bedded chert, interbedded; reddish brown; weather hematite red and mottled reddish gray; thin bedded; irregular layers; conspicuous shale partings	59
16. Shale and calcareous quartzite, interbedded. Unit is mostly covered. Dark-gray phosporite nodules in light-brown thin sandstone layers throughout unit	81
15. Phosphatic chert and shale, interbedded; black and dark gray; weather bluish white to gray as surface coating on chert	1
14. Dolomite and shale, interbedded; medium gray; weather light gray tan; medium and thin bedded; brachiopods abundant	8
13. Shale, calcareous quartzite, and calcareous sandstone, interbedded; light grayish brown and dark gray; weather tan to light brown and medium gray; thin bedded, ribbon banded appearance	14
12. Calcareous quartzite and sandstone, interbedded; medium brownish gray; weather tan to brown; thin to medium bedded; local phosphorite nodule zones; lacy tan chert; *Orbiculoidea* brachiopods. Unit is mostly covered	66
11. Orthoquartzite, medium-dark-gray; weathers tan; medium bedded; brownish-black chert nodules common	7
10. Quartzose siltstone, reddish-gray; weathers tan; thin to medium bedded. Unit is mostly covered	30
9. Dolomite medium-light-gray; weathers light tan; medium bedded. Unit is mostly covered slope	18
8. Limestone and arenaceous limestone, irterbedded; light tan to brown; weather tan; thin bedded; productid brachiopods. Unit is mostly covered	13
7. Cherty limestone, reddish-gray to brown; weathers light grayish brown; medium bedded; dark reddish-gray chert nodules and lenses; brachiopods abundant. Unit poorly exposed; mostly covered	24
6. Limestone and arenaceous limestone, interbedded; brownish gray; weather tan; locally black chert nodules and lenses; bioclastic limestone lenses common	39
5. Limestone and arenaceous (bioclastic) limestone; light brown gray; weather	

	Thickness (ft)
tan gray; medium bedded; gastropods, brachiopods, and crinoids abundant	8
4. Limestone and cherty limestone, interbedded; gray; weather medium light gray; thin to medium bedded; abundant chert nodules and lenses up to 4 inches thick	11
3. Fossiliferous limestone, medium-dark-gray; weathers light gray; thin to medium bedded; local lacy tan chert beds; brachiopods, gastropods, and crinoid stems abundant	12
2. Argillaceous limestone and silty limestone, interbedded; dark gray; weather medium dark gray; thin to medium bedded; brachiopods locally abundant	78
1. Limestone, light-gray; weathers light gray; medium bedded; tan lacy chert bands; bioclastic in part; brachiopods, bryozoans, and gastropods very abundant (USGS colln. 20240–PC, 20241–PC and 20242–PC in reference area and 19949–PC, 19948–PC, 22848–PC, 20238–PC, from unit in Little Valley)	30
Total thickness measured	760

Conformable contact.
Oquirrh Group, Kessler Canyon Formation.

Fossils are abundant and well preserved in the lower limestone unit. The fauna in table 4 includes bryozoans, crinoids, brachiopods, and gastropods of probable late Leonard (Early Permian) age; Gordon and Duncan in the section on biostratigraphy and correlation describe the several collections, their biostratigraphic relation, and correlation. They conclude that an unconformity occurs at the base of the Grandeur Member that accounts for the absence of Wolfcamp and part of the Leonard rocks in the Rogers Canyon sequence.

BINGHAM SEQUENCE

The Bingham sequence, named for the Bingham mining district in the central part of the Oquirrh Mountains where the most complete upper part of the Paleozoic stratigraphic section occurs, is the folded upper plate of the Midas thrust fault. The lower part of the sequence is exposed only in a small area in the Ophir mining district in the southern part of the range. The rocks consist of lower Paleozoic formations ranging from Cambrian through Mississippian in age; they were described by Gilluly (1932) and will not be discussed further here. The upper thick series of sediments, the Oquirrh Formation, which Gilluly did not subdivide, was raised to group status and subdivided by Welsh and James (1961). Their formational assignments are here modified and revised (fig. 5).

OQUIRRH GROUP

The Oquirrh Group rests conformably on the Manning Canyon Shale of Mississippian and Pennsylvanian age and is divided into the West Canyon Limestone, the Butterfield Peaks Formation, and the Bingham Mine Formation (fig. 3). The Bingham Mine Formation is divided into the Clipper Ridge Member and the overlying Markham Peak Member. These rocks are of Pennsylvanian age.

WEST CANYON LIMESTONE

Nygreen (1958, p. 13–14) originally applied the name West Canyon Limestone Member to the basal clastic cyclic limestone unit of the Oquirrh Formation in the Fourmile Canyon tributary of West Canyon on the east side of the Oquirrh Mountains in the Fairfield quadrangle. We have raised this unit to formational status as the West Canyon Limestone. James Gilluly (oral commun., 1967) agrees that these strata constitute a valid recognizable formational unit in the Stockton and Fairfield quadrangles. The formation is exposed on the east limb of the Ophir anticline in Manning, Ophir, and Soldier Canyons on the west side of the Oquirrh Mountains as well as on the flanks of Long Ridge anticline in West Canyon (Gilluly, 1932, pl. 12). In addition to the type section shown by Nygreen (1958, p. 13) in the E½ sec. 23 and W½ sec. 24, T. 5 S., R. 3 W., Fairfield quadrangle (fig. 4, section 4) and by Welsh and James (1961, pl. 5), three nearly comparable reference sections by Roberts and Tooker in the southern Oquirrh Mountains, in West Canyon, Soldier Canyon, and at Lewiston Peak (fig. 4, section 5; ridge west of Lewiston Peak, sec. 29, 30, T. 5 S., R. 3 W., Fairfield 15-minute quadrangle) indicate a wide areal extent for the West Canyon Limestone of the Bingham sequence. The West Canyon and Soldier Canyon reference sections are included to afford a direct comparison of lithologies; the fauna in Soldier Canyon are more abundant and better exposed (fig. 10) and preserved than those in West Canyon.

Contacts of the West Canyon Limestone with the underlying Manning Canyon Shale and the overlying Butterfield Peaks Formation are poorly exposed. Gilluly (1932, p. 32) stated that the Soldier Creek section of the Manning Canyon Shale, which he believed probably was most representative because it was least deformed by folding, apparently was conformable with, and transitional lithologically into, limestones of the Oquirrh Formation. In each of the areas where the section was measured, the base of the West Canyon Limestone is at

FIGURE 10.—Typical exposures of reference section of the West Canyon Limestone and the basal portion of the Butterfield Peaks Formation in Soldier Canyon. View is westward toward spur on north side of the canyon along the east boundary of sec. 34, T. 4 S., R. 4 W., Stockton 15-minute quadrangle.

the base of the continuous predominantly limestone section that overlies a generally concealed shale unit. The formation is also conformable with and transitional into the cyclic shale, limestone, and calcareous quartzite of the Butterfield Peaks Formation. In each section, the upper contact is mapped at the base of a continuous, though variable in thickness, crossbedded, silica- and carbonate-cemented orthoquartzite and calcareous sandstone separating two less resistant limestone and argillaceous limestone units.

The West Canyon Limestone is 1,450 feet thick in the type section (Nygreen, 1958, p. 14, 39) and is 1,436 feet thick in the reference locality in West Canyon (section 6a). Comparable rocks are 1,180 feet thick at Lewiston Peak, and 1,060 feet thick in the Soldier Canyon reference sections.

The West Canyon rocks are principally cyclical clastic arenaceous limestone composed of quartz and calcite grains and fossil fragments and interbedded thin cherty argillaceous dense crystalline limestone beds as much as 1 or 2 feet thick. Thin calcareous quartzite beds or partially silica-cemented calcareous sandstone, generally banded or crossbedded, separate much thicker limestone strata. The limestone generally is medium dark gray; it weathers light and medium gray if pure or brownish gray if arenaceous and contains tan and black chert nodules and lenses. The rocks are medium grained, containing coarse angular to subrounded sands, and are thin to medium bedded, ranging from less than 1 foot to 3 feet in thickness. The calcareous quartzite is medium gray to tan; the sandy-weathered surface rind is of variable thickness and is tan to light gray brown. The quartzite is composed of detrital quartz and calcareous sand grains cemented by silica and calcite. Evidence of small-scale rhythmic sedimentation may be seen in these rocks, although the environment favored the formation of limestone. Toward the upper contact of the formation, the calcareous quartzite beds become thicker and more abundant.

FIRST REFERENCE SECTION OF WEST CANYON LIMESTONE
(see fig. 4, section 6a)

Ridge on north side of West Canyon, opposite Maple Canyon, NE¼NW¼ sec. 27, T. 4 S., R. 3 W., Fairfield quadrangle, Utah

[Measured by E. W. Tooker and R. J. Roberts]

	Thickness (ft)
Oquirrh Group:	
Butterfield Peaks Formation.	
Conformable contact.	
West Canyon Limestone:	
14. Limestone, cherty limestone, and arenaceous limestone, interbedded; medium to gray; weather medium to light gray; thin to medium bedded; black chert nodules; shale partings; local bioclastic limestone; sparse brachiopods	201
13. Calcareous quartzite and limestone, interbedded; brownish gray; weather tan to rusty brown; quartzite is medium bedded and crossbedded; limestone is thin bedded, fine grained, and locally bioclastic	15
12. Arenaceous limestone, cherty limestone, argillaceous limestone, and limestone, inbedded; medium gray; weather light gray; thin to medium bedded; local crossbedding; black cherty lenses and nodules; local shale partings and bioclastic limestone beds; abundant brachiopods (USGS colln. 20331–PC)	87
11. Calcareous quartzite, tan; weathers rusty brown; medium bedded; crossbedded and thinly laminated; well jointed	11
10. Cherty limestone, arenaceous limestone, argillaceous limestone, and limestone, interbedded; medium gray; weather medium light gray; thin to medium bedded; fine-grained dense silty limestone and platy shale partings; black chert nodules and thin irregularly layered brown-weathering white chert; local bioclastic limestone layers; brachiopods abundant	347
9. Calcareous quartzite and calcareous sandstone, interbedded; medium grayish tan; weather medium light gray; medium bedded; crossbedded and laminar bands; inlayered limestone and shale partings	29
8. Arenaceous limestone and argillaceous limestone, interbedded; medium gray; weather medium light gray; thin bedded; irregular thin bioclastic limestone layers	32
7. Calcareous sandstone, medium-gray; weathers brown; fluted weathered surface; medium bedded; crossbedded	13
6. Arenaceous limestone, cherty limestone, and argillaceous limestone, interbedded; medium gray; weather light gray; thin to medium bedded; black chert layers and lenses; shale partings; local bioclastic limestone layers	43
5. Argillaceous limestone, arenaceous limestone, and dense limestone, interlayered; medium gray; weather light gray with brown streaks in coarser sand layers; thin to medium bedded; local cherty limestone and carbonaceous shale partings; crossbedded bioclastic limestone layers; abundant brachiopods (USGS colln. 20330–PC and 21157–PC)	231
4. Limestone, medium-gray; weathers light gray; thin to medium bedded; coarse sandstone laminae irregularly distributed through the limestone; fossiliferous (USGS colln. 21156–PC)	80
3. Calcareous sandstone, brown-gray; weathers light brown; medium bedded	3
2. Limestone, arenaceous limestone, and argillaceous limestone, interbedded; medium gray to brownish gray; weather light to medium gray and tan; thin to medium bedded; crossbedded sandstone and carbonaceous shale lenses and partings; abundant bioclastic limestone; abundant brachiopods, bryozoan, crinoid, and *Antiquatonia coloradoensis* assemblage (USGS colln. 20329–PC, 21154–PC, 21155–PC)	262
1. Limestone and argillaceous limestone, interbedded; medium dark gray; weather brownish gray and medium gray; thin to medium bedded; interlayered arenaceous and bioclastic limestone, cherty limestone, and carbonaceous shale; abundant fossils in cherty limestone. Unit is poorly exposed, mostly covered	82
Total thickness measured	1,436
Conformable contact.	
Manning Canyon Shale.	

SECOND REFERENCE SECTION OF WEST CANYON LIMESTONE
(see fig. 4, section 11)

Begin at base of ridge on north side Soldier Creek lat 40° 25′ 45″, long 112° 16′ 30″, traverse N. 6° E. to ridgetop, then N. 40° E. to ridgetop west of peak 9075, secs. 26, 27, and 34, T. 4 S., R. 4 W., Stockton quadrangle, Utah

[Measured by E. W. Tooker, Mackenzie Gordon, Jr., and R. J. Roberts]

	Thickness (ft)
Oquirrh Group:	
Butterfield Peaks Formation.	
Conformable contact.	

West Canyon Limestone:

	Thickness (ft)
14. Limestone, arenaceous limestone, argillaceous limestone, interbedded; light gray to dark gray and brownish gray; weather light gray to tan; thin to medium bedded; locally interbedded black chert nodule layers, thin calcareous sandstone beds, and shale partings; locally platy; locally fossiliferous (USGS colln. 17170–PC)	121
13. Calcareous sandstone, dark-brownish-gray; weathers grayish brown; medium bedded; black chert nodules in the upper 1.5 ft	4
12. Limestone, dark-brownish-gray and medium-gray; weathers medium gray to medium light gray; thin to medium bedded; nodular chert layers and dark-brown bioclastic sandy streaks in upper 4 ft; lower part contains interbedded bioclastic limestone and argillaceous limestone layers and shale partings; lower 81 ft along line of section concealed due to faulting; Tertiary monzonite porphyry sill 28 ft thick underlies top 4 ft of unit	153
11. Calcareous quartzite, light-brownish-gray; weathers tan; thick bedded; well jointed	12
10. Limestone, medium-dark-gray; weathers medium gray; medium to thin bedded; lenticular nodules of black chert 2 in. thick and 6 in long; locally grades into thin bioclastic and shaley interlayers in the upper part	98
9. Limestone, argillaceous limestone, and shale, interbedded; medium dark gray to brownish gray and dark gray; weather light gray to grayish tan; thin to medium bedded; well jointed; calcareous sandstone in lower 3 ft; 1–2-ft shale layers near the top are mostly covered	48
8. Limestone, dark-gray; weathers light gray; medium bedded; in part, silty; in part, arenaceous and bioclastic; locally sparse black chert nodules; locally, thin fine-grained dolomite lenses; abundantly fossiliferous locally; silicified bryozoans and brachiopods	86
7. Arenaceous limestone, gray to brownish-gray; weathers light gray with brownish sandy streaks; medium bedded; locally poorly sorted sand particles; chert nodules in middle part; fossiliferous, derbyid and spiriferid brachiopods (USGS colln. 17169–PC)	33
6. Limestone, medium-dark-gray; weathers light olive gray; thin bedded; argillaceous limestone interlayers; sparse black chert nodules in upper part	59
5. Limestone, argillaceous limestone, and shale, interbedded; light olive gray and dark gray; weather light gray; medium to thin bedded; shale partings and interbedded argillaceous limestone; sparse black chert nodular limestone; locally, thin bioclastic limestone layers. Upper 30 ft is predominantly shale and mostly covered	80
4. Argillaceous limestone, medium to dark-gray; weathers dark brownish gray; thin bedded and platy; interbedded black nodular chert and calcareous sandstone layers at base; fossiliferous, brachiopods and bryozoans (USGS colln. 17168–PC)	5
3. Limestone, medium-olive-gray; weathers light olive gray; medium bedded; in part, platy and well-jointed blocky float; forms cliffs along section line	25
2. Limestone, arenaceous limestone, argillaceous limestone, carbonaceous shale, cherty limestone, and calcareous quartzite interbedded with cyclic repetition; light olive gray, light gray to dark gray; weather medium gray to brownish gray and buff; thin to medium bedded; locally crossbedded; bioclastic limestone and calcareous quartzite; thin shale layers and partings; locally at base of unit interbedded argillaceous limestone and shale are fossiliferous; brachiopods (USGS colln. 17167–PC). The unit is mostly covered in lower 100 ft	288
1. Argillaceous limestone, arenaceous limestone, and calcareous quartzite, interbedded; olive gray to light tan; thin bedded; irregularly interbedded ferruginous shale and arenaceous limestone; locally crossbedded and banded. The unit is mostly covered	41
Total thickness measured	1,053

Conformable contact.

Manning Canyon Shale.

Fossils are locally abundant and similar to those found in the upper part of the Lake Point Limestone of the Rogers Canyon sequence, but are often fragmented in the argillaceous and flaggy limestone. The collections are located in the reference sections and in table 5; a detailed description of the fauna and its correlation is given by Gordon and Duncan in the section on biostratigraphy and correlation. Brachiopods typical of the *Rugoclostus* zone are most abundant, bryozoans are fairly common, corals are very rare, mollusks are limited to a few scattered pelecypods, and trilobites are present as rare fragments. Nygreen (1958) reported finding the fusulinid *Millerella* in the upper part. A Morrow age is suggested for the West Canyon Limestone. The Mississippian-Pennsylvanian boundary lies in the upper part of the underlying Manning Canyon Shale.

BUTTERFIELD PEAKS FORMATION

The Butterfield Peaks Formation is here named for Butterfield Peaks, 3 miles south of Bingham in the Fairfield quadrangle. The formation, which rests conformably on the West Canyon Limestone, includes the medial cyclic series of rocks of the Oquirrh Group in the Bingham sequence. These rocks formerly were believed to represent the upper part of the Maple Formation and all of the "White Pine" and Butterfield Formations of Welsh and James (1961) (fig. 5). The rocks crop out along the Long Ridge anticline northwest of West Canyon and along the Pole Canyon syncline (fig. 2). The type section of the Butterfield Peaks Formation, however, was measured up the ridge at the head of West Canyon, westward along the ridge separating the Middle and Settlement Canyons (fig. 11), and then northward across Middle Canyon west of the mouth of Left Hand Fork (fig. 4, section 7a). Here the formation is 9,072 feet thick. The upper contact is at the base of a banded quartzite layer underlying the Jordan marker unit (fig. 12). A reference section of the lower part of the formation, which continues the West Canyon Limestone reference section and which also was the type section of the Butterfield and White Pine Formations of Welsh and James (1961, pl. 5), is on the north side of West Canyon, opposite Maple Canyon, in the north center part of sec. 27 and the south center part of sec. 22, T. 4 S., R. 3 W., Fairfield quadrangle. A second reference section of the lower part (3,900 feet) of the Butterfield Peaks Formation measured in Soldier Canyon, a continuation of the West Canyon Lime-

FIGURE 11.—Typical exposures of the middle part of the Butterfield Peaks Formation as exposed in part of its type section along the skyline at the head of White Pine Canyon tributary of Middle Canyon. Cyclically repeated beds measured along the skyline ridge appear as prominent bands; light-colored beds are mostly calcareous sandstone and arenaceous and cherty limestone, darker beds are covered argillaceous limestone zones.

FIGURE 12.—Typical exposures of the Jordan (limestone) marker bed (a thick cherty limestone) within the base of the Clipper Ridge Member of the Bingham Mine Formation at the type locality of the member in Middle Canyon. View looking west toward W¼ cor. NE¼ sec. 3, T. 4 S., R. 3 W. Bingham Canyon 7½-min. quadrangle. Light-colored rocks at the base and top are calcareous quartzite.

stone reference section, contains several important fossil collections.

The rocks are predominantly calcareous quartzite and silica-cemented orthoquartzite, calcareous sandstone, and arenaceous, cherty, argillaceous, and fine-grained dense limestones. The calcareous quartzite is brown gray, fine to medium grained, medium to massive bedded, and locally may contain argillaceous limestone laminations. In places the quartzite is crossbedded and ripplemarked on bedding surfaces. It weathers tan to light brown to red brown. The silica-cemented orthoquartzite beds stand in prominent relief and have a hard vitreous weathered surface; the carbonate-cemented calcareous quartzite beds weather, forming a soft outer surface rind of variable thickness up to one-third inch thick. These units grade into one another and locally weather in the form of ribs outlining crossbeds in the orthoquartzite or parallel bands in the calcareous quartzite. Limestones typically are medium dark gray, fine crystalline to medium sandy, and thin to medium bedded; they weather light gray. Thin black chert nodules and lenses locally band the rocks; thin coarse arenaceous layers, some of which are bioclastic and many of which are crossbedded, and interlaminated shale and argillaceous limestone beds occur in the strata. Limestones in the lower part of the formation are very fossiliferous.

TYPE SECTION OF BUTTERFIELD PEAKS FORMATION
(see fig. 4, section 7a)

Ridge along the divide beginning at the head of West Canyon and between Settlement and Middle Canyons to point 8944 thence northeast to base of Middle Canyon, secs. 6, 7, 18, 19, 20, and 21, T. 4 S., R. 3 W., and sec. 12, T. 4 S., R. 4 W., Fairfield, Stockton, and Bingham Canyon quadrangles, Utah

[Measured by E. W. Tooker and R. J. Roberts]

	Thickness (ft)
Oquirrh Group:	
Bingham Mine Formation:	
Clipper Ridge Member.	
Conformable contact.	
Butterfield Peaks Formation:	
50. Calcareous quartzite, orthoquartzite, and calcareous sandstone, interbedded; tan to light orange gray; weather light brown; medium bedded to massive; interlayered thin- to medium-bedded arenaceous limestone and silty limestone; fossil fragments in limestone. Unit is poorly exposed	215
49. Arenaceous limestone, olive-gray; weathers light gray; thin to medium bedded; interlayered argillaceous and silty limestone; fossil fragments	11
48. Calcareous quartzite and arenaceous limestone, interbedded; pale grayish orange; weather light brown and olive gray; interstratified with banded medium-bedded orthoquartzite and thin-bedded argillaceous limestone. Unit is partly covered	473
47. Orthoquartzite and calcareous quartzite, interbedded; pale grayish orange; medium bedded to massive; crossbedded and banded	9
46. Calcareous quartzite and calcareous sandstone, interbedded; medium grayish tan; weather tan; medium bedded; banded; locally crossbedded; interlayered thin fossiliferous and bioclastic limestones. Unit is partly covered	196

	Thickness (ft)
45. Arenaceous limestone, olive-gray; weathers pale yellowish brown; thin bedded; poorly preserved fusulinids	1
44. Calcareous quartzite, calcareous sandstone, arenaceous limestone, and argillaceous limestone, interbedded; quartzite is banded and crossbedded. Unit is poorly exposed on slope	231
43. Cherty limestone, medium-dark-gray; weathers medium gray; thin bedded; small black chert nodules and layers; grades downward into platy silty limestone without chert	7
42. Arenaceous limestone, brownish-gray; weathers yellowish gray; thin bedded; platy float	51
41. Orthoquartzite and calcareous quartzite, interlayered; light grayish orange and brownish gray; weather pale yellowish brown and yellowish gray; medium bedded to massive; well jointed	222
40. Calcareous quartzite and arenaceous limestone, interbedded; locally crossbedded; fossil fragments in sandy layers in limestone	182
39. Arenaceous limestone; contains bioclastic limestone layers and poorly preserved fusulinds; poorly exposed	6
38. Calcareous quartzite and limestone, interbedded. Unit is poorly exposed	232
37. Limestone, silty limestone, and arenaceous limestone, interbedded; medium dark gray; weather light olive gray; thin to medium bedded; banded layers contain abundant brachiopods and bryozoans	140
36. Cherty limestone, medium-dark-gray; weathers dark yellowish brown; thin bedded to laminar; interlayered arenaceous and argillaceous limestone; black chert layers and nodules up to 6 in. thick. Lower 20 ft grades into arenaceous limestone	101
35. Orthoquartzite, light-grayish-tan, medium-bedded	23
34. Arenaceous limestone, calcareous quartzite, calcareous sandstone, orthoquartzite, and platy silty limestone, interbedded with cyclic repetition; medium dark gray and light grayish tan; weather medium light gray and olive gray; thin bedded to thick bedded. Unit contains thin bioclastic limestone layers. Unit is poorly exposed	213
33. Orthoquartzite and calcareous quartzite, interbedded; light grayish tan to light olive gray; weather tan to yellowish brown; medium bedded to massive; pitted and mottled on weathered surfaces; interlayered thin-bedded arenaceous and cherty limestone, calcareous sandstone, and silty and argillaceous limestone; USGS colln. f22576 from bioclastic sand. Unit is mostly covered	392
32. Argillaceous and cherty limestone, interbedded; medium gray; weather tan and light gray; thin bedded; platy. Cherty limestone contains both black and tan chert nodule layers	236
31. Arenaceous limestone, medium-gray; weathers light grayish brown; thin to medium bedded; local bioclastic limestone layers and shale partings; abundant fusulinids found locally in lowe. half (USGS coll. f22583 and f22584)	95
30. Calcareous quartzite and orthoquartzite, interbedded; tan; weather tan to buff; medium bedded; banded; locally crossbedded; interlayered thin beds of calcareous sandstone	222
29. Cherty limestone and calcareous sandstone, interbedded; medium gray and light brownish gray; weather brownish gray and tan; medium bedded; contain black chert nodule layers; interlayered thin platy argillaceous limestone in upper part; abundant bryozoans, spiriferid brachiopods, and crinoids in upper part	79
28. Calcareous quartzite, light-grayish-tan; weathers tan; platy to massive bedded; interlayered orthoquartzite and argillaceous limestone	107
27. Shale and argillaceous limestone, interbedded; dark gray; weather tan; thin bedded; platy; contain sparse chert nodules; thin interlayers of arenaceous and silty limestone	66
26. Cherty limestone, medium-gray; weathers light gray; thin to medium bedded; interlayered bioclastic limestone and argillaceous limestone; black chert nodules and irregular chert lenses; basal platy limestone; abundant shale partings; crinoids, bryozoans, corals, and fusulinids (USGS colln. 20308–PC, f22580, f22581, and f22582)	308
25. Arenaceous limestone, calcareous quartzite, and orthoquartzite, interbedded; gray, dark gray, and grayish tan; weather tan to grayish tan; thin to medium bedded; locally laminar	41
24. Orthoquartzite, light-grayish-tan; weathers white to light gray; medium bedded to massive; locally laminated with thin calcareous limestone layers	104
23. Argillaceous limestone, shale, and limestone, interbedded; dark gray; weather medium gray. Thin-bedded chert band	

