Mississippian Stratigraphy of the Diamond Peak Area, Eureka County, Nevada

GEOLOGICAL SURVEY PROFESSIONAL PAPER 661

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By DAVID A. BREW

With a section on the BIOSTRATIGRAPHY AND AGE OF THE CARBONIFEROUS FORMATIONS

By MACKENZIE GORDON, JR.

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More than 7,000 feet of Late Mississippian synorogenic detrital clastic and limy sediments of the Chainman and Diamond Peak Formations were deposited in a narrow trough east of the Antler orogenic belt

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1971

UNITED STATES DEPARTMENT OF THE INTERIOR

WALTER J. HICKEL, *Secretary*

GEOLOGICAL SURVEY

William T. Pecora, *Director*

Library of Congress catalog-card No. 70-608211

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

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By David A. Brew

ABSTRACT

Synorogenic clastic rocks of Mississippian age deposited in an elongate rapidly subsiding trough east of the Antler orogenic belt in east-central Nevada consist of about 7,000 feet of the Chainman and Diamond Peak Formations. In the mapped area these rocks unconformably overlie the Devonian and Mississippian Pilot Shale and the Mississsippian Joana Limestone and are overlain by the Ely Limestone of Mississippian and Pennsylvanian age. Younger rocks present are the Carbon Ridge Formaton of Permian age, the Newark Canyon Formation of Early Cretaceous age, and a series of fanglomerates and megabreccias of Cretaceous and (or) Tertiary age.

Contrasting facies of the Chainman Formation occur above and below a thrust fault of possible regional extent. The facies below the thrust is dominantly black shale but includes minor amounts of sandstone; it is interpreted to be the eastern basinward correlative of the structurally overlying dominantly silty and sandy facies that has been displaced eastward for an unknown distance. Scanty fossil evidence indicates that both facies are Meramec in age. The stratigraphic relations of the Diamond Peak Formation in the type locality at Diamond Peak are complicated by this same thrust.

Eight members can be recognized in the relatively uncomplicated type section, here proposed, as well as elsewhere in the type locality. Stratigraphic and petrologic evidence indicates that the clayey siltrock, sandstone, and conglomerate of the lower two members (A and B) were deposited rapidly in the subsiding marine basin during the Meramecian and that reworked sediments were few. Most of the conglomerate, limestone, siltrock, and sandstone of members C and D were rapidly deposited sediments; conditions were unstable, but subsidence was less continuous than before. Some of the conglomerates were deposited in areas of marine limestone accumulation. The overlying siltrock, sandstone, conglomerate, and limestone-phenoplast conglomerate of members E–G were deposited under conditions which changed repeatedly, causing alterations of reworked and rapidly deposited sediments. The highest member (H) of the Diamond Peak Formation is transitional to the conformably overlying Ely Limestone of Mississippian and Pennsylvania age. This member was deposited in an environment similar to that of the underlying three members, but reworked sediments were more common, indicating longer periods of relative stability.

The terrigenous debris in the Chainman and Diamond Peak Formations was derived from a eugeosynclinical suite of rocks of Ordovician age known to have been present in the Antler orogenic belt. Detritus was contributed from the provenance terrane as folows: steady influx of mostly silt-, clay- and sand-size debris with minor amounts of coarser material during deposition of the Chainman and the lower two members of the Diamond Peak; then more irregular pulses of conglomeratic debris accompanying proportionally smaller amounts of finer clastics; finally, a decrease in overall volume of terrigenous clastic material as the transition to Ely Limestone deposition took place.

Most of the folds and low-angle faults probably formed in response to east-west-oriented forces which affected the Paleozoic rocks after deposition of the Permian Carbon Ridge Formation. The folds have horizontal axes, trend generally north-south, and are upright and open, except locally where greater compression caused slight overturning to the east. Low-angle thrusting probably occurred shortly after the folding. A few minor structures suggest that movement on the thrusts was to the southeast or east. During the Tertiary, high-angle faults outlined the main part of the Diamond Mountain range and caused differential movements of subblocks within the range.

INTRODUCTION

Stratigraphic, structural, and petrologic methods have been used to study and interpret part of the well-known stratigraphic section in the vicinity of Eureka, Nev. The results reported here are (1) revision of the Mississippian stratigraphy, including that of the type Diamond Peak Formation; (2) recognition of a previously undescribed thrust fault of possible regional significance; and (3) elucidation of the Carboniferous biostratigraphy and age assignments. Brief preliminary reports on the first two subjects have been published (Brew, 1961a, b). The studies also resulted in the description and classification of a sequence of compositionally mature, but texturally immature, siltstone, sandstone, and conglomerate; these results, in turn, form the basic for a petrogenetic interpretation of the tectonic history of the dominantly synorogenic rocks deposited to the east of the Antler orogenic belt (Roberts and others, 1958). These petrographic and petrogenetic interpretive results are contained in a separate article in preparation.

The studies were restricted primarily to rocks of Mississippian and Pennsylvanian age exposed within the Eureka 15-minute quadrangle (fig. 1), but older and younger formations were also mapped and studied. Although the geology was studied over most of the

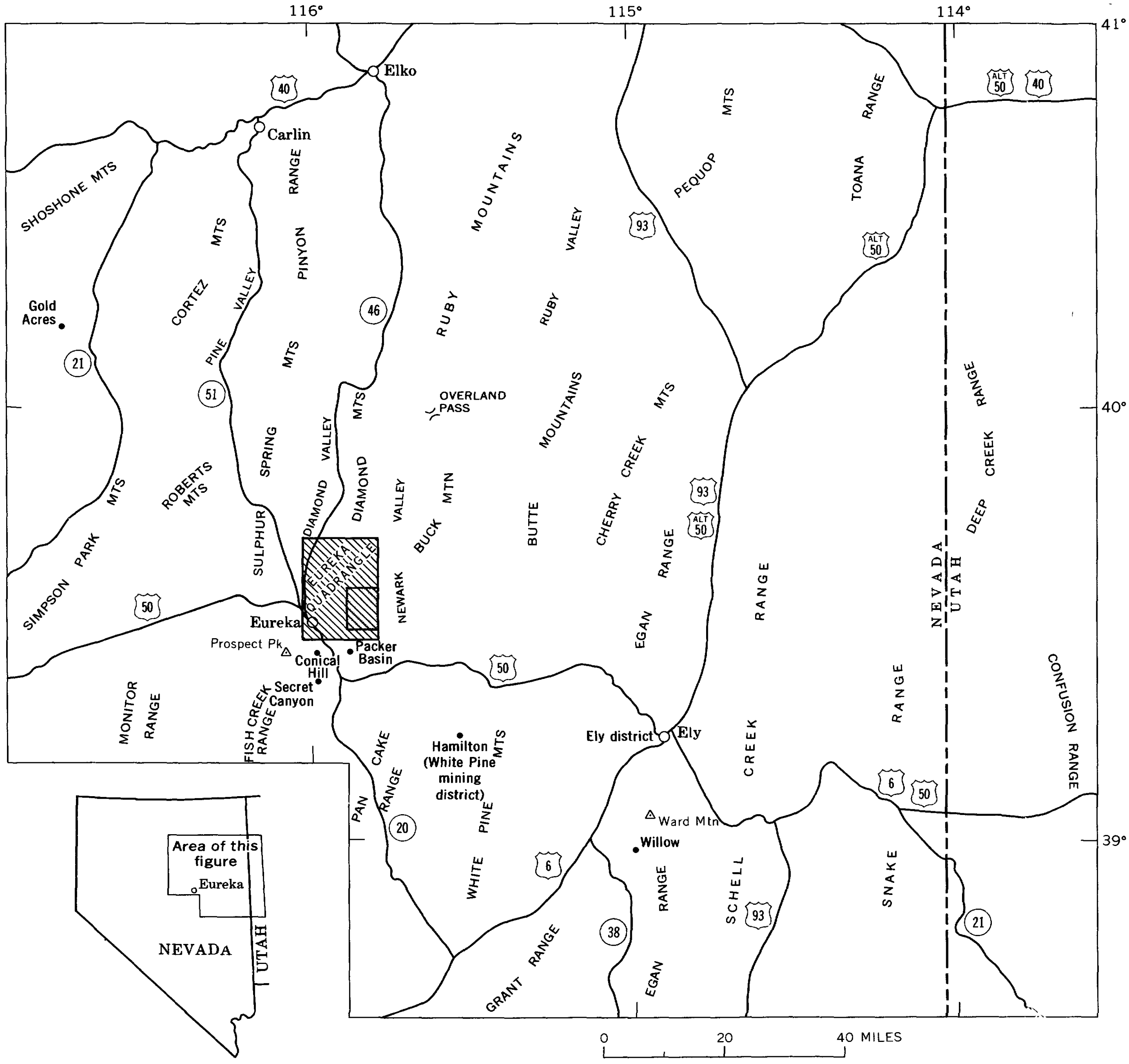


FIGURE 1.—Index map of east-central Nevada, showing the Eureka quadrangle and localities referred to in text. Outlined area within Eureka quadrangle is area of plate 1.

quadrangle, this report emphasizes the relationships in the vicinity of Diamond Peak (fig. 4).

The fieldwork upon which the studies are based was done during the summers of 1956–59. About 50 square miles were mapped on topographic maps at a scale of 1:15,840 using open-sight alidade and planetable. During the summer of 1959 the proposed type section of the Diamond Peak Formation was studied in detail.

ACKNOWLEDGMENTS

The studies described in this report were done as part of the U.S. Geological Survey's regional mapping program centered around Eureka mining district. Thomas B. Nolan is chief of this project, and the author acknowledges with thanks his encouragement, advice, supervision, and patience. Charles W. Merriam contributed in similar measure suggestions and en-

couragement. The report was improved greatly by the suggestions of Professor Robert R. Compton, of Stanford University, during the early stages of writing and by those of T. B. Nolan, M. D. Crittenden, and Mackenzie Gordon, Jr., in the final stages.

Fossil determinations were made by various members of the U.S. Geological Survey, who are cited individually in the text.

LOCATION AND GEOGRAPHY

The area of the field study (fig. 1) lies within the Eureka quadrangle, Nevada, and is between lat 39°32′ N. and lat 39°45′ N. and between long 115°45′ W. and long 115°51′ W. The area is centered in the Diamond Mountains about 12 miles northeast of Eureka, Nev., a small town situated on U.S. 50.

Both flanks of the Diamond Mountains are accessible from county-maintained roads in Diamond Valley to the west of the range and in Newark Valley to the east of the range. In addition, a gravel road crosses the range at Newark Summit about half a mile south of the southern edge of the mapped area. The area studied straddles the single north-trending ridge that here makes up the Diamond Mountains. The ridge ranges in altitude from 10,614 feet at Diamond Peak to 7,469 feet at Newark Summit and ranges in width from about 5 miles at the southern limit of the mapped area to 2½ miles at the northern edge of the quadrangle. This long fairly uniform ridge gives way in the northern part of the quadrangle to a less regular series of elevated knobs and saddles which have altitudes ranging from 8,250 feet to almost 9,000 feet (fig. 2).

FIGURE 2.—Diamond Range and Diamond and Newark Valleys from Diamond Peak. Prominent light-colored bands near center of picture are the rocks transitional between the Diamond Peak Formation (left) and Ely Limestone (right). Ridge extending to the center left margin of photograph is Black Point and is underlain by Black Point facies of Chainman Formation.

PREVIOUS WORK

The Eureka mining district was visited by members of the 40th Parallel Survey in the 1870's (Hague and Emmons, 1877, p. 547–548), and the first systematic study was undertaken by Arnold Hague in 1880. He published a series of articles (1880, 1882, 1883, 1892) which included descriptions and discussions of the rocks exposed in the southern Diamond Mountains. C. D. Walcott assisted Hague in the field and in 1884 published on the paleontology of the district.

In 1932, T. B. Nolan started a restudy of the Eureka mining district, and in the late 1930's, C. W. Merriam began a study of the Devonian rocks in the vicinity of Eureka. These studies established the section in the vicinity of Eureka as a standard for the Paleozoic of the east-central Basin and Range province and led to the publication of two reports (Nolan and others, 1956; Nolan, 1962). Dott (1955) described the structure and stratigraphy of the northern Diamond Mountains and visited the southern Diamond Mountains. Langenheim (1956) attempted a partial regional analysis of the Mississippian rocks of east-central Nevada, including the Diamond Peak Formation. Riva (1957) studied the upper Paleozoic rocks north of the Eureka quadrangle on the east side of the range. Larson mapped several areas within the Diamond Mountains and published (1959) an abstract on some structural features north of the Eureka quadrangle. Larson and Riva (1963) mapped the quadrangle north of the Eureka quadrangle. The geologic map of the Eureka quadrangle itself has been compiled by Nolan, Merriam, and Brew (1970).

Lehner, Tagg, Bell, and Roberts (1961) published a small-scale reconnaissance geologic map that includes the Eureka County portion of the Eureka quadrangle.

Immediately following the author's fieldwork, two small nearby areas were mapped and studied by Stewart (1962).

TERMINOLOGY

Thicknesses of strata described in this report are classified according to the scheme of McKee and Weir (1953) as modified by Ingram (1954). The color terms used are from Goddard and others (1948).

The terrigenous clastic rocks are classified by the size of their constituent particles according to the modified Wentworth scheme proposed by Dunbar and Rodgers (1957, p. 161). The fine-grained terrigenous clastics are further classified by grain size and fissility as proposed by Dunbar and Rodgers (1957, p. 166).

Terrigenous clastic rocks containing between 5 and 30 percent fragments greater than 2 mm in diameter are termed "conglomeratic" in this report, and those with more than 30 percent of such particles are "conglomerates." This usage is simplified from that proposed by Folk (1954, p. 346). Modifiers describing the composition of the dominant gravel-size clasts precede the term "conglomerate" throughout most of the report.

The limestones described were found to be readily adapted to Folk's (1959) proposed classification of carbonate rocks, and that classification was used with the single exception that 2 mm, rather than 1 mm, was used for the limit separating the calcarenites from the calcirudites (Folk, 1959, p. 16).

Throughout the report, references to roundness of sedimentary particles are based on visual comparison with the chart prepared by Powers (1953), and particle shapes are described using Zingg's (1935, p. 53–55) shape terms.

GEOLOGIC SETTING

The lower and middle Paleozoic sediments in the vicinity of Eureka were deposited in a generally stable miogeosyncline situated between a eugeosynclinal area to the west and a stable shallow shelf to the east. Deformation associated with the Antler orogeny began in Late Devonian and disrupted the miogeosynclinal pattern of sedimentation; this deformation apparently culminated in the low-angle thrusting of eugeosynclinal rocks from the west over miogeosynclinal rocks. The upper Paleozoic sediments were deposited, in part, in basins related to this regional tectonism, and most of the sediments of Mississippian and Permian age are clearly synorogenic. Uplift preceded deposition of Lower Permian clastic and carbonate rocks, and several thousand feet of Pennsylvanian and Mississippian strata were locally eroded. Folding, low-angle faulting, and uplift followed deposition of the Permian sediments and apparently continued intermittently throughout the Mesozoic. Pertinent papers concerning the regional stratigraphic and structural relations include those by Nolan, Merriam, and Williams (1956), Nolan (1928, 1943), Roberts, Hotz, Gilluly, and Ferguson (1958), Roberts and Lehner (1955), Merriam and Anderson (1942), Winterer and Murphy (1960), and Sharp (1942).

REGIONAL STRATIGRAPHY

Roberts, Hotz, Gilluly, and Ferguson (1958) grouped the Paleozoic rocks of north-central Nevada into four tectonostratigraphic units: (1) a western assemblage of lower and middle Paleozoic eugeosynclinal rocks that have been tectonically transported by thrusting over (2) an eastern assemblage of lower and middle Paleozoic miogeosynclinal rocks, (3) a western-eastern transitional assemblage, and (4) an overlap assemblage of upper Paleozoic rocks deposited on the western, eastern, and transitional assemblages after the thrusting. Roberts and his coworkers consider the thrusting to be of Late Devonian and Early Mississippian age.

Rocks of the western assemblage exposed closest to Eureka make up the upper plate of the Roberts Mountains thrust fault and are assigned to the Vinini Formation. The Vinini probably is the source of most of the debris in the synorogenic terrigenous clastic rocks of Mississippian age. The lower part of the Vinini Formation (Merriam and Anderson, 1942, p. 1694–1698) includes dark-gray-brownish-weathering quartzite, cross-laminated gray sandy limestone and limy sandstone, fine-laminated brownish-gray and greenish-brown sandy siltstone, "true black shale," green volcanic sandstone, cherty shale, and tuff, tuff-breccia, and amygdaloidal hornblende andesites which have been extensively albitized and chloritized. The upper Vinini is characterized by bedded chert and black organic shale. Some of the shale and most of the pale-green to black chalcedonic chert contain what are probably Radiolaria.

Rocks of the eastern assemblage exposed near Eureka consist of dominant carbonates, shales, and minor coarser detrital clastics. Roberts, Hotz Gilluly, and Ferguson (1958) assigned the lower part of the Mississippian section to this assemblage and the upper part to the overlap assemblage. Transitional assemblage rocks are not exposed in the Eureka area.

The regional relations of the Mississippian rocks are important background for the understanding of the present study. Throughout most of east-central Nevada the Mississippian consists of three main units: a thin lower limestone unit with underlying shale; a thick medial black shale unit with varying proportions of limestone and of coarser material in lenses and tongues; and a thin upper sandstone, shale, and conglomerate unit. Locally near the western limit of these three units, as at Diamond Peak, the upper unit is thickened at the expense of the medial unit, and the medial unit itself is appreciably coarser than normal. These regional units are discussed briefly below.

The lower unit consists of the Pilot Shale of Devonian and Mississippian age and the overlying Joana Limestone of Early Mississippian age. Near Eureka, the upper contact is an erosional unconformity, and in places, the Joana was completely eroded before deposition of the overlying Chainman Shale. The Joana consists mainly of dark limestone with minor partings of dark-gray shale. Although the Joana or its equivalent has been recognized over most of Nevada east and south of the Diamond Mountains, it is missing to the west and north of the southern and central Diamond Mountains. Roberts, Hotz, Gilluly, and Ferguson (1958) believe that clastic sediments of the overlap assemblage were being deposited in the region north and northwest of Eureka during the time interval represented by the Joana.

The medial unit is the Chainman Shale. The Chainman is typically a black shale sequence with scattered sandstone, minor conglomerate, and limestone lenses. Many abrupt facies changes are apparent, and the amount of sandstone present differs radically from section to section (Stewart, 1962). The formation is known to extend eastward into Utah and possibly extends southward and southwestward for several hundreds of miles.

The type Chainman occupies a geographic position between the synorogenic coarse clastics of the Diamond Peak Formation to the west and north and the Mississippian shelf carbonates some distance to the east and southeast. In the areas near the Diamond Peak prism of clastics, the Chainman shows much local variation, and these facies changes are the ones that complicate the Chainman section near Eureka.

The upper unit, the Diamond Peak Formation and correlative units, is difficult to distinguish from the Chainman in many areas because the contact is gradational, and the lowermost typically coarser clastics of the Diamond Peak occur at different stratigraphic levels. The rocks here referred to the upper unit are mappable intermittently over an area extending from the White Pine Range northwestward to beyond the vicinity of Carlin. They indicate a significant change in regimen during Late Mississippian time in this general area. The Diamond Peak facies disappears eastward into the Chainman black shales, and at Ely and points to the east no Diamond Peak-type rocks are present.

To the southeast, the stratigraphic interval represented by the Diamond Peak Formation is occupied by similar, but thinner, clastic units, usually referred to as the Scotty Wash Quartzite. There is some question whether the Scotty Wash was derived from the same source as the Diamond Peak and therefore whether it has the same tectonic significance as the Diamond Peak, but the general relationships are the same.

Mississippian rocks have not been recognized to the west of Eureka in the area considered to be the locus of the Antler orogeny. Synorogenic sediments of the westernmost sequences of the overlap assemblage (Roberts and others, 1958) are present much farther west.

REGIONAL STRUCTURE

The geologic structure around Eureka is characterized by folds and thrusts upon which basin-and-range-type block faulting is superimposed. The isolated nature of the individual mountain masses and the lack of detailed mapping precludes an exact delineation of the extensive fold systems. The overall picture is one of broad, open, north-south-trending folds with apparently near-horizontal axes. The Diamond Range is somewhat unusual in that several folds, some of which are overturned, are well exposed.

Thrust faults of varying importance and displacement are associated with the large-scale folds. The best known of these faults is the Roberts Mountains thrust (Merriam and Anderson, 1942; Roberts and others, 1958; Gilluly, 1960a, b). It is present only a few miles to the west of the area studied and is thought to be the major thrust which brought lower and middle Paleozoic eugeosynclinal rocks tens of miles eastward over miogeosynclinal sedimentary rocks. The detailed mapping in the Diamond Mountains demonstrated the presence of still another thrust fault of possible regional significance (Brew, 1961b).

