Devonian and Mississippian Rocks and the Date of the Roberts Mountains Thrust In the Carlin-Pinon Range Area, Nevada

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Prepared in cooperation with the Nevada Bureau of Mines

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By J. FRED SMITH, JR., *and* KEITH B. KETNER

CONTRIBUTIONS TO GENERAL GEOLOGY

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By J. Fred Smith, Jr., and Keith B. Ketner

ABSTRACT

Devonian and Mississippian rocks of the Carlin–Pinon Range area are separated into eight principal units. Two Devonian units make up the carbonate (eastern) assemblage, one the siliceous (western) assemblage and one the transitional assemblage. Mississippian units compose an overlap assemblage that is unconformable on the lower Paleozoic rocks.

Mississippian rocks overlie unconformably Devonian and older rocks of both siliceous and carbonate assemblages, and this relation serves to date the Roberts Mountains thrust in this area. The youngest strata involved in the thrusting are of late Late Devonian age. The oldest strata that rest unconformably on both lower and upper plate rocks of the thrust are at least as old as late Kinderhook or Early Mississippian age. Movement of upper plate rocks of the Roberts Mountains thrust into the Carlin–Pinon Range area, then, probably started in late Late Devonian time and must have been concluded no later than late Kinderhook time of the Early Mississippian.

INTRODUCTION

Lower Paleozoic rocks in north-central Nevada are separable into three broad groupings: a carbonate (eastern) assemblage deposited in the Cordilleran miogeosyncline; a siliceous (western) assemblage deposited in a eugeosyncline to the west; and a transitional assemblage that contains lithologic types found in both of the other two. These assemblages of sedimentary rocks were brought together by movement along the Roberts Mountains thrust (Merriam and Anderson, 1942) during the Antler orogeny, and then covered unconformably by younger Paleozoic sedimentary rocks which make up an overlap assemblage. (For discussion of the general relations see Roberts and others, 1958.)

In the Carlin–Pinon Range area in northeastern Nevada (fig. 1) the Devonian and Mississippian rocks of the general stratigraphic section are classified into eight units (fig. 2). Four of the units are recognized as established formations in the region, two are given new formation names, one will be named by others as a result of studies in an adjoining area to the south, and one is unnamed because it is not yet recognized over a large enough area to warrant formation status.

The youngest beds involved in movement along the Roberts Mountains thrust are of late Late Devonian age, and the oldest beds of the overlap assemblage are of early Early Mississippian age, so that beds moved along the Roberts Mountains thrust probably reached this area in latest Devonian or earliest Mississippian time.

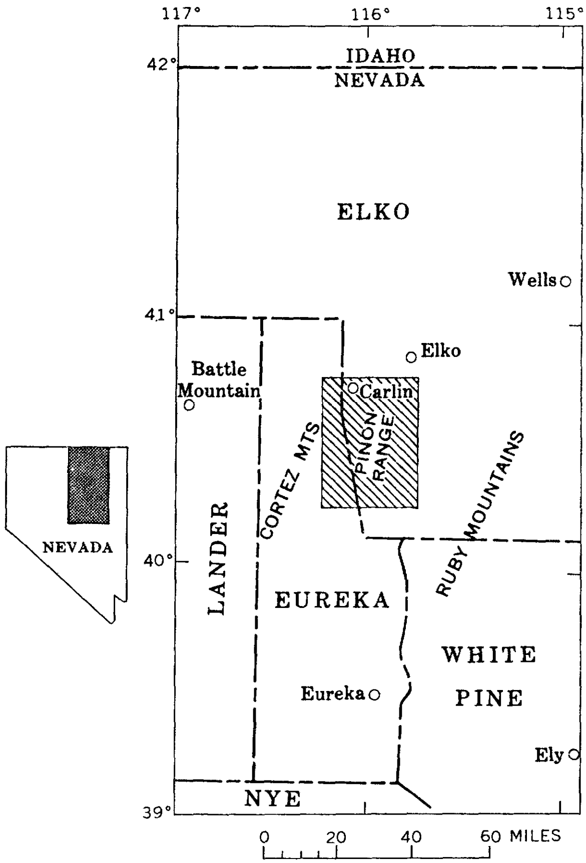


Figure 1.—Location of the Carlin–Pinon Range area.

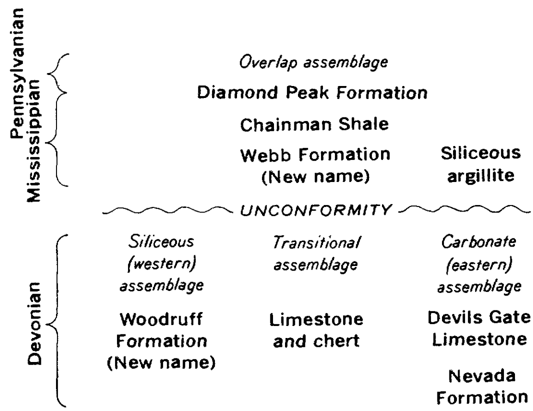


FIGURE 2.—Devonian and Mississippian rocks in the Carlin–Pinon Range area.