	Thickness (ft)
in shale in upper part of unit. Dolomite breccia in middle part of unit. Unit is poorly exposed	68
22. Orthoquartzite and calcareous sandstone, interbedded; grayish brown and medium gray; weather grayish tan and brownish gray; interlayered argillaceous limestone and cherty limestone parting layers	149
21. Limestone and shale, interbedded; dark gray; weather medium gray; thin bedded; locally contain bioclastic limestone lenses	85
20. Limestone, dark-gray; weathers light gray; thin to medium bedded; locally abundant black chert nodules in irregular lenses and layers; thin bioclastic limestone layers. Thick-bedded chert zone in middle part of unit. Bryozoans locally abundant in upper part (USGS colln. 20307–PC)	479
19. Calcareous quartzite, argillaceous limestone, calcareous sandstone, and limestone, interbedded with cyclic repetition; brownish gray and dark gray; weather grayish tan and medium gray; thin bedded to massive	133
18. Arenaceous limestone and limestone, interbedded; dark gray; weather brownish gray; medium bedded; interlayered argillaceous limestone. 1-ft fault breccia at base of unit. Fault displacement unknown, but it does not appear to be very great. Brachiopods and prismoporoid bryozoans are present (USGS colln. 20306–PC)	73
17. Calcareous quartzite, gray-brown; weathers tan; medium bedded to massive; locally banded and crossbedded; interlayered laminar calcareous sandstone	90
16. Cherty limestone and argillaceous limestone, interbedded; medium to dark gray; weather brownish gray; thin to medium bedded; prismoporoid bryozoans and spiriferid brachiopods	60
15. Calcareous quartzite, brownish-gray; weathers tan; medium bedded to massive; thin argillaceous limestone and orthoquartzite parting layers	115
14. Cherty limestone, arenaceous limestone, and argillaceous limestone, interbedded; dark gray; weather brownish gray and light gray; thin to medium bedded; black chert nodules and layers throughout unit; abundant brachiopods (USGS colln. 20305–PC)	364
13. Orthoquartzite and calcareous quartzite, interbedded; brownish gray; weather tan; medium bedded to massive	66
12. Limestone, dark-gray; weathers medium gray; medium bedded; interlayered argillaceous limestone in middle part; spiriferid brachiopods at base	43
11. Orthoquartzite and calcareous quartzite, interbedded; brownish gray; weather tan; locally laminar; in part medium bedded to massive	115
10. Limestone, dark-gray; weathers medium light gray; thin bedded to platy	82
9. Orthoquartzite and calcareous quartzite, interbedded; brownish gray; weather tan; medium bedded	39
8. Limestone, arenaceous limestone, and cherty limestone, interbedded; arenaceous limestone and cherty limestone are brownish gray, limestone is mottled medium dark gray and dark gray; weather medium gray to grayish tan; thin to medium bedded; locally platy; sparse brachiopods in lower half of unit	109
7. Calcareous quartzite, calcareous sandstone, silty limestone, arenaceous limestone, cherty limestone, and argillaceous limestone, interbedded with cyclic repetition. Calcareous quartzite and calcareous sandstone are grayish tan to brownish gray, weather sandy brown and tan (in many places in variegated bands) are locally crossbedded, and are thin to medium bedded. Silty limestone, arenaceous limestone, cherty limestone, and argillaceous limestone are dark gray and medium gray, weather medium gray, and are thin to medium bedded. Brachiopods are locally abundant (USGS colln. 20303–PC)	612
6. Calcareous quartzite, orthoquartzite, and calcareous sandstone, interbedded; brownish gray; weather sandy brown to tan; banded laminae; crossbedded in upper part; locally platy and blocky float. Unit is poorly exposed	121
5. Limestone, calcareous quartzite, arenaceous limestone, argillaceous limestone, cherty limestone, and calcareous sandstone, interbedded with cyclic repetition. Limestone, arenaceous limestone, argillaceous limestone, and cherty limestone are dark gray and medium dark gray, weather medium gray, and are thin to medium bedded; limestone contains shale and sand partings. Calcareous quartzite and calcareous sandstone are grayish brown, weather brownish tan and medium grayish tan, and are thin to medium bedded; sandstone is locally crossbedded. Bioclastic limestone layers are present locally in the unit. Unit is locally fos-	

	Thickness (ft)
siliferous (USGS colln. f22578 and 20302–PC)	780
Porphyry dike 7 ft thick.	
4. Limestone, calcareous quartzite, arenaceous limestone, argillaceous limestone, and cherty limestone, interbedded with cyclic repetition; medium dark gray; weather light gray; thin to medium bedded; crossbedded bioclastic limestone and shale parting layers locally; horn corals and fusulinids present (USGS colln. f22577 and 20299–PC)	630
3. Calcareous sandstone, limestone, calcareous quartzite, arenaceous limestone, and argillaceous limestone, interbedded. Calcareous sandstone and calcareous quartzite are brownish gray, weather yellowish tan and tan, and are thin to medium bedded; sandstone is locally crossbedded. Limestone, arenaceous limestone, and argillaceous limestone are dark gray, weather medium gray, and are thin to medium bedded; limestone locally contains black chert nodules. Unit contains shale partings and thin interlayers of bioclastic limestone. *Chaetetes* is found in limestone at 150 ft in nearby reference section (6a) (USGS colln. 20332–PC and 20333–PC)	610
2. Arenaceous limestone and cherty limestone, interbedded; medium gray; weather medium dark gray; thin to medium bedded; interlayered argillaceous limestone and bioclastic limestone. Lower part of unit covered	279
1. Calcareous quartzite, brown-gray; weathers tan; locally crossbedded	7
Total thickness measured	9,072

Conformable contact.

Oquirrh Group, West Canyon Limestone.

REFERENCE SECTION OF LOWER PART OF BUTTERFIELD PEAKS FORMATION (see fig. 4, section 11)

Begins approximately 7250 contour on traverse beginning at base of ridge on north side Soldier Creek, opposite unnamed stream heading at the d in Bald Mountain, traverse N. 6° E. to ridge top, then N. 40° E. to ridge top west of peak 9075, secs. 26, 27, and 34, T. 4 S., R. 4 W., Stockton quadrangle, Utah

[Measured by E. W. Tooker, Mackenzie Gordon, Jr., and R. J. Roberts]

	Thickness (ft)
Fault contact near ridge crest.	
Oquirrh Group:	
Butterfield Peaks Formation (upper part).	
Butterfield Peaks Formation (lower part):	
15. Cherty limestone, medium gray; weathers medium light gray; thin bedded; black chert nodules	66
14. Orthoquartzite, medium brownish gray; weathers grayish tan; medium bedded; local thin interbedded bioclastic limestone	129
13. Argillaceous limestone, arenaceous limestone, and limestone, interbedded; medium gray; weather medium light gray; thin to medium bedded; locally bioclastic limestone and cherty limestone in lower part of unit; argillaceous limestone and carbonaceous shale partings in limestone; argillaceous limestone at top of unit abundantly fossiliferous, *Prismopora* bryozoans, brachiopods, and crinoid stem fragments, locally fusulinids (USGS colln. 20324–PC and 20325–PC)	445
12. Orthoquartzite, medium brownish gray, weathers tan; medium bedded; in part crossbedded and banded	59
11. Limestone, cherty limestone, argillaceous limestone, and calcareous quartzite and orthoquartzite, interbedded with cyclic repetition. Limestone intervals 50–100 ft thick are medium dark gray, weather medium gray to medium light gray, are thin to medium bedded; locally arenaceous limestone is bioclastic; argillaceous limestone and shale form parting layers locally; sparse black chert nodules occur locally in the dense limestone layers. Unit is fossiliferous; bryozoans, crinoid stems and brachiopods (USGS colln. 20322–PC and 20323–PC). Quartzite intervals 6–50 ft thick are medium brownish gray, weather grayish tan, are medium bedded, are locally crossbedded and banded; calcareous quartzite has characteristic sanded weathered surface	670
10. Calcareous quartzite, medium-brownish-gray to light-gray; weathers medium gray to brownish tan; medium bedded to massive; locally well jointed. Medial 13-ft limestone is medium dark gray, weathers medium gray, is medium bedded, and is in part bioclastic. Unit is fossiliferous, spiriferid brachiopods (USGS colln. 20321–PC)	196
9. Limestone, cherty limestone, arenaceous limestone, argillaceous limestone, and calcareous quartzite, interbedded with cyclic repetition; medium to dark gray and grayish tan; weather medium light gray, grayish tan to brownish gray; thin to medium bedded; locally arenaceous beds are crossbedded and banded, occasionally are bioclastic; thin carbonaceous shale partings, bedded chert, and quartzite lenses and layers occur throughout unit; limestone locally con-	

	Thickness (ft)
tains abundant black chert nodules. Quartzite makes up less than one-fifth of unit, is crossbedded and banded, and locally has a thin-sanded weathered surface. Fossils are locally abundant in the limestone—mostly productid brachiopods. A 22-ft Tertiary monzonite dike crops out at 343 ft	348
8. Orthoquartzite, calcareous quartzite, and limestone, interbedded; medium light gray and medium dark gray; weather medium light gray; thin to medium bedded. Quartzite intervals 50–150 ft thick predominate in the unit; however, quartzite units contain thin interbedded limestone layers and limestones contain thin interbedded quartzitic layers. Limestones are locally arenaceous, bioclastic, and argillaceous. Argillaceous limestones contain abundant fossils locally, spiriferid brachiopods, crinoids, and corals	358
7. Calcareous quartzite, limestone, arenaceous limestone, and argillaceous limestone, interbedded with cyclic repetition; medium gray to medium light grayish tan; weather light gray and tan; thin to medium bedded. Quartzite intervals predominate and average 10-30 ft thick; half as many limestone intervals average about 20 ft thick. Quartzite is poorly exposed. Limestone locally contains black chert nodular zones, shale parting layers and bioclastic limestone beds; locally abundantly fossiliferous (USGS colln. 20320–PC)	309
6. Limestone, arenaceous limestone, argillaceous limestone, and calcareous quartzite, interbedded with cyclic repetition; medium dark gray to gray; weather medium light gray to light gray grayish tan; thin to medium bedded; shale partings; locally medium bedded bioclastic limestone and cherty limestone interlayers. Quartzite has brownish sand streaks along crossbeds and layer bands that weather in fluted relief. Unit topped by a 2-ft light-tan chert with interstitial limestone; weathers light tan to white; locally fossiliferous (USGS colln. 20319–PC). Tertiary monzonite sill 3 ft thick 30 ft above base of unit	271
5. Limestone, arenaceous limestone, and calcareous quartzite, interbedded; medium gray to medium dark gray; weather medium light gray and brownish gray; thin to medium bedded; thin fissile shale and argillaceous limestone and bioclastic limestone interlayers. Quartzite intervals make up a minor part of the unit, range from 2 to 15 ft thick, and are poorly exposed. Argillaceous limestone is fossiliferous, containing abundant horn corals, bryozoans, and spiriferid brachiopods (USGS colln. 20318–PC). A Tertiary monzonite sill with characteristic greenish weathered surface is 7 ft thick, occurs 2 ft above the base of the unit	146
4. Calcareous quartzite, orthoquartzite, limestone, arenaceous limestone, and argillaceous limestone, interbedded. Quartzite beds are color banded in medium gray and brownish medium gray, are weathered medium light brownish gray to dark brownish gray, are medium bedded to massive, occur in intervals ranging from 10 to 55 ft thick at the base, middle, and upper parts of the unit; crossbedding prominent locally. Unit characteristically forms cliffs in outcrop. The weathered surface of orthoquartzite is characteristically smooth; a thin sanded rind occurs on calcareous quartzite. Limestones are medium gray to medium dark gray, weather medium light gray to grayish tan with brownish rust streaks along coarse sand zones, are fine to medium bedded, are locally crossbedded, have occasional bioclastic limestone layers and shale partings, have local black chert nodule limestone beds, and are fossiliferous, containing productoid brachiopods and bryozoans (USGS colln. 20317–PC)	141
3. Limestone, arenaceous limestone, argillaceous limestone, and calcareous quartzite, interbedded with cyclic repetition. Limestones are medium gray to medium dark gray, weather medium gray to light gray, are thin to medium bedded, have interbedded thin bioclastic limestone, argillaceous limestone, and shale partings, contain sparse chert nodules locally, contain interlayers of thin quartzite locally; locally abundantly fossiliferous containing spiriferid and derbyid brachiopods, brachiopods, corals, bryozoans, and crinoids (USGS colln. 20316–PC and 20315–PC). Limestone intervals range from 10 to 15 ft thick and make up more than three-fourths of the unit. Quartzite intervals range from 2 to 10 ft thick, are medium brownish gray to grayish tan, weather grayish tan and tan, and are medium bedded. Quartzite locally forms cliffs in outcrop. Locally crossbedded and banded thicker limestone intervals generally contain calcareous sandstone and limestone interbeds	441
2. Limestone, argillaceous limestone, arenaceous limestone, cherty limestone, orthoquartzite, and calcareous quartzite, interbedded with cyclic repetition. Lime-	

	Thickness (ft)
stones are medium gray to medium dark gray, weather medium to light gray to tan, are thin to medium bedded, contain thin fissile chert, shale, and bioclastic limestone interlayers, and commonly contain crossbedded brown quartz sand partings. Limestones are fossiliferous locally, containing brachiopods, crinoids and fusulinids fragments. A white chert layer 1 ft thick is a marker unit at 137 ft. Quartzites are gray to grayish tan and medium brownish gray, weather buff to tan, are medium bedded to massive, are commonly crossbedded, are locally banded, locally contain limestone, chert, and shale parting layers. Limestones make up three-quarters of the unit in intervals ranging from 2 to 15 ft thick; quartzite intervals range from 2 to 5 ft thick. A Tertiary monzonite porphyry sill 12 ft thick occurs at 92 ft above base of unit	279
1. Calcareous quartzite, light-gray-brown; weathers reddish to brownish tan; thick bedded; blocky	5
Total measured thickness	3,863

Conformable contact.

Oquirrh Group, West Canyon Limestone.

The limestone beds in the Butterfield Peaks Formation contain an abundant fauna of brachiopods, bryozoans, corals, and fusulinids, as noted by Welsh and James (1961, p. 8–11). The positions of fossil collections are shown in the stratigraphic sections and in table 6; a detailed discussion of the faunas and their correlation is given by Gordon and Duncan in the section on biostratigraphy and correlation. In general the fauna resemble those of the Erda Formation in the Rogers Canyon sequence. The age is Des Moines (Middle Pennsylvanian) although the lower few hundred feet may be Atoka.

BINGHAM MINE FORMATION

The Bingham Mine Formation was named by Welsh and James (1961, p. 8–9) for limestone and quartzitic sandstone in the Bingham mining district. It was originally defined as the predominantly calcareous quartzite strata of Pennsylvanian age above the base of the Jordan marker bed. Their type section was specified to be on South Mountain in secs. 20, 21, and 22, T. 4 S., R. 5 W., Stockton quadrangle.

The Bingham Mine Formation is 7,311 feet thick and is divided into two members. The Clipper Ridge Member, 2,985 feet thick, is composed predominantly of cyclically interbedded orthoquartzite and calcareous quartzite. The overlying Markham Peak Member, 4,327 feet thick, is composed predominantly of calcareous quartzite and ferruginous sandstones.

CLIPPER RIDGE MEMBER

The Clipper Ridge Member, here named for the area of excellent exposure on the south side of Clipper Ridge in Middle Canyon on the west side of the Oquirrh Mountains, is about 3,000 feet thick and is the lower member of the Bingham Mine Formation (fig. 5). The type section is in N½ sec. 6, T. 4 S., R. 3 W., and S½ sec. 31, T. 3 S., R. 3 W., Bingham Canyon quadrangle (fig. 4, section 7a). The lower contact of the member is at the base of the 10-foot quartzite that underlies the prominent and distinctive cliff outcrops of the 360-foot thick laminar cherty limestone Jordan marker bed (unit 2). The Jordan can be traced from the range front south of the mouth of Middle Canyon, eastward across the Long Ridge anticline to the south edge of the Bingham porphyry intrusive mass. The upper contact is immediately above a fossiliferous sandy limestone marker unit, which contains an abundant well-preserved assemblage of fusulinids, *Caninia* and *Syringopora* corals, and bryozoans; the contact is beneath a quartzite and sandstone unit, which contains the first prominent ferruginous sandstone in a predominantly calcareous sandstone and quartzite unit.

The Clipper Ridge Member consists mostly of orthoquartzite, calcareous quartzite, and calcareous and quartzose sandstone, but also contains several limestone layers more than 100 feet thick. The quartzite commonly is medium to thick bedded and is fine to medium grained. Some beds are finely banded and locally crossbedded. In the mining district the limestone units include conspicuous mappable beds such as the Parnell, York-Phoenix, Jordan, and Commercial marker beds. Interbedded cherty, arenaceous, and argillaceous limestones and shale are as much as 270 feet thick in the lower part of the member. In the upper part of the member, limestones are thinner, ranging from less than 10 feet to 70 feet in thickness, and are interbedded with quartzite units, ranging from 150 feet to 300 feet in thickness.

TYPE SECTION OF CLIPPER RIDGE MEMBER (see fig. 4, section 7a)

Ridge southwest from hill 8745, north side of Middle Canyon, N½ sec. 6, T. 4 S., R. 3 W. and S½ sec. 31, T. 3 S., R. 3 W., Bingham Canyon quadrangle, Utah

[Measured by E. W. Tooker and R. J. Roberts]

Oquirrh Group:

Bingham Mine Formation:

	Thickness (ft)
Markham Peak Member.	
Conformable contact.	
Clipper Ridge Member:	
20. Limestone, dark-gray; weathers light bluish gray; thin to medium bedded; interlayered thin arenaceous limestone; locally black chert nodules; abundant well-preserved bryozoans, brachiopods, syringoporoid corals, and fusulinids (USGS colln. f22604)	5
19. Calcareous quartzite, light-tan; weathers light brownish tan; medium bedded; interlayered thin silty limestone and calcareous sandstone; fusulinids abundant	18
18. Arenaceous limestone, medium-gray; weathers medium grayish brown; banded; abundant fusulinids and syringoporoid corals (USGS colln. f22603, f22572, and 23890-PC)	10
17. Orthoquartzite and calcareous quartzite, interbedded; light grayish tan to brown; weather light brownish tan; medium bedded to massive; banded	160
16. Silty limestone, arenaceous limestone, and calcareous quartzite, interbedded; medium gray and buff tan; weather medium light gray and tan; thin to medium bedded; brown sandstone partings in limestone; fusulinids (USGS colln. f22601 and f22602)	23
15. Calcareous quartzite and orthoquartzite, interbedded; light grayish tan; weather light brown and gray; medium bedded; locally banded; interlayered thin arenaceous limestone; cherty limestone, and silty limestone; fusulinids, caninoid corals, and productid brachiopods occur in limestone (USGS colln. 20295-PC and f22574)	142
14. Arenaceous limestone and calcareous quartzite, interbedded; medium gray and grayish tan; weather light reddish brown and light gray; medium bedded	26
13. Calcareous quartzite, arenaceous limestone, and calcareous sandstone, interbedded; grayish tan and medium gray; weather reddish brown to light brown and light gray; platy to medium bedded	65
12. Limestone, medium-gray; weathers mottled grayish brown and light brown; thin to medium bedded; interlayered thin arenaceous and argillaceous limestones; worm trails shale partings	10
11. Calcareous quartzite, arenaceous limestone, orthoquartzite, and cherty limestone, interbedded; quartzite is tan to light gray, limestone is dark gray; quartzite weathers to light brown and tan, limestone weathers mottled gray and light brown; thin to medium bedded; locally banded, crossbedded, and ripple marked; interlayered bioclastic limestone beds and shale partings; some black chert nodules and lenses along bedding; fusulinids and bryozoans locally abundant (USGS colln. f22600)	456
10. Limestone, arenaceous limestone, and cherty limestone, interbedded; medium light gray; thin to medium bedded; locally black chert nodules along bedding; abundant fusulinids, productid and spiriferid brachiopods, crinoids, bryozoans, and caninoid and syringoporoid corals	10
9. Calcareous quartzite, tan; weathers brownish tan and medium gray; medium bedded; locally crossbedded; interlayered thin arenaceous limestone and orthoquartzite; fusulinids in limestone (USGS colln. f22599)	95
8. Silty and arenaceous limestone, interbedded; medium gray; weather medium light gray and brownish tan; medium bedded; locally crossbedded; interlayered thin dark-gray limestone; sparse crinoid and bryozoan fossils	15
7. Calcareous quartzite, calcareous sandstone, and arenaceous limestone, interbedded; grayish tan; weather brownish tan and light gray; medium bedded to massive; banded and crossbedded, and locally ripple marked; locally interlayered orthoquartzite, which has a hard weathered surface in contrast to the pitted thick punky weathered surface on calcareous quartzite; worm trails in sandstone; brachiopods and bryozoans in limestone	659
6. Limestone, medium-dark-gray; weathers light gray; thin bedded; interlayered thin arenaceous limestone partings; fusulinids (USGS colln. f22598)	14
5. Calcareous quartzite, arenaceous limestone, and orthoquartzite, interbedded; grayish tan; weather	

	Thickness (ft)
brownish tan; medium bedded to massive; crossbedding, channel scour and fill, and local ripple marks; sparse fossils in thin limestone layers	626
4. Cherty limestone and arenaceous limestone, interbedded; dark gray; weather medium dark gray and brownish gray; thin laminar to medium bedded; abundant large individual black chert nodules parallel to bedding, many of which are zonally altered; abundant brachiopods and bryozoans locally. This is the Commercial limestone marker bed	136
3. Calcareous quartzite, arenaceous limestone, and calcareous sandstone, interbedded; tan; weather brownish tan; medium bedded; crossbedded; well jointed; punky ferruginous weathered rind in sandstone and hard weathered surface on quartzite	144
2. Arenaceous limestone, cherty limestone, silty limestone, and calcareous sandstone, interbedded; dark gray to medium gray; weather medium gray, and locally near base, mottled light gray and tan; thin to medium bedded; sandstone locally banded and crossbedded. Abundant chert in thin nodule layers in the lower part unit; nodules along layers in the upper part. Sheared altered zone 6 in. thick at base of unit. Bryozoans, abundant spiriferid and productid brachiopods, and corals occur in the middle part, and fusulinids, brachiopods, and bryozoans at the base (USGS colln. f22597 and 22486–PC). This is the Jordan limestone marker bed	361
1. Orthoquartzite tan; weathers brownish tan; massive bedded; dense; banded	10
Total thickness measured	2,985

Conformable contact.

Oquirrh Group, Butterfield Peaks Formation.

Megafossils, mostly corals, are sparse and poorly preserved except in arenaceous limestone or calcareous sandstone; fusulinids are the most useful for geochronology. Positions of selected collections are shown in the stratigraphic section and are discussed by Gordon and Duncan in the section on biostratigraphy and correlation. *Triticites* is the most common fusulinid, and the forms are believed to be of probable Missouri age. The megafauna are not sufficiently diagnostic to confirm this age designation, but Syringoporoid corals, which are fairly common in the upper part of the member, may represent a Missouri fauna. On the basis of these data we consider the Clipper Ridge Member to be of Missouri age.

Markham Peak Member

The Markham Peak Member of the Bingham Mine Formation is here named for the quartzite and sandstone beds of the upper part of the Oquirrh Group; these beds are exposed on and near Markham Peak in the central part of the Oquirrh Mountains (fig. 4, section 7b). In addition to rocks of the upper part of the Bingham Mine Formation of Welsh and James (1961), the Markham Peak Member also includes about 1,200 feet of rocks on Markham Peak assigned to the lower portion of the Curry Formation by Welsh and James (1961, p. 6–7).

The lower contact with the Clipper Ridge Member is conformable, the upper part of the member has been eroded at Markham Peak, and north of the peak the sequence is cut off by the Midas thrust fault; therefore, the total thickness of the member is unknown. However, more than 4,300 feet have been measured in the type section on the ridge between Spring and Dry Canyons west of the Occidental fault (secs. 30 and 31, T. 3 S., R. 3 W., Bingham Canyon quad.), and on Markham Peak east of the Occidental fault (secs. 21 and 22, T. 3 S., R. 3 W., Bingham Canyon quad.) (fig. 4, sections 7a, 7b).

Orthoquartzite and calcareous quartzite, calcareous sandstone, calcareous silt, and all possible intergradations of these lithologies constitute the Markham Peak Member. A few thin 1–3-foot fusulinid-bearing arenaceous limestone beds provide marker horizons. Layers and lenses of chert pebble conglomerate occur on Markham Peak in the upper part of the section. Welsh and James (1961, p. 12) believed that this conglomerate represented an unconformity at the Pennsylvanian-Permian boundary. The orthoquartzite is buff to tan, weathers tan to light brown, is medium grained, detrital, silica-cemented, medium bedded to massive, locally banded, crossbedded, ripplemarked, and locally shows channel scour and fill. Calcareous quartzite is light tan gray, weathers yellow gray to yellow orange, is sandy, and is carbonate cemented; locally pitting and a soft sandy rind develops on weathered surfaces.