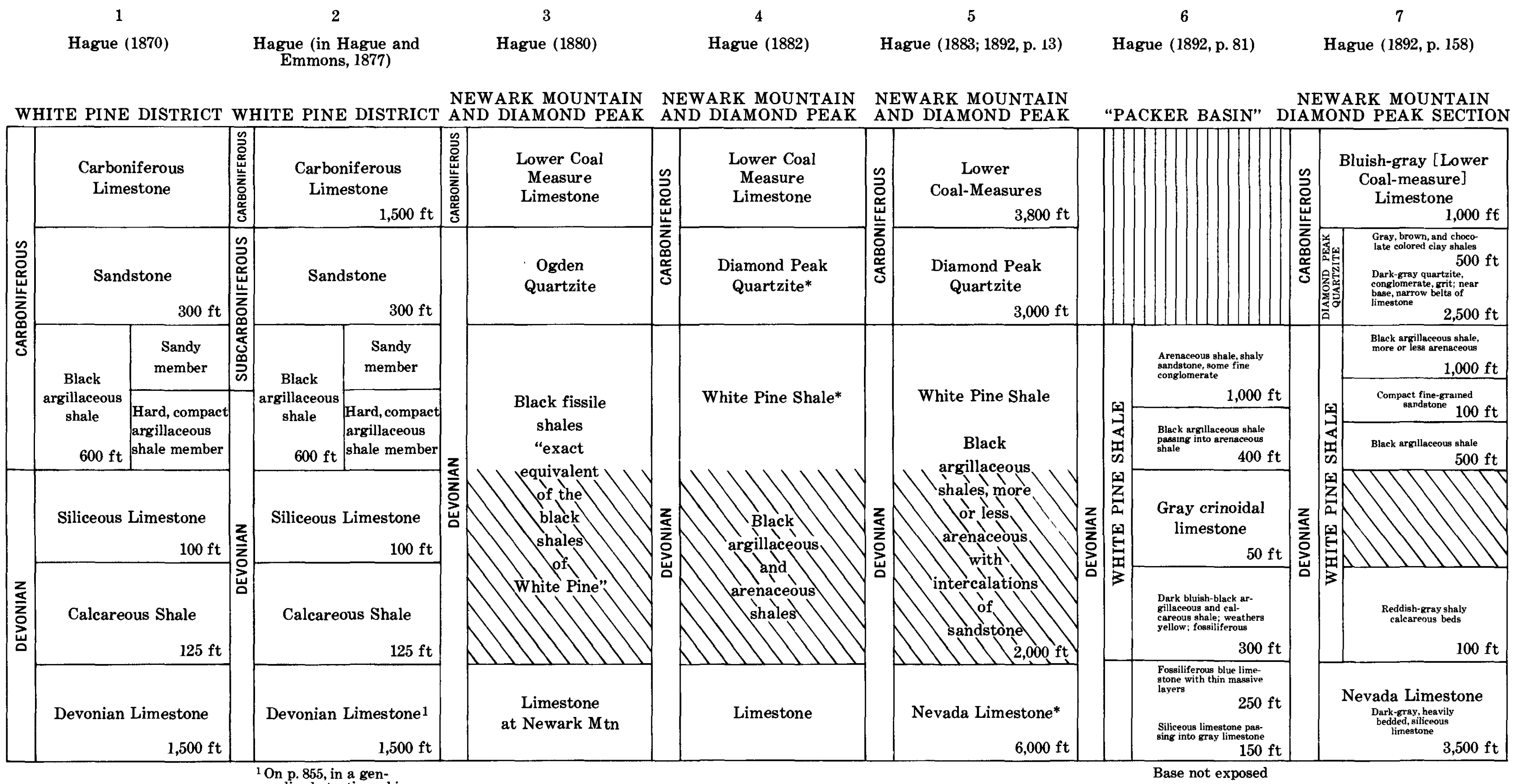
The folding in the Eureka quadrangle can be dated no closer than post-Permian and pre-Cretaceous. The thrusting in the area studied seems to be of about the same age. These events may be related to the rejuvenation of the Late Devonian and Early Mississippian thrusting of Roberts, Hotz, Gilluly, and Ferguson (1958).

High-angle faulting has occurred throughout the region. Faults which may have originated during earlier tectonism have, in many places, been obscured by the later block faulting, and the age relationships are difficult to establish. The block faulting responsible for the general configuration of the mountain ranges in east-central Nevada is typified by the straight range fronts that are many miles long and by many intrarange high-angle faults. Each block has adjusted internally by means of faults of varying orientations. This faulting probably started in early Tertiary and continued intermittently to the present (Nolan, 1943, p. 183).

STRATIGRAPHIC NOMENCLATURE

The nomenclature of the Upper Devonian and Mississippian rocks exposed in the Eureka district is controversial, particularly with respect to the application of the term "White Pine Shale." The area studied includes some of the localities to which this name was first applied, and a brief discussion of the term is necessary.

The nomenclatorial history of the strata formerly included in the White Pine Shale and of the overlying



1 On p. 855, in a generalized stratigraphic column, this unit is called "Nevada Devonian"

8	9	10	11	12	13	14
Lawson (1906, p. 295-297)	Spencer (1917, p. 24)	Merriam (1938, 1940) Watson (1939, p. 4)	Easton and others (1953)	Nolan, Merriam, and Williams (1956)	Humphrey (1960)	This paper
ELY DISTRICT	ELY DISTRICT	NEWARK MOUNTAIN AND DIAMOND PEAK	EUREKA DISTRICT	EUREKA DISTRICT	WHITE PINE DISTRICT	
CARBONIFEROUS: Ely Limestone* 1,500 ft	PENNSYLVANIAN: Ely Limestone 2,500 ft	UPPER CARBONIFEROUS: "Lower Coal Measures" (from Hague, 1892) DISCONFORMITY 3,800 ft	PENNSYLVANIAN: Ely Limestone	PENNSYLVANIAN: Ely Limestone 1,500 ft	PENNSYLVANIAN: Ely Limestone 1,600 ft	PENNSYLVANIAN: Ely Limestone
CARBONIFEROUS: (vertical lines)	PENNSYLVANIAN: (vertical lines)	LOWER CARBONIFEROUS, DIAMOND PEAK SERIES*: Alpha Peak member* 3,500 ft	PENNSYLVANIAN: Diamond Peak Formation —?——?—	MISSISSIPPIAN: Diamond Peak Formation	MISSISSIPPIAN: Diamond Peak Formation 600-1,000 ft	MISSISSIPPIAN: Diamond Peak Formation; Bold Bluff thrust (of lower plate)
DEVONIAN, WHITE PINE SHALE 850 FT: Blue-black argillaceous shale	MISSISSIPPIAN: Chainman Shale* 250 ft	LOWER CARBONIFEROUS, DIAMOND PEAK SERIES*: Hayes Canyon Shale* 3,000 ft	MISSISSIPPIAN, WHITE PINE SHALE (formation): Chainman Shale (member)	MISSISSIPPIAN: Chainman Shale	MISSISSIPPIAN: White Pine Formation 1,800-2,000 ft	MISSISSIPPIAN: Chainman Formation; Black Point facies; Bold Bluff thrust; Water Canyon facies
DEVONIAN, WHITE PINE SHALE 850 FT: Light-gray limestone 150 ft	MISSISSIPPIAN: Joana Limestone* 100-400 ft	UPPER DEVONIAN, DEVILS GATE FORMATION* 3,000 FT: Crinoidal limestone	MISSISSIPPIAN, WHITE PINE SHALE (formation): Joana Limestone (member)	MISSISSIPPIAN: Joana Limestone 0-135 ft	MISSISSIPPIAN: Joana Limestone 150-250 ft	MISSISSIPPIAN: Joana Limestone
DEVONIAN, WHITE PINE SHALE 850 FT: Argillaceous shale	MISSISSIPPIAN: Pilot Shale* 200 ft	UPPER DEVONIAN, DEVILS GATE FORMATION* 3,000 FT: Calcareous shale	MISSISSIPPIAN, WHITE PINE SHALE (formation): Pilot Shale (member)	MISSISSIPPIAN: Pilot Shale 315-425 ft	MISSISSIPPIAN: Pilot Shale 150-200 ft	MISSISSIPPIAN: Pilot Shale
DEVONIAN: Nevada Limestone 1,000 ft	DEVONIAN: Nevada Limestone 4,000 ft	UPPER DEVONIAN, DEVILS GATE FORMATION* 3,000 FT: Dark-gray limestone	DEVONIAN: Devils Gate Formation	DEVONIAN: Devils Gate Limestone 675-2,065 ft	DEVONIAN: Nevada Limestone 1,600 ft	DEVONIAN: Devils Gate Limestone

FIGURE 3.—Nomenclature and correlation chart. Asterisk indicates original description of unit; vertical lines indicate that unit is not present in area; diagonal lines indicate that unit was not specifically noted by the worker cited, but is present at least locally in the area.

Diamond Peak Formation is so similar that both terms are discussed together.

Arnold Hague (1870) described four map units (fig. 3, col. 1) between his "Devonian Limestone" (which is the Nevada Limestone of Humphrey, 1960) and his "Carboniferous Limestone" (which is the Ely Limestone of current usage) in the White Pine mining district (fig. 1). Recent mapping (Humphrey, 1960) has shown that these units are those called (1) Pilot Shale, (2) Joana Limestone, (3) Chainman Shale, and (4) Diamond Peak Formation, in the current Geological Survey nomenclature. Hague and Emmons (1877) summarized the work and made minor descriptive additions (fig. 3, col. 2).

Hague's mapping in the Eureka mining district started 12 years after completion of the work in the White Pine district. Hague introduced the term "White Pine Shale" in the reports dealing with the Eureka area.

In his 1880 Eureka report, Hague described the Devonian limestone and the overlying black shales at Newark Mountain as being correlative with the rocks at White Pine (fig. 3, col. 3). At Newark Mountain the Chainman Shale (current usage) rests unconformably on the Pilot Shale, and it seems that, because of the absence of the normally intervening limestone, Hague did not recognize the separate shale units he had mapped at White Pine. In the same report, Hague referred the overlying "quartzite" to the Ogden Quartzite.

Hague introduced the terms "White Pine Shale" and "Diamond Peak Quartzite" in 1882 (fig. 3, col. 4). He stated clearly (1882, p. 28) that the name of the black shale unit was taken from the White Pine mining district, but did not designate a type section, locality, or area. He did note the similarity of the rocks at Newark Mountain and White Pine and mentioned "a much greater development" in the Eureka area. In proposing the name "Diamond Peak Quartzite," Hague stated that the unit formed the slopes of Diamond Peak; from this and almost all subsequent references it seems that this mountain is the type locality.

In 1883, Hague published detailed descriptions of the White Pine Shale and Diamond Peak Quartzite in the Eureka district (fig. 3, col. 5). In describing the White Pine, Hague noted the outcrops near Newark Mountain and those east of Sentinel Peak (now called the Packer Basin area). He mentioned particularly the abrupt lateral and vertical changes in lithic type which are well displayed in the Packer Basin section. Hague noted that limestone, conglomerate, "vitreous quartzite," and "thinly laminated green and brown schists and shales" were common lithic types in the Diamond Peak, the last-mentioned types occurring near the top of the unit. His description of the overlying "Lower Coal measure limestone" indicates that he included in that unit much of what is now considered part of the Diamond Peak Formation.

Hague (1892) published a monograph on the geology of the Eureka district in which he included all the material contained in the earlier reports, detailed descriptions of lithostratigraphic units in various parts of the district, and a section on regional correlation. Hayes Canyon (Tollhouse Canyon on present-day maps, fig. 4), west of Newark Mountain, was suggested as the best place to study the White Pine Shale, even though a greater thickness was recognized in the area east of Sentinel Peak. In Hayes Canyon the Joana Limestone is almost everywhere missing because of pre-Chainman erosion.

Hague described a detailed stratigraphic section from the area east of Sentinel Peak in his 1892 report (fig. 3, col. 6). Comparison of Hague's section with those of recent workers (Nolan and others, 1956, p. 54; Stewart, 1962) shows that Hague included the Pilot Shale, Joana Limestone, and Chainman Shale in his White Pine Shale at this locality and also excluded all shales from his Nevada Limestone (Hague, 1892, p. 80–81). Hague apparently did not realize that these individual units correlate with those he described from the White Pine district (1870). In the same report, Hague published a section of the White Pine Shale in Hayes (Tollhouse) Canyon. He excluded all shale from his Nevada Limestone at this locality also—a point which supports the contention that his complete White Pine unit included all of the Pilot Shale.

These two sections provided the most detailed descriptions of the White Pine Shale given by the geologist responsible for the earlier study, description, and naming of the unit. There is no documented explanation for Hague's failure to correlate his original (Hague, 1870; Hague and Emmons, 1877) units in the White Pine district with those described in Packer Basin. R. L. Langenheim, Jr. (1962, 1964), has suggested that, based on Hague's comments on correlation (1892, p. 193), Hague miscorrelated the Joana Limestone (his unit 3) of the Packer Basin section with a limestone lens within the black argillaceous (Chainman) shale in Applegarth Canyon in the White Pine district. Thus, according to Langenheim's reasoning, the White Pine Shale in the White Pine district excludes Hague's siliceous limestone (Joana) and calcareous shale (Pilot) units.

Hague's 1892 summary of the Diamond Peak Quartzite repeated the description given in 1883. A combined White Pine Shale-Diamond Peak Quartzite section from the vicinity of Newark Mountain and Bold Bluff (1892, p. 158) is summarized in column 7 of figure 3.

Hague's more complete descriptions of the White Pine Shale in the Eureka district would seem to establish that area as the type locality, even though the name was taken from a different place. Certainly, Hague developed his ideas on the White Pine Shale primarily from his study of the unit in the Eureka district.

Hague's papers on the Eureka district were not succeeded by further descriptions until almost 1940. During this time, however, Lawson (1906) and Spencer (1917) mapped and described correlative rocks in the Ely district, about 75 miles east of Eureka.

Lawson (1906, p. 295–297) extended Hague's Eureka terminology to the rocks near Ely and concurred with his age assignments (fig. 3, col. 8). Lawson's stratigraphic column includes three subdivisions within the White Pine Shale, corresponding to the Pilot, Joana, and Chainman Formations named by Spencer in 1917. Lawson recognized the correlation of these subdivisions with those in the White Pine Shale to the west.

Spencer (1917, p. 24–26) disregarded Lawson's application of Hague's prior terminology in the Ely district and formally subdivided the White Pine unit into, in ascending order, the Pilot Shale, Joana Limestone, and Chainman Shale (fig. 3, col. 9). Most, if not all, of the existing naming problems stem from this action.

Merriam (1938) included in his Devils Gate Formation in the eastern part of the Eureka district rocks now assigned to the Pilot Shale and Joana Limestone. The overlying rocks were included in his Diamond Peak Series. This usage was modified slighly by Watson (1939) who subdivided the Diamond Peak Series into two members. Merriam and Watson's terminology is reproduced in column 10 of figure 3. Merriam formally proposed the terms in 1940.

Easton and others (1953) recommended revision of this part of the Paleozoic section, stating that the consensus was that the White Pine Shale correlated with the Pilot Shale, Joana Limestone, and Chainman Shale and proposing the three last-named units as members of the White Pine Shale. Their suggestion is shown in column 11 of figure 3. They, as did Dott (1955) slightly later, considered the term "formation" a better designation for the Diamond Peak than "quartzite."

Nolan, Merriam, and Williams (1956) in their definitive paper on the stratigraphy of the Eureka district, applied Spencer's terminology to the rocks mapped by Hague as the White Pine Shale (fig. 3, col. 12).

Humphrey (1960) redescribed the stratigraphy of the White Pine district and used Spencer's terminology for the lower two units of Hague's White Pine and restricted the term White Pine" to that part of the section correlative with the Chainman Shale. Humphrey's usage is given in column 13 of figure 3.

In summary, these descriptions suggest that (1) the Eureka district may be interpreted as being the type region for the White Pine Shale, even though the name was taken from a different locality; (2) Arnold Hague included in his White Pine Shale of the Eureka district the units later named Pilot Shale, Joana Limestone, and Chainman Shale by Spencer in the Ely district; and (3) the term White Pine has priority. Nevertheless, the nomenclature of Nolan, Merriam, and Williams (1956) is used in this report. The accepted nomenclature is modified in this report by (1) using the term "Chainman Formation" in the Eureka district in preference to "Chainman Shale" and (2) using informal names for contrasting facies of the Chainman. The reasons for these modifications are given in the section of this report dealing with Chainman stratigraphy.

The name Diamond Peak has been used consistently for those rocks which generally overlie the Chainman.

STRATIGRAPHY

Nolan, Merriam, and Williams summarized the results of their stratigraphic investigations in the vicinity of Eureka in 1956. Since that time, Nolan and various assistants, including the present author, have mapped the Silurian, Devonian, and Permian rocks that occur on the west flank of the Diamond Mountains within the Eureka quadrangle. The author alone mapped the Devonian-Mississippian, Mississippian, Pennsylvanian, and Permian strata in the central part of the range.

Although the main purpose of this paper is to present new information about the Mississippian rocks, the other strata exposed above and below the Mississippian part of the section in the study area are also discussed briefly.

DEVONIAN SYSTEM

DEVILS GATE LIMESTONE

About 1 mile south of Torre Flat (pl. 1) is a complexly faulted and folded small mass of noncherty medium-light-gray and light-gray very thick bedded cavernous limestone. Two small fossil collections from this outcrop were determined to be Devonian in age; this, together with the lithology, indicates that the outcrop is Devils Gate Limestone (Merriam, 1940, p. 16–17). One of the collections was studied by W. A.

Oliver, Jr. (written commun., 1961), who reported as follows:

> Colln. ES-58-10F * * * includes a single specimen of coral identified as follows:
>
> *Alveolites*
>
> The genus *Alveolites* is restricted to rocks of Silurian and Devonian age.

The second collection was studied by P. E. Cloud, Jr. (written commun., 1961), who reported:

> Colln. ES-58-9F * * *:
>
> Thin sections of the rock show stromatoporoids, * * * apparently belonging to the genus *Amphipora*, which has an almost circumglobal distribution in certain dark Devonian limestones of Givetian and Frasnian age * * *.

No thickness could be determined from this one outcrop area. Eight miles to the north, the Devils Gate Limestone is 750 feet thick (Nolan and others, 1956, p. 49).

DEVONIAN AND MISSISSIPPIAN SYSTEMS

PILOT SHALE

The Pilot Shale was named by Spencer (1917, p. 24, 26) for Pilot Knob west of Ely. Langenheim, Hill, and Waines (1960, p. 68) have restudied the type area, and they indicate that only the lower part of the whole Pilot Shale is present there. At Willow, south of the Ely district, Langenheim, Hill, and Waines consider all the formation to be present and have established a reference section. Two members are present in the reference section: a lower shaly limestone and calcareous siltstone member and a black fissile shale upper member. Each member is about 190 feet thick.

In the area covered by the present report, the Pilot Shale is exposed in a belt extending from Tollhouse Canyon (Hayes Canyon of Hague) (fig. 4) across the saddle between Newark Mountain (fig. 4) and Bold Bluff down into Mining and Water Canyons (pl. 1). From Water Canyon the outcrops of Pilot Shale can be traced northward almost to the mouth of Sadler Canyon. Another longer outcrop belt within the Eureka quadrangle is located high on the west flank of the Diamond Mountains and extends from near Black Point to beyond the north edge of the quadrangle (fig. 4).

The Pilot Shale in the Eureka district (Nolan and others, 1956, p. 52) can be divided into two members in areas of good exposures. The lower member consists of platy calcareous shale and some thin limestone beds. This member generally weathers from its normal dark gray (*N*3 of Goddard and others, 1948) to various shades of light brown, pale red, and light red brown that contrast with the medium gray of the underlying Devils Gate Limestone. The upper member generally is less calcareous, and platy dark-gray shale and silty shale are predominant. These shales weather gray or grayish brown and are locally contorted.

The platy-weathering habit of the shales is distinctive. They commonly break down to form plates a few centimeters across and a few millimeters thick.

The contact of the Pilot Shale with the underlying Devils Gate Limestone is sharp and conformable. The upper contact with the Joana is also sharp and appears conformable; however, Langenheim, Hill, and Waines (1960, p. 69–71) suggest that the contact is a regional unconformity. It is therefore possible that some of the thickness variations of the Pilot Shale within the Diamond Mountains were caused by local pre-Joana erosion, although it is possible that they are due to unrecognized low-angle faulting. Lack of distinctive beds in the upper member of the Pilot makes recognition of the possible unconformity difficult.

In the Eureka quadrangle the thickness of the Pilot Shale varies from about 265 feet (mapped thickness) on the slopes of the range above Black Point (fig. 4) to about 425 feet in Water Canyon (pl. 1). Intermediate thicknesses—360 feet east of the Phillipsburg mine (fig. 4) near the northern edge of the quadrangle and 350 feet in Tollhouse Canyon (fig. 4)—have also been measured (Nolan and others, 1956, p. 52). The lower, more calcareous, unit is consistently 120–160 feet thick, according to Nolan, Merriam, and Williams (1956, p. 52), but it has not been mapped separately.

The detrital material in the fissile rocks of the Pilot Shale consists wholly of quartz and clay, with some clasts of probably intrabasinal limestone. Organic material and pyrite indicate a reducing bottom environment, whereas the oriented fabric of the clay-size debris suggests slow deposition by flocculation from slow-moving suspensions.

The carbon-rich rocks of the lower member of the Pilot Shale have not been studied in detail.

The paleontologic evidence for the Late Devonian age (prebasal Cassadaga Stage) of the lower unit as reported by W. H. Haas has been given by Nolan, Merriam, and Williams (1956, p. 53). The upper unit is considered Early Mississippian in age (this report, p. 34).