DEVONIAN SYSTEM

CARBONATE (EASTERN) ASSEMBLAGE ROCKS

NEVADA FORMATION AND DEVILS GATE LIMESTONE

Carbonate-assemblage rocks of Devonian age comprise the Nevada Formation and the Devils Gate Limestone. (See Nolan and others, 1956, p. 40–52, for general descriptions and regional relations.) These units form the core of the Pinon Range in the southern quarter of the range and for about 5 miles in the center of the range (fig. 3).

The Nevada Formation in the Pinon Range consists of three members; dolomite makes up most of the lower and upper members, and sandy and quartzitic rocks make up the middle member (Carlisle and others, 1957). No complete section of the Nevada Formation is exposed in any one part of the report area, but the composite total thickness of several partial sections indicates a maximum thickness of about 3,200 feet.

The Early and Middle Devonian age of the Nevada was established by studies south of the report area (Merriam, 1940, p. 50–59; Nolan and others, 1956, p. 46–47; Carlisle and others, 1957, p. 2185–2188; Johnson, 1962). Fossils are scarce and poorly preserved in the formation in the Carlin–Pinon Range area.

The Devils Gate Limestone is composed mostly of medium- to thick-bedded light- and dark-gray fine-textured limestone which weathers gray and bluish gray. The maximum measured thickness is 940 feet, which can be taken as a minimum figure for the original thickness.

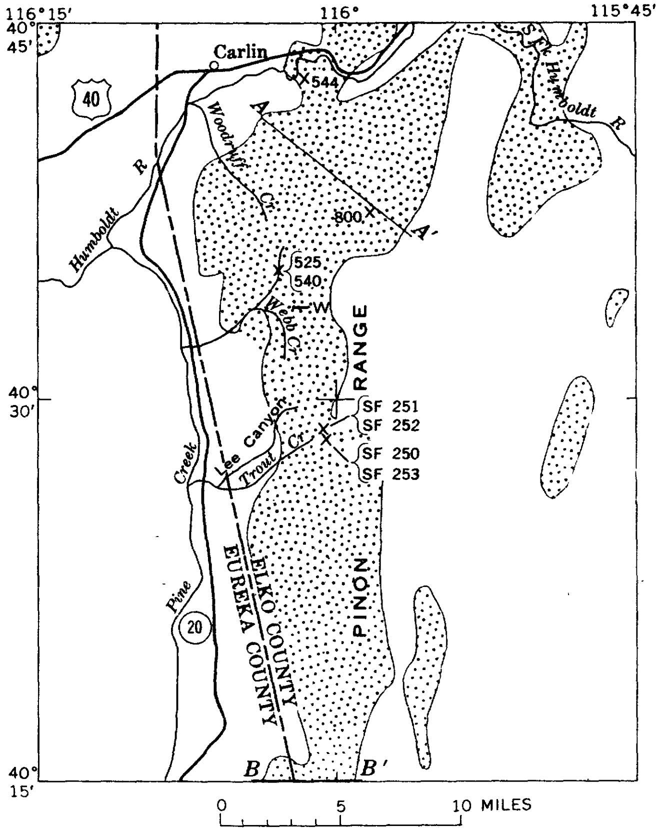


FIGURE 3.—Generalized outcrop areas (stippled) of Paleozoic rocks in the Carlin-Pinon Range area. Type section of the Webb Formation is indicated by W. Fossil localities mentioned in the text are identified by numbers. *A–A'* and *B–B'* are locations of sections shown in figure 4 (p. I 16).

SILICEOUS (WESTERN) ASSEMBLAGE ROCKS

WOODRUFF FORMATION

A thick unit of siliceous-assemblage rocks of Devonian age differs from previously recognized formations in the region and is named the Woodruff Formation in this report. The type area is along and near the upper part of Woodruff Creek (fig. 3), principally in secs. 24 and 25, T. 32 N., R. 52 E., and sec. 30, T. 32 N., R. 53 E. The Woodruff is also exposed elsewhere in the Pinon Range and forms about a 4-mile-long band of outcrop along the west side of the range at the south end of the area.

Contacts between the Woodruff and other formations are either faults or unconformities. In the southern part of the area the lowest exposed beds of the Woodruff are at the Roberts Mountains thrust. Elsewhere the lowest exposed beds are at thrust faults of lesser magnitude. The Woodruff is overlain unconformably by beds of Early Mississippian age.

The Woodruff consist principally of siliceous mudstone and chert; it contains lesser amounts of shale, siltstone, dolomitic siltstone, and dolomite and a few lenses of limestone and very few beds of sandy limestone and calcareous sandstone. The siliceous mudstone, chert, and shale are mostly dark gray to black and weather the same, so that slopes covered by weathered fragments commonly are dark. Other lithologic types are mostly tan and, locally, light gray and weather the same colors. Lack of marker beds and irregular bedding attitudes preclude accurate thickness measurements of the Woodruff. The thickness must be 3,000 feet in the southern part of the area and may be several thousand feet more than that in the entire area.

The oldest part of the formation, as established by fossils, consists of black to pale-brown siltstone in beds about 1–6 inches thick. Some of these beds are calcareous; others are carbonaceous and sooty. Oval to round nodules, which have high calcium and phosphate contents and are as much as 1½ inches across, are prominent in these beds locally.