Thin beds of arenaceous medium-dark-gray limestone, which weather olive gray, are common in the lower most part of the member; in many places they contain coarse fossil fragments as well as quartz grains. Brachiopods, corals, bryozoans, and fusulinids occur at these horizons. Arenaceous limestone and calcareous sandstone grade into each other.

TYPE SECTION OF MARKHAM PEAK MEMBER
(see fig. 4, section 7b)

East-trending ridge from Markham Peak through the middle of secs. 21 and 22, T. 3 S., R. 3 W., Bingham Canyon quadrangle, Utah

[Measured by E. W. Tooker and W. J. Moore]

		Thickness (ft)
Erosion unconformity at Markham Peak.		
Oquirrh Group:		
Bingham Mine Formation.		
Markham Peak Member (upper part):		
26.	Calcareous sandstone, medium-dark-gray; weathers light reddish brown; interlayered ferruginous sandstone; thick punky weathered surface rind	192
25.	Calcareous quartzite, orthoquartzite, and ferruginous sandstone, interbedded; local small breccia zones along bedding. Unit is poorly exposed	148
24.	Calcareous sandstone, dark-gray; weathers light gray; thin to medium bedded; platy; sparse black chert nodules irregularly scattered throughout unit	5
23.	Ferruginous sandstone and calcareous quartzite, interbedded; dark brown and grayish tan; thin to medium bedded; interlayered thin silty limestone and calcareous sandstones that contain chert nodules	189
22.	Calcareous quartzite, calcareous sandstone, orthoquartzite, and ferruginous sandstone, interbedded; thin bedded to massive; local thin breccia zones. Unit is mostly covered	111
21.	Orthoquartzite, dark-tan; weathers brownish tan; medium bedded to massive; jointed; nonbanded; 1-ft breccia at 136 ft	182
20.	Calcareous quartzite and basal 4-ft ferruginous sandstone. Unit is mostly covered	148
19.	Calcareous sandstone, olive-gray; weathers light grayish orange; medium to thick bedded; thin hard weathered surface rind	111
17–18.	Orthoquartzite, calcareous quartzite, and sandstone, interbedded; light grayish tan; weather light reddish brown and tan; medium bedded; orthoquartzite banded; interlayered thin ferruginous sandstone and thin conglomerate lenses. Unit poorly exposed	280
16b.	Orthoquartzite and calcareous quartzite, interbedded; light grayish tan; medium bedded; thinly banded; well jointed; locally crossbedded in upper half of unit	267
15–16a.	Orthoquartzite, tan, medium- to thick-bedded; nonbanded; well jointed; interlayered 3- to 4-ft ferruginous sandstone beds	144
14d.	Calcareous quartzite, ferruginous sandstone, orthoquartzite, arenaceous limestone, and silty limestone, interbedded. Dark-yellowish-brown medial sandstone; dark-gray upper and lower limestones. All are medium bedded. Upper 40 ft of unit is mostly covered	198
14c.	Orthoquartzite, tan; weathers light tan; finely banded; well jointed; smooth weathered surface; interlayered calcareous quartzite. Upper part of unit is mostly covered	534
14b.	Silty limestone, dark-gray; weathers medium gray; thin bedded; *Lithostrotion* colonial coral	37
14a.	Covered zone; brown iron-stained gossan and line of prospect pits; possible concealed fault of unknown displacement	4
13.	Calcareous quartzite, light-grayish-tan; weathers tan; medium bedded; occasional interlayered silty limestone and calcareous sandstone; fusulinid fragments found in sandstone; worm trails present in limestone (USGS colln. f23432 and f23433)	292
12.	Calcareous siltstone and sandstone, interbedded; light gray; weather tan and olive gray; thin bedded; locally banded; thin hard rind on weathered surface of sandstone; worm trails in punky siltstone; fusulinid molds in sandstone	323
11.	Calcareous sandstone; light tan to medium gray; weathers olive gray (hard weathered surface) and orange brown (soft and punky weathered surface); medium bedded; locally crossbedded; well jointed; interlayered silty and platy limestone; fusulinids found in sandy limestone unit 1 mile south along ridge (USGS colln. f23431); mostly covered above 20 ft	202
	Total thickness measured	3,367

Conformable contact.

Oquirrh Group, Bingham Mine Formation, Markham Peak Member (lower part).

TYPE SECTION OF MARKHAM PEAK MEMBER (see fig. 4, section 7a)

Ridge between Spring and Dry Canyons, south of Tooele Smelter in secs. 30 and 31, T. 3 S., R. 3 W., Bingham Canyon quadrangle, Utah

[Measured by E. W. Tooker and R. J. Roberts]

Thickness (ft)

Alluvium, covered, faulted, conformable contact at offset in section across the Occidental fault.

Oquirrh Group:

Bingham Mine Formation:

Markham Peak Member (lower part):

18. Orthoquartzite, medium-bedded, jointed. Unit is covered slope ---------- 116
17. Orthoquartzite, pale-yellowish-brown; weathers medium yellowish brown; medium bedded to massive; fine banding; well jointed; ripple mark flutes on weathered bedding surfaces; partly covered ---------- 254
16. Orthoquartzite, calcareous quartzite, and ferruginous-calcareous sandstone, interbedded; pale yellowish brown and brown; weather reddish brown; thin to medium bedded; local 2-in. chert bands; thick weathered surface rind on sandstone -------- 315
15. Arenaceous limestone, medium-dark-gray; weathers pale yellowish brown; medium bedded. Medial 4-ft calcareous sandstone. Fusulinids and *Caninia* corals (USGS colln. f23111) abundant ------------------------ 22
14. Orthoquartzite, calcareous quartzite, and calcareous and ferruginous sandstones, interbedded; pale yellowish brown; weather reddish brown to medium yellowish brown; thin to medium bedded; banded; interlayered thin fossiliferous limestone, bioclastic limestone, and cherty limestone; fusulinids near middle part of unit ------------------------- 765
13. Calcareous quartzite and ferruginous sandstone, interbedded; light grayish tan and pale yellowish brown; weather dark yellowish brown and brown; medium bedded; interlayered thin orthoquartzite and limestone beds; sandstone weathers to thick soft punky surface, locally brecciated. Sandstone locally contains worm trails; arenaceous limestone contains fusulinids (USGS colln. f23108 and f23109) -------------- 306
12. Calcareous sandstone and calcareous quartzite, interbedded; buff to tan; weather yellow; interlayered thin silty light-gray limestone and bioclastic limestone; sandstone weathers to thick soft (punky) surface. Unit is mostly covered slope ------ 125
11. Calcareous quartzite and ferruginous-calcareous sandstone, interbedded; light olive gray; weather brownish yellow to yellowish orange; medium bedded; interlayered thin gray arenaceous and silty limestones; fusulinids (USGS colln. f23105, f23106, and f23107); locally abundant worm trails; several 1-ft breccia zones, in lower 30 ft of unit. Unit is mostly covered -------------------------- 450
10. Silty limestone, medium-light-gray; weathers light olive gray and brownish gray; thin bedded; locally platy; fusulinid (USGS colln. f23112) --- 4
9. Calcareous quartzite and ferruginous sandstone, interbedded; interlayered arenaceous and bioclastic limestone and siltstone; caninoid and syringoporoid corals, and brachiopods. Unit is mostly covered ---------------- 67
8. Silty limestone, medium-light-gray; weathers light gray and light olive gray; thin bedded; platy; poorly preserved fusulinids -------------- 2
7. Calcareous quartzite and arenaceous limestone, interbedded; light olive gray; weather dark yellow orange to pale yellowish gray; medium bedded to massive; locally pitted weathered surface; sparse coral and bryozoan fauna. Unit is poorly exposed ---------------------------- 86
6. Arenaceous limestone, calcareous quartzite, and ferruginous sandstone, interbedded; light olive gray to light grayish tan; weather dark yellowish orange, grayish orange, and pale yellowish brown; medium bedded to massive; well jointed; locally platy; interlayered orthoquartzite and silty limestone; worm trails in ferruginous sandstone ---- 65
5. Orthoquartzite and calcareous quartzite, interbedded; buff to tan and light gray; weather tan to light brown; medium bedded to massive; well jointed; banded layers; local crossbedding, ripple marked in upper part; interlayered thin brownish-gray arenaceous limestone; worm trails in limestone --------------- 257

	Thickness (ft)
4. Orthoquartzite, buff to tan; weathers light brown; medium bedded; jointed; banded; ripple marked; channel scour and fill; interlayered thin calcareous quartzite	259
3. Orthoquartzite, buff to tan; weathers tan and brown; medium bedded; banded	91
2. Orthoquartzite and calcareous quartzite, interbedded; buff; weather tan to light brown; medium bedded to massive; banded; crossbedded; ripple marked. Unit is partly covered	32
1. Arenaceous limestone, medium-gray; weathers light grayish tan; medium bedded; caninoid corals up to 6 in. long, productid brachiopods, bryozoans, crinoids, and fusulinids	24
Total measured thickness	3,240

Conformable contact.

Oquirrh Group, Bingham Mine Formation,
Clipper Ridge Member.

Fossils in the Markham Peak Member are sparse and poorly preserved; the position of representative collections is shown in the measured sections and in table 7 and are discussed by Gordon and Duncan in the section on biostratigraphy and correlation. Welsh (in Welsh and James, 1961, p. 8–9) also has identified comparable fusulinid collections independently. The age assignment of the Markham Peak Member to the Missouri and Virgil is based on these sparse and poorly preserved fusulinid collections in the Oquirrh Mountains. Welsh reported that the upper 1,200–1,500 feet of the Bingham Mine Formation, below a chert pebble conglomerate that he regards as the Pennsylvanian-Permian boundary, contains a fauna of Virgil age and that the fossils above are of Wolfcamp age. However, this age relation was based largely on faunas identified in the type section of the Bingham Mine Formation at South Mountain (see fig. 4, section 6b). Subsequent studies by R. C. Douglass (written commun., March 13, 1966) indicates that probable Missouri fusulinids, *Triticites* sp., persist well up into the Markham Peak section. Collection f23431, on a ridge northeast of Clipper Peak near the crossing of an abandoned tramway line, contains Upper Pennsylvanian *Triticites* sp. Collection f23432 from the east ridge of Markham Peak at about the 8,000-foot contour contains *Triticites*? sp. and *Pseudofusulinella* sp. In collection f23433 from the same ridge at the 8,080-foot contour "the fusulinids are recrystallized, obliterating almost all structure. They appear to represent a large *Triticites* suggestive of Virgil age." Comparable Upper Pennsylvanian rocks occur in the downfaulted block east of Stockton, and south of Settlement Canyon. We find no well-identified well-preserved fossils of Wolfcamp age in the uppermost strata of the Markham Peak Member in the Bingham sequence. Gordon and Duncan describe (p. A54) an unusually large fossil collection near Lark that they believe is of Virgil age and which probably correlates (in age) with a similar assemblage in the lower part of the Kessler Canyon Formation in the Rogers Canyon sequence.

While the absence of a Wolfcamp fauna in the Rogers Canyon sequence may well indicate a period of nondeposition or erosion during that time, we do not believe that the absence of these fauna in the Bingham sequence is a strictly comparable phenomenon. Indeed recognition of the presence of what we consider to be Oquirrh Group strata of Wolfcamp age on South Mountain by Welsh and James (1961, p. 6), in a sequence lithologically related to the Bingham sequence, and confirmed in our South Mountain collections by R. C. Douglass (written commun., 1962), and recognition in the southern East Tintic Mountains in the Bingham sequence of the fusulinids *Schwagerina* and *Pseudoschwagerina* Douglass (written commun., 1959) in uppermost Oquirrh sediments underlying the Diamond Creek Sandstone, suggests to us that sediments of Wolfcamp age were deposited in the Bingham sequence rocks wherever they were accumulated before thrusting. These rocks have since been eroded in the Oquirrh Mountains, following the uplift of the range during late Tertiary time. Gordon and Duncan discuss some of the broader regional correlations of the Bingham Mine Formation.

BIOSTRATIGRAPHY AND CORRELATION OF THE OQUIRRH GROUP AND RELATED ROCKS IN THE OQUIRRH MOUNTAINS, UTAH

By MACKENZIE GORDON, JR., and HELEN M. DUNCAN

The Carboniferous and Early Permian rocks of the Oquirrh Mountains are very fossiliferous locally. The fossils provide a reasonably accurate basis for dating these rocks. They also provide a faunal or biostratigraphic framework for correlating the formations of the Rogers Canyon and Bingham sequences, which on a lithologic basis alone would probably have been correlated somewhat differently. It was in part the discovery of Mississippian fossils in the Green Ravine–Rogers Canyon measured section through a considerable thickness of rocks that resemble those of the Pennsylvanian Oquirrh Group in Soldier Canyon that ultimately led to the concept proposed by Tooker and Roberts of two different rock sequences separated by thrust faults.

Because these sections are of considerable interest and import and because the fossil faunas have played a prominent part in setting forth the geologic story, the biostratigraphy is being presented in this separate discussion. We are indebted to the authors of the main part of this paper for the opportunity to record our fossil determinations and biostratigraphic interpretations. We also are indebted to them for their continuous interest in these aspects of the problem and for having been indefatigable fossil collectors during the course of their fieldwork.

Most of the fossils upon which this report is based were collected by Tooker and Roberts between the years 1956 and 1966. Some of the largest collections were made by them in company with the writers. Brief visits were payed to the area by Gordon in 1957, 1962, and 1969 and by Duncan in 1961 and 1962 at which times extensive collections were made.

The megafossil collections used in preparing this report, 119 in all, are confined with few exceptions to the type and reference sections of the formations in both sequences. The collections are shown on six tables, which list the fossils identified in each formation. Five of the tables are arranged in stratigraphic sequence and record the distance in feet above the base of the formation of the bottom of the unit from which the collection was taken, as well as the number of the unit in which it was made. On the sixth, which records collections from a relatively narrow stratigraphic interval, such an arrangement was not feasible. The fossils in these lists were identified by several paleontologists. Most of the corals and bryozoans were identified by H. M. Duncan; several Late Mississippian colonial corals were studied and reported upon by W. J. Sando, and two sponges were examined by R. M. Finks. Gastropods were identified by E. L. Yochelson. The rest of the fauna, principally brachiopods and pelecypods, were identified by M. Gordon, Jr. The fossils were classified principally as to genus because many of the species appear to be new.

Fusulinids are abundant in some beds, particularly in the upper part of the Oquirrh Group. These were studied by R. C. Douglass, who also made collecting trips into the Oquirrh Mountains in 1958 and 1962. The forams in 36 collections identified by Douglass are listed in the register of late Paleozoic fusulinid collecting localities given later in this report His age determinations are included here in the discussion that follows. These results constitute only a minor part of Douglass' study as most of his collections were from areas outside of the type sections. Other microfossils, such as ostracodes and conodonts, were not studied.

In the fossil tables the letter symbols opposite each species give an indication of relative abundance as follows:

R = rare,

X = fairly common,

C = common,

A = abundant.

These were determined in most collections by the following criteria: rare=less than 5 specimens; fairly common=5 to 25 specimens; common=26 to 100 specimens; abundant=more than 100 specimens. In small collections and where large colonial forms were involved, an augmentative factor was applied more or less subjectively in order to give a more realistic estimate.

Most of the fossils in the formations of both sequences are silicified, or at least partly silicified. This includes the fusulinids, many of which appear to have been reworked. Limestone beds in the formations below the Grandeur Member of the Park City Formation generally contain a considerable content of silt. The silt component interferes with the process of etching out the fossils in dilute hydrochloric acid and forms an interlocking matrix that must be removed manually by scraping the surface of the fossils with a needle or dental tool. Many of the fossils have been distorted by structural disturbances that have taken place since their deposition. Nevertheless, it is possible to secure reasonably well preserved examples by working carefully and by selecting from fairly large samples.

ROGERS CANYON SEQUENCE

About two-thirds of our collections, 83 in all, came from the Rogers Canyon sequence. The five late Paleozoic formations that make up this sequence are in ascending order: the Green Ravine Formation of Mississippian age, the Lake Point Limestone of Mississippian and Pennsylvanian age,[4] the Erda Formation of Pennsylvanian age, the Kessler Can-

[4] Since the preparation of this report, it has been determined that paleontologic evidence shows a slight difference in the boundary of the Lower and Middle Pennsylvania Series as used in the midcontinent when correlated with the type Pennsylvanian in the Appalachian region. Indications are that part of the Morrow is Middle Pennsylvanian in age.

yon Formation of Pennsylvanian and Permian(?) age, and the Grandeur Member of the Park City Formation of Permian age. Collecting localities in these formations are listed at the end of this report.

GREEN RAVINE FORMATION

The Green Ravine Formation can be separated into three parts biostratigraphically: a pre-*Caninia* Zone part containing a predominantly bryozoan-brachiopod fauna and locally a number of small mollusks; the *Caninia* Zone with corals and chaetetiform bryozoans predominant; and a post-*Caninia* Zone part populated mainly by brachiopods. The fossils in 25 collections from the type section of this formation are listed in table 1.

TABLE 1.—*Megafauna of the Green Ravine Formation in its type section*

[Symbols explained in text]

Unit	6					10	11																12			
Distance, in feet, above base of formation	75	92	92	92	97	799	1,029	1,031	1,039	1,060	1,060	1,061	1,069	1,074	1,104	1,104	1,129	1,129	1,169	?	?	?	1,289	1,290	1,290	1,299
USGS colln. No.	21128–PC	20243–PC	20246–PC	21129–PC	20247–PC	16335–PC	16332–PC	20253–PC	20249–PC	20248–PC	16329–PC	21130–PC	20258–PC	16330–PC	21131–PC	20257–PC	16331–PC	17143–PC	20256–PC	20250–PC	20252–PC	20251–PC	20254–PC	17144–PC	21132–PC	16333–PC
Corals:																										
Amplexizaphrentis sp		X	X	?											R						R					
Caninia cf. *C. excentrica* (Meek)									C			X	X	X						X	X					
nevadensis (Meek)?						X					X															
Caninoid, gen. & sp. indet			X					X			X			X	R											
Horn coral, gen. & sp. indet					R			X	R			X								X						
small form, gen. & sp. indet			R		R															R						
Lithostrotion stelcki Nelson									X		X															
Multithecopora? n. sp								X													X					
Syringoporoid, n. gen. n. sp												R									X					
Aulopora sp			C		?																					
Favositid, small form, gen. & sp. indet			R																							
Bryozoans:																										
Fistuliporoid, encrusting form					R																					
ramose form			X		X																					
Ramiporalia sp			X	X																						
Trepostome, encrusting form			R	R	R										?					X						
ramose form			X					X				R													X	
Stenoporoid, massive form									R																	
ramose form									R			R								R						
Tabulipora sp												R			X	R								R		
Stenophragmidium? sp								R																		
Chaetetiform bryozoan, n. gen. A, sp. 1								X				R			X	X			X							
sp. 2																R										
Chaetetiform bryozoan, n. gen. B, sp. 1														X												
Fenestella spp			C	X	R				X						X		C									
Polypora sp			C		R			R												X						
Penniretepora sp			C	R	R																					
Ichthyorachis? sp			R																							
Thamniscus? sp				C											R											
Rhomboporoid, gen. & sp. indet	X		X		R				X						R					R						
Cystodictya sp. A	X		C	C	C				X								C									
sp. B			A		R																					
Echinoderms:																										
Crinoid columnals			A	X	C				C					X			X				X				C	
Crinoid plates and spines			C		X				R																	
Pelmatozoan debris																			X							
Worms:																										
Spirorbis sp			R																							
Brachiopods:																										
Schizophoria sp			R		X																			R		R
Leptagonia sp																										X
Schuchertella sp			R		R																					X
Orthotetes aff. *O. occidentalis* Lane															X											
Rugosochonetes sp			X									R								R	C			X	R	
Heteralosia sp			X																					R		
Promarginifera n. sp			C																							
Inflatia sp					?		C								R									C	X	R
Flexaria sp			X												X											
Buxtonia sp					R																					
Echinoconchus rodeoensis Hernon, var																					R					
Diaphragmus aff. *D. cestriensis* (Worthen)							X								C					R	?			R		X
Antiquatonia aff. *A. pernodosa* Easton			R	R		?		R	?			X		?	R					X	R			R	X	
Ovatia sp. A			R				R	R							R									R		
sp. B																								R		
Productoid, gen. & sp. indet					R																			R		
Leiorhynchus carboniferum Girty?															R									R		
Psilocamara? sp	R																									
Spirifer brazerianus Girty			R	?										R												
Anthracospirifer sp			R	R					R						R						X			?	R	
Spiriferoid, gen. & sp. indet					R																					
Punctospirifer transversus (McChesney)																					X					
Reticulariina campestris (White)			C	X	X				R					R						R	R			X		
Hustedia sp			R		R																					
Cruithyris sp			X		R																			X		R
Martinia? sp			R																							
Cleiothyridina sp. A			A	C	X				R											X	R					
sp	X											R												R		

TABLE 1.—*Megafauna of the Green Ravine Formation in its type section*—Continued

[Symbols explained in text]

Unit	6					10	11																12			
Distance, in feet, above base of formation	75	92	92	92	97	799	1,029	1,031	1,039	1,060	1,060	1,061	1,069	1,074	1,104	1,104	1,129	1,129	1,169	?	?	?	1,289	1,290	1,290	1,299
USGS colln. No	21128–PC	20243–PC	20246–PC	21129–PC	20247–PC	16335–PC	16332–PC	20253–PC	20249–PC	20248–PC	16329–PC	21130–PC	20258–PC	16330–PC	21131–PC	20257–PC	16331–PC	17143–PC	20256–PC	20250–PC	20252–PC	20251–PC	20254–PC	17144–PC	21132–PC	16333–PC
Brachiopods—Continued																										
Composita sp					R				R											X	R					
Nucleospira? sp			X																	R						
Beecheria sp			?																	R						
Pelecypods:																										
Lithophagus sp			R																							
Promytilus sp			R																							
Aviculopecten sp			R																							
Cypricardella sp			R																							
Gastropods:																										
Bellerophontid, gen. & sp. indet																X			X				X			
Rhineoderma pealeana (Girty)			X																							
Baylea sp			R																							
Gen. indet. aff. *Baylea* sp			R																							
Spiroscala? sp			R																							
Neilsonia? sp. indet			R																							
Gen. indet. cf. *Gosseletina* sp			R																							
Portlockiella sp			R																							
Borestus sp			R																							
Anomphalus? sp. indet			X																							
Naticopsis sp			R																							
Murchisoniid indet			R																							
Gen. indet. aff. *Stegocoelia* sp			R																							
Paleostylus (Pseudozygopleura) sp			R																							
Cephalopods:																										
Rayonnoceras? cf. *R.*? *excentricum* Gordon															R											
Orthoconic nautiloid, gen. & sp. indet			R																							
Fish:																										
Cladodus? sp	R																									

The lowest of these faunas occurs in unit 6 of the type section. Five collections through the lower 30–35 feet of this unit have yielded some 65 species of megafossils. The principal coral in these beds is *Amplexizaphrentis* sp., and locally *Aulopora* sp. is common; however in general corals are not nearly as abundant as in the upper middle part of the formation. A few caninoid corals occur in loose slabs on the slopes but probably have come from higher in the section.

Bryozoans are present in profusion. Among the common forms are species of *Fenestella, Polypora, Penniretepora,* and *Cystodictya* of the group of *C. lineata* Ulrich. A narrower species of *Cystodictya* is even more abundant. The most common brachiopods include the tiny productoid *Promarginifera* n. sp., *Reticulariina campestris* (White), and a small species of *Cleiothyridina*. In one collection, 18 molluscan species were identified, most of them small gastropods.

The *Caninia* Zone occupies units 10 and 11 of the type section. The top of unit 11 coincides with the type of this zone. The stratigraphic position of the base of this zone is as yet undetermined but may lie within unit 9. The *Caninia* Zone exceeds 400 feet in thickness and may be more than 500 feet thick. Sixteen collections from this zone have been examined, all but one of them from unit 11. The dominant fossils of this zone are the large solitary corals *Caninia* cf. *C. excentrica* (Meek) and the less common form referred with some question to *Caninia nevadensis* (Meek).

Two species of syringoporoid corals in this zone were examined by W. J. Sando (oral commun., 1969) who found them identical to new species of syringoporoids he is describing from the *Caninia* Zone in the Amsden Formation in western Wyoming. One of them, having closely packed corallites, represents a new genus and the other is referred with question to *Multithecopora*. *Lithostrotion stelcki* Nelson, a colonial coral that is widely distributed in the late Chester equivalents in western Canada and Alaska, occurs locally.

Chaetetiform bryozoans in colonies up to nearly 1 foot across also are common. Many of these colonies, particularly the smaller ones, started by growing on bellerophontid gastropod shells, at least some of them during the life of the snail. Continued growth of the colonies probably robbed the snail of its ability of locomotion and brought the unfortunate animal to an untimely end. Also present in the *Caninia* Zone are *Tabulipora* and other stenoporoid bryozoans and *Fenestella*.

Among the brachiopods, a species of *Antiquatonia* related to *A. pernodosa* Easton is commonly found in limestone beds that alternate with the coralbearing limestones. Other characteristic brachiopods include *Flexaria* sp., a form related to *Diaphragmus cestriensis* (Worthen), *Spirifer brazerianus* Girty, *Reticulariina campestris* (White), and *Cleiothyridina* sp., which attest to the Chester age of the beds.