MISSISSIPPIAN SYSTEM

JOANA LIMESTONE

The Joana Limestone was named by Spencer (1917, p. 24, 26) from exposures near the Joana mine in the Ely district. Chilingar and Bissell (1957) have summarized the regional distribution of the formation. Langenheim (1960) reexamined the Joana in east-central Nevada and proposed detailed reference sections. Langenheim stated that only part of the lower

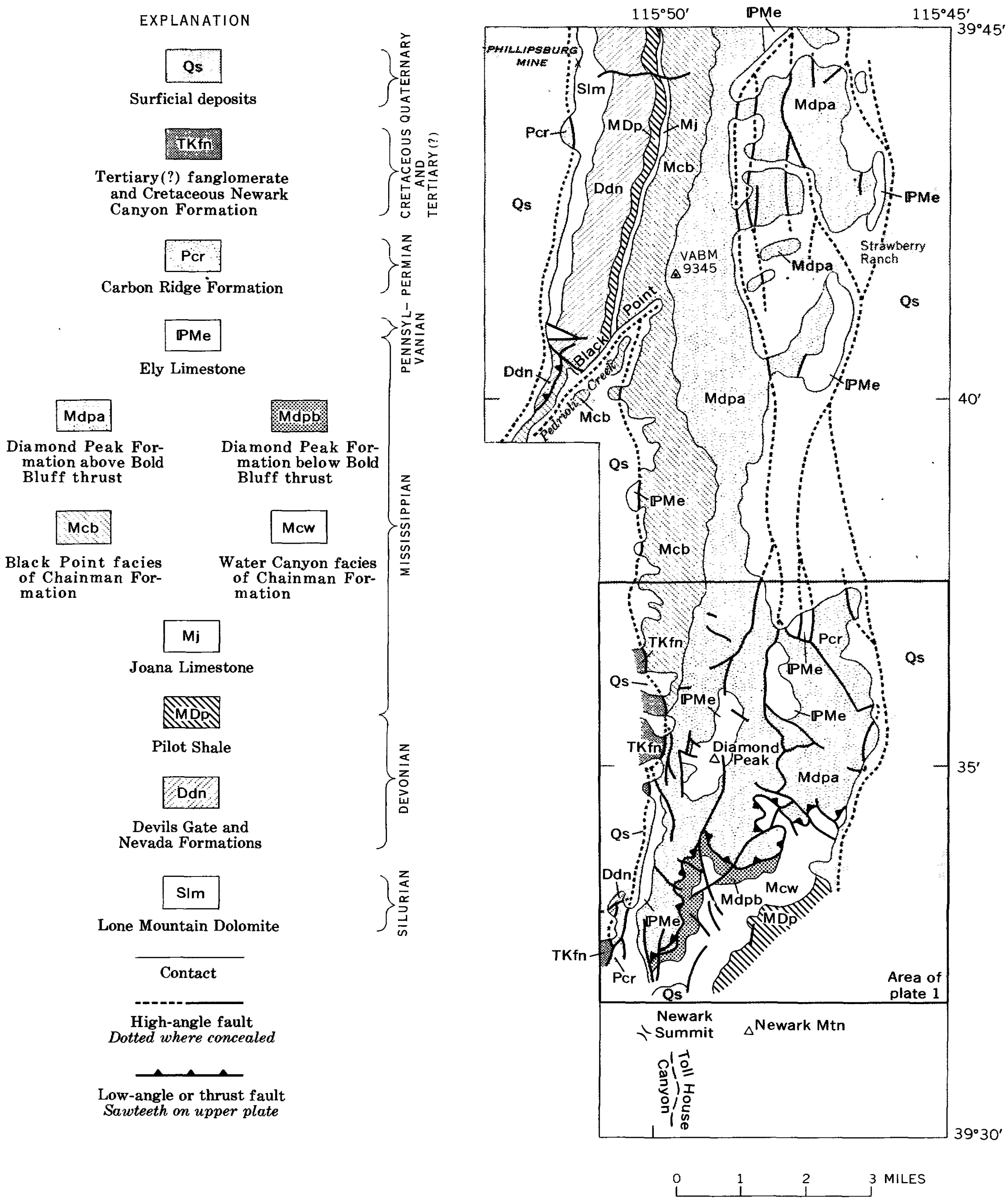


FIGURE 4.—Generalized geologic map of the eastern part of the Eureka quadrangle, Nevada. Geology by D. A. Brew, except as follows: by T. B. Nolan and D. A. Brew north of 39°40′ and east of 115°48′; by T. B. Nolan, A. T. Miesch, J. B. Stone, and D. A. Brew north of 39°37′30″ and west of 115°50′. Rectangle shows area of plate 1.

of the three members that he has described is present in the type locality. This, according to his interpretation, is also the situation in the Eureka district; however, the Joana described by Nolan, Merriam, and Williams (1956, p. 45, 55) is unlike his basal member.

A few thin isolated lenses of Joana Limestone are present in Tollhouse Canyon (fig. 4), where the formation has largely been removed by post-Joana, pre-Chainman erosion, but the best exposures in the quadrangle are in an outcrop belt high on the west flank of the range (fig. 4). This outcrop belt is covered by tree growth that marks its position between the Pilot Shale and Chainman Formation.

Where exposed in the south-central Diamond Mountains, the Joana Limestone is typically thin- to medium-bedded dense black and dark-gray (*N*3) crinoidal limestone that weathers light olive gray (5*Y* 6/1) and other shades of gray. The limestone is commonly fossiliferous but is locally coarsely crystalline and nonfossiliferous. Interbedded with these limestone are thin beds of nonfissile very silty dark-gray (*N*3) limestone that weathers yellowish gray (5*Y* 7/2). Some dark gray shale interbeds are also present. Nolan, Merriam, and Williams (1956, p. 55) noted the presence of beds of black chert in the Joana in Tollhouse Canyon.

The contact of the Joana with the underlying Pilot Shale is apparently conformable in the best exposures available, but, as mentioned above, the possibility of an unconformable relation exists. Nolan, Merriam, and Williams (1956, p. 52, 55) have cited the similarity of the shales mapped within the Joana to those of the upper part of the Pilot Shale and consider the Pilot-Joana contact to be gradational. The contact with the overlying Chainman Formation is sharp and, as abrupt lateral variations in thickness of the Joana indicate, unconformable.

In most of Tollhouse Canyon and in all the area covered by plate 1, the Joana Limestone has been completely removed by pre-Chainman erosion, and the Chainman Formation rests directly on the upper unit of the Pilot Shale. In Tollhouse Canyon, Nolan, Merriam and Williams (1956, p. 55) measured 84 feet of beds assigned to the Joana. However, near the crest of the Diamond Range east of the Phillipsburg mine (fig. 4) the thickness varies from 115 to 250 feet in about 1 mile, whereas 400 feet of Joana is present 3 miles south in the area east of Black Point. E. R. Larson (written commun., 1962) reports about 400 feet of Joana on the west side of the range not far north of the northern boundary of the Eureka quadrangle. That these variations in thickness are due to post-Joana, pre-Chainman erosion is proved by the mapping of individual beds within the overlying Chainman Formation.

Sparse oolitic limestone with very fine grained calcite matrix indicates that some of the carbonate rocks were deposited in shallow, but quiet, environments, as was probably the shale. Limestone with appreciable amounts of terrigenous debris commonly has more fossil fragments and is cemented with coarse-grained clear sparry calcite, indicating, according to Folk (1959), a higher energy environment and considerable reworking of the original sediment. Small amounts of pyrite suggest a reducing environment after burial of the sediment.

Nolan, Merriam, and Williams (1956, p. 55) gave evidence for the Early Mississippian age of the Joana Limestone. Chilingar and Bissell (1957) presented evidence for a late Kinderhook and early Osage age. Langenheim (1960, p. 79) reviewed evidence for an age ranging from Osage through Meramec for the middle and upper parts of the Joana Limestone to the east and southeast of Eureka. Gordon (p. 36 of this report) assigns a Kinderhook age to the Joana Limestone that is preserved in the Diamond Peak area.

RELATIONS OF CHAINMAN AND DIAMOND PEAK FORMATIONS

The close lithogenetic relation of the Chainman Formation and the Diamond Peak Formation has made it difficult to map them separately in some areas. Nolan, Merriam, and Williams (1956, p. 56) felt that the two formations were not satisfactory map units everywhere and cited the extreme lateral variation in lithologic character and in thickness and the difficulty of separating the two formations. The present detailed study, however, proved it possible to map the Diamond Peak Formation separately from the underlying unit in the Diamond Mountains. The contact is gradational, but it can be mapped by (1) walking out individual beds, (2) estimating the change in percent of various lithic types present, and (3) utilizing a particular discontinuous conglomerate that contains limestone pebbles. As mapped, the contact undoubtedly transgresses bedding to some extent and in some places is projected laterally with little evidence. Nevertheless, it is a significant surface, separating the dominantly finer clastics below from the overlying interbedded fine and coarse clastics of the Diamond Peak Formation.

Stewart (1962) did not differentiate the Chainman and Diamond Peak in his study of two small areas south and southeast of the area of the present study. There, the uppermost beds of the Diamond Peak-type rocks are not exposed, and the section is characterized by a mixture of fine and coarse clastic units; the "pure" black shale and Diamond Peak lithic types do not have a simple relation to one another. It appears that in these and other nearby areas the Diamond Peak lithic types intertongue with dominantly finer grained rocks.

The problem of differentiating the Chainman and Diamond Peak has been confused by previously undescribed structural complications. In short, the "typical" Chainman of the Diamond Peak area (herein referred to informally as the "Water Canyon facies"), as exposed in the area around Tollhouse Canyon, Newark Summit, and Water Canyon, occurs in a different thrust plate than does most of the Diamond Peak Formation exposed on the flanks of Diamond Peak. This "typical" Chainman is in part truncated upward by the Bold Bluff thrust fault (Brew, 1961b) and is elsewhere overlain by a few hundred feet of interbedded silicified sandstone and siltstone that is mapped as "Diamond Peak Formation of the lower thrust plate" but does not closely resemble the Diamond Peak Formation of the upper plate. However, these lower plate Diamond Peak rocks are also truncated by the thrust fault and therefore may not be representative of all the Diamond Peak originally associated with the "typical" Chainman.

The "Diamond Peak Formation of the upper plate" forms the overwhelming bulk of the Diamond Peak exposed in the type locality of the formation. Associated with it is a different, coarser type of Chainman, herein referred to informally as the Black Point facies of the Chainman. From these relations it follows that (1) the type Diamond Peak Formation was not originally associated with the "black shale" facies of the Chainman, but with a coarser grained facies; and (2) the coarser clastic rocks that originally overlaid the typical "black shale" facies of the Chainman in this area are incompletely known. This situation is shown diagrammatically in figure 5, to which, for purposes of regional comparison, have been added selected sections from the Carlin area, the northern Diamond Range, the White Pine district, the Buck Mountain area, the Butte Mountains, and the Ely district (fig. 1).

The overall picture shown in figure 5 is that of a dominantly coarser clastic prism (Tonka Formation of Dott, 1955, and Diamond Peak Formation) extending eastward and southeastward into and over the finer clastics (Chainman Shale), which also apparently coarsen westward. Numerous irregularly distributed coarser clastic lenses occur within the Chainman itself, and the margin of the dominantly coarser clastic prism is undoubtedly marked by intertonguing of the two formations (Hague, 1883, p. 253, 266; 1892, p. 69, 81; Nolan and others, 1956, p. 57; Stewart, 1962), but more detailed work is needed to establish the exact relationships.

CHAINMAN FORMATION

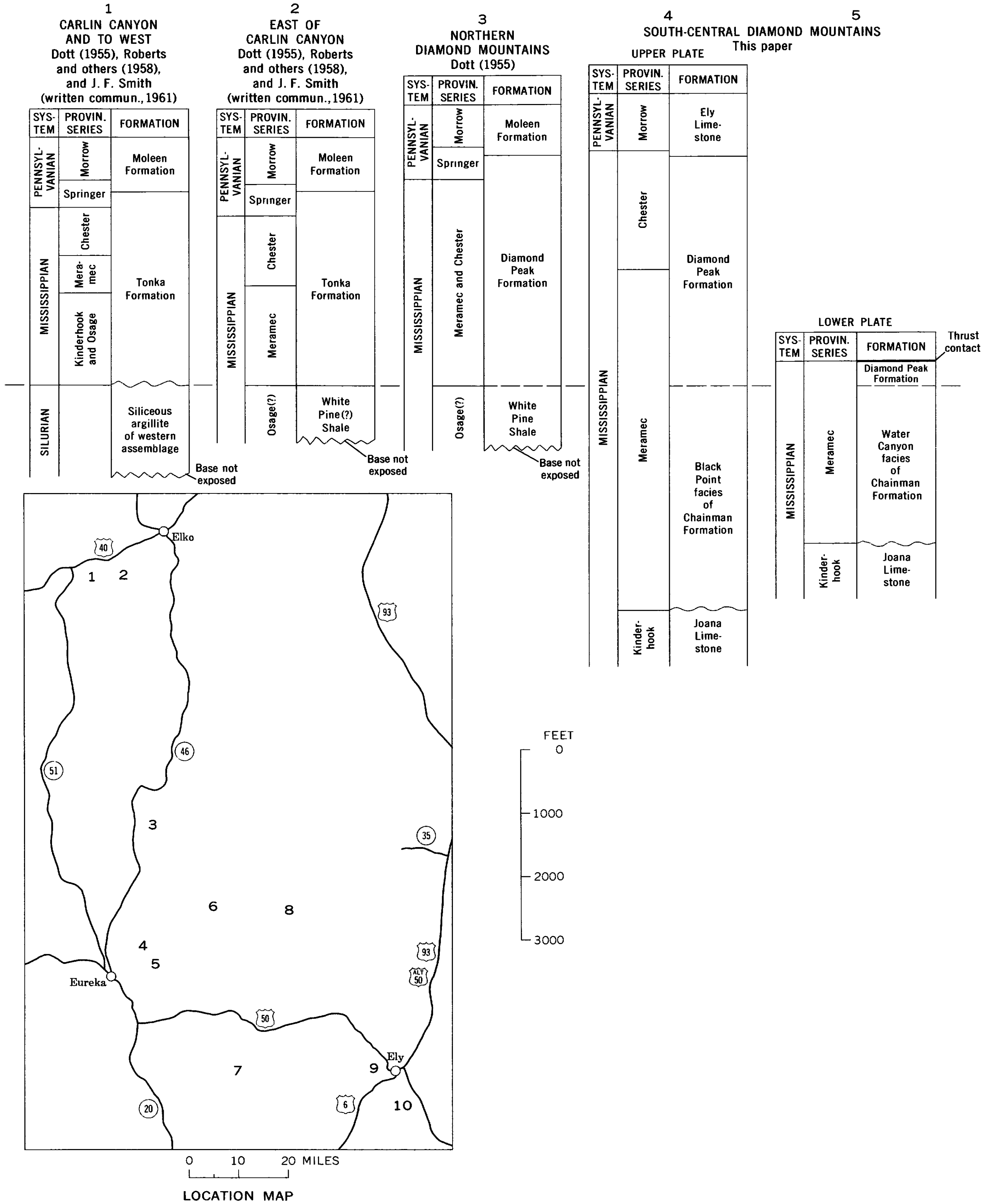
The Chainman Shale, as noted previously, was first named by Spencer (1917, p. 24, 26). The name was extended to the Eureka area by Nolan, Merriam, and Williams (1956, p. 59) and applied to the upper part of the rocks mapped by Hague (1882, 1883, 1892) as White Pine Shale. Because of the abundant nonshaly lithic types mapped in this unit, the term "formation" seems more apt than the term "shale" for the area covered by this report.

Within the area of the present study, two facies of the Chaiman Formation are present. This situation was first noted by Nolan, Merriam, and Williams (1956, p. 57) and has been summarized by the present author (Brew, 1961b). The informally named Water Canyon facies consists mostly of black shale and is exposed in the southern and southeastern parts of the mapped area; it extends from Tollhouse Canyon and Newark Summit northeastward to beyond the mouth of Sadler Canyon (pl. 1.; fig. 4). The informally named Black Point facies consists mostly of siltstone and crops out on the west side of the range from south of Black Point northward to beyond the northern boundary of the quadrangle.

WATER CANYON FACIES

The Water Canyon facies of the Chainman Formation consists largely of clayrock and clayey siltrock with minor discontinuous intercalations of sandstone and conglomerate. The informal name is taken from Water Canyon southeast of Diamond Peak where it is well exposed. The finer grained rocks generally are medium dark gray (*N*4), grayish black (*N*2.5), or grayish green, and weather to slightly brownish or olive shades or even to dark yellowish brown (10*YR* 4/2). The weathered rock is not fissile, but forms distinctive angular pencillike fragments as much as 20 cm (centimeters) in length and 2.5 cm in diameter. The clayrock and siltrock are commonly carbonaceous and pyritiferous and locally contain minor amounts of sand-size quartz grains. Some of the siltrock beds are micaceous. Plant-fragment impressions are common.

The coarser grained beds intercalated with the siltrock and clayrock are in most places less than 10 cm thick, but one or two coarse local lenses are more than 10 m (meters) thick. The most persistent of these thicker sandstone layers has been traced for slightly more than 1 mile. The sandstone is medium light gray to light gray (*N*5–*N*6) on fresh surfaces and weathers to brownish and reddish-brown hues. Many of these layers are pyritiferous, and most are cemented by secondary silica. The few beds of chert-pebble conglomerate and conglomeratic sandstone that occur grade laterally into nonpebble-bearing sandstone.


1
CARLIN CANYON AND TO WEST
Dott (1955), Roberts and others (1958), and J. F. Smith (written commun., 1961)
SYSTEM
PROVIN. SERIES
FORMATION
PENNSYLVANIAN
Morrow
Springer
Moleen Formation
MISSISSIPPIAN
Chester
Meramec
Kinderhook and Osage
Tonka Formation
SILURIAN
Siliceous argillite of western assemblage
Base not exposed
2
EAST OF CARLIN CANYON
Dott (1955), Roberts and others (1958), and J. F. Smith (written commun., 1961)
Osage(?)
White Pine(?) Shale
3
NORTHERN DIAMOND MOUNTAINS
Dott (1955)
Meramec and Chester
Diamond Peak Formation
White Pine Shale
4
5
SOUTH-CENTRAL DIAMOND MOUNTAINS
This paper
UPPER PLATE
Ely Limestone
Black Point facies of Chainman Formation
Kinderhook
Joana Limestone
LOWER PLATE
Thrust contact
Water Canyon facies of Chainman Formation
FEET
0
1000
2000
3000
Elko
Eureka
Ely
40
93
46
51
35
50
ALT 50
20
6
0 10 20 MILES
LOCATION MAP

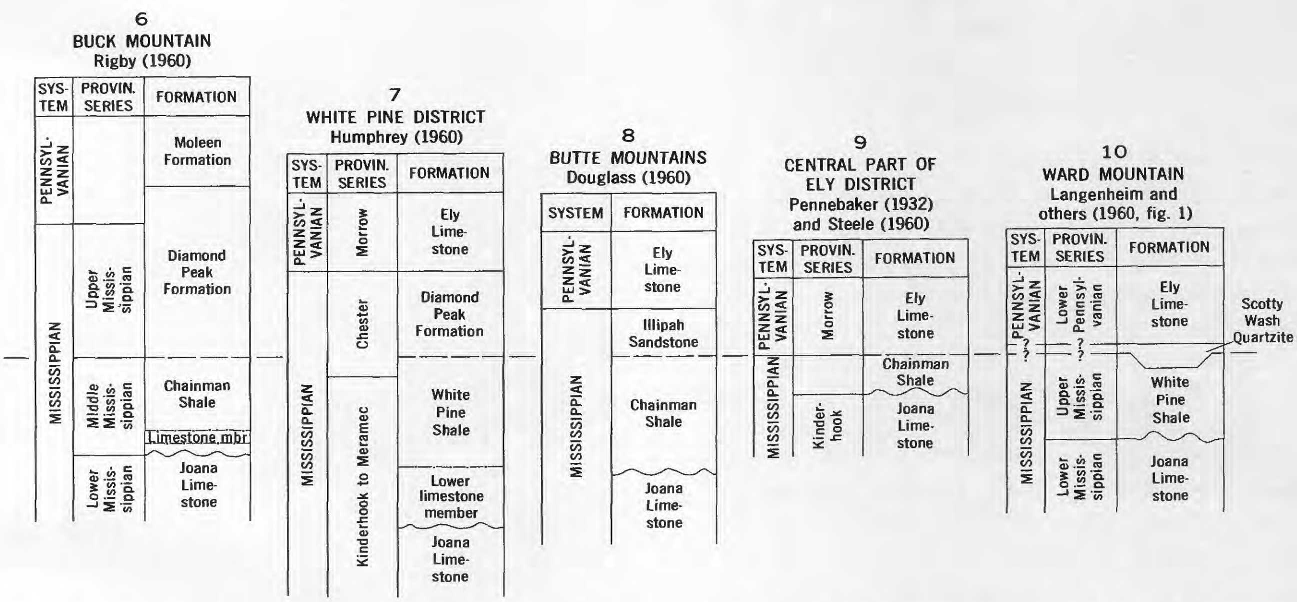


Figure 5.—Correlation chart of rocks referred to the Chainman Shale, Diamond Peak Formation, and lithically equivalent units. Datum is base of Diamond Peak or top of the Chainman, where the Diamond Peak is missing.

The Water Canyon facies rests unconformably on the Pilot Shale over most of its outcrop. South of the mapped area some Joana Limestone is present, as mentioned above. The contact is everywhere sharp and north of Water Canyon may have an angular relation to the underlying Pilot Shale (T. B. Nolan, oral commun., 1958). To the south in Tollhouse Canyon (T. B. Nolan, written commun., 1961), the contact may be a low-angle fault.

The upper contact of the Water Canyon facies of the Chainman with the interbedded silicified sandstone, conglomerate, and siltstone of the Diamond Peak Formation of the lower plate is gradational and is well exposed on the southeast side of Bold Bluff. The change involves a gradual increase in the number of beds of silicified sandstone through about 100 feet of section.

The plotted thickness of these exposures of Chainman is of questionable value because the section may have been thickened (Nolan and others, 1956, p. 57) or thinned by unrecognized faulting or folding. No repetitions were mapped, and the lack of key beds or other similarly useful features make detailed structural analysis impossible.