In its type area, the Woodruff consists of siliceous mudstone and chert, and lesser amounts of shale and dolomite. The mudstone is carbonaceous and is brown to gray on fresh surfaces and light gray on weathered ones, and it breaks into tabular nonfissile chips about ½–4 inches across; in places a soft soil has been developed on slopes underlain by the mudstone. The chert, which forms prominent exposures locally, is mainly black and weathers gray to brown. Bedding in the chert generally is 1–4 inches thick, but laminae a few millimeters thick are visible on weathered surfaces of some layers. Argillaceous partings are common. Abundant spheres and elongate pods of white chert one-fourth inch across and up to 4 inches long contrast with the dark chert. The chert is very brittle and breaks with an uneven to conchoidal fracture. Examination of thin sections indicates that the chert contains argillaceous material, commonly abundant organic material, and many spheres of radiolarian tests and molds. Detrital grains of quartz form as much as 1 percent of some thin sections. Round nodules mostly ½–1 inch in diameter and commonly gray to black occur locally in the chert and in the mudstone. Shale, which makes up a minor amount of the formation in the type area, is dark gray, siliceous, and poorly fissile.

Gray to brown dolomite that weathers yellow to brown forms a small but conspicuous part of the formation. Dolomite beds are ¼–6 inches thick, and some have prominent laminae about 1 mm thick. In thin section the dolomite is seen to consist mostly of dolomite rhombohedrons, which range in length from 0.005 to 0.03 mm. Some rhombs have rounded edges, and others do not; evidently some are clastic grains and others are diagenetic or primary grains or secondary crystals. One thin section contains 95 percent dolomite grains between 0.01 and 0.03 mm in diameter that appear to be mostly clastic fragments and 5 percent rounded quartz grains of the same size; all grains are set in a dolomite cement. Quartz grains compose as much as 50 percent of some thin sections; they range from 0.01 to 0.04 mm in diameter and are subangular to rounded. Clastic grains of barite or possibly of carbonate minerals replaced by barite occur in a few places.

Woodruff units exposed away from the type area include characteristic gray to tan dolomitic siltstone and claystone, which weather tan and buff and break into platy pieces and into irregularly shaped fragments mostly 1–2 inches across. These rocks are in beds mainly one-half inch thick or less and, at many places, composed of laminae 0.1–0.2 mm thick. In thin sections these rocks are seen to consist of dolomite grains that range mostly from 0.005 to 0.05 mm across. Quartz grains form less than 5 percent of most sections and less than 1 percent of some. Light-colored calcareous shale and shaly dolomite with pink and lavender tints and black shale that weathers to form splintery fragments up to about 3 inches long are distinctive lithologic types in the southern part of the report area. Very carbonaceous black to brown siltstone, *Tentaculites*-bearing gray limestone in a few thin lenses, and coarse-grained sandy limestone and calcareous sandstone make up a very small part of the formation.

The beds that are considered youngest, on the basis of fossil evidence, consist of dark-gray to black siliceous shale; they are exposed near the central part of the type area. Because of structural complexities, the exact stratigraphic position of these beds in the formation is not determinable.

The Devonian age of the Woodruff Formation is based on conodonts, goniatites, and graptolites. Conodonts were found in several localities, goniatites in one, graptolites in one, and clawlike rami of *Angustidontus* in many.

The oldest dated beds in the Woodruff cover a small area in the eastern part of sec. 33 and the western part of sec. 34, T. 32 N., R. 52 E. Conodonts collected there by David L. Clark of the University of Wisconsin and Raymond L. Ethington of the University of Missouri are of Early Devonian age (D. L. Clark, written commun., 1963). The graptolite *Monograptus hercynicus* from beds near those containing the conodonts is also of Devonian age (Berry, 1967, p. B27). Other beds from this same locality contain abundant *Tasmanites* (J. M. Schopf, written commun., 1957).

Clawlike or jawlike rami of the fish *Angustidontus* (Jean M. Berdan, written commun., 1964) are so widespread in the formation that with diligent search one can find them almost anywhere in the gray shale or mudstone, the tan-weathering dolomitic siltstone, and the black splintery shale. Two collections (USGS 4981–SD and 4982–SD) containing *Angustidontus* also contain goniatites of the genus *Platyclymenia* (*Pleuroclymenia*), according to Mackenzie Gordon, Jr. (written commun., 1958), who stated that this fossil is found in rocks about equivalent to the middle Famennian of Europe. The ages of two conodont collections were reported by the late W. H. Hass (written commun., 1959) to be Middle or early Late Devonian chiefly on the basis of the forms *Polygnathus linguiformis* and *Polygnathus pennata.* D. L. Clark (written commun., 1961) considered two of the three conodont collections he studied to be medial Late Devonian in age and one to be early Late Devonian.

The Woodruff Formation, then, seems to be an age equivalent of the Nevada Formation, the Devils Gate Limestone, and the lower part of the Pilot Shale. The youngest dated beds are in the *Platyclymenia* zone, about the middle of the Famennian of Europe, or late Late Devonian. This age is of critical importance in dating the Roberts Mountains thrust, as these are the youngest siliceous-assemblage rocks involved in the thrusting.