The post-*Caninia* Zone part of the formation is limited to unit 12 of the type section. Its fauna is distinguished by the absence of the corals so abundant in the underlying rocks, the continued survival of most of the brachiopod species of the *Caninia* Zone, and the appearance of several new forms. Relatively common in unit 12 are species of *Schuchertella, Rugosochonetes, Inflatia, Diaphragmus, Antiquatonia, Reticulariina,* and *Cleiothyridina.* One of the four collections consists of a single bellerophontid gastropod.

Correlation and age.—The *Caninia* Zone is distributed widely in Late Mississippian rocks of the western United States. This is the K Zone recorded by Dutro and Sando (1963, p. 1974) in the Monroe Canyon Limestone of the Chesterfield Range, Idaho. This zone occurs also in the lower part of the Amsden Formation in the Salt River Range, Wyoming (Sando, 1968, p. D34). It has been recognized also in the Doughnut Formation in the northern part of the Wasatch Range and is present also within the upper part of the Chainman Shale in the Confusion Range and at Granite Mountain, Utah.

In the southern part of the Wasatch Range and in the Bingham sequence in the southern part of the Oquirrh Mountains, the *Caninia* Zone lies within the Great Blue Limestone. In the Bingham sequence it occupies an intermediate position between the Long Trail Shale Member and the top of the formation. The age of this zone is principally middle Chester, but it is probably in part late Chester in age.

The shaly fossiliferous beds of the lower part of the formation contain fossils such as *Spirifer brazerianus* Girty and *Reticulariina campestris* (White) that in association indicate Chester age. A precise correlation with the Upper Mississippian Chester type section is not possible at present. Lithologically, according to stratigraphic position, and in part faunally, these beds are correlated with the Long Trail Shale Member of the Great Blue Limestone in the Bingham sequence of the Oquirrh Mountains and to the Paymaster Member of the same formation in the East Tintic Range. Some of the common and characteristic Long Trail and Paymaster species are absent. This is believed to be a facies, rather than an age difference, suggesting a somewhat restricted distribution and a more remote point of origin for the Green Ravine assemblage than its present geographical location in relatively close proximity to the Bingham sequence indicates.

LAKE POINT LIMESTONE

Two faunal zones, widely distributed in Carboniferous rocks in the Great Basin, are recognized in the Lake Point Limestone. The *Rhipidomella nevadensis* Zone in the lower part of the formation is Late Mississippian (late Chester) in age. What is yet informally called the *Rugoclostus* zone, in the upper two-thirds of the formation, is Early Pennsylvanian (Morrow) in age. The productoid brachiopod genus *Rugoclostus* Easton is widely distributed in the Great Basin and Rocky Mountain regions and, so far as we have been able to determine, is restricted to west American rocks of Morrow age. The stratigraphic distribution of these two zones, represented by 23 fossil collections, is shown in table 2.

The lowest occurrence of *Rhipidomella nevadensis* (Meek) was recorded 143 feet above the base of the formation. This species continues in some abundance through the next 30–35 feet of beds upward, but in rocks still higher it seems to be absent. The same brachiopod is common in a 54-foot cliff-forming limestone (unit 2 of the type section), the top of which lies roughly 390 feet stratigraphically above the lowest occurrence of *R. nevadensis* and 48 feet stratigraphically below the base of a 5-foot limestone bed crowded with phaceloid colonies of the coral *Orygmophyllum*? (unit 4 of the type section).

In between the two intervals with abundant *R. nevadensis* the rocks are not highly fossiliferous, but several thin shaly limestone beds are crowded with frondescent *Archimedes.* Two such beds occur in unit 1 at 192 and 208 feet, respectively, below the top of the cliff-forming limestone (unit 2). The *Archimedes* resemble those that occur in the type section of the Manning Canyon Shale, 405–415 feet above its base, in the Bingham sequence.

In the cliff-forming limestone (unit 2), besides the relatively abundant *R. nevadensis,* the following faunal elements indicate Mississippian age: *Inflatia* sp. A and B, *Flexaria* sp. A, *Carlinia phillipsi* (Norwood and Pratten), *C. diabolica* Gordon, *Ovatia* sp. A, and *Spirifer brazerianus* Girty, var. All of these species are fairly common in very late Mississippian beds in other parts of the Great Basin, and none of them is known in beds of Pennsylvanian age. In some areas, for example at Conger Mountain in the Confusion Range, Utah, *R. nevadensis* is also found

TABLE 2.—*Megafauna of the Lake Point Limestone in its type section*

[Symbols explained in text]

Unit	1							2		3	4			5				7				9	11
Distance, in feet, above base of formation	143	147	154	173	285	327	339	511	519	562	583	583	583	622	628	643	738	766	773	870	908	1,197	1,636
USGS colln. No	17145-PC	21134-PC	21135-PC	17031-PC	21136-PC	21138-PC	21137-PC	21139-PC	21141-PC	21140-PC	16318-PC	20259-PC	17146-PC	16319-PC	16322-PC	17147-PC	16323-PC	16324-PC	17148-PC	17149-PC	17150-PC	23854-PC	23855-PC
RHIPIDOMELLA NEVADENSIS ASSEMBLAGE																							
Corals:																							
Amplexizaphrentis sp									X														
Bryozoans:																							
Fistuliporoid, encrusting form							X																
Fistuliporoid, massive form				R																			
Stenoporoid, ramose form				R																			
Trepostomatous bryozoan, gen. & sp. indet		X			R																		
Polypora sp		X																					
Archimedes					X		X																
Rhomboporoid, gen. & sp. indet		X						R															
Echinoderms:																							
Crinoid columnals								R															
Pelmatozoan debris					C		C																
Echinoid (?) spines		R																					
Brachiopods:																							
Schizophoria cf. *S. texana* Girty		X						X															
cf. *S. resupinoides* (Cox)				X																			
Rhipidomella nevadensis (Meek)	R		X	X				R	X														
Schuchertella sp. A		R																					
Orthotetes sp						R		X															
Rugosochonetes aff. *R. pseudoliratus* (Easton)	C	A							R						R	R				X			
Inflatia sp. A				R				R	X														
sp. B								R															
Scoloconcha sp								R															
Marginiferid, gen. & sp. indet								R															
Flexaria sp. A		R						X															
Carlinia phillipsi (Norwood & Pratten)								R															
diabolica Gordon		R				?		X															
Ovatia sp. A					R	C		X															
sp. B		R		R																			
Spirifer brazerianus Girty, var									R														
Anthracospirifer sp				X		C	R	X															
Crurithyris sp		C		R																			
Cleiothyridina cf. *C. sublamellosa* (Hall)								X															
Composita sp								R															
Beecheria sp				X				X															
Pelecypods:																							
Sulcatopinna sp				R																			
Scaphopods:																							
Laevidentalium? sp. indet		R																					
Gastropods:																							
Bellerophon? sp. indet		R																					
Knightites (Retispira) sp. indet		R																					
Euphemites sp. indet		R																					
Gen. indet. cf. *Colpites* sp		R																					
Rhineoderma? sp. indet		R																					
Trepospira (Trepospira) sp		X																					
Baylea? sp. indet		R																					
Pleurotomariacean, gen. & sp. indet		R																					
Strophostylus? sp. indet		R																					
Naticopsis sp				R																			
Stegocoelia sp		R																					
Eotrochus? sp. indet		R																					
Paleostylus? sp. indet		R																					
Strobeus sp		X		R																			
Meekospira sp		X																					
Cephalopods:																							
Reticycloceras sp	R	R																					
Trilobites:																							
Paladin sp		R																					
Fish:																							
Fish dentition									R														
RUGOCLOSTUS SEMISTRIATUS ASSEMBLAGE																							
Corals:																							
Amplexizaphrentis? sp																			R				
Lophophyllidium sp																							R
Orygmophyllum? sp											C	C	C										
Caninia sp																						X	
Bryozoans:																							
Fistuliporoid, encrusting form																	R		R				
Eridopora? sp																				R			
Tabulipora? sp																X			R	R			
Stenoporoid, encrusting form																				?			
ramose form																						X	
Fenestella spp														R			R	R	X				
Polyporella sp																			X				
Poylpora sp																			X				
Enallopora? sp																			X				
Rhomboporoid, gen. & sp. indet																X		R	X				
Echinoderms:																							
Crinoid columnals																X							
Pelmatozoan debris																				X		X	X
Echinoid spines																			R				
Brachiopods:																							
Schizophoria sp														R	R				R				
Orthotetes? sp											R				R	R							
Rugoclostus semistriatus (Meek)																	X			X			

TABLE 2.—*Megafauna of the Lake Point Limestone in its type section*—Continued

[Symbols explained in text]

Unit	1							2		3	4			5				7				9	11
Distance, in feet, above base of formation	143	147	154	173	285	327	339	511	519	562	583	583	583	622	628	643	738	766	773	870	908	1,197	1,636
USGS colln. No.	17145–PC	21134–PC	21135–PC	17031–PC	21136–PC	21138–PC	21137–PC	21139–PC	21141–PC	21140–PC	16318–PC	20259–PC	17146–PC	16319–PC	16322–PC	17147–PC	16323–PC	16324–PC	17148–PC	17149–PC	17150–PC	23854–PC	23855–PC
Brachiopods—Continued																							
Rugoclostus—Continued																							
aff. *R. semistriatus* (Meek)										C			R	X		C			C	X		R	X
Spinose productoid indet											R								R	R			
Flexaria sp. B																R							
Echinoconchus sp															R	X						?	
Juresania sp																							R
Antiquatonia aff. *A. coloradoensis* (Girty)																	R		X	X			
Linoproductus sp. A																X			R	R		R	R
sp. B										R													R
Pugnoides cf. *P. quinqueplecis* Easton																				X	R		
Anthracospirifer occiduus (Sadlick)										C				X		X		X		X	C		?
aff. *A. rockymontanus* (Marcou)																R				X			
Neospirifer cf. *N. cameratus* (Morton)																	R	R	X			R	
Punctospirifer transversus (McChesney)															R				X	X			
sp																				R			
Reticulariina campestris (White)															R	X			X	X	R	R	
Hustedia sp																			R	X			
Cleiothyridina cf. *C. orbicularis* (McChesney)															R	X		R	C	C			
Composita sp										X						X		R	X	X			X
Beecheria cf. *B. bovidens* (Morton)																?				X			
Dielasmoid, gen. & sp. indet																				R			
Gastropods:																							
Straparolus (*Amphiscapha*) sp																				R			
Trilobites:																							
Paladin sp										R									R				

sparingly in beds of undoubted Pennsylvanian age, but our observations have shown that where this species is common to abundant, other associated faunal elements indicate Mississippian, rather than Pennsylvanian age. In the Oquirrh Mountains *R. nevadensis* was not found in the Pennsylvanian.

Between the top of unit 2 and the base of the next fossiliferous bed, which is Pennsylvanian in age, is 24 feet of beds without megafossils. For all practical purposes the top of unit 2 can be regarded as the top of the Mississippian in this section. Nevertheless, the actual Mississippian-Pennsylvanian boundary probably lies within unit 3 of the type section. A detailed breakdown of this unit, measured by Gordon, is as follows:

Unit 4: *Orygmophyllum*? bed.

Unit 3:

	Thickness (ft)
j. Limestone, medium-dark-gray, silty, interbedded with some gray limestone; poorly fossiliferous	23
i. Silty limestone, like bed below but crowded with silicified productoids (USGS colln. 21140–PC)	1
h. Silty limestone, medium-dark-gray (weathers brownish gray); some gray limestone	6
g. Limestone, gray (weathers light bluish gray), rather fine grained	5
f. Covered	2
e. Sandy limestone, medium-dark-brownish-gray, fine-grained, in two slabby layers	1
d. Limestone, gray (weathers bluish gray), medium to fine-grained; some vertical calcite veinlets up to ½ in. wide	2.5
c. Covered	3
b. Brecciated limestone, gray, containing light-brown siliceous boxwork surrounding limestone fragments up to 1 in. across, particularly well developed in upper 6 in.	1.5
a. Shale, buff, silty, and nodular limestone (weather brownish gray)	3
Total	48

Unit 2: Cliff-forming limestone.

At our present state of knowledge of Great Basin Carboniferous stratigraphy we are inclined to place bed *a* of unit 3 in the Mississippian and refer the rest of the unit to the Pennsylvanian. This reasoning is based upon the fact that beds of lithology similar to bed *a* occur in the Confusion Range above beds containing *Carlinia* (Gordon, 1970) and carry Mississippian fossils including *R. nevadensis* (Meek), *Inflatia* n. sp., *Diaphragmus* n. sp., and locally *Pentremites* n. sp. (of Mississippian affinities). These Mississippian beds in western Utah were included by Hose and Repenning (1959, p. 2173) in the lower part of the Ely Limestone.

The brecciated limestone, bed *b* of unit 3, is regarded as marking the base of the Pennsylvanian and delimiting a minor hiatus wherein these latest Mississippian beds, generally thicker in sections near the western limits of Utah, may have been partly removed by erosion.

The lowest fossils of undoubted Pennsylvanian age occur in bed *i* of unit 3. This bed is crowded with shells of the productoid *Rugoclostus* aff. *R. semistriatus* (Meek) associated with *Anthracospirifer occiduus* (Sadlick). The *Rugoclostus* fauna is distributed through at least 1,075 feet of section in the Lake Point Limestone, from the middle of unit 3 to the upper part of unit 11. It is typically an assemblage of large productoid brachiopods of the genera *Rugoclostus, Flexaria, Echinoconchus, Antiquatonia,* and *Linoproductus.* Commonly associated with them are *Anthracospirifer occiduus* (Sadlick), *Neospirifer* cf. *N. cameratus* (Morton), *Composita* sp. *Punctospirifer transversus* (McCheshney), and *Reticulariina campestris* (White), the last two continuing upward from beds of Late Mississippian (Chester) age.

The 5-foot limestone bed with *Orygmophyllum*? (unit 4) occurs in the type section of the Lake Point Limestone only 24 feet above the base of the *Rugoclostus* zone. Most of the corals in this bed are concentrated in a 2-foot zone in the middle of it. Another area where *Orygmophyllum*? occurs in countless numbers in a single bed is the Confusion Range. The corals are in a 5-foot calcareous shale about 550 feet above the base of the Ely Limestone. This coral was identified as *Barbouria* sp. in Hose and Repenning (1959, p. 2171). They (p. 2173) as well as the writers regard the lower 40–60 feet of the Ely Limestone in that area as Mississippian in age. Because the *Orygmophyllum*? bed occurs there high in the *Rugoclostus* zone, some 500 feet above the base of the Pennsylvanian, scant likelihood exists that its deposition was contemporaneous with the one in the Lake Point Limestone.

Typical silicified brachiopods of the *Rugoclostus* zone are abundant in the lower 200 feet of the zone. Above this the fossiliferous beds are fewer and more widely spaced. In some beds *Anthracospirifer* is present to the exclusion of almost all other species. In several of these the spirifers are not silicified. Silicified *Rugoclostus* and *Antiquatonia* were observed well up in unit 9 of the type section, but were not collected. *Flexaria* was recognized in a calcareous sandstone bed a few feet below collection 23855–PC. No collections were made in the upper 100 feet of the formation in the type section.

One other collection, from the upper part of the formation but not from the type section, should be mentioned. This is from a bed on the north side of Big Canyon, the first canyon south of Green Ravine (USGS colln. 16337–PC), which contained the following species:

Hederella sp	X
Fistuliporoid bryozoan, incrusting form	R
Stenoporoid bryozoan, incrusting form	R
Derbyia? sp. indet	R
Flexaria sp	R
Linoproductus nodosus (Newberry)	C
Anthracospirifer opimus (Hall)?	X
Cleiothyridina cf. *C. orbicularis* (McChesney)	R
Composita sp	C

The presence of numerous shells of *Linoproductus nodosus* in this bed is noteworthy because of similar occurrences of the same species near the top of the West Canyon Limestone of the Oquirrh Group in the Soldier Canyon section of the Bingham sequence and at approximately the same stratigraphic level in Provo Canyon in the Timpanogos sequence in the Wasatch Range.

Correlation and age.—As interpreted in the foregoing discussion the type section of the Lake Point Limestone measured by Tooker and Roberts includes 538 feet of beds of Late Mississippian (late Chester) age and 1,199 feet of beds of Early Pennsylvanian (Morrow) age. The zone of uncertainty (without megafossils) as to the precise level of the Mississippian-Pennsylvanian boundary is actually 24 feet thick.

Some of the fossils of the *Rhipidomella nevadensis* Zone are present also in the type section of the Manning Canyon Shale, about 15 miles to the south of the Lake Point Limestone type section, in the same range. The topmost 100 feet of the Manning Canyon, which is gradational into the overlying Oquirrh Group at Soldier Canyon, contains fossils typical of the *Rugoclostus* zone. The top of the Manning Canyon corresponds to an undetermined level in the Lake Point Limestone, probably a few tens of feet above the *Orygmophyllum*? bed (unit 4). *Orygmophyllum*?, however, has not been found in the Manning Canyon Shale. The entire thickness of the Manning Canyon is believed to be represented by little more than the lower 600 feet of the Lake Point Limestone.

The upper part of the Lake Point Limestone is stratigraphically equivalent to the West Canyon Limestone of the Oquirrh Group. The upper contact of both units is believed, on faunal as well as lithologic grounds, to lie at approximately the same stratigraphic level.

The significance of the bed (or beds) with abundant *Linoproductus nodosus* near the top of the Lake Point Limestone as well as the West Canyon Limestone of the Oquirrh Group is an indication of late Morrow age. In the Appalachian region, in eastern Kentucky, *L. nodosus* is abundant in the Kendrick Shale Member of the Breathitt Formation, formerly thought to be of Atoka age but now regarded as Morrow. This species is replaced by a different *Linoproductus* in the slightly higher Magoffin Beds of Morse (1931). The ammonoids of the Kendrick (Furnish and Knapp, 1966) belong to the same zone that occurs in the Trace Creek Shale Member of the Bloyd Formation in the type section of the Morrow Series in northwest Arkansas. *L. nodosus* is not known in the Atoka Formation of Arkansas and Oklahoma. For these reasons *L. nodosus* is presently regarded as a late Morrow species with a geographically extensive peak zone.

ERDA FORMATION

The Erda Formation contains several faunal assemblages which indicate that this formation is Middle Pennsylvanian in age. Twenty collections from the type section and two from recognizable horizons in nearby sections were studied; the fossils are listed in table 3. Microfossils in four collections determined by Douglass are listed in the lithologic

TABLE 3.—*Megafauna of the Erda Formation type section*
[Symbols explained in text]

Unit	1				3	4		6	8	10		11	13			14	19		25		27	
Distance, in feet, above base of formation	?	157	182		526	604	640	752	921	1,097	1,127	1,280		1,494	1,687	1,703	2,153	2,204	2,515	2,686	?	?
USGS colln. No	16334-PC	17151-PC	17152-PC	17153-PC	17154-PC	17155-PC	17156-PC	17157-PC	17158-PC	17159-PC	17161-PC	17163-PC	16325-PC	16326-PC	17164-PC	16327-PC	17165-PC	17166-PC	16328-PC	20232-PC	20235-PC	20236-PC
MULTITHECOPORA-KOZLOWSKIA ASSEMBLAGES																						
Corals:																						
Caninia sp								C														
sp. indet					R							R								X		
Horn coral, gen. & sp. indet						R			R													
Multithecopora sp. A					X	cf.		R														
Multithecopora? sp. B							X															
sp. indet		X																				
Chaetetes sp			R																			
Bryozoans:																						
Fistuliporoid, incrusting form								R		R								X			R	R
Rhombotrypella sp								R				X								R		
Ascopora sp. A								X														
Fenestella cf. *F. serratula* var. of Condra & Elias								X														
sp		R	R					X	X	X					R	X	R	R		X	R	
Polyporella sp			R																	X		
Polypora sp				R											X		R		R	R	R	
Penniretepora sp								R	R	X						R		R				
Rhomboporoid, gen. & sp. indet									R						C		R	X			R	R
Streblotrypa sp								R		R						R						
Echinoderms:																						
Pelmatozoan debris						X			X	X								X				
Brachiopods:																						
Eolissochonetes? sp									R													
Kozlowskia aff. *K. haydenensis* (Girty)						X		R	C													
Desmoinesia ingrata (Girty)?						R																
Rugoclostus? sp								R														
Linoproductus sp. indet								R														
Spinose productoid, gen. & sp. indet									R													
Rhynchopora? sp. indet								R														
Anthracospirifer opimus (Hall)	R	R						X					?	C								
occiduus (Sadlick)?															R			R				
Neospirifer cf. *N. coloradoensis* Stevens						R			R													
Reticulariina campestris (White)						R		R	?													
Cleiothyridina cf. *C. orbicularis* (McChesney)						R																
Composita ovata Mather		?						X	?	R		?					X	R				
ANTIQUATONIA-HYSTRICULINA ASSEMBLAGE																						
Corals:																						
Amplexus? sp										R												
Stereostylus sp												R										
Auloporoid, gen. & sp. indet												X										
Bryozoans:																						
Ascopora sp. B												X										
Tabulipora sp. A												X										
sp. B												X										
Stenoporoid, ramose form												R										
Diploporaria sp										R												
Rhombocladia sp										R												
Worms:																						
Spirorbis sp										R											R	
Brachiopods:																						
Derbyia cf. *D. crassa* (Meek & Hayden)										X					R		?	R		?		
Meekella striatocostata (Cox)										R												
Chonetinella cf. *C. alata* (Dunbar & Condra)										R		?										
Hystriculina sp										C		R										

TABLE 3.—*Megafauna of the Erda Formation type section*—Continued

[Symbols explained in text]

Unit	1				3	4		6	8	10		11	13			14	19		25		27	
Distance, in feet, above base of formation	?	157	182		526	604	640	752	921	1,097	1,127	1,280		1,494	1,687	1,703	2,153	2,204	2,515	2,686	?	?
USGS colln. No	16334–PC	17151–PC	17152–PC	17153–PC	17154–PC	17155–PC	17156–PC	17157–PC	17158–PC	17159–PC	17161–PC	17163–PC	16325–PC	16326–PC	17164–PC	16327–PC	17165–PC	17166–PC	16328–PC	20232–PC	20235–PC	20236–PC
Brachiopods—Continued																						
Rugoclostus? sp										X												
Flexaria sp										R					R							
Echinaria sp										R												
Antiquatonia aff. *A. coloradoensis* (Girty)										C												
Linoproductus prattenianus										R		cf. X						R			R	R
Rhynchonelloid, gen. & sp. indet												R										
Anthracospirifer rockymontanus (Marcou)										X					X					?	?	
Neospirifer? sp. indet							R			R												
Hustedia mormoni (Marcou)										R		R										
Crurithyris planiconvexa (Shumard)										C												
Phricodothyris perplexa (McChesney)										X												R
Gastropods:																						
Euphemites sp. indet											X											
Neilsonia sp										C					R	?						
Goniasma sp											R											
Platyceras sp. indet										R												
PRISMOPORA-DESMOINESIA ASSEMBLAGES																						
Corals:																						
Caninoid, gen. & sp. indet															X						R	
Bryozoans:																						
Prismopora cf. *P. triangulata* (White)																		C				
sp																	X				R	
Rhombotrypella? sp. indet																		R				
Stenoporoid, incrusting form																R					R	
Trepostomatous bryozoan fragments															R	R			R			
Septopora sp															R			R				
Ichthyorachis sp																			X			
Penniretepora? sp																			R			
Acanthocladiid, gen. & sp. indet																					R	
Rhabdomeson sp																			C			
Rhombocladia sp																			X			
Rhombopora? sp																			X			
Echinoderms:																						
Crinoid columnals															X	X	X			R	X	R
Brachiopods:																						
Davidsoniacean, gen. & sp. indet																					R	R
Chonetinella cf. *C. alata* (Dunbar & Condra)																					X	C
Mesolobus euampygus (Girty)																					R	
Neochonetes granulifer (Owen)																						C
Kozlowskia sp																R						
Inflatia? sp																				X		R
Cancrinella? sp															X							
Desmoinesia muricatina (Dunbar & Condra)													X	R	A							
Juresania? sp. indet																					R	
Antiquatonia sp																	R				?	
Rhynchopora sp															R							
Punctospirifer kentuckensis (Shumard)													R		R		C					
Cleiothyridina sp. indet																					R	
Composita subtilita (Hall)													R	R	X							
Pelecypods:																						
Parallelodon sp																						R
Acanthopecten sp																					R	
Myalina? sp. indet																	R					
Trilobite:																						
Ameura? sp. indet																					R	

descriptions of the measured sections. With the possible exception of *Anthracospirifer opimus* (Hall) from an uncertain level near the base, no fossils were collected in the lower 157 feet of the formation, much of which is quartzite.

Multithecopora, a syringoporoid coral represented by two distinct species, ranges through 600 feet of beds in units 1 through 6 at levels from 157 to 757 feet above the base of the formation. We have been referring to this interval informally as the *Multithecopora* zone. *Chaetetes* was collected 182 feet (in unit 1) and *Profusulinella* 502 feet (in unit 3) above the base of the formation. These occurrences probably do not, however, represent the *Profusulinella-Chaetetes* faunizone of Dott (1955, p. 2239). According to our observations in other parts of the Great Basin, the compound coral *Chaetetes* is commonly in or interbedded with limestone beds containing *Fusulinella* and locally ranges upward into beds of Des Moines age. Raymond Douglass (oral commun., 1969) informs us that his identification of *Profusulinella* mentioned above is based upon fragmentary and presumably reworked specimens.