A generalized section of this facies of the Chainman Formation, taken from the exposures in the saddle between the west side of Newark Mountain and Bold Bluff, is as follows:

	Feet
Diamond Peak Formation of the lower plate of the Bold Bluff thrust fault:	
Silicified gray sandstone, some chert-pebble conglomerate, interbedded with siltstone.	
Chainman Formation (Water Canyon facies):	
3. Gray and grayish-black clayrock and siltrock; thin interbeds of gray silicified sandstone becoming more common at top of unit	660
2. Gray silicified sandstone and chert-pebble conglomerate	70
1. Gray and grayish-black clayrock and siltrock; weathers to pencillike fragments; sparse thin interbeds of sandstone	1,670
Total of Chainman Formation	2,400
Pilot Shale:	
Gray platy clay shale.	

Another generalized section of this facies, from the exposures north of the middle part of Water Canyon, is as follows:

	Feet
Diamond Peak Formation of the lower plate of the Bold Bluff thrust fault:	
Gray silicified sandstone with some chert-pebble conglomerate.	
Chainman Formation (Water Canyon facies):	
3. Grayish-green and dark-gray clay shale and siltrock; some discontinuous thin silicified sandstone and chert-pebble conglomerate beds; projected position of fossil colln. ES-58-4F (= U.S. loc. 21269-PC) is about 300 ft below top	1,120

	Feet
2. Gray silicified sandstone and chert-pebble conglomerate; weathers brown and brownish gray	30
1. Grayish-green and gray clayrock and siltrock; thin sandstone beds	680
Total Chainman Formation	1,830

Pilot Shale:
Gray clay shale, weathers tan.

These section serve to illustrate the consistent nature of the black shale facies in this part of the Diamond Mountains, and the discontinuous nature of the more obvious resistant silicified sandstone and conglomerate layers. Siltrock may be more abundant in the exposures to the northeast than in the vicinity of Newark Summit, but this cannot be proved with the information available at this time.

An estimated 10 percent of the rocks forming the Water Canyon facies of the Chainman Formation are sandstone and chert-pebble conglomerate; the remainder is siltrock and clayrock.

BLACK POINT FACIES

The Black Point facies of the Chainman Formation consists of interbedded siltstone, clayrock, sandstone, and conglomerate. The informal name is taken from the prominent topographic feature (fig. 2) that extends from the valley floor almost to the crest of the range on the west side of the Diamond Mountains. The unit is well exposed from the Joana Limestone outcrops eastward toward vertical-angle bench mark 9358 (figs. 4, 6).

This facies consists of gray (*N*5–*N*7) silicified pyritiferous sandstone and conglomeratic sandstone; silicified chert- and quartzite-pebble and cobble conglomerate; pyritiferous grayish-olive-green (5*GY* 3/2), grayish-olive (10*Y* 4/2), pale-olive (10*Y* 6/2), and dark-gray (*N*3) siltstone and clayrock, and pale-olive (10*Y* 6/2) conglomeratic siltstone and siltstone-matrix conglomerate.

The rocks weather to more pronounced olive and brown shades, and many of the sandy beds are distinctly brown. Some interbedded silicified sandstone and siltstone units are as resistant as the sandstone and conglomerate units; these form steeper slopes than do the more common interbedded siltstone and clayrock units. The more resistant units are also the ones in which discontinuous conglomerate lenses occur. Although the units locally separable in the Black Point facies of the Chainman are discontinuous in detail and vary both laterally and vertically, several can be mapped in gross fashion throughout the whole outcrop belt.

Worm trails are present in some of the siltstone units, and pyrite and crinoid casts are also abundant in places. Well-preserved fossils are rare, but some collections have been made by C. W. Merriam (written commun., 1958).

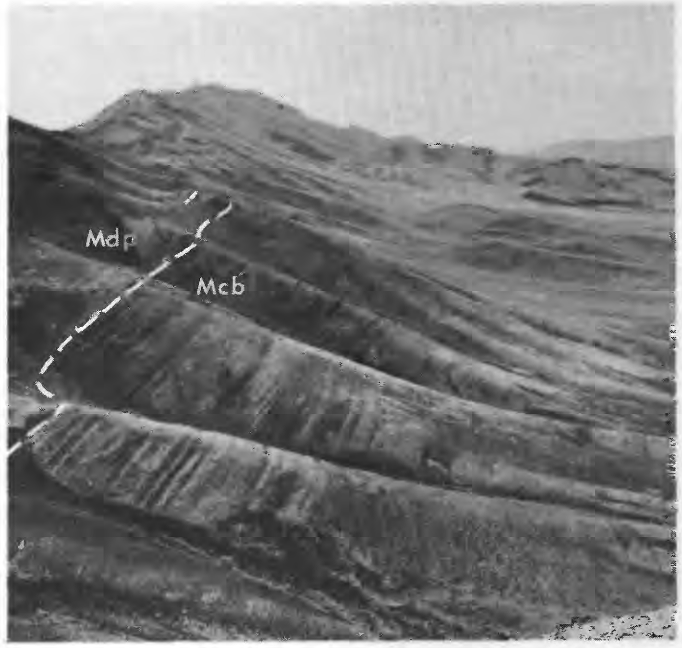


FIGURE 6.—Outcrop area of Black Point facies of the Chainman Formation showing uniform banded outcrop of the Black Point facies (Mcb) overlain by the Diamond Peak Formation (Mdp).

Rocks similar to the dominant types in the Water Canyon facies of the Chainman occur irregularly throughout the section, but they seem to be more prevalent in the lower few hundred feet. Platy and pencil-like weathered fragments occur only on the west side of the range about opposite the headwaters of Mau Creek (fig. 4). Shale is much less common to the north, and the average grain size in the section at the north edge of the quadrangle is slightly greater than to the south.

The contact of the Black Point facies of the Chainman with the underlying Joana Limestone is everywhere sharp, and, as described previously, unconformable. It is particularly well exposed near the crest of the range east of the Phillipsburg mine (fig. 4). The contact with the overlying Diamond Peak Formation is gradational—an increase in the number of sandstone beds marks the lower part of the gradational interval. Lenses of silicified chert- and quartzite-pebble and cobble conglomerate and some beds of siltstone-matrix conglomerate occur with the sandstone strata. Overlying this zone of interbedded conglomerate, sandstone, and siltstone is the discontinuous silicified sandstone that has been mapped as the basal part of the Diamond Peak Formation.

The thickness of the Black Point facies ranges from about 3,500 to 4,000 feet in the Eureka quadrangle. These thicknesses may be in error because of unrecognized faults or folds, although special efforts were made to determine their presence.

A generalized section of the Black Point facies as exposed on the upper part of Black Point ridge is given below:

	Feet
Diamond Peak Formation:	
Gray and brown silicified chert-pebble and cobble conglomerate and sandstone with some interbedded siltstone; some gray limestone cobbles in the conglomerate.	
Chainman Formation (Black Point facies):	
7. Gray siltstone and clayrock with abundant worm trails; also some silicified brown sandstone at base; overlain by gray and grayish-green siltstone succeeded upwards by interbedded brown sandstone and gray and pale-olive-weathering clayrock and siltrock	1,160
6. Olive and gray siltstone; some clayrock and lenses of brown-weathering sandstone; forms steep resistant slopes	350
5. Pale-olive, grayish-olive, and gray siltrock and clayrock	400
4. Interbedded gray siltstone and clay shale; some pale-olive siltstone	410
3. Interbedded gray siltstone and clayrock	270
2. Interbedded gray and grayish-green siltrock and thin-bedded brown sandstone; minor lenses of conglomerate and sandstone; forms resistant knobs and slopes	320
1. Interbedded gray and grayish-green siltstone and clayrock; some thin beds of silicified gray sandstone; highly fractured locally	620
Total Chainman Formation	3,530
Joana Limestone:	
Gray crinoidal and dense limestone with minor intercalations of gray shale.	

The Black Point facies contains on the average, but subject to great local variation, about 2 percent chert- and quartzite-pebble and cobble conglomerate, 24 percent sandstone, 39 percent siltrock, and 35 percent siltrock and clayrock lithologically similar to the Water Canyon facies of the Chainman.

The sediments that now constitute the rocks of the Black Point facies of the Chainman Formation were deposited in many different environments. The abundance of pyrite and pyrite casts throughout the section indicates that reducing conditions prevailed during diagenesis, but the mode of deposition of the original sediments was varied. Pebble-size detritus with a low proportion of matrix may have been transported by strong bottom currents or wave action, whereas similar detritus wtih a high proportion of matrix may have been transported by submarine slides or turbidity currents. Turbidity-current transport may also be inferred for the few graded thin sandstone beds and perhaps also for the very common poorly sorted clay-rich sandstone, silty sandstone, and sandy siltstone. Other thin beds of sandstone are commonly intercalated with the finer grained rocks and may have been deposited by low-energy bottom currents; however, their persistence may indicate that they are turbidites.

The other finer grained rocks in the section appear to have been deposited by slow-moving bottom currents or from suspension by flocculation. Most of the clay shales and silt shales have well-oriented fabrics that suggest compaction of an originally water-rich sediment.

There is no direct evidence of the depth at which these sediments were deposited. The abundance of fossil plant debris and crinoid casts suggests that the environment was not deeper than the neritic zone and may have been in part epineritic. The variation in the depositional mechanism probably is an indication of instability in nearshore areas. The lack of sedimentary structures, other than in the few graded beds noted, probably excludes the possibility of extensive littoral or estuarine deposition. The graded layers are not necessarily indicative of great depth, for similar features are known to have developed in Pleistocene sediments deposited at depths of less than 100 feet (D. M. Hopkins, oral commun., 1961).

Nolan, Merriam, and Williams (1956, p. 58-61) have summarized the fossil evidence that supports the Late Mississippian (Chester) age assignment of the Chainman and Diamond Peak rocks exposed near Eureka. As shown in figure 5, this is a shorter time span than is represented by the lithically correlative rocks in the Carlin area. The Chainman Formation in the Diamond Peak area is considered to be entirely Meramec in age by Mackenzie Gordon, Jr. (this report, p. 37).

DESCRIPTIVE STRATIGRAPHY OF DIAMOND PEAK FORMATION

In the Eureka quadrangle the Diamond Peak Formation is exposed in a continuous band that extends from near Poison Spring on the south to the northern boundary of the quadrangle (pl. 1; fig. 4). At the north, the band is relatively narrow, except for the downfaulted blocks that form the hills north and south of Strawberry Ranch. At the south, the outcrop belt of the Diamond Peak is broader and is interrupted by masses of the overlying Ely Limestone.

As mentioned above, almost all of the Diamond Peak exposed in the quadrangle are part of one structural element—the upper plate of the Bold Bluff thrust fault. The few hundred feet of strata assigned to the Diamond Peak Formation of the lower plate is discussed separately.

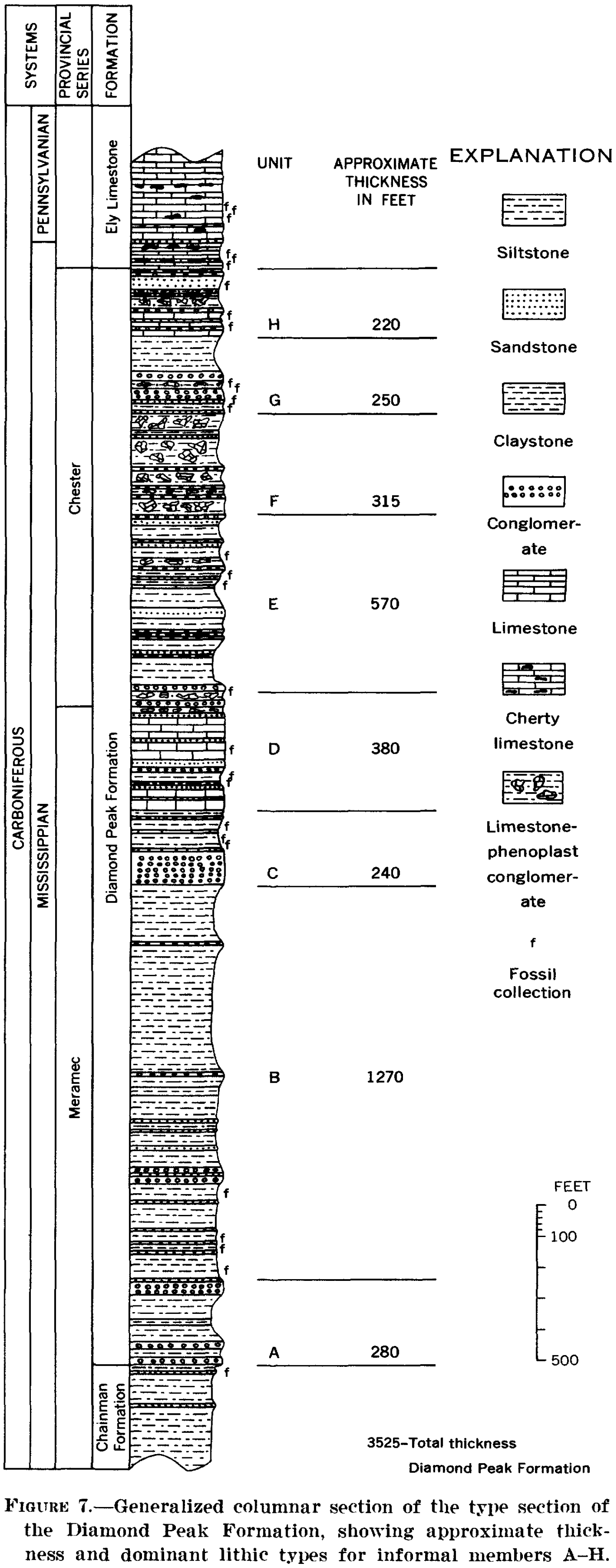


FIGURE 7.—Generalized columnar section of the type section of the Diamond Peak Formation, showing approximate thickness and dominant lithic types for informal members A–H.

Hague's original designation of the slopes of Diamond Peak as the type locality of the formation leaves considerable latitude for the selection of a type section, for these slopes cover about 15 square miles. Detailed mapping showed that a relatively unfaulted section is exposed on the northwestern slope of Diamond Peak in secs. 7 and 18 (unsurveyed), T. 20 N., R. 55 E. (between lat 39°36′ N. and lat 39°37′ N. and between long 115°48′30″ W. and long 115°50′ W.), and this section is herein designated as the type section. The detailed section is presented on page 67 of this report, and its base is plotted on plate 1; the section is summarized in figure 7 and in the discussion of individual members which follows.

The 3,525 feet of strata assigned to the Diamond Peak Formation in this section have been divided into eight informal members, all of which have been mapped throughout the type area. It is possible that these conformable and gradational members persist for several tens of miles; all the members were mapped at the northern boundary of the Eureka quadrangle, about 10 miles north of the type locality, but there two of the members are thickened relatively at the expense of the intervening member, and a third member differs in overall lithology. Minor abrupt lateral and vertical variations within members are common, and only a few individual beds persist more than 2 or 3 miles.

The type section provides information that supports the conclusions of Dott (1955, p. 2233, 2265–2266) and Nolan, Merriam, and Williams (1956, p. 56–61) that all previous workers had overestimated the amount of coarse clastic material in the Diamond Peak Formation and underestimated the amount of clayrock and siltrock. About 13½ percent of the measured section of the formation is conglomerate, 20 percent is sandstone, 6½ percent limestone, 5½ percent limestone-phenoplast conglomerate, 9½ percent claystone, and 45 percent siltstone. The individual members commonly contain at least three of these six rock types. In the upper members all six occur together, but in varying proportions (fig. 7).

In another section of this report (p. 38–47) Mackenzie Gordon, Jr., discusses in detail the biostratigraphy and age assignments of the members of the Diamond Peak Formation. He concludes that members A through C are Meramec in age, the Meramec-Chester boundary is near the top of member D, and members E through H are Chester in age.

CONTACT OF DIAMOND PEAK AND CHAINMAN FORMATIONS

The contact of the Diamond Peak Formation is gradational with the underlying Black Point facies of the Chainman Formation (p. 16). Throughout most of the quadrangle the lowest member of the Diamond

Peak is set off from the Chainman by its characteristic silicified thick- or very thick bedded gray-weathering polymictic pebble and cobble conglomerate that contrasts with the dominantly thinner bedded finer grained underlying strata. The occurrence of limestone clasts in the conglomerate is diagnostic, as these were not noted elsewhere in the section. In addition, these basal conglomerates contain sand- and pebble-size clasts of fine-grained volcanic rock that are readily recognizable in thin section, but which are difficult to distinguish from the siltstone clasts in hand specimen.

The increase in the frequency of conglomeratic units is not always abrupt, and the contact has been placed at the horizon where the coarser grained rocks become dominant. It is unlikely, therefore, that the mapped contact is everywhere at exactly the same stratigraphic level, and its placement may vary vertically more than 100 feet.

Locally, the sandstone and conglomerate beds of the lowest member of the Diamond Peak Formation seem to be completely missing, either by nondeposition or, possibly, by faulting. In such localities the contact between Black Point facies of the Chainman and the Diamond Peak has been projected between outcrops where member A is present.

MEMBER A

Member A, the lowermost member of the Diamond Peak Formation, is characterized by conglomerate beds, 60 cm to 3 m thick, interbedded with silicified sandstone, clayrock, and much siltstone. The conglomerate is gray and weathers in part to olive gray. It consists of pebbles and cobbles of light- and dark-gray chert and quartzite, silicified siltstone, gray limestone, and some dark volcanic rocks in a matrix of fine- to medium-grained silicified sandstone. Sparse pyrite euhedra and poorly preserved casts of fossils are present. The thin-bedded sandstone is gray when fresh, weathers brown, and is fine to medium grained and poorly sorted. Although silicified for the most part, it contains calcareous cement locally. Some pyrite is also present. The siltstone is gray to black and weathers either grayish brown or olive gray, resembling the dominant lithic type of the underlying Chainman Formation. These strata are 5–30 cm thick and contain casts of pyrite cubes, crinoid and bryozoans remains, a few scattered thin chert pabble beds, and worm trails. The clayrock is medium gray to medium dark gray and weathers pale olive and grayish olive.

This member contains, at the type section, about 12½ percent silicified conglomerate, 6½ percent siltstone-matrix conglomerate and conglomeratic siltstone, 10 percent sandstone, 4 percent clayrock, and 67 percent siltrock.

At the type section, member A is about 280 feet thick and forms prominent ledges. The ledge-forming beds are discontinuous in detail (fig. 6) but they have been traced with some gaps all the way to the northern boundary of the quadrangle.

Near the crest of the range due east of the Phillipsburg mine (fig. 4), this member is about 385 feet thick, according to the unpublished notes of C. W. Merriam (written commun., 1958), and includes minor beds of gray limestone. A single yellowish-gray-weathering limestone bed about 1 m thick was mapped in the member in the headwaters of Mau Creek, about 3 miles north of the type section. These are the only known occurrences of limestone in this member, although limestone mapped as part of member B east of Cottonwood Spring could conceivably be incorrectly assigned.

MEMBER B

The slope-forming rocks of member B consist mainly of siltstone with lesser amounts of interbedded sandstone, clayrock, and minor amounts of lenticular conglomerate. The siltstone is commonly gray, weathers to light olive gray and pale olive, and forms irregular fragments and large flakes 1 cm thick and 5–15 cm in diameter. Individual strata are 1–3 cm thick and display casts of former pyrite euhedra, worm trails, and poorly preserved casts of crinoid columnals, brachiopods, corals, and plant fragments. Clayrock interbedded with the siltstone contains fewer fossil impressions, but otherwise differs only in grain size. Thin beds (5–10 cm) of very fine grained to fine-grained gray silicified sandstone are intercalated with the siltstone and clayrock. They weather gray, brown, and light olive gray, are pyritic, and form resistant "ribs." Several somewhat coarser poorly sorted sandstone beds 2.5–10 cm thick are also present. Some of the sandstone contains casts of brachiopods, horn corals, crinoid columnals, and bryozoans. The few conglomerates present are of two types—a silicified gray-weathering chert and quartzite pebble and cobble variety that occurs in lenses as much as 7.5 cm thick and several meters long, and a gray- to light-olive-gray-weathering variety with a siltstone matrix that locally contains abundant brachipod and crinoid columnal impressions.

At the type section, the member includes 4 percent silicified conglomerate, 2½ percent siltstone-matrix conglomerate and conglomeratic siltstone, 19 percent sandstone, 11 percent clayrock, and 63½ percent siltstone.

In general, the unit closely resembles the Black Point facies of the Chainman Formation. The measured thickness of the unit at the type section is about 1,270 feet.

C. W. Merriam's unpublished data (written commun., 1958) and the present study indicate that the member is lithically similar at the north edge of the quadrangle and of similar thickness, namely 1,280 feet. Merriam's descriptions suggest that more sandstone may be present than at the type section and also emphasize the presence of worm trails throughout the member.

Merriam noted a 10-foot-thick crinoidal limestone bed close to the top of the member. The limestone resembles those described from the upper part of member C at the type section. As mentioned previously, limestone was also mapped in member B near the foot of the range due east of Cottonwood Springs, but it may not be in place.

MEMBER C

Member C consists of a prominent series of ledge-forming conglomerates overlain by interbedded siltstone and clayrock with sparse sandstone and conglomerate. Thin limestone beds occur in increasing numbers in the upper third of the member. The thick- and very thick bedded conglomerates are for the most part gray, although some brownish-white ledges are present in the upper half of the member. These rocks weather gray and brownish gray and consist of cobbles and pebbles of chert and quartzite in a matrix of silicified medium-grained sandstone. The overlying siltstone and claystone are gray on fresh exposures and weather to light olive gray. Commonly, the beds are laminated and aggregate 5–10 cm thick. Pyrite casts and bryozoan impressions are conspicuous in the siltstone. Parts of the claystones are carbonaceous. The few limestone strata in the upper part of the member are gray and dense, and attain a maximum thickness of 15 cm; interbedded with the limestone in the dominant siltstone and clayrock are sparse thin conglomerate lenses and very minor amounts of limestone-phenoplast conglomerate.