The Slaven Chert, which consists of gray to black chert, less dark shale and sandstone, and a small amount of limestone, crops out in the Shoshone Range (Gilluly and Gates, 1965, p. 37–42) and in the southern part of the Cortez Mountains (Gilluly and Masursky, 1965, p. 59–61) west of the Carlin–Pinon Range area. The Slaven, like the Woodruff, is a siliceous-assemblage unit in the upper plate of the Roberts Mountains thrust, but the Woodruff differs from it chiefly in containing relatively much less chert and much more very fine grained clastic siliceous rock and fine-grained dolomite. The Slaven Chert is of Middle Devonian and possibly of Late Devonian age (Gilluly and Gates, 1965, p. 41), and the Woodruff Formation is of Early to Late Devonian age; so the two formations are in part equivalent.

TRANSITIONAL-ASSEMBLAGE ROCKS

Devonian rocks placed in the transitional assemblage in the Carlin–Pinon Range area consist of limestone, sandy limestone, and chert, and thus have lithologic types common to both the carbonate and siliceous assemblages. This transitional unit has been studied in the Sulphur Springs Range south of this report area by Donald Carlisle and others, who plan to give the unit a formal name.

The Devonian age of this unit in the Carlin–Pinon Range area is based on four conodont collections from sandy limestones which also contain *Tentaculites* in places. These collections probably are Middle Devonian and possibly early Late Devonian (W. H. Hass, written commun., 1958). This unnamed unit and the Woodruff Formation are at least in part age equivalents. The unit also is equivalent to the Devils Gate Limestone and may be equivalent to the upper part of the Nevada Formation. Contacts between this unnamed formation and other Paleozoic formations probably are faults.

MISSISSIPPIAN SYSTEM

OVERLAP ASSEMBLAGE

WEBB FORMATION

Mississippian and younger rocks that are unconformable on siliceous- and carbonate-assemblage units brought together by the Roberts Mountains thrust have been called the overlap assemblage (Roberts and Lehner, 1955; Roberts and others, 1958, p. 2838–2839). The oldest Mississippian rocks in the Carlin–Pinon Range area are mostly siliceous mudstone and claystone; sandstone and limestone occur in much smaller amounts. This sequence is here named the Webb Formation for exposures near Webb Creek. The designated type section is near the north edge of sec. 19, T. 31 N., R. 53 E., and in the SE¼ sec. 13, T. 31 N., R. 52 E., where only the mudstone is well exposed in many places.

The following type section of the Webb Formation was measured by use of an Abney level mounted on a Jacob's staff. Location of section is shown in figure 3.

	Thickness (ft)
Mississippian System:	
Chainman Shale.	
Gradational contact.	
Webb Formation:	
3. Mudstone, very dark gray; weathers gray and brown; siliceous; contains minute hollow spheres having septa; some beds near top are finer grained than most and are black and argillitic; barite nodules at top	385
2. Mudstone, gray; weathers light gray to tan; siliceous; coarser grained than units above and below, some beds are sandy; breaks into larger pieces than units above and below, some pieces about 6 in. across	250
1. Mudstone, gray; weathers brown; siliceous; breaks into chips about 2 in. across; many minute spheres with septa	100
Total thickness	735
Contact uncomformable; poorly exposed.	
Woodruff Formation.	

In the north half of the area the Webb Formation occurs as a wedge-shaped mass that is thickest at the north and pinches out between the type section and the head of Webb Creek. To the south it crops out in lenticular bodies. It is 735 feet thick at the type section and at least 800 feet thick to the north. Lenticular bodies east and north of the upper part of Trout Creek may be 300 feet thick in places; these bodies consist of limestone, less shale, and a very small amount of chert. The most southerly exposure of the Webb is limestone.

The siliceous mudstone and claystone of the Webb Formation are mostly gray and weather gray to brown; a few beds have a pink cast. Some strata, particularly near the top of the formation, are black and weather black; they are argillitic and finer grained than most beds in the formation. All these rocks are thin bedded, a few are faintly laminated, and some are shaly. They break into chips and chunky fragments, mostly about 2 inches across. Spicules are abundant locally in the mudstone. In thin section the mudstone is seen to consist of angular grains of quartz and chert, each forming about 10 percent of the section, set in a submicroscopic matrix. The grains have diameters of about 0.05 mm. Some of the chert appears to be in small chalcedonic nodules that probably are recrystallized radiolarians. Hematite is abundant. Composition of Webb Formation siliceous mudstone is shown by chemical analyses of three samples (table 1).

TABLE 1.—*Chemical analyses (in weight percent) of samples of siliceous mudstone from the Webb Formation, Carlin–Pinon Range area, Nevada*

[Analysts, Paul Elmore, Samuel Botts, and Gillison Chloe, 1962; rapid rock analyses by methods similar to those described by Shapiro and Brannock (1962)]

Lab No	159697	159698	159699
Field No	525	823–B	872
SiO_2	84.0	84.2	86.4
Al_2O_3	4.0	6.6	4.8
Fe_2O_3	.38	.72	.36
FeO	.56	.15	.22
MgO	.74	.43	.40
CaO	.67	.04	.02
Na_2O	.12	.14	.12
K_2O	.89	1.6	1.2
TiO_2	.22	.33	.29
P_2O_5	.13	.12	.08
MnO	.01	.00	.00
Loss on ignition (1,050°)	7.0	4.7	3.5
Total C [1]	3.54	.16	.43
H_2O^-	.52	.76	.74
H_2O^+	2.5	2.5	2.2
CO_2	.06	<.05	<.05
Acid insoluble	----------	----------	[2] 2.7

[1] Determined by I. C. Frost, 1962.
[2] Chiefly barite.