Interspersed with the coralliferous beds in the upper part of the *Multithecopora* zone and extending above them stratigraphically are brachiopod-bearing beds in which *Kozlowskia* aff. *K. haydenensis* (Girty) and *Neospirifer* cf. *N. coloradoensis* Stevens are rather common. These two species were found associated in units 4 through 8, in beds 604–921 feet above the base of the formation.

The next highest brachiopod assemblage in the type section of the Erda Formation is dominated by productoids of the genera *Hystriculina* and *Antiquatonia* and introduces the genus *Chonetinella*. This assemblage was found in two beds, in units 10 and 11, at levels 1,092 and 1,280 feet above the base of the formation. *Crurithyris planiconvexa* (Shumard) and the small gastropod *Neilsonia* are numerous in the lower bed. Among the bryozoans, *Ascopora* sp. B and two species of *Tabulipora* are present in the upper bed.

Desmoinesia muricatina (Dunbar and Condra) is the dominant species in unit 13, where it occurs with *Punctospirifer kentuckensis* (Shumard) and *Composita subtilita* (Hall) in beds of gray-black calcareous shale or shaly limestone. Silicified specimens of *D. muricatina* are abundant in these dark shaly beds, 1,494–1,690 feet above the base of the formation. This species was found only in unit 13.

In the higher beds of the formation bryozoans are locally dominant, including such distinctive genera as *Prismopora*, *Ichthyorachis*, and *Rhabdomeson*. *Prismopora* cf. *P. triangulata* (White) is common in unit 19, 2,204 feet above the base of the formation. *Prismopora* appears in the section 2,153 feet above the base of the Erda and is found intermittently in the rocks above for more than 500 feet. The highest specimens stratigraphically occur in unit 27 associated with the brachiopods *Mesolobus* and *Chonetinella*. Douglass has identified *Fusulina* sp. (USGS colln. f22570) in unit 24 of the type section, 2,488 feet above the base of the formation. He also has recognized in unit 27 but outside of the type section: *Fusulina* and *Wedekindellina*? in Black Rock Canyon and *Fusulina* in Big Canyon. No recognizable fossils were found in the upper 909 feet of the formation in the type section.

Correlation and age.—The fossils of the Erda Formation indicate a definite Des Moines age for beds 10 through 27 of the type section, from 1,017 to 2,697 feet above its base. The question as to how much of the section to assign an Atoka age is a perplexing one. We are inclined to regard the beds with *Kozlowskia* aff. *K. haydenensis* and *Neospirifer* cf. *N. coloradoensis* as of probable Des Moines age. In the Confusion Range, *Mesolobus* and *Desmoinesia* occur in a similar association with them.

Fusulinid evidence to support or to refute these tentative assignments is still lacking. The fact that the one record of *Profusulinella* in the type section of the Erda Formation is based on material that appears to have been reworked suggests the possibility that beds of Atoka age, once present, were removed by erosion. Physical evidence has not been found, however, for unconformity in the lower part of the formation.

KESSLER CANYON FORMATION

The lower part of this formation has not provided identifiable fossils in the type section. The only reasonably good collections of megafossils came from unit 10 of the type section, a 35-foot cherty limestone the base of which lies 675 feet above the base of the formation. Two collections were made from this unit. Although these come from the same general locality, they have only two species in common, which are marked by an asterisk (*) in the list below. The composite fauna follows (USGS collns. 18486-PC, 18893-PC).

	Relative abundance
Rhipidomella carbonaria (Owen)	X
Derbyia? sp. indet	R
Neochonetes cf. *N. granulifer* (Owen)	X
Retaria sp. indet	R
**Kochiproductus* aff. *K. peruvianus* (d'Orbigny)	R
Chaoiella sp	R
Linoproductus sp. indet	R
Crinoid columnals	C
**Omphalotrochus wolfcampensis* Yochelson	X
Trilobite, gen. and sp. indet	R

The *Omphalotrochus wolfcampensis* assemblage in this bed was assigned an Early Permian age by E. L. Yochelson (in Tooker and Roberts, 1961, p. 30). However, in the Southern and Western United States, many of the megafossils normally considered to indicate Early Permian (Wolfcamp) age put in an appearance in rocks of Late Pennsylvanian (Virgil) age. According to G. A. Cooper (oral commun., 1968), typical Permian genera such as *Kochiproductus*, *Waagenoconcha*, *Omphalotrochus*, and *Peruvispira* are already present in the Upper Pennsylvanian *Uddenites* Zone of Texas. It is, therefore, not possible to determine on the basis of the usual megafauna alone whether a rock is very late Pennsylvanian or Early Permian in age. Further evidence must be sought among specialized groups, particularly the fusulinids. But even these are not always definitive.

Fusulinids occur in several beds above unit 10. All of them are in chert beds and all of them are poorly preserved. The one genus that can be recognized in all of these beds is *Triticites*. According to R. C. Douglass (oral commun., 1969) the species of *Triti-*

cites that occurs in unit 21 of the type section, 2,221 feet above the base of the formation appears to be a Late Pennsylvanian form, but because of the silicification of these fossils and their occurrence in an organic detrital bed, reworking cannot be ruled out. The *Triticites* from unit 29, 3,027 feet above the base of the formation is better preserved, but is of a type that could be either Late Pennsylvanian or Early Permian in age, according to Douglass. *Triticites* from unit 37, the uppermost unit in the formation, is very poorly preserved and, Douglass felt, should not be assigned a precise age.

In summary, the recognizable fossils in the Kessler Canyon Formation type section indicate Late Pennsylvanian age for much of the formation and either a very late Pennsylvanian or Early Permian age for the uppermost beds. We cannot tell at present therefore, whether the Pennsylvanian-Permian boundary is contained within the formation or conforms to the top of it.

The age of the lower part of the formation is not known. As bed 10 can be no older than late Virgil in age, the likelihood that the lower part of the Kessler Canyon includes some beds of earlier Virgil age seems reasonable. Between the top of unit 27 of the Erda Formation and the base of unit 10 of the Kessler Canyon lies 1,584 feet of strata that have not yielded fossils. Whether these barren beds include rocks of Missouri age, it is not possible at present to say. No physical evidence of an unconformity in this part of the section has been found. Nevertheless, the presence of more than 5,500 feet of rocks containing fusulinids of Missouri age in the Bingham sequence and the absence of Missouri fossils in the Rogers Canyon sequence strongly suggests that an unconformity might be present at or near the base of the Kessler Canyon Formation.

TABLE 4.—*Megafauna of the Grandeur Member of the Park City Formation*

[Symbols explained in text]

USGS colln. No	18490–PC	19948–PC	19949–PC	20238–PC	20240–PC	20241–PC	20242–PC	21152–PC	22484–PC
Bryozoans:									
Timanodictya sp							C	X	
Stenoporoid, massive form								X	
Trepostomatous bryozoans, ramose form					X				
Fenestellid, gen. & sp. indet	R								
Brachiopods:									
Derbyia sp		X				R			
Lissochonetes sp				C				X	
Dyoros sp								R	
Heteralosia sp					C			A	
Krotovia aff. K. wallaciana (Derby)		X							P
Avoniid, gen. & sp. indet					R				
Grandaurispina sp		R							
Kochiproductus aff. *K. peruvianus* (d'Orbigny)								R	
Penniculauris cf. *P. bassi* (McKee)			R		R	R		X	
Dictyoclostid, gen. & sp. indet		R					R		
Liosotella sp. A			X		C	R	R	A	X
Megousia sp. A	X	R		C	X			C	X
Cancrinella sp								R	
Wellerella sp			R	R				R	
Rhynchopora cf. *R. taylori* Girty		R		R				X	
Neophricodothyris sp. A	C		C	C	R	C		R	X
Composita subtilita (Hall)		C	X					C	R
Hustedia sp. indet		R							R
Beecheria cf. *B. boridens* (Morton)		R							
Pelecypods:									
Nuculopsis (*Nuculanella*) sp	R							R	
Polidevcia sp	R								
Parallelodon cf. *P. politus* Girty	X								
Aviculopecten sp	R								
Streblopteria? sp. indet								R	R
Cyrtorostra? sp. indet									R
Cypricardinia? sp								R	
Astartella cf. *A. subquadrata* Girty	X							R	
Gen. & sp. indet	R								
Gastropods:									
Euphemites n. sp	R								
Babylonites sp				R				X	
Glabrocingulum? sp. indet	X								
Worthenia sp	X								
Pleurotomariacean, gen. & sp. indet									R
Orthonema cf. *O. socorroense* Girty	C								
Meekospira? sp. indet	R								
Donaldina? sp. indet	R								
Echinoderms:									
Crinoid columnals	X	X			R		R	X	
Arthropods:									
Barnacle borings		X						X	

PARK CITY FORMATION, GRANDEUR MEMBER

Abundant and well preserved fossils, most of them brachiopods, occur in the lowermost limestone unit of the Grandeur Member of the Park City Formation. Eight collections from unit 1 of Tooker and Roberts' section of the Grandeur Member have been studied; the fossils are listed in table 4. As all of the collections have come from a single unit only 30 feet thick, we have not attempted to list them in stratigraphic order.

The presence of the genera *Timanodictya, Penniculauris, Megousia, Liosotella,* and *Babylonites* indicate a definite post-Wolfcamp and probable Leonard (Early Permian) age for this unit. G. A. Cooper (oral commun., 1962) who was interested in the occurrence of *Liosotella* in our collections, suggested a late Leonard to early Word (Early Permian) age for this limestone. He pointed out that *Liosotella* in the west Texas section is particularly characteristic of the Road Canyon Formation, the fauna of which has much stronger ties to that of the Leonard Series than to the overlying Word fauna. Independently, E. L. Yochelson (oral commun., 1969) suggested that the gastropod *Babylonites* in this unit resembles specimens found near the Leonard-Word boundary in Texas. Yochelson (in Tooker and Roberts, 1961, p. 32) has previously suggested a late Leonard age for this Utah fauna.

The bryozoan *Timanodictya* is also common in and characteristic of the Kaibab Limestone of southwest Utah and northern Arizona. In the Confusion Range in extreme western Utah *Timanodictya* was also collected by Hose and Repenning (1959, p. 2177) in the upper part of the Arcturus Formation. It is regarded as a good indicator of Leonard age.

Unconformity at the base of the Park City Formation.—Although the possibility cannot be eliminated that the uppermost beds of the Kessler Canyon Formation are Early Permian (Wolfcamp) in age, nevertheless, typical Wolfcamp and early Leonard faunal assemblages are unknown in the Rogers Canyon sequence. This is in contrast to the sequence on South Mountain, west of the Bingham block, where presumed pre-Grandeur rocks totaling nearly 6,000 feet in thickness were found by Welsh and James (1961, p. 4–7) to contain Early Permian (Wolfcamp) fusulinids, at least in their middle part.

We conclude, therefore, that an unconformity at the base of the Grandeur Member of the Park City Formation in the Rogers Canyon sequence accounts for most, if not all, of Wolfcamp time and part of Leonard time.

BINGHAM SEQUENCE

The Paleozoic rocks of the Bingham sequence include formations of Cambrian to Late Pennsylvanian age. The pre-Oquirrh rocks have been described in some detail by Gilluly (1932) and are not the concern of this paper. The rocks of Gilluly's Oquirrh Formation were not subdivided; Welsh and James (1961) proposed the Oquirrh Group and subdivided it. These subdivisions are modified in Tooker and Robert's part of this report, where they have been divided in ascending order into the West Canyon Limestone, Butterfield Peaks Formation, and the Bingham Mine Formation, the last composed of the Clipper Ridge and Markham Peak Members.

Thirty-seven collections of megafossils from the Oquirrh Group have been studied. Most of these came from the type and reference sections of the formations enumerated above. In addition, some 30 fusulinid collections were studied by R. C. Douglass.

WEST CANYON LIMESTONE

The fauna of the West Canyon Limestone is similar to that found in the upper part of the Lake Point Limestone of the Rogers Canyon sequence. Fossils identified in seven collections from the reference section in West Canyon (p. A51) and four collections from the reference section in Soldier Canyon (p. A51) are listed in table 5. Brachiopods are by far the most abundant constituents of the fauna; bryozoans are fairly common; corals are very rare; mollusks are limited to a few scattered pelecypods; and rare fragments of trilobites complete the list. All are typical of the *Rugoclostus* zone, and many of them are found also in the Lake Point Limestone. Several differences with regards to abundance are apparent, however. *Rugoclostus* is relatively rare in the West Canyon Limestone, while *Flexaria* sp. A, not a very common species in the Lake Point, is locally abundant in the West Canyon.

A small coarse-ribbed marginiferid productoid referred to *Elliottella* in table 5 is absent in the Lake Point but found locally in the lower part of the West Canyon; it is particularly common at a level about 165 feet above its base. This same species occurs in Provo Canyon in the Wasatch Range, where it is abundant in the top few feet of the Manning Canyon Shale. The difference in the stratigraphic level of the peak zone of this species at the two localities is paralleled by the base of the *Rugoclostus* zone. The first appearance of the fossils of this zone occurs roughly 100 feet below the top of the Manning Canyon Shale in Soldier Canyon (Oquirrh Mountains) and at the base of the medial limestone of the Manning Canyon Shale in the area just south of Provo Canyon (Wasatch Range). These two pairs of biostratigraphic tie points indicate an eastward transgression of the base of the Oquirrh Group from the Oquirrh Mountains to the Wasatch Range.

Microfossils were not collected in the West Canyon Limestone, but Nygren (1958, p. 14) reported that he found the fusulinid genus *Millerella* present 890 feet above the base of the formation.

The bed crowded with *Linoproductus nodosus* (Newberry), mentioned earlier in the discussion of the Lake Point Limestone, occurs in the Soldier Canyon section, 90 feet below the top of the West Canyon Limestone. The abundance of this species at this level is believed to signal a late Morrow age for the upper part of the formation. The top of the West Canyon Limestone in the Bingham sequence approximates the top of the Lake Point Limestone of the Rogers Canyon sequence. A Morrow age is suggested for the entire West Canyon Limestone.

BUTTERFIELD PEAKS FORMATION

The fauna of the Butterfield Peaks Formation approximates that of the Erda Formation of the Rogers Canyon sequence. Nine collections from the type section (p. A52) and 11 collections from the reference section (p. A52) (measured from the ridge north of Soldier Creek to peak 9075, secs. 26, 27, and 34, T. 4 S., R. 4 W. Stockton quadrangle) have

TABLE 5.—*Megafauna of the West Canyon Limestone in its reference sections in West Canyon and Soldier Canyon.*

[Symbols explained in text]

	West Canyon reference section							Soldier Canyon reference section			
Unit	2			4		5	12	2	4	7	14
Distance, in feet, above base of formation	165	142	142	246	438	438	1,173	53	354	513	962
USGS colln. No	21155–PC	21154–PC	20329–PC	21156–PC	21157–PC	20330–PC	20331–PC	11767–PC	11768–PC	11769–PC	11770–PC
Corals:											
Amplexizaphrentis sp											R
Amplexus sp									R		
Bryozoans:											
Hederella sp				X							
Fistulipora sp											X
Fistuliporoid, encrusting form		R	R	R					R		
Tabulipora? sp											R
Stenoporoid, thin encrusting form		X		X						R	X
Stenoporoid, irregularly ramose form		X	X	X							
Trepostomatous bryozoan, ramose form				R							
Fenestella sp								R			R
Polypora sp				R				X			X
Rhomboporoid, gen. & sp. indet								X			R
Cystodictya								X			
Echinoderms:											
Crinoid columnals		R									R
Brachiopods:											
Orthotetes sp										X	?
Schizophoria sp			R								
Elliottella sp. A	C	R	X	R							
Rugoclostus semistriatus (Meek)			X	R					R		
Flexaria sp. B			X	X	X	X		X			
Echinoconchus sp. A			R	X	R			X			
Antiquatonia aff. *A. coloradoensis* (Girty)		X	X	C	R			C	X		
Linoproductus sp. A		R	R	C		R					
nodosus (Newberry)											C
Pugnoides cf. *P. quinqueplecis*		R	?					X			
Anthracospirifer occiduus		X				?	C	X			X
aff. *A. rockymontanus* (Marcou)			X	X						X	
Reticulariina campestris (White)		?	R	R	R			X			
Hustedia sp			R								
Cleiothyridina cf. *C. orbicularis* (McChesney)		X	X	X					R		
Composita sp		X	X	X		X		C	R	R	X
Pelecypods:											
Myalina? sp. indet		R		R							R
Modiomorphid, gen. & sp. indet		R									
Limipecten sp. indet					R						
Cypricardinia? sp. indet								R			
Wilkingia? sp. indet			R								
Trilobites:											
Paladin? sp. indet		R									R

been studied. The fossils from these 20 collections are listed in table 6.

Chaetetes was found in the type section only, 436 feet above the base of the formation. According to Welsh and James (1961, p. 11), *Profusulinella* occurs in the *Chaetetes*-bearing limestone beds, but whether in place or reworked, as is the case in the Erda Formation, is not clear. They also reported *Fusulinella* from limestone beds higher in the section. The *Multithecopora* zone was recognized in the type section at levels 940 and 1,027 feet above the base; in the more intensely collected reference section, corals typical of this zone occur from 525 to 1,470 feet above the base. As in the Erda Formation, *Kozlowskia* aff. *K. haydenensis* (Girty) and *Neospirifer* cf. *N. coloradoensis* Stevens range through much of this zone.

The occurrence of *Fusulina* sp., recognized by R. C. Douglass (written commun., 1962) at a level 941 feet above the base of the reference section indicates a Des Moines age for this part of the section, but does not indicate earliest Des Moines age.

Desmoinesia muricatina (Dunbar and Condra) was represented only by a single example in one collection, 920 feet above the base of the formation in the reference section, where it was associated with *Kozlowskia* and *Neospirifer*. The absence of beds with abundant *Desmoinesia muricatina* in the Butterfield Peaks Formation type section is a local facies condition. The gray-black shale beds in which this species is found in profusion in the Erda Formation are also present in other sections of the Butterfield Peaks Formation.

Beds crowded with bryozoans occur in the upper part of the formation. A large collection from one of these beds was made in the reference section,

TABLE 6.—*Megafauna of the Butterfield Peaks Formation at its type and reference sections*
[Symbols explained in text]

	West Canyon type and reference sections									Soldier Canyon reference section										
Unit	3		4	5	7	14	18	20	26	3		4	5	6	7	10	11		13	
Distance, in feet, above base of formation	436	940	1,327	1,813	2,592	3,811	4,131	4,675	5,419	525	655	783	920	1,204	1,466	2,399	2,813	3,105	3,553	3,627
USGS colln. No	20332-PC	20333-PC	20299-PC	20302-PC	20303-PC	20305-PC	20306-PC	20307-PC	20308-PC	20315-PC	20316-PC	20317-PC	20318-PC	20319-PC	20320-PC	20321-PC	20322-PC	20323-PC	20324-PC	20325-PC
MULTITHECOPORA-KOZLOWSKIA ASSEMBLAGES																				
Corals:																				
Caninia sp											R		C							
Caninoid? fragment indet															R					
Horn coral, gen. & sp. indet			R	X					R											
Multithecopora sp. A		X	X							cf.	X				X					
Chaetetes sp	X																			
Bryozoans:																				
Hederella sp												R								
Fistuliporoid, incrusting form											R		R					R		
Stenoporoid, thin incrusting form								R		R		R	R					R		
Ascopora? sp										X										
Rhombotrypella sp										X										X
Fenestella spp				X			X	X	R			R	X					X	X	C
Polypora sp				R				R					R							X
Penniretepora sp								R	R			?	R					R	X	X
Rhomboporoid, gen. & sp. indet								R			R	R						X	X	C
Brachiopods:																				
Derbyia? sp. indet																				
Kozlowskia aff. *K. haydenensis* (Girty)											X	R	R							
Desmoinesia muricatina (Dunbar & Condra)													R							
Flexaria? sp. indet										R										
Linoproductus sp										R		R		R						
Anthracospirifer opimus (Hall)												R				cf.				
occiduus (Sadlick)					C					C	?						R			
Neospirifer cf. *N. coloradoensis* Stevens												X	R					R		
Phricodothyris perplexa (McChesney)											X	R						R		F
Composita ovata Mather										X	R	R								
elongata Dunbar & Condra												R								
Beecheria cf. *B. bovidens* (Morton)												R								
Trilobite:																				
Ameura? sp						R				R										
INTERMEDIATE & PRISMOPORA ASSEMBLAGES																				
Corals:																				
Caninoid, gen. & sp. indet																		R		
Bryozoans:																				
Prismopora sp							X												?	X
Tabulipora sp																			R	
Chainodictyon sp																				X
New genus aff. *Penniretepora* sp																				X
Ichthyorachis? sp								X										R	R	X
Diploporaria sp																				X
Septopora sp																		R		X
Matheropora sp																				X
Rhabdomeson sp																				X
Rhombocladia sp																				X
Streblotrypa sp																			R	
Echinoderms:																				
Crinoid columnals									X											
Pelmatozoan debris							X													
Brachiopods:																				
Orbiculoidea sp																		R		
Eolissochonetes sp						C														
Juresania sp						R														
Linoproductus prattenianus (Norwood & Pratten)						R														
Cleiothyridina sp. indet							R													
Composita subtilita (Hall)																				F

3,627 feet above the base of the formation. Characteristic genera are *Prismopora, Chainodictyon, Ichthyorachis?, Diploporaria, Matheropora, Rhabdomeson,* and *Rhombocladia.* These were not recorded lower in the formation. The beds containing these forms are correlative with the *Prismopora*-bearing beds in the upper-middle part of the Erda Formation and are regarded as late Des Moines in age.

Fusulinid evidence for Des Moines age was encountered by R. C. Douglass (written commun., 1962) at several levels in the type section. *Fusulina* sp. occurs in association with textulariids and *Wedekindellina* sp. 1,327 feet above the base of the formation (unit 4), and in association with textulariids 5,429 feet above the base (unit 26); *Fusulina* is present without associated larger Foraminfera 5,449 (unit 26) and 6,081 (unit 31) feet above the base. *Fusulinella* sp. was identified by Douglass at levels 2,301 (unit 6) and 6,048 (unit 31) feet above the base of the type section.

Only 235 feet of beds at the top of the reference section have not as yet provided fossil evidence as to the age of the rocks. We regard the beds in the reference section, from the first appearance of *Kozlowskia* aff. *K. haydensis* to the final appearance of the *Prismopora* assemblage, as Des Moines in age. For practical purposes, we include all but the lower few hundred feet in the Des Moines Series. The lower beds are Atoka in age. The Butterfield Peaks Formation correlates directly with the Erda Formation of the Rogers Canyon sequence.

BINGHAM MINE FORMATION

Megafossils are scarce and poorly preserved in the Bingham Mine Formation, except at one locality of uncertain stratigraphic position, where a large and varied fauna was found. The fossils found most frequently and in greatest numbers are fusulinids, but many of these are silicified and show signs of having been reworked. Despite the uncertainties generated by structural complication, reworking, and poor preservation, fairly reliable deductions can be made concerning the age of this formation and of the two members into which it has been divided. In the following discussion, fossils of the type sections of both members are considered in ascending order, after which the large fauna collected west of Lark is recorded.

CLIPPER RIDGE MEMBER

The fusulinids in 11 collections from the type section were studied by R. C. Douglass (written commun., 1962). Most of them were referable to the genus *Triticites*. Foraminifera identified by Douglass are listed in the register of Late Paleozoic fusulinid collecting localities in this report. Three collections of megafossils from the type section were studied by the writers. Two of them contained corals unidentifiable as to genus. The third collection is listed below.

Fusulinid specimens that were scattered and that appeared worn, were collected from unit 2 of the type section, 10 feet above the base of the formation; they were identified by R. C. Douglass (written commun., 1962) as *Triticites* sp. of probable Missouri age. In the same unit, 114 feet above the base of the formation, the following megafossils were recognized (USGS colln. 22486-PC).

	Relative abundance
Stenoporid bryozoan, massive form	X
Trepostomatous bryozoan, ramose form	R
Fenestella sp	X
Polypora sp	R
Penniretepora sp	X
Rhombocladia sp	X
Crinoid columnals	X
Chonetinella sp	R
Antiquatonia? sp. indet	R
Linoproductus sp. indet	R

This megafauna is not sufficiently diagnostic to enable one to determine the relative age of these beds. The age assignment must necessarily depend upon the fusulinids, and it is clear that as the basal beds of the Clipper Ridge Member contain *Triticites* of a type characteristic of the Missouri Series, even though they appear reworked, this member can be no older than Missouri in age.

Triticites occurs also at levels 1,284 (unit 6), 1,967 (unit 9), 2,379 (unit 11), 2,627 (unit 15), 2,772 (unit 16), 2,957 (unit 18), and 2,980 (unit 20) feet above the base of the member (and formation). Other Foraminifera found with that genus locally include textulariids, *Millerella* sp., *Bradyina* sp., and *Kansanella*? sp. Although R. C. Douglass (written commun., 1962) pointed out that the *Triticites* at 2,790 and 2,957 feet above the base of the member are hardly distinguishable from forms of Virgil age, the presence of fairly well preserved Missouri fusulinids in the top 5 feet of the member (unit 20), as well as in the lower part of the overlying Markham Peak Member, indicates that the entire Clipper Ridge Member is of Missouri age.

Syringoporoid corals are fairly common in the upper part of the Clipper Ridge Member. One of these, from unit 18 of the type section (USGS colln. 23890-PC), was identified by Miss Duncan as *Syringopora multattenuata* McChesney?. It is not an entirely typical example of the Missourian form and may actually represent an undescribed species closely allied to *S. multattenuata*.