At the type locality the member consists of 38½ percent conglomerate, 29½ percent siltstone, 18 percent clayrock, 13½ percent sandstone, less than ½ percent limestone, and perhaps ½ percent limestone-phenoplast conglomerate.

The member is about 240 feet thick at the type section. At the northern boundary of the quadrangle the unit consists of about 535 feet of strata (C. W. Merriam, written commun., 1958), but there, as well as elsewhere north of the type section, the overlying member D is not well developed, and siltstone and sandstone occupy the equivalent stratigraphic position. This is illustrated by member D northeast from the type section; it was found to decrease markedly in thickness, whereas the upper part of C increased.

To the southeast, in the vicinity of Sadler Canyon, thick- and very thick bedded conglomerate overlying partial sections of member B has been mapped as member C. There the situation is complicated by the absence of the finer grained upper part of member C and the fact that member D in that area consists of interbedded conglomerate and limestone.

MEMBER D

Member D is a resistant cliff- and ledge-forming sequence of thick- and very thick bedded limestones interstratified with sandstone and minor amounts of clay shale, conglomerate, and siltstone. The limestone is typically gray or blue gray, weathers brownish gray in some places, and is locally very hard and dense. A few of the limestone beds have sets of planar cross-strata, and others are noticeably pyritic. Almost all are fossiliferous, containing crinoid columnals, colonial and solitary corals, bryozoans, brachiopods, and, locally, foraminifers. Many of the limestone strata have "stringers" and thin beds of dark chert granules and pebbles; others contain abundant silt-size quartz and chert grains and grade into limy siltstone. The nonlimy siltstone present is olive gray, thin bedded, and occurs also as the matrix of the limestone-phenoplast conglomerate of this member. The clay shale intercalated with the limestone is gray and fissile, weathers olive gray, and is locally either pyritic or limy. Small brachiopod casts occur in some of the beds. Light-gray, brown, and light-brown, fairly well sorted, fine-grained sandstone in beds 7.5–75 cm thick occurs between the limestone beds. Most of the sandstone is hard, dense, and moderately well sorted. Some is pyritic and some is conglomeratic. The conglomerates in the sequence are gray or brownish white and weather to brownish gray and darker brown. Chert and quartzite form the rounded pebbles and cobbles, which are a maximum of 10 cm in diameter. The chert fragments tend to be the more angular and are red, white, gray, and black. Some of the conglomerates grade to sandstone; others contain relatively little sandstone matrix and are cemented with calcite.

The limestone-phenoplast conglomerate referred to above is an unusual rock consisting of irregularly shaped nodulelike fragments of gray limestone in a matrix that commonly is mudstone. The nodules range from 0.5 to 10.0 cm in maximum dimension. The relative proportion of matrix and phenoplasts varies considerably both laterally and vertically within any individual bed. The fragments are intraformational in origin and are interpreted to have been plastic at the time of deposition. Carozzi (1956) has described somewhat similar rocks from the French Alps.

At the type section, the member consists of 43 percent limestone, 20 percent sandstone, 12 percent siltstone, 12 percent clay shale, 11½ percent conglomerate, 1 percent limestone-phenoplast conglomerate, and one-half of 1 percent siltstone-matrix conglomerate. The unit is about 380 feet thick.

C. W. Merriam's unpublished field data indicate that in the northern part of the Eureka quadrangle this limestone member has changed considerably, and the thick- and very thick bedded limestone is but a minor part of the unit; the interbedded clay shale and siltstone are dominant and are accompanied by minor conglomerate. In this area the unit is about 270 feet thick.

In the area east of Diamond Peak, particularly in the vicinity of Sadler Canyon, member D consists of interbedded thick- and very thick bedded conglomerate and limestone with subordinate amounts of clay shale and siltrock. To the southeast and south of Diamond Peak, on Diamond Table (which is the ridge between the upper parts of Sadler and Water Canyons (pl. 1)) and Alpha Peak ridge, the member in general includes more conglomerate and finer grained detrital rock. Where the member underlies Diamond Table, it is mostly conglomerate; but limestone and siltstone are more common on Alpha Peak ridge.

MEMBER E

Member E is made up of alternating beds of siltstone, sandstone, conglomerate, clayrock, limestone, and limestone-phenoplast conglomerate. Limestone and siltstone are more common near the base of the unit, but diminish upwards, sandstone and conglomerate, interstratified with clayrock and siltstone, form the upper half of the unit. The member forms steep slopes with resistant ledges.

The siltstone is commonly gray or brown and weathers olive gray, grayish green, and, locally, very dusky purple. In places it grades imperceptibly into very fine grained sandstone. The siltstone carries some brachiopod fragments locally and some limonite pseudomorphs after pyrite. Individual beds are as much as 2 m thick, but 1 m is more common.

The sandstone is brown, gray, and grayish green and weathers to brownish shades of the original colors. Although it is generally fine- and very fine-grained silicified sandstone, some conglomeratic lenses are present. Pyrite and limonite stains are common; the pyrite-rich beds are very hard and dense. This lithic type occurs in resistant uniform beds about 1 m thick.

The conglomerate forms ledges 15 cm to 1 m thick and consists of brown- and gray-weathering, gray, white, and pale-green cobbles and pebbles of quartzite and chert, dark-gray chert, and light-green chert in a silicified matrix of poorly sorted sandstone. Clasts as much as 7.5 cm in diameter were observed.

Slope-forming clayrock is less abundant than conglomerate. It is gray, weathers olive gray and grayish green, and in places grades to limestone-phenoplast conglomerate. Some brachiopod casts occur in the claystone, and some worm trails are also present.

The limestone, present as lenses and intercalations 30–60 cm thick, is generally sandy and in places contains widely scattered chert pebbles. Some beds contain crinoid columnals. Other nonfossiliferous beds grade into limestone-phenoplast conglomerate.

Limestone-phenoplast conglomerate occurs in nonresistant beds 30 cm to 1 m thick and consists of irregularly shaped fragments of gray limestone in either an olive-gray mudstone or very fine-grained sandstone matrix.

In the type section, member E consists of about 38½ percent siltstone, 28½ percent sandstone, 15½ percent conglomerate, 8½ percent clayrock, 5 percent limestone, and 4 percent limestone-phenoplast conglomerate. The member is 570 feet thick at this locality.

According to the field data of C.W. Merriam (written commun., 1958), the rocks at the north edge of the quadrangle assigned by this author to member E are about 375 feet thick. Limestone and limestone-phenoplast conglomerate were not noted by Merriam, but he did describe the occurrence of minor amounts of very dark red and dusky-red siltstone like that which is diagnostic of the overlying member F.

Between the type section and the southern boundary of the area, member E differs from the type section in the greater amount of silicified chert-pebble conglomerate present. Although conglomerate is still a relatively minor lithic type, several beds were traced for more than 1 mile, and one, near the top of the member, occurs discontinuously for perhaps 2 miles. In this area, member E contains more very dark red and dusky-red siltstone and also more limestone-phenoplast conglomerate than at the type section.

MEMBER F

Member F is characterized by purple, green, and gray limestone-phenoplast conglomerate, alternating purple and green siltstone and clayrock, pale-green silicified sandstone, and conglomerate. It is this member that has been noted by most previous works as being widespread in the upper part of the Diamond Peak Formation (Hague, 1882, 1883, 1892; Dott, 1955, p. 2265–2266; Nolan and others, 1956, p. 58).

The siltstone is typically grayish red purple and very dusky red purple or pale or blue green, with abrupt color changes; most, but not all, of which are grossly controlled by the bedding. From place to place the ratio of purple to green varies considerably. In the vicinity of Diamond Peak the purple to green ratio is perhaps 2 to 1, but elsewhere the situation may be reversed. The purple siltstone grades into claystone and limestone-phenoplast conglomerate, and the green in places grades into very fine grained sandstone. Individual layers are from less than 1 to more than 5 cm thick, and a persistently purple or green section may be as much as 3 m thick.

Limestone-phenoplast conglomerate is best developed in this member of the Diamond Peak Formation. The irregularly shaped phenoplasts of limestone are as much as 10 cm in diameter and are mostly gray, although locally, where they occur in purple claystone, some are brownish red. The matrix is variable in texture and color and includes all varieties of claystone and siltstone that occur in the member. These limestone-phenoplast conglomerate rocks grade into siltstone and claystone and, rarely, into limestone.

The clayrock is fairly consistently grayish red purple and very dusky red purple, but a minor amount is pale green. It grades locally into siltstone and into limestone-phenoplast conglomerate and typically has an argillitic appearance.

Some of the silicified very fine-grained sandstone is brown, but most is pale green or greenish gray. It grades into siltstone and also into conglomeratic sandstone containing white chert pebbles. The sandstone commonly occurs in beds 30 cm to 1.5 m thick and is intercalated with purple siltstone and claystone.

The white and pale-green conglomerate beds of this member contrast strongly with the surrounding darker, finer grained rocks. They are composed of subrounded or subangular white and very pale-green chert and white quartizite pebbles and cobbles as much as 7.5 cm is maximum diameter in a silicified matrix of poorly sorted sandstone.

The 315 feet of strata that are assigned to member F at the type section include about 37 percent siltstone (most of which is the purple variety), 30½ percent limestone-phenoplast conglomerate, 14 percent sandstone, 10½ percent clayrock (much of which is also purple), and 8 percent conglomerate.

The distribution of the distinctive purple coloration in this member is difficult to explain. Although the member can be mapped throughout the quadrangle on the basis of color, the local changes are abrupt and make detailed tracing of any individual stratum difficult. At the type section, part of this member is repeated, owing to high-angle faulting; but the local vagaries of the color distribution made recognition of the repetition difficult.

C. W. Merriam's data (written commun., 1958) on the section at the northern boundary of the quadrangle indicate that about 475 feet of strata can be assigned to member F in that area, and that lithically the unit is about the same, except for the absence of limestone-phenoplast conglomerate. This rock type is also missing in the exposures of member F on the east side of Alpha Peak ridge and on the steep slopes above Water Canyon, but it is present northward from these localities, both on the east and on the west flanks of Diamond Peak.

MEMBER G

Member G consists of thick-bedded conglomerate interstratified with siltstone, silicified sandstone, and limestone-phenoplast conglomerate in the resistant, ledge-forming lower half. The conglomerate beds are noticeably thicker than those of the underlying member, and the chert cobbles and pebbles are darker than the consistently light-colored clasts of the conglomerate of member F. The upper half of the member is poorly exposed and probably consists mainly of siltstone.

The generally gray conglomerate strata weather dark gray and brownish gray, and the cobbles and pebbles of light- and dark-gray or very pale green chert, and light-gray quartzite are generally approximately equant and well rounded. Cobbles as much as 13 cm in maximum diameter occur in a matrix of silicified sandstone that in places shows abundant limonite stain. The matrix is not always silicified, and limestone phenoclasts similar to those in the limestone-phenoplast conglomerate occur with the siliceous clasts. Intercalated with the conglomerates are gray and brown moderately well-sorted silicified sandstone beds as much as 1 m thick. The siltstone is usually gray and weathers grayish green, brown, or olive gray, but some dusky-red-weathering siltstone is also present. The siltstone grades locally to very fine grained or fine-grained sandstone and also to limestone-phenoplast conglomerate. Pyrite is present in a few beds, as are sparse "worm trails." In general, casts of brachiopods are only poorly preserved, but two horizons have yielded fair collections.

Sandstone in this unit is commonly gray, brown, or grayish green and weathers to brownish shades of gray. The sandstone is very fine to medium grained, and individual beds are well sorted or moderately well sorted; locally, the sandstone is pebbly. A few beds contain clasts of limestone like those in the limestone-phenoplast conglomerate. Much of the sandstone is silicified, but local areas of calcite cement are present. Pyrite occurs locally, as do poorly preserved casts of fossils. Some of the sandstone is cross stratified.

The limestone-phenoplast conglomerate of this member is marked by a relatively small proportion of siltstone matrix with a commensurate increase in the amount of limestone. The limestone clasts are gray or bluish gray, and the siltstone matrix is also gray, weathering olive gray. A few chert pebbles and poorly preserved fossils occur in this lithic type. One 60-cm bed of the conglomerate grades laterally into silty limestone, and another bed 5 m thick exhibits a progressive vertical decrease in the phenoclasts, ranging from a limestone-phenoplast conglomerate with relatively little matrix at the base to a limestone-free siltstone at the top.

About 250 feet of strata are assigned to member G at the type locality. The member consists of about 42 percent siltstone, 19 percent sandstone, 17½ percent conglomerate, 17 percent limestone-phenoplast conglomerate, and 4½ percent clayrock.

From Merriam's field data (written commun., 1958), it seems that northwest of Strawberry Ranch about 430 feet of strata should be considered as constituting members G and H. It may be that member G thins somewhat to the north.

MEMBER H

Member H is a transitional unit between member G of the Diamond Peak Formation and the overlying Ely Limestone of Mississippian and Pennsylvanian age. It is transitional to the lowermost unit of the Ely, which contains beds of the typical Diamond Peak lithic types. The transition is represented by the alternation of thick-bedded gray and bluish-gray noncherty limestone beds, as much as 1.2 m thick, with silicified sandstone and limestone-phenoplast conglomerate beds and with conglomerate and siltstone layers.

The limestone is gray and bluish gray and weathers to slightly lighter shades of gray. Locally, it is sandy or silty. Brachiopods and horn corals are abundant in some of the strata. The limestone commonly occurs interbedded with gray or brown limy sandstone and gray and olive-gray-weathering siltstone and limestone-phenoplast conglomerate.

The sandstone varies in color from brown to greenish gray and gray and is generally fine or very fine grained and moderately well sorted, but some poorly sorted, fine- to coarse-grained beds are present. Locally, the sandstone grades into pebbly sandstones as much as 30 cm thick or into siltstone. Both silica and calcite occur as cement, and a few beds are stained slightly with limonite. Sandstone commonly occurs in beds 30 cm to 1 m thick interbedded with limestone or conglomerate.

The conglomerate of this member contributes significantly to its overall resistance to erosion (figs. 8, 2). White, brown, and light-gray varieties occurs, and pebbles of white and light-gray quartzite and light-gray chert are the most common clasts. Also present are pebbles of pale-red, very pale green, and dark-gray chert. The largest pebble noted measured 6.25 cm in diameter. The pebbles occur in sandstone matrices cemented by either silica or calcite. The conglomerate beds are as much as 1.7 m thick and are usually interbedded with thin layers of siltstone, limy sandstone, or sandy limestone.

The siltstone is gray and dark gray and weathers olive gray or greenish gray in most places. Some beds grade into very fine grained sandstone; others contain limestone clasts less than 2 cm in diameter and grade into limestone-phenoplast conglomerate. The limestone-phenoplast conglomerate in this member of the Diamond Peak Formation commonly consists of gray limestone nodules 2–5 cm in diameter in an olive-gray-weathering, gray siltstone matrix. Locally the matrix is very fine grained sandstone or silty sandstone.

The uppermost 6 feet of this member consists of siltstone, which underlies the interbedded gray and bluish-gray fossiliferous limestone, green and very dark-red fossiliferous siltstone, and other noncarbonate rocks that have been mapped as the lower part of the Ely Limestone. This uppermost siltstone of the Diamond Peak Formation has a local disconformity at its base and fills scours (as much as 1 ft deep) cut into the underlying conglomerate and sandstone.

FIGURE 8.—Diamond Peak and cliff-forming member H (Mdph) of the Diamond Peak Formation. Overlying lower member (IPMel) of the Ely Limestone in middleground. Diamond Peak in right background; ridge extending from Diamond Peak north consists wholly of the upper member (IPeu) of the Ely Limestone. Saddle to north of member H is formed by the upper half of member G. In foreground are siltstones and sandstones of member F.

At the type section about 220 feet of strata was measured in member H. The member consists of about 31 percent sandstone, 20 percent limestone, 18½ percent conglomerate, 15½ percent limestone-phenoplast conglomerate, and 15 percent siltstone.

The section measured by Riva (1957) about 3 miles north of the quadrangle assigns about 240 feet of strata to the lower unit of his Moleen Formation. As he has mapped it, the unit probably includes part of member H, as here discussed and part of what has been mapped as the lower member of the Ely Limestone in the vicinity of Diamond Peak.

South of the type section, member H is well exposed in the cliffs on the east side of Diamond Peak and on the west flank of the Alpha Peak ridge. There, it is about the same thickness as at the type section.

CONTACT OF DIAMOND PEAK FORMATION AND ELY LIMESTONE

The contact of the Diamond Peak Formation and the Ely Limestone has been placed within the sequence of rocks that represents the transition between the terrigenous clastic strata of the Diamond Peak and the carbonate strata of the Ely.

As noted above, significant amounts of limestone are present in member H of the Diamond Peak—the lower part of the transitional sequence. The abrupt increase at the formational contact in the amount of carbonate rock present is illustrated in the following tabulation, which compares the percentages of lithic types in member H of the Diamond Peak Formation with those in the lower member of the Ely Limestone:

Lithic type	*Member H, Diamond Peak Formation (percent)*	*Lower member, Ely Limestone (percent)*
Siltrock	15.0	13.5
Sandstone	31.0	26.5
Conglomerate	18.5	8.0
Clayrock	.0	1.0
Limestone	20.0	46.5
Limestone-phenoplast conglomerate	15.5	4.5

About 110 feet above the Diamond Peak-Ely contact is a distinctive mottled yellowish-gray- and light-olive-brown-weathering cherty limy sandstone or sandy limestone that has been recognized almost everywhere in the south-central Diamond Mountains. This key bed has been used in mapping the contact in areas where the upper part of the Diamond Peak Formation is obscured by colluvium. The lowest occurrence of any cherty limestone in the transitional sequence is about 40 feet above the contact in areas of good exposures; this cherty limestone horizon has also been used in mapping less well-exposed areas.

The problem of placing a contact within a transitional sequence of rock is difficult, and it can be effectively argued that, in the case at hand, the contact would be better placed at the base of the transition unit, or above it. The important feature is the change in regimen from the deposition of dominant siliceous clastics to the deposition of carbonate rocks. As presently placed, the contact marks approximately where this change occurs, and its position can be readily determined in the field. The detailed measured section across the Diamond Peak-Ely contact is given on pages 68–70.

It should be emphasized that the placement of the formational contact is somewhat arbitrary and that it could be placed either higher or lower in the section. Nolan (written commun., 1966) has pointed out that the contact was placed higher—perhaps as high as the upper part of the lower member of the Ely Limestone—in some of the areas discussed by Nolan, Merriam, and Williams (1956).

DIAMOND PEAK FORMATION OF LOWER PLATE OF BOLD BLUFF THRUST FAULT

The rocks of the Diamond Peak Formation below the Bold Bluff thrust are exposed in and near the upper parts of Water and Mining Canyons (pl. 1).

The distribution of lithic types is not as well known as in the Diamond Peak Formation of the upper plate because of poorer exposures and a smaller outcrop area. Greenish-gray siltstone and clayrock with interbedded gray silicified sandstone that weathers brownish gray are most common. The stratigraphic sequence where best exposed consists of interbedded medium-bedded brown-weathering silicified sandstone and gray siltstone at the base, succeeded upwards by thick- and very thick-bedded silicified conglomerate and sandstone layers with increasing amounts of siltstone and clayrock. Near the top of the sequence are prominent silicified conglomerate and sandstone layers together with a thick-bedded gray fossiliferous limestone. At one place near the base, gray "pencillike" clayrock similar to that of the underlying Water Canyon facies of the Chainman Formation is intercalated with the silicified sandstone and siltstone. This stratigraphic sequence is not exactly correlative with any part of the type section, and there is no polymictic conglomerate near the lower contact. However, it resembles members A–C in general variation and proportion of lithic types and in overall thickness.

The thicknesses exposed range to a maximum of about 1,600 feet in the highly faulted ridge extending from the middle of Alpha Peak ridge eastward to the bottom of Water Canyon. At Bold Bluff about 450 feet of strata is assigned to the Diamond Peak of the lower plate.

DEPOSITIONAL ENVIRONMENTS

The different rocks in the Diamond Peak Formation record a variety of depositional environments as well as changes in the provenance terrane. Figure 9 illustrates the variation in amounts of the more important lithic types throughout the type section.

Only the major features of the general depositional environment of each of the important rock types are summarized below; conclusions based on textures and composition are presented in greater detail in another report that is in preparation.

Siltrock

Siltrock is the most abundant rock type in the Diamond Peak Formation, and almost all gradations from clayey siltstone to sandy siltstone have been noted. The poorly sorted clayey varieties are the most common. Two important subclasses of clayey siltstone are present. The more abundant of the two is the olive-gray-weathering pyritiferous type that is particularly characteristic of members A and B and which is consistently gray where fresh. The other type, prevalent in member F, is characterized by its grayish green or very dusky-red-purple and very dusky-red shades on both weathered and fresh surfaces and its lack of pyrite, or limonite formed from pyrite. This type commonly grades into clayrock. Both types of siltstone occur in members E and G.

The evidence suggests that many of these rocks were deposited below the limit of effective wave action by some type of bottom current. The locally abundant pyrite is, according to Williams, Turner, and Gilbert (1954, p. 262), indicative of a reducing bottom environment at depths of less than 100 fathoms; that is, within the neritic zone. In places, numerous casts of brachiopods, gastropods, and disarticulated crinoid columnals indicate the former presence of bottom communities. The preservation of worm trails indicates deposition below wave base and rapid burial. The abundance of poorly preserved plant fragments suggests that land was not far away.

The green and purple siltstone and clayrock in the upper part of the formation contain the few examples of ripple marks noted. This evidence of wave action, plus the association of the siltstone with the apparently shallow water deposits of limestone-plenoplast conglomerate, suggests a shallower depositional environment for these rocks than for the siltrocks lower in the section.