In places, thin layers of sandstone made of many grains as large as medium-sand size and sparse grains of very coarse sand size are interbedded with the mudstone. A thin section of the sandstone shows well-rounded chert and quartz grains. The chert grains are 0.1–0.5 mm in diameter and make up 85 percent of the grains; the quartz grains are 0.1–1.5 mm in diameter. Chert forms the cement. Hematite and limonite stains are prominent.

Limestone in the Webb Formation occurs in lenses mostly 1–30 feet thick and up to about 1½ miles long. One lens is almost 200 feet thick. The lenses are in the upper part of the formation and at the very top in some places. The rock is black to gray, generally weathers tan, is thin bedded, and commonly breaks down into platy fragments that litter a slope. Thin sections of the limestone from separated localities reveal that calcite grains from 0.003 to 0.03 mm across are its chief constituent. Quartz is less abundant and occurs as silt-size clastic grains; some of the quartz is partly replaced by a carbonate mineral. Chemical analyses of five samples of this rock by James A. Thomas of the U.S. Geological Survey show that it contains more noncarbonate material than is recognized in thin sections because of its fine grain size. Total calculated carbonate is only about 47–65 percent. All the thin sections contain sparse to abundant vague spherical microfossils, probably radiolarians, which are mostly 0.03–0.1 mm in diameter and are largely recrystallized. Vague irregularly shaped microfossils are also present but are much less common than the spherical ones.

Claystone nodules, many of which contain barite, and barite nodules occur at the top of the formation in many places and also in the lower beds of the overlying Chainman Shale. Beds of gray to black chert, generally 1 inch thick or less, crop out at a very few places in the Webb Formation.

The basal contact of the Webb is an unconformity along which the formation lies on Devils Gate Limestone of the carbonate assemblage and on the Ordovician Vinini Formation and the Devonian Woodruff Formation of the siliceous assemblage. Where the Webb rests on Devils Gate, bedding attitudes in the two formations are so nearly the same that the units appear to be conformable. Fossil ages, however, indicate a hiatus, and lateral relations across the area demonstrate the unconformity.

The conformable contact between the Webb Formation and the overlying Chainman Shale is gradational at some places and abrupt at others. The upper beds of the Webb generally are hard siliceous mudstone or shale and dark limestone in a few places, whereas the basal beds of the Chainman generally are soft gray shale. Barite nodules commonly occur at or very near this contact.

The Early Mississippian age of the Webb Formation is established on the basis of conodonts (table 2) studied by the late W. H. Hass, John W. Huddle of the U.S. Geological Survey, and David L. Clark of the University of Wisconsin.

TABLE 2.—Conodonts from the Webb Formation

[Fossil-collection localities shown in fig. 3]

USGS fossil colln. No. Field colln. No.	17304–PC 525 [1]	17306–PC 540 [1]	17303–PC 544 [2]	22839–PC 800 [3]	SF–251 SF–252 [4]	SF–250 SF–253 [4]
Bryantodus sp.	X	X	----------	----------	----------	----------
Dinodus fragosus (E. R. Branson).	X	----------	----------	X	----------	----------
Elictognathus lacerata (Branson and Mehl).	X	----------	----------	----------	----------	----------
Elictognathus sp.	----------	----------	----------	X	----------	----------
Gnathodus punctatus (Cooper)	----------	X	----------	----------	----------	----------
Gnathodus aff. *G. punctatus* (Cooper).	----------	----------	----------	X	----------	----------
Hibbardella sp.	----------	----------	----------	X	----------	----------
Hindeodella sp.	----------	----------	----------	X	----------	----------
Hindeodella spp.	X	----------	----------	----------	----------	----------
Icriodus sp. (regarded as reworked).	----------	----------	----------	X	----------	----------
Ligonodina sp.	----------	----------	----------	X	----------	----------
Lonchodina sp.	----------	----------	----------	X	----------	----------
Neoprioniodus sp.	----------	----------	----------	X	----------	----------
Ozarkodina sp.	X	----------	----------	X	----------	----------
Pinacognathus? sp.	----------	----------	----------	X	----------	----------
Polygnathus communis Branson and Mehl.	----------	----------	X	----------	----------	----------
Polygnathus inornata E. R. Branson.	----------	X	----------	X	----------	----------
Polygnathus sp.	X	X	----------	----------	----------	----------
Polygnathus spp.	----------	X	----------	----------	----------	----------
Siphonodella cooperi Hass.	----------	X	----------	----------	----------	----------
Siphonodella obsoleta Hass.	----------	X	----------	X	----------	----------
Siphonodella cf. *S. obsoleta* Hass.	----------	----------	X	----------	----------	----------
Siphonodella duplica (Branson and Mehl).	----------	----------	----------	----------	----------	X
Siphonodella quadruplicata (Branson and Mehl).	X	----------	----------	----------	X	----------
Siphonodella sp.	----------	X	----------	----------	----------	X
Siphonodella spp.	X	----------	----------	----------	----------	----------
Spathognathodus sp.	X	----------	----------	----------	----------	----------
Spathognathodus 2 species.	----------	----------	----------	X	----------	----------
Synprioniodina sp.	X	----------	----------	----------	----------	----------