MARKHAM PEAK MEMBER

The fossils in the type section of the Markham Peak Member are sparse and poorly preserved. No megafossils were collected in this section. The age determinations are based entirely upon evidence provided by fusulinids, most of which are referable to the genus *Triticites*. R. C. Douglass (written commun., 1966) recognized *Triticites* at levels 940 (unit 11), 960 (unit 11), 1,025 (unit 11), 1,566 (unit 13), 1,603 (unit 13), 2,547 (unit 15), 3,240 (unit 19), and 3,989 (unit 21) feet above the base of the member in its type section. The only other Foraminifera found associated with *Triticites* in this member is *Climacammina* sp. in units 11 and 13.

R. C. Douglass (written commun., 1966) regarded the fusulinids of units 11 and 13 as Missouri in age. Those of unit 15 are similar but appear to have been reworked. Three collections of fusulinids, from units 19 and 21 were regarded by Douglass as containing *Triticites* of Virgil affinities. The highest of these collections occurred 1,462 feet below the top of the uppermost bed in the type section of the Markham Peak Member. No fossils were found in these highest beds.

Fauna collected near Lark.—About 1¼ miles west of Lark, on the north slope of Copper Gulch, a very fossiliferous locality has yielded a fauna of 60 species of invertebrates. Three collections (USGS collns. 18892–PC, 20311–PC, and 21151–PC) made in 1959 and 1962 contained the following species:

	Relative abundance
Foraminifera:	
Bradyina sp	R
Corals:	
Caninoid coral, gen. and sp. indet	R
Michelinia? sp	R
Cladochonus? sp	R
Bryozoans:	
Fistuliporoid, incrusting form	R
Fistuliporoid, ramose form	R
Ramiporalia sp	R
Stenoporoid, incrusting form	R
Rhombopora sp	X
Fenestella aff. *F. austini* Elias and Condra	
aff. *F. archimediformis* Elias and Condra	R
(Cervella) aff. *F. (C.) cruciformis* Elias and Condra	C
(Polyporella) sp	R
Polypora cf. *P. andina* Chronic	X
sp	C
Septopora sp	R
Penniretepora sp	C
Acanthocladia? sp	R
Ptylopora sp	R
Coeloconus? sp	X
Rhombocladia sp	C
Rhomboporoid, gen. and sp. indet	X
Brachiopods:	
Derbyia sp	X
Chonetinella cf. *C. alata* (Dunbar and Condra)	C
Neochonetes cf. *N. granulifer* (Owen)	R
Krotovia sp	X
Kozlowskia aff. *K. splendens* (Norwood and Pratten)	C
Retaria sp	R
Chaoiella sp	C
Kochiproductus aff. *K. peruvianus* (d'Orbigny)	X
Antiquatonia sp	X
Linoproductus sp	X
Cancrinella sp	C
Rhynchopora sp	R
Neospirifer sp. indet	R
Phricodothyris perplexa (McChesney)	C
Crurithyris planiconvexa (Shumard)	X
Cleiothyridina orbicularis (McChesney)	X
Hustedia mormoni (Marcou)	A
Punctospirifer sp	R
Reticulariina sp	R
Echinoderms:	
Crinoid columnals	X
Echinoid spines	R
Worms:	
Spirorbis sp	R
Unidentified tubes	X
Pelecypods:	
Astartella? sp. indet	R
Conocardium sp. indet	R
Gastropods:	
Euphemites sp. indet	R
Knightites (Retispira) sp. indet	X
Sinuatina? sp. indet	R
Baylea sp	X
Peruvispira? sp. indet	R
Pleurotomariacean, gen. and sp. indet	R
"*Strophostylus*" sp	X
Naticopsis (Naticopsis) sp	X
(new subgenus) sp. indet	R
Meekospira sp	R
Omphalotrochus wolfcampensis Yochelson	X
Omphalotrochus? cf. *O. obtusispira* (Shumard)	R
Trilobites:	
Ditomopyge sp	X

The presence of such genera as *Kochiproductus, Chaoiella, Peruvispira*?, and *Omphalotrochus* suggest a late Virgil or early Wolfcamp age for this assemblage. The brachiopod fauna is very similar to that of the *Omphalotrochus wolfcampensis*-bearing beds in the lower part of the Kessler Canyon Formation at the north end of the range. In the Kessler Canyon, fusulinid evidence indicates a late Virgil (or slightly younger) age for these beds. Similar fusulinids are found in the Markham Peak Member of the Bingham Mine Formation. The rocks west of Lark containing the *Omphalotrochus wolfcampensis* assemblage are assigned, therefore, to the Markham Peak Member despite the fact that this faunal assemblage was not recognized in the type section of that member.

Complicating this problem is the geographic position of this fossil locality in an area mapped as Clipper Ridge Member by Tooker and Roberts, at a point approximately where the Commercial limestone might be expected to crop out (E. W. Tooker, oral commun., 1969). We conclude that the fossiliferous beds are part of an infaulted block of the Markham Peak Member not recognized as such in the field. Unfortunately, before this conclusion could be tested by further mapping in that area, the fossil locality was engulfed by southward extension of the waste piles from the Bingham open pit mine and buried beneath tons of loose rock.

CORRELATION AND AGE OF THE BINGHAM MINE FORMATION

The evidence recorded in the preceding discussion suggests that roughly the lower half of the Bingham Mine Formation, including the Clipper Ridge Member and the beds up to the middle of unit 13 of the type section of the Markham Peak Member, is equivalent to the Upper Pennsylvanian Missouri Series. The aggregate thickness of these beds is 4,590 feet. Missouri fusulinids 5,532 feet above the base of the formation are reworked and whether they are actually in beds of Missouri or Virgil age is a matter for conjecture.

Fusulinids of Virgil age occur in place 6,225 to 6,975 feet above the base of the formation in the Markham Peak Member. It is to this part of the formation that the large *Omphalotrochus wolfcampensis* fauna collected west of Lark should be assigned. Our reasoning is based upon the relationship of the similar though less abundant fauna near the base of the Kessler Canyon Formation in the Rogers Canyon sequence and the fusulinids contained in that same formation.

No fossils of Permian age have been recognized in the Bingham Mine Formation. The type section for this formation was originally designated by Welsh and James (1961, p. 9) as occupying part of the main ridge of South Mountain, which borders the south edge of Tooele Valley at the western base of the Oquirrh Mountains. According to E. W. Tooker (oral commun., 1969) the rocks that make up South Mountain are part of a thrust sheet that is separate from the Bingham sequence. Welsh and James regarded the formation as restricted to beds of Late Pennsylvanian age. Even though the 1,462 feet of unfossiliferous beds in the upper part of this formation in the Bingham sequence makes it impossible to say unequivocally that no Permian beds are present in it in the Oquirrh Mountains, it would seem reasonable to maintain Welsh and James' age assignment of the Bingham Mine Formation here as Late Pennsylvanian throughout unless evidence to the contrary becomes available.

The correlation of the lower part of the Bingham Mine Formation with the section in the Rogers Canyon sequence remains an enigma. Although more than 5,500 feet of this formation contains fusulinids of Missouri age, in the Rogers Canyon sequence no Missouri fossils have been recognized.

Beds of Missouri through Wolfcamp age, equivalent to the Bingham Mine Formation are known in the Oquirrh Formation of the Timpanogos sequence in the central Wasatch Mountains (Baker, 1947), in the central facies of the same formation in the Gold Hill region south of Wendover, Utah (Nolan, 1935, p. 35–39; L. C. Henbest, written commun. to R. Hose, 1957), in the Ferguson Springs Formation of Steele (1960, p. 101) at Ferguson Springs Mountain, Elko County, Nev., and at Spruce Mountain, farther west in the same county (R. C. Douglass, oral commun., 1969). A belt of such rocks extends through the southeastern and southern parts of the Great Basin, particularly in Lincoln and Clark Counties, Nev. Sections of these Late Pennsylvanian and Early Permian rocks, within the Bird Spring Formation, have been documented in the Arrow Canyon Range (Langenheim and Langenheim, 1965) and on Spring Mountain near Las Vegas (Rich, 1961).

Over much of the central part of the Great Basin a hiatus, equivalent to all or part of the Bingham Mine Formation, is present. This hiatus has previously been delineated by Steele (1961, chart 1) who referred to it as the "Regional Middle Pennsylvanian unconformity." In some places the rocks below the unconformity are as old as Meramec (early Late Mississippian) in age and the rocks above it as young as middle Wolfcamp (Early Permian) in age. In figure 13, some of the sections in which this hiatus is well developed are shown.

In the Confusion Range this hiatus is marked by an unconformity within the Ely Limestone, between the Pennsylvanian and Permian parts of the formation (Hose and Repenning, 1959, p. 2174). Hose's mapping in this region and stratigraphic studies by Gordon have shown that over a considerable area carbonate rocks of Early Permian (Wolfcamp) age rest on carbonate and fine clastic rocks of Middle Pennsylvanian (Des Moines) age. The same unconformity has been recognized in the southern part of the Schell Creek Range in White Pine County, Nev., by Drewes (1967). It extends also into the Ely mining district where the name "Ely Limestone" has been restricted to beds of Pennsylvanian age. The overlying Lower Permian limestone has been given the name Riepe Spring Limestone (Steele, 1960, p. 93, 102).

In the Eureka mining district, Nev., Early Permian (Wolfcamp) rocks above this unconformity are referred to the Carbon Ridge Formation (Nolan and others, 1956, p. 62–64). Supposed Missouri fusulinids reported from the Carbon Ridge occur, according to Douglass (oral commun., 1970), with Wolfcamp species. The youngest rocks of the Ely

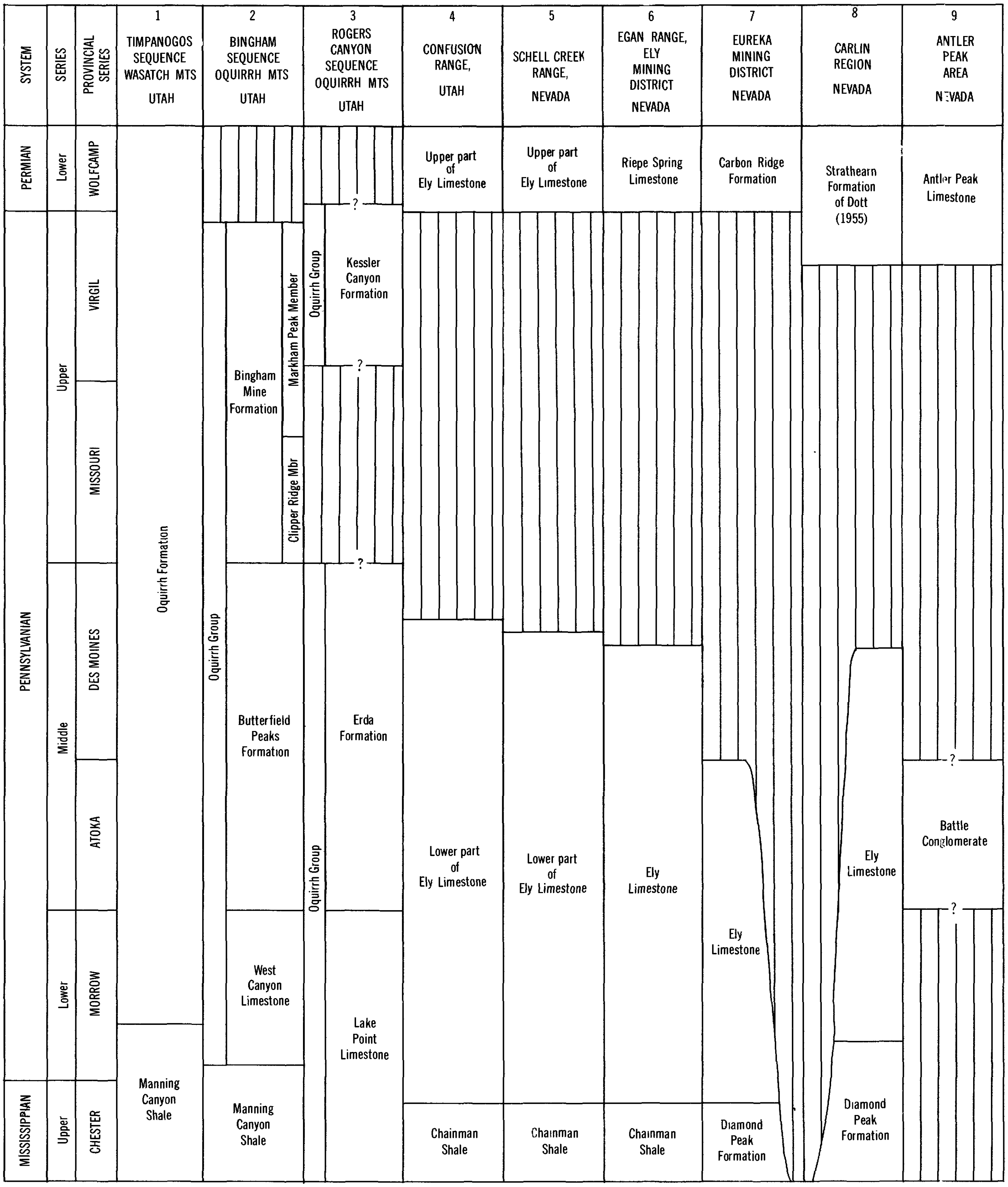

FIGURE 13.—Correlation chart of sections in the central Great Basin.

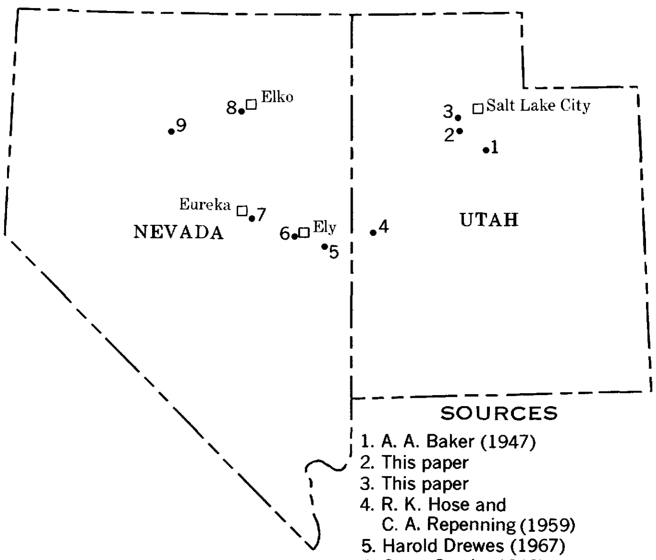

FIGURE 13.—Continued

Limestone beneath the unconformity are Middle Pennsylvanian (Atoka) in age. Locally, as at Conical Hill near Eureka, the Carbon Ridge Formation rests on rocks of late Meramec age of the Diamond Peak Formation.

In the Carlin region the same unconformity is present between the top of the Ely (Tomera Formation of Dott (1955) and the base of the Strathearn Formation of Dott (1955). The basal part of the Strathearn contains fusulinid-bearing beds of Late Pennsylvanian (Virgil) age. Locally, as in Carlin Canyon, the Strathearn rests on Diamond Peak beds of early Meramec age. At the last two localities, which lie along the Antler orogenic belt, uplift is indicated at an earlier time than in the region to the east.

In the Antler Peak area, near Battle Mountain, Nev., a similar unconformity occurs at the contact of the Battle Conglomerate, of Middle Pennsylvanian (Atoka) age, and the overlying Antler Peak Limestone of Late Pennsylvanian (Virgil) and Early Permian (Wolfcamp) age (Roberts, 1964). Like the Strathearn Formation, the Antler Peak includes fusulinid-bearing beds of late Virgil age in its lower part.

Not enough data are available to delimit the area covered by this unconformity. Subsequent tectonic events have combined to alter its original area somewhat. Rigid faunal control will be necessary to recognize its margins in places where its magnitude has dwindled. Its extent, measured by the sections shown on the correlation chart (fig. 1) is in excess of 7,000 square miles, but eventually we may find that it occupied a much greater part of the Great Basin region.

REGISTER OF LATE PALEOZOIC MEGAFAUNA COLLECTING LOCALITIES IN THE OQUIRRH MOUNTAINS, UTAH

USGS Colln. No.	*Descriptions and collectors*
16318–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. On ridge southwest of 6231 peak, in the NE¼NW¼NW¼ sec. 6, T. 2 S., R. 3 W., at approximately 5,500 ft elevation. Lake Point Limestone. Prominent 5-ft colonial coral bed, unit 4 of type section, 583 ft above base of formation. Collected by R. J. Roberts, 1956.
16319–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Same general locality as 16318–PC. Lake Point Limestone. Collected from dark-gray medium-bedded limestone about 34 ft above base of unit 5 of type section, 622 ft above base of formation. Collected by R. J. Roberts, 1956.
16322–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Same general locality as 16318–PC. Lake Point Limestone. Collected in dark-gray limestone, 40 ft above base of unit 5 of type section, 628 ft above base of formation. Collected by R. J. Roberts, 1956.
16323–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. On ridge southwest of 6231 peak at approximately 5,700 ft elevation, in the NE¼NW¼ sec. 6, T. 2 S., R. 3 W. Lake Point Limestone. Collected from dark-gray cherty limestone, 150 ft above base of unit 5 of type section, 738 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, 1956.
16324–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Same general locality as 16323–PC, at approximately 5,800 ft elevation. Lake Point Limestone. Collected from cherty dark-gray limestone, 113 ft above base of unit 7 of type section, 866 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, 1956.
16325–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. On ridge in center of sec. 31, T. 1 S., R. 3 W. Erda Formation. From dark-gray calcareous shale probably at about same level as 16326–PC. Collected by R. J. Roberts, 1956.
16326–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured sec-

USGS Colln. No.	*Descriptions and collectors*
	tion. On ridge on north side of Rogers Canyon, slightly north of center of sec. 31, T. 1 S., R. 3 W., at elevation of approximately 6,200 ft. Erda Formation. Collected from dark-gray cherty limestone, 104 ft above base of unit 13 of type section, 1,494 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, 1956.
16327–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Same general locality as 16326–PC, from about 6,300 ft in elevation. Erda Formation. Collected in dark-gray cherty limestone, 10 ft above base of unit 14 of type section, 1,703 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, 1956.
16328–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. North side of Rogers Canyon in north center sec. 31, T. 1 S., R. 3 W., at elevation of approximately 6,600 ft. Erda Formation. Collected from 4-ft light-gray crinoidal limestone, unit 25 of type section, 2,515 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, 1956.
16329–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. On ridge south of Green Ravine below tramway tower, approximately on 5,400-ft contour, in the NW¼SW¼ sec. 6, T. 2 S., R. 3 W. Green Ravine Formation. Collected in interbedded dark-gray limestone and bioclastic limestone, 189 ft above base of unit 11 of type section, 1,060 ft above base of formation. Collected by E. W. Tooker and R. J. Roberts, 1956.
16330–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Same locality as 16329–PC. Green Ravine Formation. Collected in limestone, 203 ft above base of unit 11 of type section, 1,074 ft above base of formation. Collected by E. W. Tooker and R. J. Roberts, 1956.
16331–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Same locality as 16329–PC, at 5,475 ft elevation. Green Ravine Formation. Collected in interbedded limestone and argillaceous limestone, 258 ft above base of unit 11 at type section, 1,129 ft above base of formation. Collected by E. W. Tooker and R. J. Roberts, 1956.
16332–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. At 5,300 ft elevation on north side of Green Ravine, one-eighth mile east of 5244 hill, in SW¼NW¼ sec. 6, T. 2 S., R 3 W. Green Ravine Formation. Collected in interbedded limestone, cherty limestone, and arenaceous limestone, 158 ft above base of unit 11 of type section, 1,029 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, 1956.
16333–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Same general locality as 16332–PC. Green Ravine Formation. Collected across a 60-ft section of dark-gray limestone and argillaceous limestone beginning 97 ft above base of unit 12 of type section and 1,299 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, 1956.
16334–PC	Garfield 7½-minute quadrangle, Tooele County. At about 6,000 ft elevation in tributary of Big Canyon (just north of word "Big" on topo sheet) in NE¼NE¼NW¼ sec. 7, T. 2 S., R. 3 W. Erda Formation. Collected from dark-gray fossiliferous limestone near base of unit 1. Collected by R. J. Roberts and E. W. Tooker, 1956.
16335–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. On ridge south of Green Ravine north of tramway tower at approximate elevation of 5,300 ft above sea level, in NW¼SW¼ sec. 6, T. 2 S., R. 3 W. Green Ravine Formation. Collected from interbedded banded cherty limestone and arenaceous bioclastic limestone, at base of unit 10 of type section, 799 ft above base of formation. Collected by E. W. Tooker and R. J. Roberts, 1956.
16337–PC	Garfield 7½-minute quadrangle, Tooele County. At 5,480 ft elevation on north side of Big Canyon, in NW¼NW¼ sec. 7, T. 2 S., R. 3 W. Lake Point Limestone. Collected from fossiliferous argillaceous limestone in upper part of formation. Collected by R. J. Roberts, 1956.
17031–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Same general locality as 17145–PC but from crinoidal limestone bed about 30 ft higher stratigraphically. Lake Point Limestone. Collected by M. Gordon, Jr., R. J. Roberts, and E. W. Tooker, July 8, 1957.
17143–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Below 5,400-ft contour, a few feet up north slope from bottom of Green Ravine, about one-eighth mile east of 5244 hill in the SE¼SW¼NW¼ sec. 6, T. 2 S., R. 3 W. Green Ravine Formation. Collected from in-

USGS Colln. No.	*Descriptions and collectors*
	terbedded limestone and argillaceous limestone, 258 ft above base of unit 11 of type section, 1,129 ft above base of formation. Collected by M. Gordon, Jr., and R. J. Roberts, July 8, 1957.
17144–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Same · general locality as 17143–PC. Green Ravine Formation. Collected from impure gray limestone, a few feet below 16333–PC, approximately 1,290 ft above base of formation. Collected by M. Gordon, Jr., and R. J. Roberts, July 8, 1957.
17145–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. At cairn on lower slopes of ridge southwest of 6231 peak, a few tens of feet north of unnamed ravine north of Green Ravine, near center of NW¼ sec. 6, T. 2 S., R. 3 W. Lake Point Limestone. Collected from medium-dark-gray limestone with shale partings, 143 ft above base of unit 1 of type section. Collected by M. Gordon, Jr., R. J. Roberts, and E. W. Tooker, July 8, 1957.
17146–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Same locality and bed as 16318–PC. Collected by M. Gordon, Jr., R. J. Roberts, and E. W. Tooker, July 8, 1957.
17147–PC	Garfield 7½-minute quadrangle, Tooele County. Same general locality as 16318–PC. Lake Point Limestone. Collected from dark-gray limestone and argillaceous limestone, 55 ft above base of unit 5 of type section and 643 ft above base of formation. Collected by M. Gordon, Jr., R. J. Roberts, and E. W. Tooker, July 8, 1957.
17148–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Same general locality as 16318–PC but higher on ridge. Lake Point Limestone. Collected from medium-dark-gray limestone, about 20 ft above base of unit 7 of type section, 773 ft above base of formation. Collected by M. Gordon, Jr., R. J. Roberts, and E. W. Tooker, July 8, 1957.
17149–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Same general locality as 16318–PC at elevation of 5,690 ft above sea level. Lake Point Limestone. Collected in limestone, about 117 ft above base of unit 7 of type section, 870 ft above base of formation. Collected by M. Gordon, Jr., R. J. Roberts, and E. W. Tooker, July 8, 1957.
17150–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. On ridge southwest of 6231 peak at about 5,725 ft elevation, in the NE¼NW¼ sec. 6, T. 2 S., R. 3 W. Lake Point Limestone. Collected from limestone bed just below 4-ft yellow quartzite, 155 ft above base of unit 7 of type section, 908 ft above base of formation. Collected by M. Gordon, Jr., R. J. Roberts, E. W. Tooker, July 8, 1957.
17151–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. About 700 ft southwest of summit of 6231 peak on ridge in SW¼SE¼SW¼ sec. 31, T. 1 S., R. 3 W., at elevation of 5,79[illegible] ft above sea level. Erda Formation. Collected from light-gray limestone, 157 ft above base of unit 1 of type section. Collected by M. Gordon, Jr., R. J. Roberts, and E. W. Tooker, July 9, 1957.
17152–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. On north side of Rogers Canyon about 75 ft above canyon bottom, at elevation of about 5,500 ft above sea level, in the NE¼SW¼ sec. 31, T. 1 S., R. 3 W. Erda Formation. Collected from fossiliferous gray limestone, 182 ft above base of unit 1 in type section. Collected by M. Gordon, Jr., R. J. Roberts, and E. W. Tooker, July 9, 1957.
17153–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Same locality as 17152–PC. Erda Formation. Collected from limestone a few feet above 17152–PC. Collected by M. Gordon, Jr. and E. W. Tooker, July 9, 1957.
17154–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Same general locality at 17152–PC. Erda Formation. Collected from light-gray limestone, 6 ft thick, below crossbedded calcareous sandstone or sandy limestone, 12[illegible] ft above base of unit 3 of type section, 52[illegible] ft above base of formation. Collected by M. Gordon, Jr., R. J. Roberts, and E. W. Tooker, July 9, 1957.
17155–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Same general locality as 17152–PC but at elevation of roughly 5,700 ft. Erda Formation. Collected in light-gray limestone, 10–12 feet thick, underlying calcareous sandstone, 72 ft above base of unit 4 of type section, 604 ft above base of formation. Collected by M. Gordon, Jr., and R. J. Roberts, July 9, 1957.
17156–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Same locality as 17155–PC, but from base of 6-ft light-gray limestone separated