Sandstone

Sandstone is the second most abundant rock in the Diamond Peak Formation. The common sandstone in the type section is a poorly sorted pyritiferous gray variety that weathers to olive and olive-gray hues and is composed of particles of quartz, chert, and lithic fragments in varying proportions. The less common type is compositionally similar to the first, except for a smaller "clay" material content and more common silica cement; but it is texturally dissimilar, being moderately well sorted and in general somewhat coarser grained. The second type tends to weather to brownish shades.

Large-scale crossbedding has been reported from the Diamond Peak Formation at Buck Mountain, across Newark Valley to the east (C. M. Wentworth, Jr., oral commun., 1960), but no cross-stratification was noted in the Diamond Mountains.

A few of the poorly sorted thin sandstone beds exhibit poorly developed graded bedding, suggesting that turbidity currents deposited some of the sandstone layers (Kuenen and Migliorini, 1950). Stewart (1962, p. C58) found evidence of turbidite deposition in his undifferentiated Chainman and Diamond Peak Formations.

Conglomerate

Conglomerate is the third most abundant rock in the Diamond Peak Formation. The most common variety is the lenticular silica-cemented chert and quartzite-pebble and cobble conglomerate that forms a conspicuous part of members A, C, G, and H and includes the polymictic subvariety that is characteristic of member A. A second variety is present in important amounts only in members A and B and consists of olive-weathering siltstone-matrix conglomerate with between 30 and 50 percent chert and quartzite granules and small pebbles. This type commonly grades into conglomeratic sandstone.

The most common conglomerate occurs in lenticular layers that probably resulted from the coalescing of bodies of coarse detritus brought to the depositional site by closely spaced steep-gradient streams and redistributed in the marine environment. The presence of diagenetic pyrite in some of the conglomerate units indicates deposition under reducing conditions. Textures indicate that the conglomerate may have been deposited below the limit of effective wave action for the most part and that submarine slides may have played a part in the transport. Alternatively, the poor sorting may be due to the introduction of sand-size material into a lag deposit. The association of some of these rocks with limestone units whose textures indicate quiet environments supports the hypothesis that they were deposited below the wave zone.

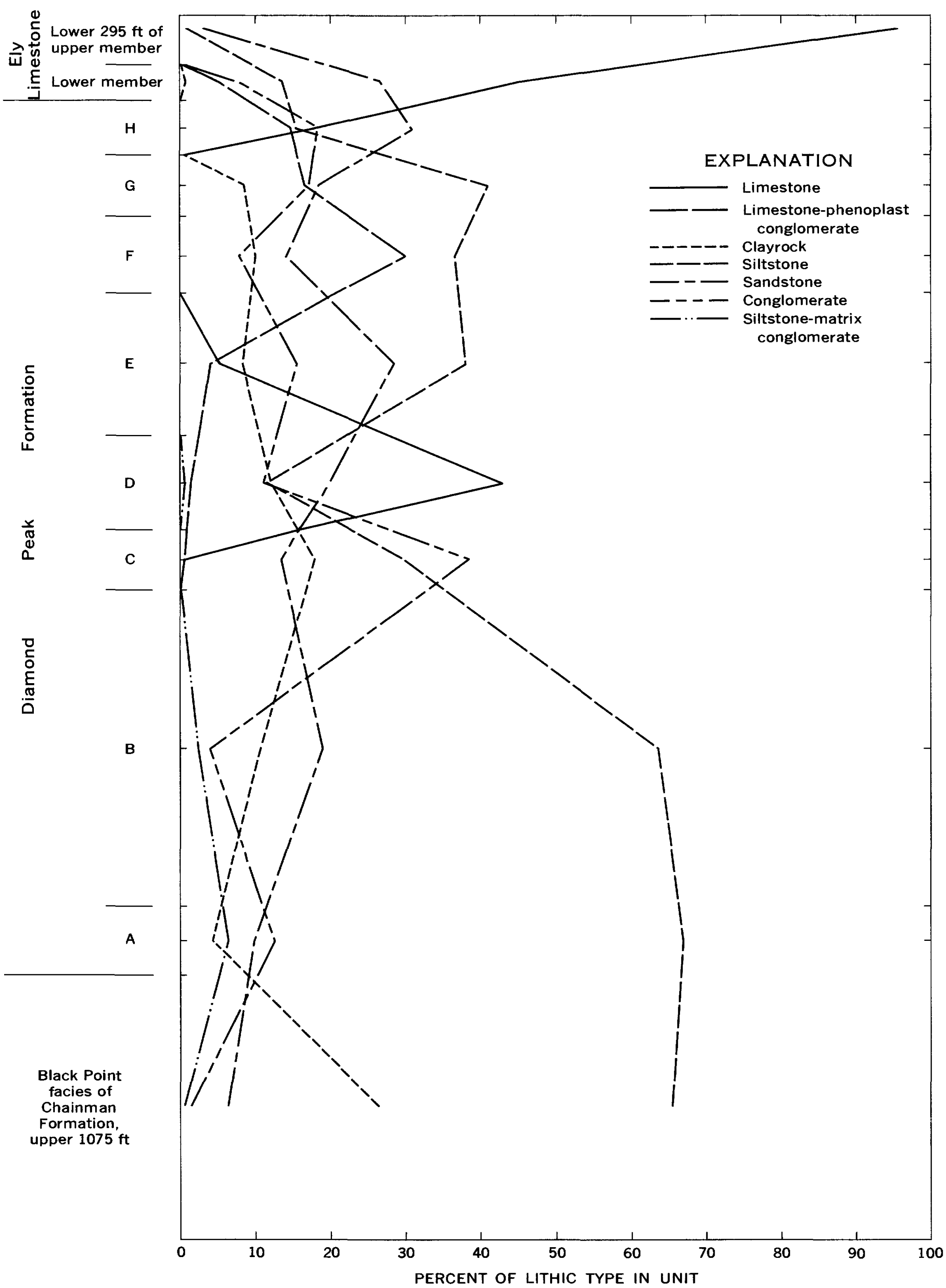


FIGURE 9.—Variation and proportion of major lithic types in members of the Diamond Peak Formation at the type section. Comparable values for the lower part of the Ely Limestone and for the upper part of the Black Point facies of the Chainman Formation are also shown.

These conglomerate units do not seem to fill channels eroded into the subjacent strata; the coarse units grade laterally into sandstone or siltrock in all places where such relations were observed.

The siltstone-matrix conglomerate is everywhere associated with conglomeratic and nonconglomeratic poorly sorted pyritiferous sandstone and siltstone, and in origin it is probably more closely tied to those rocks than to the conglomerate discussed above. The high proportion of matrix, the resulting disrupted framework, and the abundance of silt-size material suggest that these rocks may have been deposited from submarine mudslides or perhaps turbidity flows (Pettijohn, 1957, p. 254).

Clayrock

The fourth most abundant rock in the type section of the Diamond Peak Formation is clayrock, much of which is clay shale. The clayrock is consistently medium to dark gray on fresh surfaces and typically weathers to olive shades. Pyrite euhedra are common. It is characteristically gradational into the clayey siltstone discussed previously, and in many places contains many clasts of silt-size material either scattered or in lenses a few millimeters thick and a few centimeters long.

Some of the clay shale has numerous worm trails on bedding surfaces, but other fossils are absent. Plant fragments occur locally in the clay shale, and brown organic material is abundant in some thin sections, indicating that these clay shales are similar to the shales of both the Water Canyon and the Black Point facies of the Chainman Formation.

Limestone

Limestone occurs in significant amounts only in the upper part of member C, and in members D, E, and H. In member D the limestone is associated with conglomerate and other detrital rocks both as lateral gradations and as intercalations; the carbonate rocks seems to have formed where terrigenous debris was scarce.

The most important varieties of limestone are biomicrite and biosparite (Folk, 1959). Less common are intrasparite, oosparite, intramicrite, and intrasparrudite. Terrigenous material is present in some of the limestone types.

The locally fragmented fossil debris in the biomicrite and biosparite consists of endothyroid foraminifers, bryozoans, crinoid columnals, and brachiopod pieces. In most specimens studied the cement is microcrystalline calcite, which Folk (1959) considers to have been derived from undisturbed chemically precipitated ooze originally present between the biogenic clastic particles. The association of terrigenous clastic grains with the sparry calcite-cemented limestones in contrast to their absence in the micrite-cemented one supports Folk's hypothesis that the micrite type accumulates in a lower energy environment than the sparite type. The fragmented fossil debris indicates that a higher energy environment existed before accumulation and suggests that the sparry calcite-micrite relationship indicates only the amount of reworking that took place during a latter stage of the depositional process. In otherwise similar limestones this may measure the rate of subsidence, the micrite types having subsided below the agitated zone immediately after initial fragmentation and the sparite types having remained for a longer time in the wave-agitated zone.

The sum of the evidence indicates that these limestones were deposited in the neritic zone of an intermittently subsiding basin.

Limestone-Phenoplast Conglomerate

This unusual rock occurs only in the upper part of the Diamond Peak Formation and is particularly important in member F. Its inferred origin and some of its characteristics have been discussed briefly above and and are enlarged upon below.

The limestone-phenoplast conglomerate is made up of gray nodules of fine-crystalline calcite, ranging in diameter from a few millimeters to about 20 cm, set in a matrix of siltstone, claystone, or, more typically, clayey siltstone. The clasts are mostly spheroidal to blade shaped in general form (Zingg, 1935), although the surfaces are highly irregular in detail with many reentrants of several millimeters in depth. Some flattened disks are also present. The abundance of these clasts differs laterally and vertically within a single stratum; all gradations between widely scattered individuals that make up less than 10 percent of the rock to closely spaced groups of clasts that make up more than 80 percent of the rock, have been observed.

The common clayey siltstone matrix of the limestone-phenoplast conglomerate is of two types: a dusky-red and very dusky red-purple hematitic variety and a grayish-green nonhematitic type. In general, each stratum appears to have either one type of matrix or the other, but in detail the color boundaries cross the stratification surfaces at steep angles and show many minor irregularities. The control of these color differences is not clear, and their general distribution does not provide any clue.

Carozzi (1956) described a peculiar thin intraformational conglomerate from which he was able to reconstruct a history involving carbonate sedimentation followed by varying degrees of vigorous wave activity. Preserved in this conglomerate are relatively undisturbed limestone layers as well as all gradations from the undisturbed through wholly clastic, completely reworked layers in which the limestone clasts are enclosed in a siltstone matrix. Various arrested stages of this process show clearly that the carbonate was plastic during reworking and redeposition. The limestone phenoplast conglomerate of the Diamond Peak Formation is probably similar in origin, but the intermediate stages of disruption and redeposition have not been preserved. The limestone nodules have the size and shapes of clasts, and their lack of internal texture and the irregularity of their shape suggest plasticity during disruption and incorporation in the silt that entered the depositional site during reworking. It is for this reason that the term "phenoplast" (Hatch and Rastall, 1950, p. 59) has been used.

SUMMARY

The overall distribution and character of the rocks of the Black Point facies of the Chainman Formation and the Diamond Peak Formation in the Diamond Peak area indicate that material derived from a nearby tectonically active provenance terrane was transported short distances, probably by closely spaced steep-gradient streams, and deposited as a series of coalescing steep-fronted deltas in a basin that subsided rapidly enough to prevent extensive regression of the sea.

MISSISSIPPIAN AND PENNSYLVANIAN SYSTEMS

DESCRIPTIVE STRATIGRAPHY OF ELY LIMESTONE

The Ely Limestone is latest Mississippian and Early Pennsylvanian in age in the Diamond Mountains.

The formation was first named by Lawson (1906, p. 295) from exposures in the Robinson mining district near Ely. It had been described earlier as the "Lower Coal Measure Limestone" by Hague (1870, 1882, 1883, 1892) in reports dealing with the White Pine and Eureka districts. Nolan, Merriam, and Williams (1956, p. 61–62) have summarized the most important of these early descriptions. Equivalent strata in the northern part of the Diamond Mountains have been named the Moleen and Tomera Formations by Dott (1955, p. 2234–2248).

The Ely forms three outcrop belts in the Eureka quadrangle, but only one of the belts is within the area covered by this report. The northwesternmost belt in the quadrangle consists of a discontinuous series of outcrops along the western base of the range south of Pedrioli Creek (fig. 4). All these outcrop areas are small and are associated with local fanglomerates of Tertiary(?) age. The second belt is on the east side of the range (fig. 4) and extends from the north edge of the quadrangle, where the Ely occurs on the western overturned limb of a syncline, southward to Cedar Mountain (which is about 2 miles southwest of Strawberry Ranch), where only part of the same structure is present. The third belt consists of three separate outcrop areas (pl. 1): the area that forms the summit and uppermost slopes of Diamond Peak, a downfaulted portion of the same mass in the area north of Adobe Canyon, and the narrow generally fault-bounded strip extending from Newark Summit northward along Alpha Peak ridge and then along the west side of the range (pl. 1; fig. 4).

The original contact of the Ely with the overlying Carbon Ridge Formation of Permian age is not exposed in the area mapped, and, consequently, the total thickness of the Ely Limestone is not known. About 1,500 feet is present just south of the area, according to Nolan, Merriam, and Williams (1956, p. 63). About 1,400 feet of strata assigned to the Ely is present in the large downfaulted block just north of Adobe Canyon.

The Ely Limestone has been subdivided into two informal members. They were mapped only locally, however, and the subdivision is not shown on the map (pl. 1).

LOWER MEMBER

The lower member of the Ely Limestone consists of strata transitional between the mixed carbonate and terrigenous clastic rocks of member H of the Diamond Peak Formation and the wholly carbonate rocks of the upper member of the Ely Limestone. It is best exposed on Diamond Peak.

The contact of the lower member with member H of the Diamond Peak Formation is considered to be at the horizon where the amount of carbonate rock present increases abruptly (p. 24). All the rock types common in the upper Diamond Peak occur interbedded with the cherty and noncherty gray limestones of the lower member. The limestones are platy and are less resistant than the interbeds of white-weathering chert and quartzite-pebble conglomerate, sandstone, and massive dark-greenish-gray siltstone; as a result, the member forms a series of steep steps and narrow benches. The amount of terrigenous clastic rocks decreases upwards in the section, and the limestone beds increase in thickness. The amount of replacement chert in nodules and irregular layers (fig. 10) increases upwards through about the lower third of the unit and then decreases.

The noncarbonate rocks of the lower member of the Ely are lithically the same as the sandstone, siltstone, conglomerate, limestone-phenoplast conglomerate, and clayrock of the underlying member of the Diamond Peak Formation. The carbonate rocks are thin to thick bedded and consist of silty biomicrite; some oosparite and intrasparite are also present. Almost all the lime-

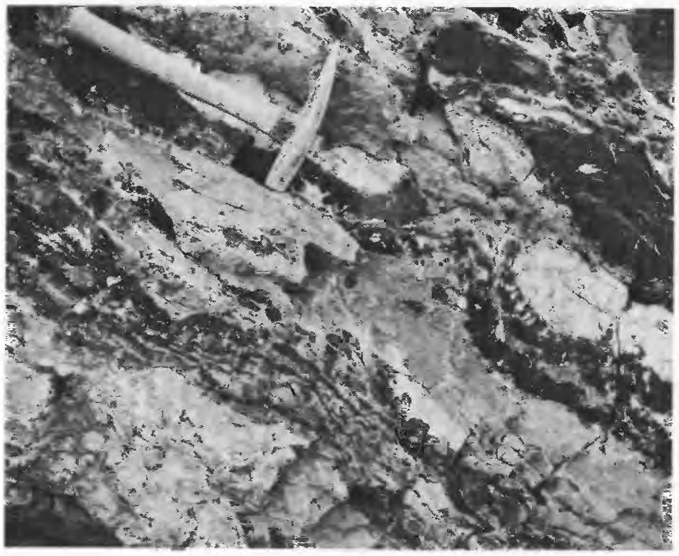


FIGURE 10.—Nodular and lenticular chert, limestone, and sandy or silty limestone in lower member of the Ely Limestone. Note displacement of limestone layers around chert masses. Hammer is about 31 cm long.

stone contains at least 5 percent terrigenous silt- and sand-size quartz and chert grains, and much of the biomicrite contains more than 10 percent. Replacement chert is generally very minor and consistently contains relict clasts of quartz or chert. All the limestone is dark bluish gray or greenish gray to medium light gray and weathers to slightly lighter shades of gray and, in some places, very pale orange.

The upper boundary of the lower member has been placed at the top of the highest chert pebble and cobble conglomerate bed. The discontinuity of these conglomerate beds means that the upper boundary is at different stratigraphic levels from place to place, but this variation is only about 50 feet. Dott (1955, p. 2237) placed the upper contact of the lower member of his Moleen Formation in the Carlin area, using the same criterion, but apparently did not note this specific lithic type where he observed the contact on Diamond Peak (1955, p. 2268).

Near the top of the member is a distinctive gray and yellowish-gray mottled bed like those noted by Dott (1955, p. 2237). This mottled bed is at some places a sandy cherty biosparite and elsewhere a cherty calcareous sandstone. The changes in the relative amounts of chert, limestone, and sandstone present are abrupt. Where exposed at the north end of the Ely outcrops on Diamond Peak, the bed is about 8.5 feet thick. Its dominant limestone part is medium dark gray, weathering to medium light gray with superimposed mottling caused by irregular patches of grayish-orange sandy limestone and gray chert. To the east of the summit of Diamond Peak the bed is slightly thicker and is mostly a medium-grained calcareous light-gray sandstone that weathers light olive gray and contains irregular nodules and lenses of medium-gray chert as much as 15 cm long in the calcite-rich parts of the sandstone.

Above the type section of the Diamond Peak, the lower member of the Ely Limestone is about 137 feet thick. Nolan, Merriam, and Williams (1956, p. 62) assigned 42.5 feet of transitional interbedded limestone, shale, and sandstone exposed on the southwest ridge of Diamond Peak to the Ely Limestone. The author consistently mapped the formational contact there lower than did Nolan, Merriam, and Williams and considers the Ely part of the whole transitional sequence to be between 150 and 200 feet thick.

As noted above, this lower member of the Ely appears to correlate with the upper part of the lower member of Dott's Moleen Formation. Mackenzie Gordon, Jr.'s studies of numerous megafossils (collections from this lower member of the Ely Limestone, p. 50–51 of this report) indicate that the lower 80-odd feet is Late Mississippian (posttype-Chester, but pretype-Morrow) and that the upper part of the member is Early Pennsylvanian (Morrow).

UPPER MEMBER

Above the mixed carbonate and terrigenous clastic rocks of the lower member is a rather monotonous section of gray cherty and noncherty limestone. The uniform aspect is interrupted locally by minor pinkish-gray platy layers, by thin pebbly beds, and by discontinuous thin greenish-gray- and olive-weathering clayrock lenses. The detrital clastics are more common near the base of the member. A complete section is not present in the mapped area, because the depositional contact with the overlying rocks is nowhere exposed. Not far to the south, Permian rocks rest with erosional unconformity on the member (Nolan and others, 1956), and a similar situation just north of the Eureka quadrangle has been mapped and described by Riva (1957).

The limestone of the upper member of the Ely is mostly thin- to very thick bedded medium-dark-gray biomicrite that weathers to medium-light-gray shades. The beds are composed of broken bryozoans, fusulinid fragments, and other allochems in a matrix of microcrystalline calcite ooze. Many of these limestones are pyritiferous and most contain a few percent of silt- and sand-size quartz grains. Locally, conglomerate biomicrite occurs in lenses less than 10 cm thick and as much as several meters long. The lenses probably make up less than 1 percent of the unit. Some oosparites were studied in thin section and found to contain as much as 10 percent silt-size quartz and chert grains.

They differ from the dominant lithic type in that their fresh surfaces are yellowish gray and their weathered surfaces are light olive gray.

Cyclic patterns of the type described by Dott (1958) were not noted.

Interbedded with the carbonate rock are a few thin beds of medium-light-gray calcareous quartz siltstone that weathers to distinctive pale-yellowish-brown platy fragments. These beds are commonly pyritiferous, and the cement is sparry calcite.

Concentrically banded chert layers occur locally near the base of this member. The chert is medium gray on fresh fracture and weathers dark gray. The concentric surfaces form very flattened spheroids with least axes as much as 5 cm long. The least axes are oriented approximately perpendicular to the bedding surfaces. More common in the member are decimeter-size nodules and irregularly shaped lenses of dark replacement chert that typically contain sand-size quartz grains and sparse dolomite rhombs.

This member probably correlates with all of Dott's middle and upper members of his Moleen Formation and part of his Tomera Formation (Dott, 1955, p. 2269–2271).

The upper member of the Ely Limestone is Early Pennsylvanian (Morrow) in age, according to the fossil determinations made by Mackenzie Gordon, Jr. (p. 51).

DEPOSITIONAL ENVIRONMENT

The uniform character of the Ely Limestone indicates a more stable and persistent depositional environment than that under which the rocks of the Chainman and Diamond Peak Formations were deposited.

The mixed carbonate and noncarbonate rocks of the lower member of the Ely were deposited in a variety of environments, as were their counterparts in the Diamond Peak. The conglomerate, sandstone, and siltstone indicate higher energy environments than generally persisted during the deposition of the limestone, but contrast mainly in the much higher proportion of terrigenous clastic material. The biosparite and biomicrite of the Ely have textures like sandstone and siltstone, but consist almost wholly of intrabasinal detritus.

The typical alternation of terrigenous clastic rocks and limestone in the lower member is a continuation of the pattern established in member H of the Diamond Peak Formation, but the noncarbonate rocks become less common upwards in the section and those present tend to have calcareous matrices. Just below the contact of the lower and upper members of the Ely, the amount of terrigenous material decreases markedly, and only thin lenses of conglomerate and siltstone are present. Little terrigenous debris is present in the upper member. Following deposition of the upper member the trough stabilized completely and became the site of carbonate deposition only.