[1] Collections from mudstone, argillitic in places, from near top of formation. Identifications by the late W. H. Hass.
[2] Collection from limestone near top of formation. Identifications by W. H. Hass.
[3] Collection from limestone at top of formation. Identifications by John W. Huddle, U.S. Geological Survey.
[4] Collections from sandstone in a mostly mudstone sequence near base of formation. Identifications by David L. Clark, University of Wisconsin.

According to Hass, collections 525, 540, and 544 are all of Early Mississippian age (equivalent to the Kinderhook Series). Regarding the age of collection 540 Hass wrote (1959):

> This collection comes from rocks of Early Mississippian age. In the Llano region of Texas, the specifically identified conodonts in the list are present in a faunal zone of the Chappel limestone; which zone is considered to be of late Kinderhook (Chouteau) age on the basis of megafossils. These same conodont species are present in other late Kinderhook rocks, including the Welden limestone of Oklahoma.

Huddle reported (written commun., 1962), concerning collection 800, that *Siphonodella obsoleta* Hass makes up about 80 percent of the specimens recovered and *Gnathodus* aff. *G. punctatus* (Cooper) about 10 percent. He stated that the presence of these species "suggests a correlation of the rock containing them with the Chappel Limestone of Texas and the Chouteau Limestone of the Mississippi Valley * * *. The rock containing this conodont fauna is probably Early Mississippian in age."

As reported by Clark (written commun., 1963), the four collections he studied are Early Mississippian in age, and probably early, although not the earliest, Kinderhook.

The Early Mississippian age of the Webb Formation makes it probably equivalent to at least part of the Joana Limestone (Nolan and others, 1956, p. 54–56; Langenheim, 1960, p. 75) of eastern Nevada. The siliceous mudstone in the Webb is similar to some mudstone of the Pilot Shale in the type locality in the Ely district (Spencer, 1917, p. 26), and the Pilot and Webb probably are equivalent in part also. These two formations differ markedly in their lower contacts, however; the Pilot near Eureka is conformable on carbonate-assemblage Devils Gate Limestone (Nolan and others, 1956, p. 52), whereas the Webb is unconformable on both carbonate- and siliceous-assemblage formations. The lower part of the Chainman Shale and Diamond Peak Formation undivided in the south half of the Carlin–Pinon Range area is also of Early Mississippian age, as based on megafossils. The Webb Formation in the south half is mostly limestone like that farther north in the uppermost part of the formation. The Webb and the undivided Chainman and Diamond Peak, then, may be equivalent in part at least, and the southward wedge-out of the Webb may be partly by gradation into the Chainman and Diamond Peak, although no actual gradation between the two units was observed.

CHAINMAN SHALE AND DIAMOND PEAK FORMATION

The Chainman Shale and Diamond Peak Formation compose one sequence of clastic rocks which records the depositional history of material derived from the region of continuing uplift in the Antler orogenic belt. In general, the texture of these rocks becomes coarser upward, but beds of coarse clastic material occur low in the sequence as well as high. Lateral changes from fine- to coarse-grained rocks are abrupt at places, and coarse- and fine-grained units also interfinger. This intimate, and in places seemingly haphazard, association of clastic rocks of different size grades makes the two formations virtually one unit (Nolan and others, 1956, p. 56–59; Sadlick, 1960, p. 82–83; Stewart, 1962). The development of the nomenclature of beds of Mississippian age in the region was reviewed by Nolan, Merriam, and Williams (1956, p. 56–59).

In our mapping we separated these chiefly Mississippian rocks into three units: Chainman Shale, where the rocks are mainly shale and sandstone; Diamond Peak Formation, where the rocks are mainly conglomerate and sandstone; and Chainman Shale and Diamond Peak Formation undivided, where conglomerate, sandstone, and shale seem to be about equally prominent. The Tonka Formation of Dott (1955) is included in the Diamond Peak. In general, the percentage of fine-grained rocks (shale and sandstone) relative to coarse-grained rocks (sandstone and conglomerate) increases southward across the Carlin–Pinon Range area; it also increases southward on a more regional scale. The upper 3,500–4,500 feet of this sequence in the report area contains 40–60 percent conglomerate, whereas the Diamond Peak Formation about 75 miles to the south, at the type locality in the Diamond Mountains, contains only 12 percent conglomerate (Brew, 1961, p. C111). About 12 miles still farther south, the top of the sequence is eroded, but conglomerate makes up less than 2 percent of the total section of 4,700 feet and only 7 percent of the highest 860 feet (Stewart, 1962, p. C58–C59).

The Chainman and Diamond Peak sequence is 6,000–7,000 feet thick in the Carlin–Pinon Range area.