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	by 4 ft of calcareous sandstone from limestone of 17155–PC. Overlain by 15 ft of yellowish chert. Collected by R. J. Roberts and E. W. Tooker, July 9, 1957.
17157–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Same ridge as 17155–PC but roughly 50 ft higher. Erda Formation. Bryozoans and *Linoproductus* from 5-ft yellow chert bed; *Spirifer* and *Composita* and corals from overlying dark-gray limestone and shale; 30 ft above base of unit 6 of type section, 752 ft above base of formation. Collected by M. Gordon, Jr., and R. J. Roberts, July 9, 1957.
17158–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. North slope of Rogers Canyon in NE¼NE¼SW¼ sec. 31, T. 1 S., R. 3 W. Erda Formation. Collected from dark-gray argillaceous limestone, at base of unit 8 of type section, 921 ft above base of formation. Collected by M. Gordon, Jr., R. J. Roberts, E. W. Tooker, July 10, 1957.
17159–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. North slope of Rogers Canyon in SW¼SW¼NE¼ sec. 31, T. 1 S., R. 3 W. Erda Formation. Collected from gray impure limestone with chert, 30 ft above base of unit 10 of type section, 1,097 ft base of formation. Collected by M. Gordon, Jr., R. J. Roberts, and E. W. Tooker, July 10, 1957.
17161–PC	Garfield 7½-minute quadrangle, Tooele County. Same locality as 17159–PC but from bed about 30 ft higher stratigraphically. Collected by R. J. Roberts, July 10, 1957.
17163–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Near middle sec. 31, T. 1 S., R. 3 W. Erda Formation. Collected from gray cherty limestone, 74 ft above base of unit 11 of type section, 1,280 ft above base of formation. Collected by M. Gordon, Jr., R. J. Roberts, and E. W. Tooker, July 10, 1957.
17164–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Same general locality as 17163–PC in saddle on ridge. Erda Formation. Collected from two 1-ft beds separated by 10 ft of dark-gray impure limestone, beginning 297 ft above base of unit 13 of type section, 1,687 ft above base of formation. Collected by M. Gordon, Jr., R. J. Roberts, and E. W. Tooker, July 10, 1957.
17165–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Higher on same ridge. Erda Formation. Collected from medium-gray cherty limestone, 16 ft above base of unit 19 of type section, 2,153 ft above base of formation. Collected by M. Gordon, Jr., R. J. Roberts, and E. W. Tooker, July 10, 1957.
17166–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. On flatter part of ridge at elevation of approximately 5,475 ft, on line between SE¼SE¼NW¼ and SW¼SE¼NE¼ sec. 31, T. 1 S., R. 3 W. Erda Formation. Collected from medium-gray thin-bedded to platy argillaceous limestone, 67 ft above base of unit 19 of type section, 2,204 ft above base of formation. Collected by M. Gordon, Jr., R. J. Roberts, and E. W. Tooker, July 10, 1957.
17167–PC	Stockton 15-minute quadrangle, Tooele County. Soldier Canyon measured section. On north slope of canyon roughly 75 ft in elevation above stream, approximately in center of south line of SE¼NE¼ sec. 34, T. 4 S., R. 4 W. West Canyon Limestone. Collected from argillaceous limestone, 12–30 feet above base of unit 2 of reference section, 53 ft above base of formation. Collected by M. Gordon, Jr., R. J. Roberts, and E. W. Tooker, July 11, 1957.
17168–PC	Stockton 15-minute quadrangle, Tooele County. Soldier Canyon measured section. Same general locality as 17167–PC but higher on ridge in SE¼NE¼ sec. 34, T. 4 S., R. 4 W. West Canyon Limestone. Collected from dark-gray argillaceous limestone, 2–7 ft above base of unit 4 of reference section, 354 ft above base of formation. Collected by M. Gordon, Jr., R. J. Roberts, and E. W. Tooker, July 11, 1957.
17169–PC	Stockton 15-minute quadrangle, Tooele County. Soldier Canyon measured section. Same general locality as last but higher on slope. West Canyon Limestone. Collected from gray to brownish-gray arenaceous and argillaceous limestone about 15 ft above base of unit 7 of reference section, 513 ft above base of formation. Collected by M. Gordon, Jr., R. J. Roberts, and E. W. Tooker, July 11, 1957.
17170–PC	Stockton 15-minute quadrangle, Tooele County. Soldier Canyon measured section. Upslope from 17169–PC in the SE¼NE¼ sec. 34, T. 4 S., R. 4 W. West Canyon Limestone. Collected from light-gray cherty argillaceous limestone, 30–41 ft above base of unit 14 of reference section, 962 ft above base of formation. Collected by M. Gordon, Jr., R. J. Roberts, and E. W. Tooker, July 11, 1957.
18486–PC	Garfield 7½-minute quadrangle, Tooele County. Black Rock Canyon measured section. Slope on west side of Black Rock Canyon at elevation of 5,700 ft in middle part of NE¼ sec. 30, T. 1 S., R. 3 W. Kessler Canyon Formation. Collected from fossiliferous light-brown-

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	ish-gray cherty limestone, unit 10 of type section, 675 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, 1958.
18490–PC	Garfield 7½-minute quadrangle, Salt Lake Co. At 6,280 ft elevation on ridge, about 0.3 mile northeast of summit of hill 7037, on east slope of Oquirrh Mountains, in the NW¼SE¼NE¼ sec. 3, T. 2 S., R. 3 W. Grandeur Member of Park City Formation. Collected by R. J. Roberts, 1958.
18892–PC	Lark 7½-minute quadrangle, Salt Lake County. Copper Gulch, west of Lark, near old Dalton and Lark mine, along west edge of SE¼SE¼ sec. 25, T. 3 S., R. 3 W., by powerline just north of road at west edge of Lark quadrangle. Bingham Mine Formation, uncertain stratigraphic position. Collected by E. L. Yochelson, R. J. Roberts, and E. W. Tooker, July 4, 1959.
18893–PC	Garfield 7½-minute quadrangle, Tooele County. Black Rock Canyon measured section. Same locality and stratigraphic unit as 18486–PC. Collected by E. L. Yochelson, R. J. Roberts, and E. W. Tooker, July 4, 1959.
19948–PC	Magna 7½-minute quadrangle, Salt Lake County. On slope west of town of Magna (west of word "Mining" on topo sheet) in NW¼SW¼ sec. 30, T. 1 S., R. 2 W. Grandeur Member of Park City Formation. Same unit as 19949–PC but 7.5 ft higher stratigraphically in an overlying bed. Collected by R. J. Roberts, 1961.
19949–PC	Magna 7½-minute quadrangle, Salt Lake County. West of town of Magna in SW¼NW¼ sec. 30, T. 1 S., R. 2 W., on Provo Bench (at about 4,800-ft contour) just north of small draw that lies at intersection of powerline and section line. Grandeur Member of Park City Formation, basal limestone bed. Collected by R. J. Roberts, 1961.
20232–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. At nose on ridge just above 6.850 ft elevation in SW¼NW¼NE¼ sec. 31, T. 1 S., R. 3 W. above prominent cliff of dark-gray cherty limestone with medial band of light-gray crinoidal limestone. Erda Formation. Collected from dark-gray cherty limestone, 149 ft above base of unit 27 of type section, 2,686 ft above base of formation. Collected by E. W. Tooker and R. J. Roberts, 1957. Fusulinids, f22568, from same unit 1 mile east-northeast of type section.
20235–PC	Garfield 7½-minute quadrangle, Tooele County. Black Rock Canyon, bed and east slope of middle fork, in the NW¼NE¼NE¼ sec. 32, T. 1 S., R. 3 W., between 6,200- and 6,240-foot contours. Erda Formation. Collected from same gray cherty limestone as in 20232–PC from unit 27 of type section, 1 mile to west-southwest. Collected by E. W. Tooker, 1957.
20236–PC	Garfield 7½-minute quadrangle, Tooele County. On south slope of Big Canyon at 6,840-ft contour, 1,300 ft west of tramway tower marked 7417 on topo sheet, in the NE¼NW¼ sec. 7, T. 2 S., R. 3 W. Erda Formation. Random collection from upper 50 ft of same cherty limestone that is unit 27 in type section, about 2 miles to north. Collected by E. W. Tooker, 1957. Fusulinids, f22569, from unit 1½ miles south of type section.
20238–PC	Garfield 7½-minute quadrangle, Salt Lake County. East slope of hill 5561 capped by flagpole north of Little Valley. Outcrops 1,300 ft southeast of flagpole and 500 ft northeast from check spot elevation 5,166 at 5,240-ft contour, in the SE¼NW¼ sec. 25, T. 1 S., R. 3 W., 1 mile southeast of copper mill at Arthur. Grandeur Member of Park City Formation. Collected from fossiliferous shaly limestone in basal limestone units. Collected by E. W. Tooker, 1957.
20240–PC	Garfield 7½-minute quadrangle, Salt Lake County. Coon Canyon, 400 ft due east of junction of Right Hand and Left Hand Forks of Coon Creek, 150 ft north of road at or near base of hill approximately at 5,800-ft contour, in the NW¼NW¼ sec. 14, T. 2 S., R. 3 W. Grandeur Member of Park City Formation. Collected from fossiliferous medium- to thin-bedded limestone in upper part of unit 1 of measured section. Collected by E. W. Tooker, 1957.
20241–PC	Garfield 7½-minute quadrangle, Salt Lake County. In Porter Hollow in the SE¼SW¼ sec. 11, T. 2 S., R. 3 W., near 20240–PC but along strike north of Coon Creek; outcrops 100 ft above stream. Grandeur Member of Park City Formation, unit 1. Collected by E. W. Tooker, 1957.
20242–PC	Garfield 7½-minute quadrangle, Salt Lake County. In Porter Hollow in vicinity of 20241–PC but farther along strike north of Coon Creek, in SE¼SW¼ sec. 11, T. 2 S., R. 3 W. Grandeur Member of Park City Formation, unit 1. Collected by E. W. Tooker, September 18, 1957.
20243–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. On lower western slope of Oquirrh Mountains, south of tramway in NE¼SE¼ sec. 1, T. 2 S., R. 4 W., almost on quarter section line. Green Ravine Formation. Collected from light-olive-gray calcareous sandstone, 3 ft thick, 26 ft above base of unit 6 of type section, 92 ft above base of formation. Collected by H. M. Duncan, E. W. Tooker, and R. A. Lewandowski, July 20, 1961.

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20246–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. About 200 ft along strike from 20243–PC and including limestone ledges higher in section. Green Ravine Formation. Collected from same sandstone as 20243–PC and from higher limestone beds, 26–45 ft above base of unit 6 of type section, 92 ft above base of formation. Collected by H. M. Duncan, E. W. Tooker, and R. A. Lewandowski, July 20, 1961.
20247–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Same general locality as 20246–PC at 4,960-ft contour. Green Ravine Formation. Collected from limestone about 10 ft higher stratigraphically than 20246–PC. Collected by H. M. Duncan, E. W. Tooker, and R. A. Lewandowski, July 20, 1961.
20248–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Northern part of SW¼SW¼ sec. 6, T. 2 S., R. 3 W., at 5,320-ft contour. Green Ravine Formation. Collected in limestone of unit 11, about 20 ft above locality 20249–PC. Collected by H. M. Duncan, E. W. Tooker, and R. A. Lewandowski, July 20, 1961.
20249–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine measured section, on north edge of SW¼SW¼ sec. 6, T. 2 S., R. 3 W., approximately at 5400–ft contour. Green Ravine Formation. Collected from interbedded limestone, cherty limestone, and arenaceous limestone, 168 ft above base of unit 11 of type section, 1,039 ft above base of formation. Collected by M. Gordon, Jr., H. M. Duncan, E. W. Tooker, and R. A. Lewandowski, July 20, 1962.
20250–PC	Garfield 7½-minute quadrangle, Tooele County. South of tramway in NW¼SW¼SW¼ sec. 6, T. 2 S., R. 3 W., at 5,480-ft contour. Green Ravine Formation. Collected in limestone of unit 11, one-half mile southeast of type section, about 100 ft above locality 20249–PC. Collected by H. M. Duncan, E. W. Tooker, and R. A. Lewandowski, July 20, 1961.
20251–PC	Garfield 7½-minute quadrangle, Tooele County. Same locality as 20250–PC but from about 5 ft higher in section. Collected by H. M. Duncan, E. W. Tooker, and R. A. Lewandowski, July 20, 1961.
20252–PC	Garfield 7½-minute quadrangle, Tooele County. Random collection from limestone beds in unit 11 between localities 20249–PC and 20250–PC. Collected by H. M. Duncan and R. A. Lewandowski, July 20, 1961.
20253–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. North slope of Green Ravine at 5,320-ft contour in SW¼SE¼NW¼ sec. 6, T. 2 S., R. 3 W. Green Ravine Formation. Collected from limestone about 160 ft above base of unit 11 of type section, near locality 16832–PC, 1,031 ft above base of formation. Collected by H. M. Duncan, E. W. Tooker, and R. A. Lewandowski, July 21, 1961.
20254–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. North of Green Ravine near middle of west line of SE¼NW¼ sec. 6, T. 2 S., R. 3 W., at 5,400-ft contour. Green Ravine Formation. Collected from interbedded fissile limestone and argillaceous limestone, 87 ft above base of unit 12 of type section, 1,289 ft above base of formation. Collected by H. M. Duncan, E. W. Tooker, and R. A. Lewandowski, July 21, 1961.
20256–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. On ridge north of Green Ravine in the NE¼SW¼NW¼ sec. 6, T. 2 S., R. 3 W., at 5,320-ft contour. Green Ravine Formation. Collected from argillaceous limestone, 298 ft above base of unit 11 of type section, 1,169 ft above base of formation. H. M. Duncan, E. W. Tooker, and R. A. Lewandowski, July 21, 1961.
20257–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. On ridge north of Green Ravine, same locality as 17143–PC. Green Ravine Formation, first limestone ledge below yellowish shale, 258 ft above base of unit 11 of type section, 1,129 ft above base of formation. H. M. Duncan, E. W. Tooker, and R. A. Lewandowski, July 21, 1961.
20258–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Same locality as 20257–PC but from 5,240-ft contour. Green Ravine Formation. Collected from limestone, 198 ft above base of unit 11 of type section, 1,069 ft above base of formation. Collected by H. M. Duncan, E. W. Tooker, and R. A. Lewandowski, July 21, 1961.
20259–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Same locality as 16318–PC and 17146–PC. Lake Point Limestone. *Orygmophyllum*? bed, unit 4 of type section. Collected by H. M. Duncan, E. W. Tooker, and R. A. Lewandowski, July 21, 1961.
20295–PC	Bingham Canyon 7½-minute quadrangle, Tooele County. Middle Canyon measured section. On ridge that trends southwest from 8745 peak, then curves southeastward, in NE¼SW¼SE¼ sec. 31, T. 3 S., R. 3 W., at 7,940 ft in elevation. Clipper Ridge Member of Bingham Mine Formation. Collected from limestone at base of unit 15, same locality as f22574. Collected by R. J. Roberts, 1959.

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20299–PC	Fairfield 15-minute quadrangle. Toole–Utah Counties boundary. Measured section on ridges at head of West Canyon. On crest of main ridge approximately at 9,200 ft elevation in SW¼NE¼ sec. 20, T. 4 S., R. 3 W. Butterfield Peaks Formation. Collected from arenaceous limestone, 431 ft above base of unit 4 of type section, 1,327 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, 1959.
20302–PC	Fairfield 15-minute quadrangle, Tooele–Utah Counties boundary. Measured section on ridges at head of West Canyon. Along crest roughly 800 ft west of 20299–PC approximately at 9,600-ft contour. Butterfield Peaks Formation. Collected from limestone, 287 ft above base of unit 5 of type section, 1,813 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, 1959.
20303–PC	Fairfield 15-minute quadrangle, Tooele–Utah Counties boundary. Measured section on ridges at head of West Canyon. Along crest roughly 900 ft west-southwest of 20302–PC, approximately at 9,900-ft contour, in the SE¼ NW¼ sec. 20, T. 4 S., R. 3 W. Butterfield Peaks Formation. Collected from fossiliferous limestone, 165 ft above base of unit 7 of type section, 2,592 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, 1959.
20305–PC	Fairfield 15-minute quadrangle, Tooele County. Measured section on ridge between Middle and Settlement Canyons. On northwest flank of 9745 peak on ridge, just above 9,600-ft contour, near center NE¼ sec. 18, T. 4 S., R. 3 W. Butterfield Peaks Formation. Collected from arenaceous limestone, 318 ft above base of unit 14 of type section, 3.811 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, 1959.
20306–PC	Fairfield 15-minute quadrangle, Tooele County. Measured section on ridge between Middle and Settlement Canyons. In saddle southeast of 9590 peak on ridge, roughly 1,000 ft northwest of 20305–PC, in the NW¼NE¼ sec. 18. Butterfield Peaks Formation. Collected from arenaceous limestone, 9 ft above base of unit 18 of type section, 4,131 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, 1959.
20307–PC	Fairfield 15-minute quadrangle, Tooele County. Measured section on ridge between Middle and Settlement Canyons. On 9590 peak on ridge, roughly 1,600 ft northwest of 20306–PC. Butterfield Peaks Formation. Collected from cherty limestone, 347 ft above base of unit 20 of type section, 4,675 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, 1959.
20308–PC	Fairfield 15-minute quadrangle, Tooele County. Measured section on ridge between Middle and Settlement Canyons. On ridge roughly 3,900 ft northwest of 20307–PC where crossed by line between R. 3 W. and R. 4 W., just above 8,850-ft contour line. Butterfield Peaks Formation. Collected from fossiliferous cherty limestone, 165 ft above base of unit 26 of type section, 5,419 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, 1959.
20311–PC	Lark 7½-minute quadrangle, Salt Lake County. On nose on northwest slope of Copper Gulch, 6,400 ft due west of Lark, in SE¼SE¼ sec. 25, T. 3 S., R. 3 W. Same locality and horizon as 18892–PC. Bingham Mine Formation. Collected by R. J. Roberts, 1959.
20315–PC	Stockton 15-minute quadrangle, Tooele County. Soldier Canyon measured section. Same ridge as that of 17168–PC but near 7,200-ft contour, SE¼NE¼ sec. 34, T. 4 S., R. 4 W., Butterfield Peaks Formation. Collected from medium-light-gray limestone, 241 ft above base of unit 3 of reference section, 525 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, July 1957.
20316–PC	Stockton 15-minute quadrangle, Tooele County. Soldier Canyon measured section. Approximately at 7,300-ft contour. Butterfield Peaks Formation. Collected from interbedded limestone and bioclastic limestone, 371 ft above base of unit 3 of reference section, 6?5 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, July 1957.
20317–PC	Stockton 15-minute quadrangle, Tooele County. Soldier Canyon measured section, NE¼NE¼ sec. 34, approximately at 7,500-ft contour. Butterfield Peaks Formation. Collected from medium-gray limestone, 58 ft above base of unit 4 of reference section, 783 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, July 1957.
20318–PC	Stockton 15-minute quadrangle, Tooele County. Soldier Canyon measured section, near 7,700-ft contour. Butterfield Peaks Formation. Collected from medium-gray limestone, 54 ft above base of unit 5 of reference section, 920 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, July 1957.
20319–PC	Stockton 15-minute quadrangle, Tooele County. Soldier Canyon measured section, at 7,900-ft contour. Butterfield Peaks Formation. Collected from cherty limestone, 192 ft above base of unit 6 of reference section, 1,204 ft above base of formation. Collected by E. W. Tooker and R. J. Roberts, July 1957.
20320–PC	Stockton 15-minute quadrangle, Tooele County. Soldier Canyon measured section, at 8,000-ft contour. Butterfield Peaks Formation. Collected from medium-gray limestone, 183 ft above base of unit 7 of reference section,

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	1,466 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, July 1957.
20321–PC	Stockton 15-minute quadrangle, Tooele County. Soldier Canyon measured section, SW¼SW¼ sec. 26, T. 4 S., R. 4 W., at approximately 8,500-ft contour. Butterfield Peaks Formation. Collected from medium-dark-gray arenaceous limestone, 101 ft above base of unit 10 of reference section, 2,300 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, July 1957.
20322–PC	Stockton 15-minute quadrangle, Tooele County. Soldier Canyon measured section, approximately at 8,600-ft contour. Butterfield Peaks Formation. Collected from interbedded bioclastic and argillaceous limestone, 319 ft above base of unit 11 of reference section, 2,813 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, July 1957.
20323–PC	Stockton 15-minute quadrangle, Tooele County. Soldier Canyon measured section, approximately at 8,850-ft contour. Butterfield Peaks Formation. Collected from interbedded medium-gray limestone, cherty limestone, and bioclastic limestone, 611 ft above base of unit 11 of reference section, 3,105 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, July 1957.
20324–PC	Stockton 15-minute quadrangle, Tooele County. Soldier Canyon measured section, approximately at 8,900-ft contour. Butterfield Peaks Formation. Collected from thin-bedded dark-gray cherty and argillaceous limestone, 330 ft above base of unit 13 of reference section, 3,553 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, July 1957.
20325–PC	Stockton 15-minute quadrangle, Tooele County. Soldier Canyon measured section, SW¼SW¼ sec. 26, T. 4 S., R. 4 W., approximately at 8,950-ft contour. Butterfield Peaks Formation. Collected from medium-dark-gray arenaceous cherty limestone, 404 ft above base of unit 13 of reference section, 3,627 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, July 1957.
20329–PC	Fairfield 15-minute quadrangle, Utah County. West Canyon measured section. Ridge on north slope of West Canyon at Maple Flat, in the SE¼NW¼ sec. 27, T. 4 S., R. 3 W., between 6,800- and 6,850-ft contours. West Canyon Limestone. Fossils weathering from several feet of argillaceous limestone, beginning 60 ft above base of unit 2 of reference section, 142 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, July 25, 1957.
20330–PC	Fairfield 15-minute quadrangle, Utah County. West Canyon measured section. Same ridge as 20329–PC, approximately at 7,050-ft contour. West Canyon Limestone. Collected from argillaceous and arenaceous limestone near base of unit 5 of reference section, 438 ft above base of formation. Collected by E. W. Tooker and R. J. Roberts, July 25, 1957.
20331–PC	Fairfield 15-minute quadrangle, Utah County. West Canyon measured section. On same ridge as 20329–PC, in SE¼SE¼SW¼ sec. 22, T. 4 S., R. 3 W., approximately at 7,350-ft contour. West Canyon Limestone. Collected from limestone, 40 ft above base of unit 12 of reference section, 1,173 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, July 25, 1957.
20332–PC	Fairfield 15-minute quadrangle, Utah County. West Canyon measured section. On same ridge as 20329–PC, just below 7,500-ft contour. Butterfield Peaks Formation. Collected in limestone, approximately 150 ft above base of unit 3 of reference section, 436 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, July 25, 1957.
20333–PC	Fairfield 15-minute quadrangle, Utah County. West Canyon measured section. Same ridge as 20329–PC, in NW¼SW¼SE¼ sec. 22, T. 4 S., R. 3 W., approximately on 7,650-ft contour. Butterfield Peaks Formation. Collected in limestone, approximately 316 ft above base of unit 3 of reference section, 752 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, July 25, 1957.
21128–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Just above jeep road south of aerial tramway on slope about 20 ft below Provo level (about 4,800-ft contour), in NE¼SE¼ sec. 1, T. 2 S., R. 4 W. Green Ravine Formation. Collected from light-buff-gray argillaceous limestone, 4 ft thick, top of which is 13 ft stratigraphically below base of bed of 20243–PC. Collected by M. Gordon, Jr., H. M. Duncan, E. W. Tooker, and R. A. Lewandowski, September 8, 1962.
21129–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Same locality and approximately same stratigraphic interval as 20246–PC. Collected by M. Gordon, Jr., H. M. Duncan, E. W. Tooker, and R. A. Lewandowski, September 8, 1962.
21130–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Summit of ridge north of Green Ravine, about one-eighth mile east of 5244 knoll; same general locality as 20258–PC. Green Ravine Formation. Collected from 8 ft of dark-gray shaly limestone immediately underlying base of bed of 20258–PC. Collected by M. Gordon, Jr., and R. A. Lewandowski, September 8, 1962.