The composition as well as the contained fossils of the Ely Limestone indicates that extensive microfaunas and megafaunas existed in the stable basin. The allochems consist largely of broken and comminuted fossil debris, although micritic intraclasts and oolites occur locally. These latter indicate intrabasinal erosion of lithified micrite material and local chemical precipitation of calcite (Dunbar and Rodgers, 1957, p. 234), respectively. The microcrystalline calcite matrix of most of the limestone suggests only limited reworking of the allochems after breaking and before final lithification. The scattered subrounded sand- and silt-size quartz and chert grains apparently were introduced from distant sources and transported singly among the allochems, although scattered lenses of sandy or even conglomeratic limestone indicate sporadic minor influxes of terrigenous clastics into the basin.

Local concentrations of authigenic pyrite in the carbonate layers indicate that in some places a reducing environment existed during and after deposition.

PERMIAN SYSTEM

Nolan, Merriam, and Williams (1956, p. 64–67) assigned the Permian rocks of the Diamond Mountains to the Carbon Ridge Formation—the type area of which is at Carbon Ridge, about 10 miles southwest of the study area. Nolan and his coworkers noted the presence of two facies in the Carbon Ridge Formation: the relatively carbonate-rich facies in the Diamond Mountains and a carbonate-rich facies at the type locality. A third, more westerly, facies exposed in the Sulphur Spring Range west of Diamond Valley was assigned to the Garden Valley Formation. Nolan, Merriam, and Williams (1956, p. 64) have summarized Hague's original description of these and younger rocks and have pointed out the discrepanices and inadequacies which made their thorough revision necessary.

The Carbon Ridge Formation is exposed in three separate localities in the Eureka quadrangle. The northernmost is between the alluvium of Diamond Valley and the major fault that bounds the west side of the range near the northern boundary of the quadrangle (fig. 4). Farther south, on the same side of the range but at about the latitude of Cottonwood Spring, is the north end of a band of discontinuous outcrops that extend southward to beyond the limits of the present mapping (pl. 1). The third locality is in the downfaulted blocks that form foothills on the east side of the range north of Circle Ranch (pl. 1).

Both the upper and lower contacts of the Carbon Ridge Formation are erosional unconformities, and any thickness figures are therefore of limited significance. In the mapped area, structural complications precluded thickness estimates. Nolan, Merriam, and Williams (1956, p. 65) considered the Carbon Ridge Formation to be about 1,500 feet thick along the Newark Canyon Road, just to the south of the mapped area. Riva (1957) studied and mapped six units of Permian and younger age in the area just north of the northern boundary of the quadrangle and stated that the units are bounded by remarkable unconformities, which cause a variation in aggregate thickness from about 1,600 feet to more than 6,200 feet. (The uppermost unit that Riva included in his Permian probably is actually correlative with the Newark Canyon Formation of Cretaceous age.) Lithologically and lithogenetically, all of Riva's members are similar, but the upper third of the complicated section contains no fossils. Dott (1955, p. 2271) reported 800–1,000 feet of Permian siltstone, limestone, and chert in the northern Diamond Mountains and stated that the unit thickened southward.

The relations of the three separate facies of the Permian discussed by Nolan, Merriam, and Williams (1956, p. 64) to the Permian in the northern Diamond Mountains are not known. The westernmost of the three facies—the Garden Valley Formation—is similar to the section described by Riva (1957), but the apparent widespread instability during sedimentation that is suggested by the studies of Riva and Dott makes the interpretation of possible facies relationships difficult. Dott (1958, p. 3) suggests that local facies changes are more than adequate to explain the observed differences; certainly, more information is needed.

CARBON RIDGE FORMATION

Rocks of Permian age occur in the area only in fault-bounded blocks overlapped by Quaternary alluvium, and the original contacts are nowhere exposed. Not far to the south, however, the Carbon Ridge Formation rests with angular unconformity on the Ely Limestone (Nolan and others, 1956, p. 64) and is, in turn, unconformably overlain by the Newark Canyon Formation of Cretaceous age. Just north of the Eureka quadrangle, Riva (1957) mapped basal Permian resting unconformably on the Moleen (= lower Ely Limestone) Formation of Dott (1955). As mentioned above, Riva's youngest Permian member rests unconformably on all the older members and is lithically similar to the Newark Canyon Formation as described by Nolan, Merriam, and Williams (1956). Dott (1955, p. 2273), in his discussion of the Permian in the Diamond Mountains describes a locality where E. R. Larson considers flat-lying Permian rocks to overlie steeply dipping Diamond Peak conglomerate. This locality and the rest of the area west of the main range have been mapped by T. B. Nolan and the authors, and the relation is actually that of an angular unconformity between overlying Tertiary(?) monolithologic megabreccia containing only Permian clasts and underlying upturned conglomerate of Cretaceous age.

There are only minor differences between the Permian rocks exposed west of Alpha Peak ridge and those in the downfaulted blocks north-northwest of Circle Ranch (pl. 1). At both localities the Carbon Ridge Formation includes calcareous sandstone, limestone, mudstone, and conglomerate. West of Alpha Peak ridge, gray, locally sandy, medium-bedded fusulinid-bearing limestone is the commonest lithic type; reddish- and yellowish-brown fine- to coarse-grain thin- to medium-bedded calcareous sandstone (some containing fusulinids), both limestone-matrix and sandstone-matrix chert-pebble conglomerate, and calcareous siltstone are also present. In this particular area the sandstone, conglomerate, and siltstone are practically identical with corresponding lithic types in the overlying Newark Canyon Formation of Cretaceous age; only the presence of intercalated fusulinid-bearing strata allows consistent separation of the units. In the downfaulted blocks north-northwest of Circle Ranch, reddish-brown and yellowish-brown thin-bedded calcareous sandstone is characteristically interbedded with gray and pinkish-gray fusulinid-bearing limestone, much of which is sandy and some of which is crinoidal. Less common rock types are gray and dark-bluish-gray cherty limestone, fine-grained silicified sandstone (some of which is crossbedded), limestone-matrix conglomerate, and gray shale.

The limestone is mostly fusulinid biosparite and biosparrudite and almost all contains at least a few percent coarse silt- to medium- sand-size quartz, chert, and rare lithic grains. Local replacement chert occurs in some beds as nodules and nodular beds of limited extent. The allochems are fragmented and unfragmented fusulinid, bryozoans, and crinoid debris. Some brachiopod fragments were also noted. Sparry calcite cement is most common, but some of the more poorly sorted limestone have micritic cements.

Poorly to moderately sorted sandstone and siltstone with sparry calcite and brown organic-rich clay cements are also present. The clasts in these rocks consist of irregularly shaped subangular fragments of quartz, chert, and calcite; the latter clasts tending to be more rounded than the siliceous ones. Also noted were zircon, muscovite, oligoclase or andesine, chlorite, microcline, and tourmaline grains. Some specimens contain about 1 percent diagenetic euhedral pyrite. With an increase in the amount of clastic and cementing calcite, the sandstone and siltstone grade into the common sandy limestone.

The composition, texture, and stratification of these varied rocks of the Carbon Ridge Formation indicate that they were deposited in agitated shallow waters into which a considerable volume of terrigenous clastic debris was introduced. The less disturbed calcareous rocks alternate with well-sorted sandstone and minor conglomerate. Some poorly sorted biomicrudite indicates possible rapid removal of the sediment to below the limit of effective wave action, either by subsidence or submarine sliding. The evidence indicates mixed sedimentation in a shallow unstable basin.

The rocks of the Carbon Ridge Formation correlate with the Garden Valley Formation in the Sulphur Springs Range to the northwest, with the Strathearn and younger Permian formations of Dott (1955) in the Elko region to the north, and perhaps with several formations to the east.

Previous fossil collections from the Carbon Ridge Formation indicated a Wolfcamp age for most of the formation, although there is the unlikely possibility that some older strata might be included at the base and some slightly younger beds at the top (Nolan and others, 1956, p. 65–66). Riva (1957) concluded that the several Permian units he mapped were dominantly late Wolfcamp and Leonard but noted that no collections were obtained from about the upper third of the section.

Five new collections were made from rocks of Permian age during the mapping. All were from the downfaulted block adjacent to Newark Valley. One additional collection of Permian material was made from the Tertiary(?) fanglomerate unit in the area north of Cottonwood Spring on the west side of the range.

The exact stratigraphic positions of these collections are not known, but the relative positions are established. R. C. Douglass (written commun., 1961) reported these collections as follows (in ascending order):

f21916 (=ES–57–8F) White Pine County, Nev.
5,500′ S. 70½° W. of BM. 5,871 south of DeBernardi Ranch, Eureka 15-minute quadrangle.

The fusulinids are of the genus *Schwagerina* and suggest an Early Permian age. They are more like the Carbon Ridge forms from farther south along this range than the forms submitted by George Simmons from the Garden Valley Formation. * * *

f21917 (=ES–57–9F) White Pine County, Nev.
5,100′ S. 72° W. of BM. 5,871, south of DeBernardi Ranch, Eureka 15 minute quadrangle.

This sample is similar to the above in fauna and age significance. * * *

f21921 (=ES–57–14F) White Pine County, Nev.
1,450′ N. 69° W. of ele. 6,798 northwest of Newark Valley School, west of sec. 15, T. 20 N., R. 55 E., Eureka quadrangle.

This sample is dominated by bryozoa of ramose and fenestrate forms. It also contains scattered abraded fusulinid Foraminfera and other fossil debris. The fusulinids are of the genus *Schwagerina* and do not appear to be too different from those in sample f21917=ES–57–12F. * * *

f21919 (=ES–57–12F) White Pine County, Nev.
6,400′ S. 83½° W. of BM. 5,874, south of DeBernardi Ranch, near center of sec. 9, T. 20 N., R. 44 E., Eureka quadrangle.

This sample is very similar to f21916. * * *

f21920 (=ES–57–13F) White Pine County, Nev.
7,300′ S. 74° W. of BM. 5,874 south of DeBernardi Ranch in SW¼ sec. 9, T. 20 N., R. 55 E., Eureka quadrangle.

The fusulinids are of a form which has been variously called *Pseudofusulina* or *Schwagerina*. The form in this sample is relatively advanced and suggests an age which, although still Early Permian, is probably younger than the other samples in this shipment.

In summary:

All these samples suggest Early Permian age with affinities to the Carbon Ridge Formation insofar as had been determined.

These collections are all apparently from the zones recognized earlier (Nolan and others, 1956, p. 65–66), but they did not contain diagnostic forms and were therefore not assigned to the zones. All these collections are from the same few hundred feet of section.

The collection of Permian forms obtained from probable fanglomerate was reported on by R. C. Douglass as follows (written commun., 1961):

f21918 (=ES–57–11) Eureka County, Nev.
Elev 7,887 (prominent hill) north-northeast of Cottonwood Spring in SE½ sec. 12, T. 20 N., R. 54 E., Eureka quadrangle.

* * * Only fragments of fusulinids were recognized and appear to represent *Schwagerina* of Early Permian age. The form of *Schwagernia* was not determined from the sample, but from the random sections it is apparent that this also is not the *Schwagerina* reported from the Garden Valley Formation.

This sample shows considerably more agitation and probable reworking than the others from this shipment.

CRETACEOUS SYSTEM

NEWARK CANYON FORMATION

The Cretaceous System is represented by the Newark Canyon Formation near Diamond Peak. This formation was named by Nolan, Merriam, and Williams (1956, p. 68–70), who described the type exposures and other outcrops in its vicinity. The type section is located about 1 mile southwest of the southern part of the area shown on plate 1, and the formation is exposed from there northward, in part under a cover of Tertiary(?) fanglomerate, to beyond Cottonwood Spring (pl. 1). Only a few small areas of Newark

Canyon rocks are included on plate 1 and in figure 4 because the main mass of the formation lies west of the faults that are the approximate western limit of the mapping.

Within the area shown on plate 1, the rocks mapped as Newark Canyon Formation consist of polymictic conglomerate and lithic sandstone interbedded with siltstone. The dense fresh-water limestone that is typical of the Newark Canyon nearby does not occur in the area mapped. The conglomerate and sandstone units are much more resistant that the finer grained clastics and form prominent ridges. Angular clasts of limestone (some with Devonian fossils), chert, and quartz are important components of the conglomeratic units, and similar lithic types occur in the sandstone. These terrigenous clastic rocks are generally poorly sorted, and the compositional and textural evidence indicate a strictly local source and rapid deposition. The unit is hard to differentiate from the unconformably overlying Tertiary(?) fanglomerates unless the angular relationship is exposed. Where the limestone clasts are lacking, it is difficult to separate Newark Canyon rocks from the locally underlying Diamond Peak rocks. The Diamond Peak and Carbon Ridge Formations probably were the source of most of the coarse detritus in this Cretaceous unit, but all the older formations apparently contributed some material.

TERTIARY SYSTEM

The rocks of inferred Tertiary age include extensive megabreccias and dissected fanglomerates on the west side of the Diamond Mountains (pl. 1; fig. 4) and two dikes.

FANGLOMERATE AND MEGABRECCIA

A megabreccia unit and a fanglomerate unit are exposed over large areas along the west flank of the range. The two units are considered together here, even though they are different in origin. The best exposures are found in the vicinity of Palmer Ranch, Bank Ranch, and in the canyons heading in the area west of Alpha Peak ridge; these localities are west of the mapped area. Those exposures shown on the map, however, exhibit most of the characteristic features of both units, as follows:

Megabreccia unit:

1. Individual layers are as much as 100 feet thick, lensing out abruptly within less than 2 miles.
2. Layers are composed of angular fragments ranging from silt size up through blocks as much as several tens of meters in maximum horizontal dimension.
3. Within most layers the clasts are derived from only one of the two most common source formations, that is, the Carbon Ridge Formation or the Ely Limestone.
4. A total thickness of more than 300 feet is locally present.

Fanglomerate unit:

1. Individual layers, as much as 50 feet thick, are traceable for only a few hundred feet at the most.
2. Layers are composed of angular to subrounded fragments from silt size up through blocks as much as several meters long.
3. Within most layers the clasts are derived mostly from either the Ely Limestone or the Carbon Ridge Formation, but the overall composition is more heterogenous than that of the megabreccia unit layers.
4. A total thickness of more than 300 feet is locally present.

The combined fanglomerate and megabreccia unit is overlain by thin Quaternary colluvium and alluvium in the mapped area. The unit appears to overlie, at various places, rocks belonging to the Ely, Carbon Ridge, and Newark Canyon Formations. The unconformable relationship over the Newark Canyon Formation is well exposed at several places west of the area of the map; inasmuch as the megabreccia unit dips less than 20° to the west and the Newark Canyon rocks are within 20° of vertical, the relationship is an impressive one.

The origin of the megabreccia unit is not well understood. The present distribution suggests a genetic relationship with the higher structural blocks, and the breccia probably formed as slide masses from the crest of the range. The occurrence of rock types derived from but one formation in each layer indicates that the Ely and Carbon Ridge Formations were at different times singly available as source material. The fanglomerates appear to be more local in origin and occur only high on the flanks of the range. Both the megabreccias and fanglomerates include fragments of questionable Cretaceous rocks.

T. B. Nolan (oral commun., 1956–59) believes that the megabreccias are probably Cretaceous in age. It seems more likely to the author that the breccias formed during the final uplift of the range and hence predate the erosion that gave the range its present form, including the erosion which results in the fanglomerate. The degree of dissection of the megabreccias is considerably greater than that of the Quaternary(?) alluvial fans that predate the Pleistocene lakes. Moreover, the sequence of megabreccias has been extensively faulted. The megabreccias therefore are probably older than fanglomerates and the alluvial fans. The possible relation of the megabreccia unit and the fanglomerate unit to the volcanic rocks outside the mapped area is discussed on page 62.

IGNEOUS ROCKS

The only igneous rocks in the area studied are two lamprophyric dikes of unknown age—one cutting the Ely Limestone on the northeast side of Diamond Peak about 4,800 feet north of the summit, and the other intruding the Black Point facies of the Chainman Formation low on the west side of the range south of the head of Pedrioli Creek (fig. 4).

The dike on Diamond Peak is exposed for about 280 vertical feet in a shallow gully extending eastward from the crest of the summit ridge. The rock is a nepheline-bearing kersantite that is rich in diopsidic augite.

The other dike was studied by J. H. Wallace (written commun., 1961) who reports that the rock is a camptonite.

QUATERNARY DEPOSITS

Quaternary deposits of various types have been mapped together as one unit. Little attention was given these deposits in the field, other than to map their contact with the bedrock.

ALLUVIUM

Four main types of alluvium were noted during the mapping. The first consists of younger deposits of sand and gravel along the stream courses that have been cut into the mountains. The second consists of isolated patches of apparently formerly widespread older gravels that may have been dissected as a result of recent uplift and westward-tilting of the Newark Mountain-Alpha Peak ridge structural block. The third type is the pediment gravel in the topographic embayments on the east side of the range. A fourth type consists of great thicknesses of fanglomerate and other deposits that fill Diamond and Newark Valleys. Unpublished seismic work in both valleys and deep exploratory drilling in Diamond Valley indicate the presence of several thousand feet of deposits on both sides of the range.

COLLUVIUM

A veneer of rock fragments covers most of the unforested slopes of the range. At places this layer of mechanically derived weathered material is thick enough to obscure all the bedrock. Landslide deposits are not common, although one or two partially dissected probable landslides are located high on the east flank of the range.

LAKE DEPOSITS

Deposits formed in the extensive lakes that filled the large intermontane valleys during the Pleistocene Epoch constitute part of the valley fill. The only lake deposits examined are terraces, bars, and spits which are younger than the major alluvial fans and pediments.

BIOSTRATIGRAPHY AND AGE OF THE CARBONIFEROUS FORMATIONS

By Mackenzie Gordon, Jr.

INTRODUCTION

The Carboniferous formations of the Diamond Peak area include, in ascending order, the Joana Limestone, Chainman Formation (as defined by D. A. Brew in this report), Diamond Peak Formation, and the Ely Limestone. This sequence ranges from Early Mississippian (Kinderhook) to Middle Pennsylvanian (Atoka) in age. The uppermost beds of the Pilot Shale in the north-central part of the Pancake Pange, as indicated by conodonts of the *Siphonodella* zone, identified by J. W. Huddle (written commun., 1968), are also Kinderhook in age, but this age has yet to be demonstrated in the Diamond Peak area. These highest Pilot beds seem to be missing on the east side of the Diamond Mountains because of erosion before deposition of the Chainman Formation. They are probably present on the west side of the range beneath the Joana Limestone, but fossils have not been collected from them in that area.

The author's interest in this sequence of Carboniferous rocks began in 1957, when he and D. A. Brew made several fossil collections on the east slope of Diamond Peak. Studies of these collections, Brew's numerous collections, fossils collected from the area by T. B. Nolan and J. S. Williams (made available by Nolan), and one large collection taken by G. H. Girty in the area constitute the basis for this report. In addition, a restudy of C. D. Walcott's fossils from Conical Hill (fig. 1) and other localities in the Pinto Summit quadrangle (now in the U.S. National Museum collection) has been made to provide a firm basis for identifying and interpreting the faunas from the type Diamond Peak section. The author is indebted to U.S. Geological Survey colleagues Helen Duncan for identification of the corals, E. L. Yochelson, the gastropods, and I. G. Sohn, the ostracodes. Six collections of calcareous foraminifers from members C and D of the Diamond Peak Formation were studied by Betty A. Skipp.

Relationships between the Joana Limestone, Chainman Shale, and Diamond Peak Formation are rather

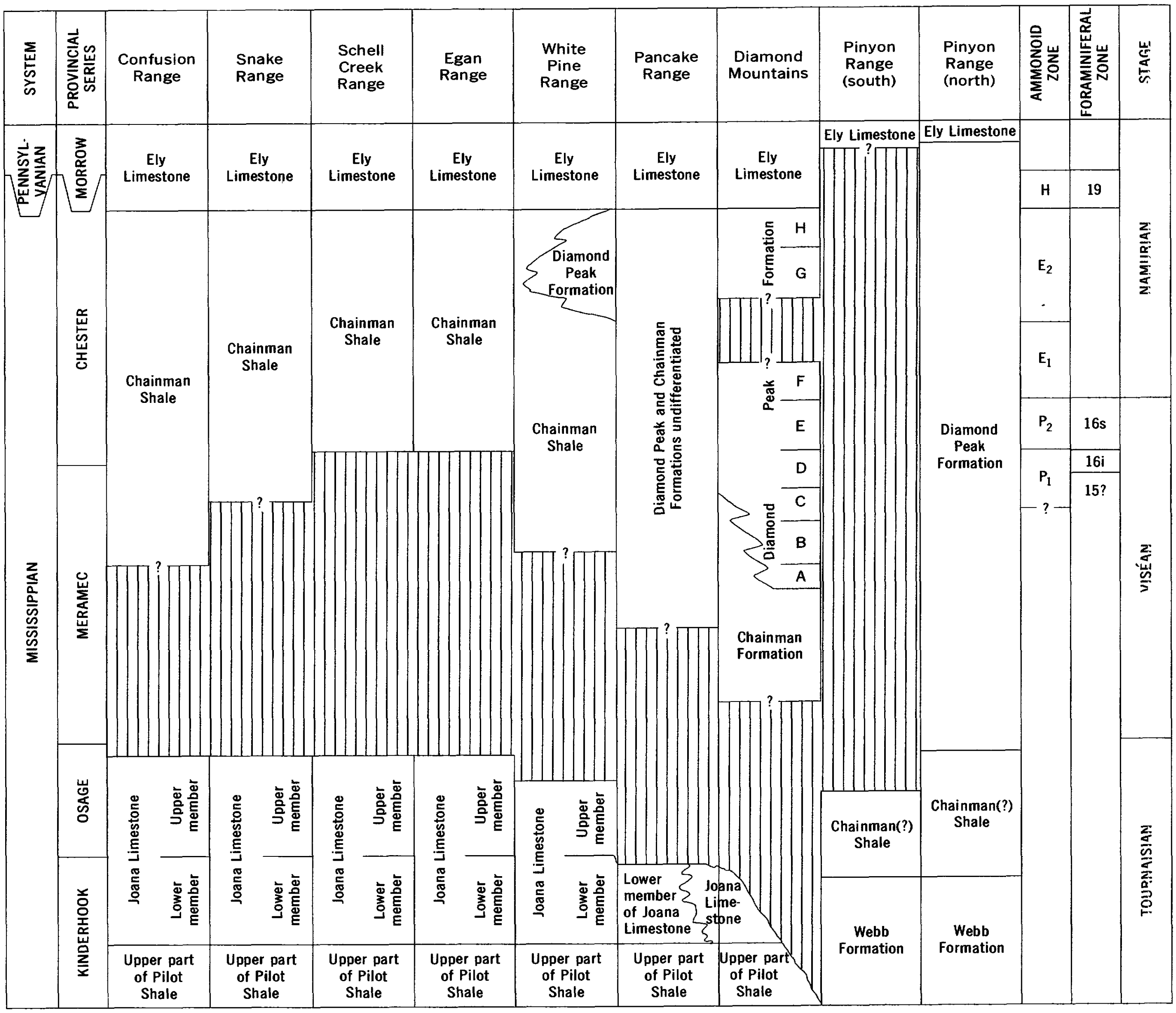


Figure 11.—Correlation of Mississippian and earliest Pennsylvanian formations of the central part of the Great Basin, Utah and Nevada.

complex in the east-central part of Nevada. The stratigraphic limits of these formations differ somewhat from range to range. Biostratigraphic studies by the author in support of various U.S. Geological Survey mapping programs in this part of the country have shown the approximate age limits of some of the rock sequences assigned to these formations. This information is summarized on the correlation chart (fig. 11).