In the northern part of the Carlin–Pinon Range area the Chainman and Diamond Peak rock sequence is conformable on the Webb Formation of the overlap assemblage. In the southern part of the area this rock sequence is unconformable on Devonian units of the carbonate assemblage and on the Woodruff Formation of the siliceous assemblage.

The age of beds composing the Chainman Shale and the Diamond Peak Formation in the Carlin–Pinon Range area spans Early Mississippian to Early Pennsylvanian time. Dating is based on many fossil collections studied mostly by MacKenzie Gordon, Jr., and Helen Duncan. This sequence of beds is somewhat older in the report area than it is elsewhere in most of eastern Nevada, but because no lithologic basis is evident for subdivision of these shales in the Carlin area, they are all included in the Chainman and Diamond Peak sequence. Good collections are from rocks of Early Mississippian age and from the tan and yellow silty beds of late Early and possibly early Late Mississippian age (Osage and possibly early Meramec). After making a preliminary report (1961) on the early Mississippian faunas, MacKenzie Gordon, Jr., and Helen Duncan have been continuing their studies of collections from this area. Other good collections are from beds of late Late Mississippian and early Early Pennsylvanian ages. Only poorly preserved fossils were found in much of the sequence between those rocks containing Early Mississippian fossils and those containing late Late Mississippian ones, but a late Meramec age is indicated by one collection (MacKenzie Gordon, Jr., written commun., 1967), and the lack of other well-dated fossil collections does not indicate a break in this continuous rock sequence.

ARGILLITE UNIT OF LEE CANYON

Black siliceous argillite and some black chert are exposed in a band centered in Lee Canyon (Ketner and Smith, 1963, p. B10). The unit crops out on bare black slopes and ridges. Beds are mostly an inch to several inches thick, and the entire unit is about a mile thick. In thin section this dense rock is seen to consist mainly of quartz grains about 0.10 mm in diameter making a mosaic texture. Carbonaceous material is so abundant in much of the argillite that thin sections are cloudy or opaque. A few beds of conglomerate and quartzite occur in the upper part of the unit.

The only fossil found in the argillite unit of Lee Canyon is a poorly preserved plant stem from near the top of the unit. The siliceous argillite is similar to black siliceous argillitic mudstone near the top of the Webb Formation, and the coarser grained beds in the upper part of the argillite are similar to beds in the Chainman Shale and the Diamond Peak Formation.

A thrust contact with the Chainman Shale, the Webb Formation, and the Woodruff Formation marks the base of the argillite unit. A normal fault along most of the length and a conformable contact beneath probable Chainman Shale for a short distance mark the upper contact. We interpret the argillite unit of Lee Canyon to be allochthonous in the Carlin-Pinon Range area; it probably was moved into the area from somewhere to the east on a thrust fault younger than the Roberts Mountains thrust. An anticline in the lower plate of this younger thrust is sharply overturned to the west in places (Ketner and Smith, 1963, p. B14).

PRESENT RELATIVE POSITIONS OF THE DEPOSITIONAL UNITS

The units of the carbonate, siliceous, and transitional assemblages, although probably deposited many miles apart, were juxtaposed by movement along the Roberts Mountains thrust. Those rocks of the carbonate assemblage now appear in the lower plate of the thrust, and those of the siliceous and transitional assemblages in the upper plate. Devonian units in the lower plate are the Nevada Formation and the Devils Gate Limestone, and those in the upper plate are the Woodruff Formation and the transitional-assemblage limestone and chert unit.

Sedimentary units of Ordovician and Silurian ages also were brought together by the thrusting and occur in both the upper and lower plates in the area. Carbonate-assemblage units of Ordovician age in the lower plate include the uppermost part of the Pogonip Group, the Eureka Quartzite, and the Hanson Creek Formation. Siliceous-assemblage units of Ordovician age in the upper plate are the Valmy and Vinini formations. Silurian age rocks include the carbonate assemblage in the Lone Mountain Dolomite in the lower plate and a siliceous-assemblage unnamed unit in the upper plate.

Mississippian units that make up the overlap assemblage unconformable on the older rocks comprise the Webb Formation, the Chainman Shale, and the Diamond Peak Formation. The youngest beds in the Diamond Peak are of Early Pennsylvanian age.

DATE OF THE ROBERTS MOUNTAINS THRUST IN THE CARLIN–PINON RANGE AREA

The overlap relations which cause the Mississippian rocks to rest unconformably on Devonian and older rocks of both siliceous and carbonate assemblages serve to date the Antler orogeny and the Roberts Mountains thrust in this area. Previously the principal deformation in the Carlin–Pinon Range area could not be dated more precisely than pre-Meramec (Dott, 1955, fig. 11), but closer control on the time of principal deformation is afforded from evidence farther south. The general unconformable relations are clearly shown a few miles south of the Humboldt River, where the Webb Formation rests unconformably on the Ordovician Vinini Formation of the siliceous assemblage and on the Devonian Devils Gate Limestone of the carbonate assemblage (fig. 4, section *A–A′*). The unconformable relations also are clearly seen in the southern part of the area, where the Nevada Formation of the carbonate assemblage is exposed in a window in the Roberts Mountains thrust. Upper plate rocks surrounding this window are in the Woodruff Formation of the siliceous assemblage, which is overlain