USGS Colln. No.	Descriptions and collectors
21131–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Same locality and bed as 20257–PC. Green Ravine Formation. Collected from 15 ft of massive dark-gray limestone underlying shaly limestone, in unit 11 of type section. Collected by M. Gordon, Jr., H. M. Duncan, E. W. Tooker, and R. A. Lewandowski, September 8, 1962.
21132–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Along trail about 50 ft above bottom of first ravine north of Green Ravine, on its south slope, in the NW¼SE¼NW¼ sec. 6, T. 2 S., R. 3 W. Approximately same locality and stratigraphic interval as 17144–PC. Green Ravine Formation. Collected through 10 ft of dark-gray silty limestone exhibiting fracture cleavage, in unit 12 of type section. Collected by M. Gordon, Jr., H. M. Duncan, E. W. Tooker, and R. A. Lewandowski, September 8, 1962.
21134–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Near base of south slope of 6231 hill. Same locality as 17145–PC (marked by cairn). Lake Point Limestone. From dark-gray silty limestone, 147—150 ft above base of unit 1 of type section. Collected by M. Gordon, Jr., H. M. Duncan, E. W. Tooker, and R. A. Lewandowski, September 8, 1962.
21135–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Same locality as 17145–PC but 10–15 ft stratigraphically higher. Lake Point Limestone. Collected from 5-ft crinoidal limestone with silicified *Rhipidomella*, 154–159 ft above base of unit 1 of type section. Collected by M. Gordon, Jr., H. M. Duncan, E. W. Tooker, and R. A. Lewandowski, September 9, 1962.
21136–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. On ridge extending southwestward from summit of 6231 hill, approximately at 5,280-ft contour. Lake Point Limestone. Loose block with *Archimedes* on slope, 296 ft stratigraphically below base of unit 4 of type section. Collected by R. A. Lewandowski, September 8, 1962.
21137–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Same locality as 21136–PC but from 4-in. *Archimedes*-bearing limestone bed, 54 ft stratigraphically higher. Collected by M. Gordon, Jr., and R. A. Lewandowski, September 8, 1962.
21138–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Same locality as 21137–PC but from loose block on slope, 12 ft stratigraphically lower and believed to be approximately in place. Collected by M. Gordon, Jr., September 8, 1962.
21139–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. From lower part of cliff-forming limestone bed in the NW¼NW¼NW¼ sec. 6, T. 2 S., R. 3 W., one-fourth mile northwest of line of type section, approximately at 5,200-ft contour. Lake Point Limestone. Collected from massive impure limestone; interval in type section lies in unit 2, 69–76 ft below base of unit 4. Collected by M. Gordon, Jr., H. M. Duncan, E. W. Tooker, and R. A. Lewandowski, September 9, 1962.
21140–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. About 300 yards upslope from 21139–PC in the NE¼NW¼NW¼ sec. 6, T. 2 S., R. 3 W., at about 5,400 ft elevation. Same locality as 16318–PC and 17146–PC. Lake Point Limestone. Brachiopod-bearing gray limestone, base of which is 24 ft stratigraphically above top of cliff-forming limestone (unit 2) and 24 ft below base of *Orygmophyllum*? bed (unit 4). Collected by M. Gordon, Jr., H. M. Duncan, E. W. Tooker, and R. A. Lewandowski, September 9, 1962.
21141–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. On ridge trending southwest from summit of 6231 hill. Same locality as 21140–PC. Lake Point Limestone. Fossils from upper 20 ft of cliff-forming limestone (unit 2 of type section), top of which is 48 ft stratigraphically below base of *Orygmophyllum*? bed (unit 4). Collected by M. Gordon, Jr., E. W. Tooker, and R. A. Lewandowski, September 9, 1962.
21151–PC	Lark 7½-minute quadrangle, Salt Lake County. Fossiliferous limestone exposed on south side of hill at north side of Copper Gulch along line of telephone poles between 6,480 and 6,500 ft in elevation in the SW¼SE¼SE¼ sec. 25, T. 3 S., R. 3 W., a little over 1 mile west of Lark. Same locality as 18892–PC and 20311–PC. Collected by M. Gordon, Jr., H. M. Duncan, E. W. Tooker, and R. A. Lewandowski, September 13, 1962.
21152–PC	Garfield 7½-minute quadrangle, Salt Lake County. Outcrops on north side of Coon Canyon, about 0.1 mile downstream from junction of Left Hand and Right Hand Forks, in the SE¼NW¼NW¼ sec. 14, T. 2 S., R. 3 W. Same locality as 20240–PC and also from outcrops ascending slope to east. Grandeur Member of Park City Formation. Basal 30-ft limestone, unit 1 of Tooker-Roberts section. Collected by M. Gordon, Jr., H. M. Dun-

USGS Colln. No.	Descriptions and collectors
	can, E. W. Tooker, and R. A. Lewandowski, September 13, 1962.
21154–PC	Fairfield 15-minute quadrangle, Utah County. West Canyon measured section. North slope of West Canyon due north of mouth of Maple Canyon and east of unnamed spring, in the SW¼NE¼NW¼ sec. 27, T. 4 S., R. 3 W. West Canyon Limestone. Weathered out fossils from lowest covered outcrop on slope, 100–150 ft above canyon floor. Same locality and approximately same interval as 20329–PC. Collected by M. Gordon, Jr., H. M. Duncan, E. W. Tooker, and R. A. Lewandowski, September 14, 1962.
21155–PC	Fairfield 15-minute quadrangle, Utah County. West Canyon measured section. About 100 yards east of line of section in next little depression on slope. West Canyon Limestone. Silicified bracihopods from 1-ft band in lowest outcrop in place, approximately in middle of interval from which float fossils of 21154–PC were collected, probably in unit 2 of Tooker–Roberts section. Collected by M. Gordon, Jr., H. M. Duncan, E. W. Tooker, and R. A. Lewandowski, September 14, 1962.
21156–PC	Fairfield 15-minute quadrangle, Utah County. West Canyon measured section. From approximate line of section in 2-ft bed in place, roughly 100 ft above base of unit 3 of type section. Collected by M. Gordon, Jr., H. M. Duncan, E. W. Tooker, and R. A. Lewandowski, September 14, 1962.
21157–PC	Fairfield 15-minute quadrangle, Utah County. West Canyon measured section. Fossils weathered out from slightly more than 100 ft of beds in unit 4 of Tooker-Roberts section. Fossils consisted almost exclusively of *Flexaria*. Collected by M. Gordon, Jr., H. M. Duncan, E. W. Tooker, and R. A. Lewandowski, September 14, 1962.
22484–PC	Magna 7½-minute quadrangle, Salt Lake County. SW¼NW¼ sec. 30, T. 1 S., R. 3 W., at 4,800–4,820 ft elevation, on Provo Terrace, west of Magna. Same as 19948–PC. Grandeur Member of Park City Formation. Collected from basal limestone unit. Collected by R. J. Roberts and E. W. Tooker, October 1961.
22486–PC	Bingham Canyon 7½-minute quadrangle, Tooele County. Middle Canyon measured section. On northwest side of ravine in the SE¼NW¼ sec. 6, T. 4 S., R. 3 W., at altitude 6,240 ft. Clipper Ridge Member of Bingham Mine Formation. Collected from thin-bedded limestone, 104 ft above base of unit 2 of type section. Collected by E. W. Tooker and R. J. Roberts, October 1961.
23854–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. On southwest-trending ridge of hill 6231, approximately in NE. cor NW¼NW¼ sec. 6, T. 2 S., R. 3 W., at altitude of approximately 5,850 ft. Lake Point Limestone. Collected from 2-ft bed of gray argillaceous limestone, 15 ft above top of yellowish-brown-weathering bed (unit 8 of type section). Collected by M. Gordon, Jr., and K. R. Moore, August 22, 1969.
23855–PC	Garfield 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section. Southwest-trending ridge of 6231 hill approximately at line between T. 1 S. and T. 2 S. Lake Point Limestone. Collected from 2-ft bed of argillaceous limestone, top of which is 100 ft stratigraphically below top of formation. Collected by M. Gordon, Jr., and K. R. Moore, August 22, 1969.
23890–PC	Bingham Canyon 7½-minute quadrangle, Tooele County. Middle Canyon measured section. On south of 8745 summit, in NE¼SE¼ sec. 31, T. 3 S., R. 3 W., at 8,420-ft contour. Clipper Ridge Member of Bingham Mine Formation. Collected from fine-grained arenaceous limestone, 5 ft above base of unit 18 of type section, 2,957 ft above base of member. Collected by R. J. Roberts and E. W. Tooker, October 1961.

REGISTER OF LATE PALEOZOIC FUSULINID COLLECTING LOCALITIES IN THE OQUIRRH MOUNTAINS, UTAH

Identification of and comments concerning fusulinids by R. C. DOUGLASS

[Dates following Douglass' comments are of his written reports]

USGS Colln. No.	Descriptions and collectors
f20479	Garfield 7½-minute quadrangle, Salt Lake County. Center of east side, SE¼ sec. 22, T. 1 S., R. 3 W., approximately 1 mile north of type section near 4,820-ft contour. Kessler Canyon Formation. Collected from bioclastic limestone lens in fusulinid chert bed 6 ft above base of unit 29, 3,027 ft above base of formation. Collected by R. J. Roberts, 1958. "limestone * * * has been recrystallized, destroying all but gross structures. *Triticites* sp. Possibly a *Pseudofusulinella* also present, but too badly recrystallized for positive identification. Late Pennsylvanian or Early Permian age is indicated." 1959.
f20486	Garfield 7½-minute quadrangle, Tooele County. North slope Rogers Canyon, center sec. 31, T. 1 S., R. 3 W. Erda Formation. Collected from limestone 101 ft above base of unit 3 of type section, 502 ft above base of formation. Collected by R. C. Douglass and R. J. Roberts, 1958. " * * * Sample contains a few scattered specimens of *Profusulinella* which suggests an early Atoka–early Middle Pennsylvanian age." 1961.

USGS Colln. No.	Descriptions and collectors
f21018	Garfield 7½-minute quadrangle, Salt Lake County. West side tributary of Little Valley Wash, SW¼SW¼NE¼ sec. 35, T. 1 S., R. 3 W., at 5,400-ft contour, approximately ¾ mile southeast of type section. Kessler Canyon Formation. Collected from poorly sorted fine-grained sandstone nearly 200 ft above base of unit 37, 4,409 ft above base of formation. Collected by R. J. Roberts, 1958. "* * * Clear area [in sandstone] representing recrystallized fusulines. Some specimens showing a little residual structure. *Triticites* sp. probably Upper Pennsylvanian." 1959.
f22568	Garfield 7½-minute quadrangle, Tooele County, Black Rock Canyon area, same locality as 20232–PC, 1 mile east-northeast of type section, NE¼NW¼ sec. 32, T. 1 S., R. 3 W. Erda Formation. Collected from gray cherty limestone. Collected by E. W. Tooker, 1957. "This sample represents late Middle Pennsylvanian age (Des Moines equivalent). *Climacammina* sp. *Bradyina* sp. *Fusulina* sp. *Wedekindellina*?." 1962.
f22569	Garfield 7½-minute quadrangle, Tooele County. Big Canyon area, 1½ miles south of type section, ½ mile west of tower 7417 on tramway, SW¼NE¼ sec. 7, T. 2 S., R. 3 W., same locality as 20232–PC. Erda Formation. Collected from cherty limestone. Collected by E. W. Tooker, 1957. "This sample represents late Middle Pennsylvanian (Des Moines) age. *Fusulina* sp." 1962.
f22570	Garfield 7½-minute quadrangle, Tooele County. Type locality north side Rogers Canyon, SW¼NE¼ sec. 31, T. 1 S., R. 3 W., near 6,440-ft contour. Erda Formation. Collected from thin-bedded cherty limestone 11 ft above base of unit 24, 2,488 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, 1957. "This sample represents late Middle Pennsylvanian (Des Moines) age. Textularid *Fusulina* sp." 1962.
f22572	Bingham Canyon 7½-minute quadrangle, Tooele County. Ridge nose north of Middle Canyon, NW¼SE¼SE¼ sec. 31, T. 3 S., R. 3 W., 8,440-ft contour southwest of summit 8745. Clipper Ridge Member, Bingham Mine Formation. Collected from limestone at base of unit 18 of type section, a few tens of feet west of the type section, 2,952 ft above base of member, 2,952 ft above base of formation. Collected by R. J. Roberts, 1959. "Fragments of textularids and *Triticites* sp. in a fine sand matrix. The age suggested by the *Triticites* is Late Pennsylvanian, probably Missouri equivalent." 1962.
f22574	Bingham Canyon 7½-minute quadrangle, Tooele County. Ridge nose south north of Middle Canyon, SW¼NE¼SE¼ sec. 31, T. 3 S., R. 3 W., at 7,940-ft contour south-southwest of summit 8745. Clipper Ridge Member, Bingham Mine Formation. Collected from coarse bioclastic limestone at the base of unit 15 of type section, 2,627 ft above base of the member and formation. Collected by R. J. Roberts and E. W. Tooker, 1959. "Coarse bioclastic limestone with textularids and *Triticites* sp. suggesting Late Pennsylvanian age, probably Missouri equivalent." 1962.
f22576	Fairfield 15-minute quadrangle, Tooele County. Ridge on south side of Middle Canyon about 1,000 ft north of 8944 Peak, NE¼NE¼ sec. 12, T. 4 S., R. 4 W., at 8,500-ft contour. Butterfield Peaks Formation. Collected from arenaceous limestone approximately 109 ft above base of unit 33 of type section, 6,476 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, 1959. "Fine sand with textularids and abundant fusulinids including *Fusulina* sp. and *Wedekindellina* sp. The age indicated is Middle Pennsylvanian, Des Moines equivalent." 1962.
f22577	Fairfield 15-minute quadrangle, Utah County. Ridge east of White Pine Canyon, SE¼NW¼, sec. 20, T. 4 S., R. 3 W., at 9,200-ft contour. Butterfield Peaks Formation. Collected from bioclastic limestone 431 ft above base of unit 4 of type section, 1,327 ft above base of formation. Location of colln. 20299–PC. Collected by R. J. Roberts and E. W. Tooker, 1959. "Bioclastic limestone with textularids, *Fusulina* sp. and *Wedekindellina* sp. similar in age to f22576 above." 1962.
f22578	Fairfield 15-minute quadrangle, Tooele-Utah County line. Ridge separating White Pine and West Canyon at 9,750-ft contour, SE¼NW¼ sec. 20, T. 4 S., R. 3 W. Butterfield Peaks Formation. Collected from bioclastic limestone 775 ft above base of unit 5 of type section, 2,301 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, 1959. "Fine bioclastic limestone with *Fusulinella* sp. The age suggested is Middle Pennsylvanian, early Des Moines equivalent," 1962.
f22580	Fairfield 15-minute quadrangle, Tooele County. Ridge southwest of Middle Canyon in saddle south of 8944 Peak, SE½NE¼ sec. 12, T. 4 S., R. 4 W. Butterfield Peaks Formation. Collected from bioclastic limestone layer in cherty

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	limestone 175 ft above base of unit 26 of type section, 5,429 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, 1959. "Bioclastic limestone with textularids and abundant *Fusulina* sp. of an advanced type. The age indicated is Middle Pennsylvanian, late Des Moines equivalent." 1962.
f22581	Fairfield 15-minute quadrangle, Tooele County. Same locality as f22580, about 3 ft higher in section. Collected by R. J. Roberts and E. W. Tooker, 1959. "The lithology and fauna are similar and the same age is suggested." 1962.
f22582	Fairfield 15-minute quadrangle, Tooele County. Same locality as f22580, 20 ft higher in section. Butterfield Peaks Formation. Collected from silty bioclastic limestone of type section. Collected by R. J. Roberts and E. W. Tooker, 1959. "The limestone * * * contains abundant bryozoa in addition to the *Fusulina* sp. The age suggested is still Middle Pennsylvanian, late Des Moines equivalent." 1962.
f22583	Fairfield 15-minute quadrangle, Tooele County. Ridge southwest of Middle Canyon, 8944 Peak, NE¼NE¼, sec. 12, T. 4 S., R. 4 W. Butterfield Peaks Formation. Collected from arenaceous limestone 12 ft above base of unit 31 of type section, 6,048 ft above base of formation. Collected by E. W. Tooker and R. J. Roberts, 1959. "Fine sand with *Fusulinella* sp. The age suggested is Middle Pennsylvania." 1962.
f22584	Fairfield 15-minute quadrangle, Tooele County. Same locality as f22583, but 33 ft higher stratigraphically. Butterfield Peaks Formation. Collected from fine sand of type section. Collected by E. W. Tooker and R. J. Roberts, 1959. "Fine sand with *Fusulina* sp. The age suggested is Middle Pennsylvanian, Des Moines equivalent." 1962.
f22588	Garfield 7½-minute quadrangle, Salt Lake County. Nose of ridge on slope southeast of Kessler Canyon, west of Peak 5984, center SE¼SE¼ sec. 27, T. 1 S., R. 3 W., approximately at 5,720-ft contour. Kessler Canyon Formation. Collected from arenaceous limestone 92 ft above base of unit 21 of type section, 2,221 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, 1959. "The rock of this sample is completely altered. It looks like it may have been a fine bioclastic limestone, and it apparently contained small brachiopods and fusulinids. Only the gross features of the fusulinids are left, and I would not feel safe in any generic identification of this material. Comparisons with the other samples from the area suggest closest relationship to some of the *Triticites* of Late Pennsylvanian age, but I certainly couldn't count on this. Early Pennsylvanian and Permian ages are not likely." 1962.
f22597	Bingham Canyon 7½-minute quadrangle, Tooele County. North side Middle Canyon, ridge leading to Peak 8745, center west side NE¼ sec. 6, T. 4 S., R. 4 W., at 6,360-ft contour. Clipper Ridge Member, Bingham Mine Formation. Collected from arenaceous limestone in the lower 8 ft of unit 2 of type section, 10 ft above base of member and the formation. Collected by R. J. Roberts and E. W. Tooker, 1961. "Fine sand with scattered worn *Triticites* sp. The age suggested is Late Pennsylvanian, Missouri equivalent." 1962.
f22598	Bingham Canyon 7½-minute quadrangle, Tooele County. Same locality as f22597, NW¼NE¼, sec. 6, T. 4 S., R. 3 W., at 7,760-ft contour. Clipper Ridge Member, Bingham Mine Formation. Collected from arenaceous limestone about 7 ft above base of unit 6 of type section, 1,284 ft above base of the member and the formation. Collected by E. W. Tooker and R. J. Roberts, 1961. "Fine sand with abundant *Triticites* sp. The age suggested is Late Pennsylvania, Missouri equivalent." 1962.
f22599	Bingham Canyon 7½-minute quadrangle, Tooele County. Same locality as f22597, SW¼SE¼ sec. 31, T. 3 S., R. 3 W., at 7,760-ft contour. Clipper Ridge Member, Bingham Mine Formation. Collected from arenaceous limestone 2 ft above base of unit 9 of type section, 1,967 ft above base of the member and of the formation. Collected by R. J. Roberts and E. W. Tooker, 1961. "Fine sand with fragments of *Triticites* sp. The age is probably still Missouri equivalent." 1962.
f22600	Bingham Canyon 7½-minute quadrangle, Tooele County. Ridge on north side Middle Canyon, south of Peak 8745, SW¼SE¼ sec. 31, T. 3 S., R. 3 W., at 8,000-ft contour. Clipper Ridge Member, Bingham Mine Formation. Collected from 2-ft-thick coarse bioclastic limestone 309 ft above base of unit 11 of type section, 2,379 ft above base of member and formation.. Collected by R. J. Roberts and E. W. Tooker, 1961. "Coarse bioclastic limestone with *Bradyina* sp., bryozoa, and *Triticites* sp. The age suggested is still Late Pennsylvanian, Missouri equivalent." 1962.
f22601	Bingham Canyon 7½-minute quadrangle, Tooele County. Same locality as f22600, NW¼SE¼

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	sec. 31, T. 3 S., R 3 W., at 8,280-ft contour. Clipper Ridge Member, Bingham Mine Formation. Collected from fine-grained arenaceous limestone 3–5 ft above base of unit 16 of type section, 2,772 ft above base of member and formation. Collected by E. W. Tooker and R. J. Roberts, 1961. "Fine sand with fragments of textularids and *Triticites* sp. of Late Pennsylvanian age." 1962.
f22602	Bingham Canyon 7½-minute quadrangle, Tooele County. Same locality as f22600, NW¼SE¼ sec. 31, T. 3 S., R. 3 W., at 8,300-ft contour. Clipper Ridge Member, Bingham Mine Formation. Collected from fine-grained arenaceous limestone 21 ft above base of unit 16 of type section, 2,790 ft above base of member and formation. Collected by R. J. Roberts and E. W. Tooker, 1961. "Fine sand with *Triticites* sp. This sample looks more advanced than the others along this line of section. If I saw it by itself, I would call it Virgil equivalent. It may be late Missouri, however." 1962.
f22603	Bingham Canyon 7½-minute quadrangle, Tooele County. Same locality as f22600, NE¼SE¼ sec. 31, T. 3 S., R. 3 W., at 8,420-ft contour. Clipper Ridge Member, Bingham Mine Formation. Collected from fine-grained arenaceous limestone 5 ft above base of unit 18 of type section, 2,957 ft above base of member and formation. Collected by R. J. Roberts and E. W. Tooker, 1961. "Fine sand with textularids and *Triticites* sp. Again, this sample has an early Virgil aspect but could be late Missouri." 1962.
f22604	Bingham Canyon 7½-minute quadrangle, Tooele County. Same locality as f22600, NE¼SE¼ sec. 31, T. 3 S., R. 3 W., at 8,440-ft contour. Clipper Ridge Member, Bingham Mine Formation. Collected from arenaceous limestone at base of unit 20 of type section, 2,980 ft above base of member and formation. Collected by R. J. Roberts and E. W. Tooker, 1961. " * * * Includes some specimens of *Triticites* sp. [and] * * * common ?*Kansanella* sp., a form originally described from beds of Missouri age in the midcontinent area. *Millerella* sp. and the bryozoans are also found in this sample. The range of *Kansanella* in the Basin Ranges is not yet established." 1962.
f23112	Bingham Canyon 7½-minute quadrangle, Tooele County. Ridge between Peak 8745 and 8536, SW¼NE¼NE¼ sec. 31, T. 3 S., R. 3 W., at 8,600-ft contour. Markham Peak Member, Bingham Mine Formation. Collected from silty limestone of unit 10 of type section, 883 ft above base of member, 3,868 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, 1963. "Recrystallized specimens of small fusulinids which resemble the *Triticites* of many of the other samples in size and shape, but which are indeterminate." 1964.
f23105	Bingham Canyon 7½-minute quadrangle, Tooele County. Clipper Ridge north of Middle Canyon, NE¼SE¼SW¼ sec. 36, T. 3 S., R. 3 W., at 6,280-ft contour. Markham Peak Member, Bingham Mine Formation. Collected from arenaceous limestone approximately 53 ft above base of unit 11 (in reference section) about 1 mile west of type section, 940 ft above base of member. Collected by R. J. Roberts and E. W. Tooker, 1963. "*Triticites* sp." 1964.
f23106	Bingham Canyon 7½-minute quadrangle, Tooele County. Same locality as f23105 but 20 ft higher in section. Markham Peak Member, Bingham Mine Formation. Collected from arenaceous limestone of unit 14. Collected by R. J. Roberts and E. W. Tooker, 1963. "*Triticites* sp." 1964.
f23107	Bingham Canyon 7½-minute quadrangle, Tooele County. Same locality as f22105, but 85 ft higher in section. Markham Peak Member, Bingham Mine Formation. Collected from arenaceous limestone of unit 14 in reference section. Collected by R. J. Roberts and E. W. Tooker, 1963. "*Triticites* sp. *Climacammina*" 1964.
f23108	Bingham Canyon 7½-minute quadrangle, Tooele County. Same locality as f22105. Markham Peak Member, Bingham Mine Formation. Collected from cherty arenaceous limestone 104 ft above base of unit 14 of reference section, 1 mile west of type section, 1,566 ft above base of member, 4,551 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, 1963. "*Triticites* sp.—abundant and well preserved. *Climacammina* sp." 1964.
f23109	Bingham Canyon 7½-minute quadrangle, Tooele County. Same locality as f23108, but 37 ft higher in section. Markham Peak Member, Bingham Mine Formation. Collected from limestone of unit 14 of reference section. Collected by R. J. Roberts and E. W. Tooker. "*Triticites* sp." 1964.
f23111	Bingham Canyon 7½-minute quadrangle, Tooele County. Ridge west of Spring Canyon, north center SE¼NW¼ sec. 30, T. 3 S., R. 3 W., at 7,125-ft contour. Markham Peak Member, Bingham Mine Formation. Collected from sandy limestone 14 ft above base of unit 15

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	of type section, 2,547 ft above base of member, 5,532 ft above base of formation. Collected by R. J. Roberts and E. W. Tooker, 1963. "*Triticites* sp. but reworked specimens." 1964.
f22431	Bingham Canyon 7½-minute quadrangle, Tooele-Salt Lake Counties. Ridge northeast of Clipper Peak separating Baltimore Gulch and Bingham Canyon, immediately north of abandoned tramway, NE¼SE¼SE¼ sec. 28, T. 3 S., R. 3 W., at 8,340-ft contour. Markham Peak Member, Bingham Mine Formation. Collected from limestone at base of unit 11 (1 mile south along ridge from measured section), approximately 1,370 ft above base of member, 4,355 ft above base of formation. Collected by E. W. Tooker and R. J. Roberts, 1964. "*Triticites* sp." 1966.
f23432	Bingham Canyon 7½-minute quadrangle, Salt Lake County. Ridge east from Markham Peak, center south edge SE¼NW¼ sec. 22, T. 3 S., R. 3 W., at about 8,000-ft contour. Markham Peak Member, Bingham Mine Formation. Collected from calcareous sandstone 76 ft above base of unit 13 of Markham Peak (continuation of the upper part) type section, 1,446 ft above base of member, 4,431 ft above base of formation. Collected by E. W. Tooker and W. J. Moore, 1964. "*Triticites* sp. *Pseudofusulinella* sp." 1966.
f23433	Bingham Canyon 7½-minute quadrangle, Salt Lake County. Same locality as f23432, at about 8,080-ft contour. Markham Peak Member, Bingham Mine Formation. Collected from calcareous sandstone 224 ft above base of unit 13 in Markham Peak type section, 1,594 ft above base of member, 4,579 ft above base of formation. Collected by E. W. Tooker and W. J. Moore, 1964. "The fusulinids are recrystallized, obliterating almost all structure. They appear to represent a large *Triticites* suggestive of a Virgil age." 1966.

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