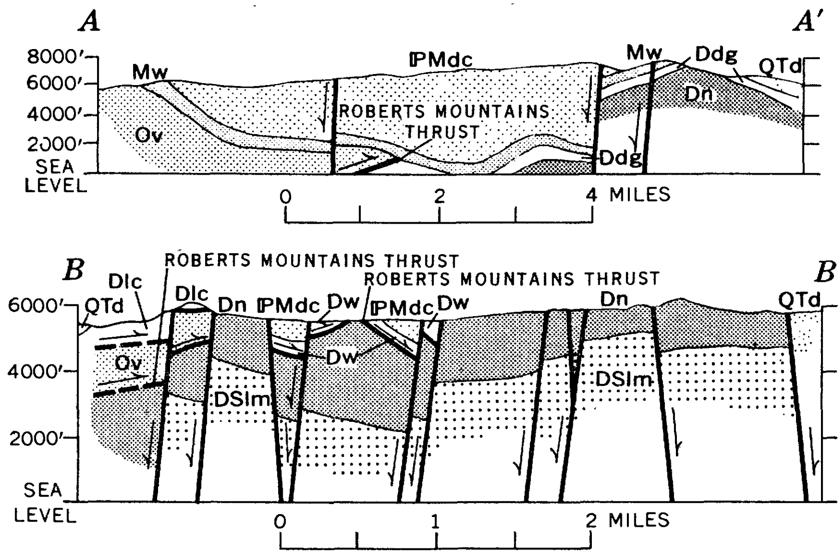
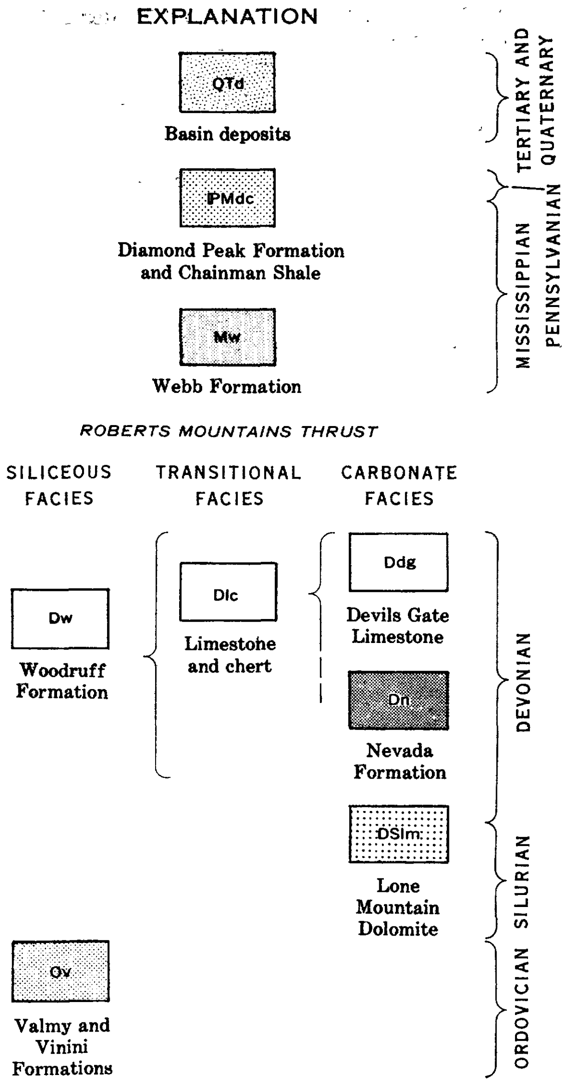


FIGURE 4.—Generalized structure sections showing evidence for dating the Roberts Mountains thrust. Note that in section B–B′ the transitional facies (Dlc) is in thrust contact with the siliceous facies (Ov) and the siliceous facies (Dw) is in thrust contact with the carbonate facies (Dn). Location of sections is shown in figure 3 (p. I 4). Explanation on facing page.

unconformably by the Chainman Shale and Diamond Peak Formation undivided of the overlap assemblage (fig. 4, section *B–B′*).

The overlapping relations of the Webb Formation, which lies with sedimentary contacts on both the allochthonous and autochthonous sequences in the northern part of the area, effectively dates the Roberts Mountains thrust as post-late Late Devonian, and pre-early Early Mississippian. In the southern part of the area, the Chainman Shale rests unconformably on both allochthonous and autochthonous formations. The youngest allochthonous siliceous-assemblage rocks are dated as late Late Devonian. This date was established by Mackenzie Gordon, Jr., who identified fossils that belong in the *Platyclymenia* ammonoid zone of late Late Devonian age. Thrust transport of these rocks was certainly concluded by Early Mississippian time, as the Webb Formation of late Kinderhook age rests unconformably on both allochthonous and autochthonous units of the Roberts Mountains thrust.

Confirmation of uplift of nearby siliceous-assemblage rocks by Mississippian time is found in the sediments deposited in the Carlin–Pinon Range area. These sediments consist largely of both fine and coarse detritus derived from upper plate rocks of the Roberts Mountains thrust.



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