Beginning at the Confusion Range in west-central Utah, the chart compares the sequences of Carboniferous rocks along a line due west through the succeeding five mountain ranges in east-central Nevada; turning northward near the north end of the Pancake Range, the chart compares three more areas in geographic succession, ending in the vicinity of Carlin, Nev. This chart calls attention to (1) the rather conspicuous and extensive mid-Mississippian unconformity in much of this region, (2) the disappearance of the Osage part of the Joana Limestone westward beneath the unconformity, (3) the lateral equivalence of the typical Chainman Shale and a large part of the Diamond Peak Formation, and (4) the considerable range in age of rocks assigned to the Chainman Shale in various areas.

JOANA LIMESTONE AND ITS REGIONAL RELATIONS

In the Diamond Peak area the Joana Limestone is somewhat different lithologically, and represents a shorter time span than in typical exposures in its type area in the Ely district. The type locality of this formation is in Robinson Canyon in the Egan Range, 2 miles northwest of Ely, Nev. As the exposure lies in a rather highly mineralized area, the limestone is altered and little of its original lithic character and faunal content has been preserved.

Outcrops on the west flank of Ward Mountain, roughly 9 miles south-southwest of the type locality, are typical of the Joana Limestone over much of east-central Nevada. Here, the two-fold division of the formation into a lower massive crinoidal limestone member and an upper slabby fossiliferous limestone member of roughly equal thickness is well exposed. At the base of the formation, but commonly concealed by talus and slope wash, is a zone of relatively thin shaly nodular limestone. The massive crinoidal unit, including the basal shaly beds, and the overlying slabby fossiliferous limestone unit are indicated on the correlation chart (fig. 11) as L and U (lower and upper) subdivisions, respectively. Both units can be recognized in the mountain ranges east of the Pancake Range.

The age of the lower unit in the type region is Early Mississippian (Kinderhook). J. W. Huddle (written commun., 1968) recognized the *Siphonodella* conodont zone in a collection from the top of the crinoidal member on Ward Mountain. The upper thin-bedded limestone unit contains corals and brachiopods of the *Homalophyllites-Vesiculophyllum* zone throughout. This zone is Early Mississippian (Osage) in age, according to Helen Duncan (written commun., 1965). Corals typical of the upper limestone unit in the Ely district are given in the U.S. Geological Survey Professional Paper 276 (in Nolan and others, 1956, p. 56).

Both subdivisions of the Joana Limestone can be recognized in the various mountain ranges from the Confusion Range westward to the White Pine Range. In the north-central part of the Pancake Range, however, only the crinoidal lower unit is present, and the shaly and nodular limestone beds at its base contain brachiopods of late Kinderhook age.

West and north of the Pancake Range exposure, the Joana becomes considerably more shaly; limestone is no longer the dominant rock type in the formation but occurs only as interbeds, commonly crinoidal, in a shale and siltstone sequence. Studies of conodonts by Huddle and of other fossils by the author in support of Nolan's detailed mapping in the Pinto Summit quadrangle, which includes some of the north-central part of the Pancake Range, show that this more shaly facies of the Joana Limestone contains beds only of late Kinderhook age. These beds are present in Tollhouse Canyon in the southern part of the Eureka quadrangle, just south of the Diamond Peak area. A list of fossils identified by Merriam (in Nolan and others, 1956, p. 55) from the basal limestone bed of the Joana includes the Kinderhook brachiopod *Shumardella* cf. *S. missouriensis* (Shumard).

North of Tollhouse Canyon and on the east side of the Diamond Mountains, no outcrops of Joana are known. The Joana is truncated beneath the Chainman Shale, which rests unconformably on the Pilot Shale in the more northerly sections on the east slope of the Diamond Range. The Joana is present, however, along the west side of the range in the northern part of the Eureka quadrangle. Conodonts collected by Nolan from that band of exposure in the upper reaches of Phillipsburg Canyon, include *Siphonodella*, according to J. W. Huddle (written commun., 1968), and are Kinderhook in age.

CHAINMAN FORMATION

In the area covered by Brew's map, the Chainman Formation is restricted to that part of the section which lies beneath the Diamond Peak Formation and above the Joana Limestone. Where the Joana is absent, because of an erosional unconformity, and Chainman rests directly upon the Pilot Shale. The mapped Chainman does not include any of the similar shale beds that intertongue with clastic beds of the Diamond Peak Formation. These intertongued shales have been mapped by Brew as part of the Diamond Peak. As the earliest Diamond Peak beds datable by their fossil content are Meramec in age and the highest beds of the Joana in this region are Kinderhook in age, a fairly sizable time span could be assigned to the Chainman Formation, but much of this time is instead probably represented in the unconformity at the base of the Chainman.

The lowest collection stratigraphically (USGS loc. 21269–PC) was made by Brew from the Water Canyon facies of the Chainman Formation on the east slope of the Diamond Range, about 300 feet below the base of the Diamond Peak Formation. The collection consists of a single impression of an ammonoid, the evolute shell of which indicates that it belongs in the family Prolecanitidæ. The absence of a suture precludes a firm generic assignment. Although this shell superficially resembles shells from the lower part of the Chainman Shale(?) in the Pinyon Range, Elko County, Nev., and from the Joana Limestone in the Pancake Range, White Pine County, that have been identified as belonging in the Kinderhook genus *Pro-*

tocanites, the fact remains that this shell from the Water Canyon facies cannot be identified as to genus. Shells of this shape range well up into the Mississippian, even as high as Chester.

A second collection, also from the Water Canyon facies, was made by J. S. Williams in 1938 in a section that he and Nolan measured up the southeast slope of Bold Bluff. A plot of the section shows that the collection came from a dark-gray limestone lens 227 feet below the base of the Diamond Peak Formation. The following fossils were recognized (USGS loc. 14690–PC):

Cystodictya sp.
Quadratia hirsutiformis (Walcott)
Auloprotonia sp.
Leiorhynchus carboniferum Girty
Tylothyris sp.

This faunule is Late Mississippian (Meramec) in age. As the mapping shows Chainman Formation at this locality, places the Chainman-Diamond Peak contact approximately at the same horizon, and recognizes no faults between the fossil bed and the top of the Chainman where this section was measured, it seems safe to regard it as a *bona fide* collection from the Chainman Formation.

A third collection was made by Brew, 20 feet below the top of the Black Point facies of the Chainman Formation on the west side of the range. The following fossils occur as molds in fine-grained sandstone (USGS loc. 21277–PC):

Fenestella sp.
Cystodictya? sp.
Crinoid columnals
Schizophoria sp.
Strophomenoid brachiopod, gen. and sp. indet.
Cleiothyridina cf. *C. incrassata* (Hall)
Naticopsis? sp. indet.

In the southern part of the Mississippi Valley region, *Cleiothyridina incrassata* and a closely related species are characteristic late Osage forms and do not occur in the Meramec Series. The temptation to regard this Nevada assemblages as Osage in age, however, gives way to the more sober reflection that perhaps so far away from the Mississippi Valley Cleiothyridinas of this sort might not have the same stratigraphic range. Like *Spirifer brazerianus* Girty and *Dimegalasma eurekensis* Linz and Lohr, the large *Cleiothyridina* from the Diamond Range might be a Late Mississippian version of a closely related but different and earlier species in the American Midcontinent. We simply lack sufficient knowledge at present to employ in the American West a rule of thumb based upon relations in a depositional basin so remote from it.

This collection, were it Osage in age, would be the only one of that age found in the Eureka and Pinto Summit quadrangles. Occurring as it does almost at the top of the Chainman Formation, there is little likelihood that it is earlier than Late Mississippian (Meramec) in age.

As to the age of the lower part of the Chainman, no paleontologic evidence has been found in the Diamond Peak area. The nearest available evidence comes from near the southeast corner of the Pinto Summit quadrangle in the section shown by Stewart (1962, p. C59) as undifferentiated Chainman-Diamond Peak. In this part of the Pancake Range the basal unit of the Chainman Shale is a dark-grayish-brown platy hard siliceous shale, which is devoid of fossils and is slightly more than 200 feet thick.

The basal shale unit is overlain by several hundred feet of dark-gray soft shale containing sideritic and clay-ironstone nodules. In this second unit the author and F. G. Poole collected specimens of *Rayonnoceras*, a nautiloid genus known elsewhere in the United States in beds of Late Mississippian (late Meramec through Chester) age. These fossils came from near the east edge of SE¼ sec. 27 (unsurveyed), T. 17 N., R. 55 E. They were estimated to occur between 250 and 300 feet above the base of the Chainman Shale. Conodonts have been searched for in these lower beds of the Chainman by Huddle and the author, but none has, as yet, been found.

These basal units of the Chainman Shale can be recognized farther north in the Pinto Summit quadrangle, in Secret Canyon and the Packer Basin. They do not, however, seem to be present in sections on the slopes of Diamond Peak.

The faunal evidence discussed above, though meager, points to a Meramec age for the Chainman Shale in the Diamond Peak area. This agrees with the Late Mississippian age suggested for this formation in the Eureka district by Nolan, Merriam, and Williams (1956, p. 60).

An idea of the extent of the hiatus represented by the unconformity at the base of the Chainman can be gained by the realization that no fossils positively identifiable as Osage or early Meramec in age have been found in the Eureka and Pinto Summit quadrangles. Locally, the Chainman rests directly upon the Upper Devonian part of the Pilot Shale.

DIAMOND PEAK FORMATION

The Diamond Peak Formation, unlike the Chainman Shale beneath it, is abundantly fossiliferous at many localities. The most profusely fossiliferous beds, in numbers of species present, are limestones intercalated with the dominantly clastic sequence. Many calcareous pebbly sandstones abound with limy fossils, however, and various finer grained sandstones and coarse-grained siltstones bear mold faunas. The shale units are relatively unfossiliferous, except in sparsely distributed lenses of dark-gray limestone.

The subdivision by Brew of the Diamond Peak into eight members for mapping has been extremely helpful in delineating the faunal succession. His collections from the measured type section on the relatively undisturbed northwest slope of Diamond Peak have contributed greatly to our knowledge of the biostratigraphy of the formation. Brew's material also has enhanced our ability to correlate the formation with other Upper Mississippian sections in the American West.

Identifications of fossils from the 59 Diamond Peak Formation collections are given in tables 1–4. These include calcareous foraminifers from member D of the Diamond Peak Formation, studied by Betty A. Skipp. Foraminifers from member C are listed in the text. About 210 species of invertebrates have been recognized in this formation in the Diamond Peak area. The faunas are discussed below, member by member.

The location of the Meramec-Chester boundary as it relates to the formation is also discussed. As nearly as can be determined, this boundary is located near the top of member D. The Mississippian (Chester)-Pennsylvanian (Morrow) boundary is not believed to occur within the Diamond Peak Formation.

MEMBER A

No fossils have been found in member A, which, therefore, must be dated by interpolation based upon its stratigraphic position. Having argued for the Meramec age of the Chainman Shale, based principally upon the collection of that age from the upper part of the Chainman at Bold Bluff, the author obviously believes that member A also is Meramec in age.

One piece of negative evidence for this belief is the absence in the Diamond Peak area, in fact in the entire Eureka district, of the late Osage to early Meramec fauna that occurs at, or near, the base of the Diamond Peak Formation at Ferdelford Creek and at other localities in the Carlin quadrangle (Gordon and Duncan, 1962). The most likely explanation for this is that the same span of geologic time represented by the Ferdelford beds falls within the hiatus at the base of the Chainman Shale in the Diamond Peak area. But the possibility that the Ferdelford fauna is absent because of facies differences cannot be ruled out at present.

MEMBER B

Twelve collections, most of them small, were studied from rocks assigned by Brew, either definitely or tentatively, to member B. Four collections are from the measured type section of the Diamond Peak Formation. The fossil content of all 12 collections is given in table 1.

The fauna of member B is similar to faunas of Meramec age, such as that of the Moorefield Formation of Arkansas and Oklahoma. It is similar also to the fauna of the Diamond Peak beds at Conical Hill, near Eureka, Nev. (fig. 1), which is considered to be late Meramec in age. However, as members C and D have greater percentages of species in common with the Conical Hill fauna, member B is believed to be slightly older than the beds at Conical Hill.

Of 48 species recognized in member B, 20 species (42 percent) occur also at Conical Hill (table 1). Distinctive species common to member B and Conical Hill include *Schellwienella* n. sp., *Neochonetes* sp. A, *Inflatia* sp. B, *Moorefieldella eurekensis* (Walcott), *Spirifer* aff. *S. arkansanus* Girty, and *Tylothyris* n. sp. Apparently restricted to member B and not occurring at Conical Hill are *Anopliopsis* sp., *Brachythyris* sp. A, and *Echinocœlia* sp.; all three of these genera are represented by similar forms in the Moorefield Formation and its stratigraphic equivalents. The Moorefield fauna also has many genera represented by closely related species in the Conical Hill fauna of the Diamond Peak Formation.

Few, if any, species of the Conical Hill fauna occur in the Ferdelford beds at, or near, the base of the Diamond Peak in the Carlin region, although several of the same genera are present. Moreover, none of the Ferdelford species appears to be present in member B. The fauna of member B therefore has a closer relation with late Meramec than with early Meramec species, and the member is believed to be middle to late Meramec in age.

MEMBER C

Six collections of megafossils made by Brew from member C, three of them from the measured type section, have been studied by the author (table 1). In addition to these collections, foraminifers from a limestone in the type section were studied by Betty A. Skipp. The megafossils came mostly from calcareous shales and coarse siltstones or fine sandstones; the fossils, relatively few in number of species, occur as molds. The preliminary study of this fauna indicates that of a total of 30 megafossils, 17 (55 percent) are represented also in the fauna from Conical Hill. One of the most striking species is *Dimegalasma eurekensis* Linz and Lohr, a large spiriferoid brachiopod, which

TABLE 1.—*Fauna from members B–D of the Diamond Peak Formation, Diamond Peak area, Nevada and from Conical Hill, Eureka district, Nevada*

[See register for descriptions of fossil localities]

Fauna	Member B											Member C							Member D								
	Collecting localities																										
	16608–PC	16681–PC	16682–PC	16683–PC	16684–PC	16685–PC	21270–PC	21278–PC	21279–PC	21280–PC	21281–PC	ES–57–5F	21271–PC	21272A–PC	21272B–PC	21282–PC	21283–PC	21284–PC	21273–PC	21285–PC	21286–PC	21287–PC	21288–PC	21289–PC	21290–PC	F14–59–ES	Conical Hill
Corals:																											
Zaphrentoid coral indet										X																	
Amplexizaphrentis sp																				X							
Menophyllum? sp. indet											X																
Cyathaxonia? sp. indet										X	X																
Horn coral indet						X																					
Siphonodendron n. sp																			X	X	X						
Bryozoans:																											
Stenoporoid, gen. and sp. indet																	X										
Fenestella sp. indet				X							X					X	X	X		X					X		
Fenestrate forms, indet		X											X	X						X							
Archimedes sp. indet										X																	
Cystodictya sp			X	X					X		X		X					X									*
Encrusting forms, indet														X						X							
Pelmatozoans:																											
Pelmatozoan debris													X													X	
Crinoid columnals	X	X	X	X		X	X		X	X	X				X	X	X	X									*
Echinoid plates and spines																		X									*
Brachiopods:																											
Rhipidomella sp											X																?
Schizophoria sp. indet										X																	
Schellwienella n. sp											X																*
Orthotetes cf. *O. kaskaskiensis* (McChesney)							X									X	?	X		X							*
Strophomenoid, gen. and sp. indet									X	X															X		
Neochonetes sp. A	X				X					X	X						X						X				*
Neochonetes sp. B															X			X				X			X		*
Anopliopsis cf. *A. subcarinata* (Girty)											X																
Quadratia hirsutiformis (Walcott)?											X																
Krotovia sp				X																							?
Inflatia sp. B			X		X			X						X											X		*
Echinoconchus cf. *E. alternatus* (Norwood and Pratten)										X										X							*
Echinoconchus aff. *E. biseriatus* (Hall)										X																	*
Auloprotonia sp							X										X			X							*
Ovatia cf. *O. latior* (Snider)							X			X				X		X		?		X							*
Ovatia?			X														X										
Productoid gen. and sp. indet						X				X																	
Rhynchonelloid, gen. and sp. indet											X																
Moorefieldella eurekensis (Walcott)							X																				*
Rhynchopora sp																								X			*
Anthracospirifer aff. *Anthracospirifer pellaensis* (Weller)																	?	X		X				X			*
Spirifer aff. *S. arkansanus* Girty					?		X		?																		*
Brachythris sp. A							X			X	X																
Tylothyris n. sp											X																*
Torynifer sp. indet													X														
Echinocoelia sp									X	X																	
Cleiothyridina sp		X					X						X	X			X										?
Composita? sp. indet											X		X														
Reticulariina aff. *R. spinosa* (Meek and Worthen)							X																				*
Dimegalasma eurekensis Linz and Lohr													X														*
Eumetria cf. *E. verneuiliana* (Hall)					X		X																				*
Hustedia sp							X																				*
Beecheria? sp. indet											X																
Dielasma aff. *D. bisinuatum* (Weller)																								X			
Pelecypods:																											
Nuculopsis sp											X																*
Aviculopecten affinis Walcott																	X			X							*
Aviculopecten eurekensis Walcott																	?								X		*

TABLE 1.—*Fauna from members B–D of the Diamond Peak Formation, Diamond Peak area, Nevada and from Conical Hill, Eureka district, Nevada*—Continued

Fauna	Member B												Member C						Member D								
	Collecting localities																										
	16608–PC	16681–PC	16682–PC	16683–PC	16684–PC	16685–PC	21270–PC	21278–PC	21279–PC	21280–PC	21281–PC	ES–57–5F	21271–PC	21272A–PC	21272B–PC	21282–PC	21283–PC	21284–PC	21273–PC	21285–PC	21286–PC	21287–PC	21288–PC	21289–PC	21290–PC	F14–59–ES	Conical Hill
Pelecypods—Continued																											
Limipecten sp		X									X	X															*
Streblopteria similis Walcott?																				X							*
Pectenoid, gen. and sp. indet										X																	
Posidonia becheri Bronn																						X					*
Caneyella cf. *C. richardsoni* Girty																							X				
Myalina sp. indet											X																
Leptodesma protoforme (Walcott)?										X															X		?
Schizodus sp											X																*
Sphenotus sp																	X			X							
Cypricardinia cf. *C. moorefieldana* Girty													X												?		*
Edmondia? sp										X																	
Gastropods:																											
Bellerophontid gen. and sp. indet											X																
Glabrocingulum? sp. indet								X																			
Neilsonia sp							X																				
Cephalopods:																											
Tylonautilus gratiosus (Girty)?														X													*
Trilobites:																											
Kaskia sp								?							X	X											
Ostracode:																											
"*Paraparchites*" sp													X														

was found at USGS locality 21271–PC. This collection was not from the measured section, but is believed to have come from member C.

Betty A. Skipp (written commun., 1963) identified the following foraminifers from a limestone bed 161 feet above the base of member C (USGS foraminiferal loc. f21922):

C *Endothyra tantala* (D. Zeller) 1953

C. *Endothyra* ex gr. *E. bowmani Brady* 1876, emend CIZN 1965

C *Cornuspira* sp.

C *Brunsia* spp.

C *Earlandia* spp.

C *Calispheara* sp.

R *Archaediscus* ex gr. *A. moelleri* Rauzer-Chernoussova 1948

R. *Glomospira*? sp.

C = common, R = rare, CIZN = Commission Internationale de la Nomenclature Zoologique.

She commented on the collection as follows:

This fauna belongs to zone 15 or 16, but does not contain the distinguishing elements of either. It is thought to be younger than 14, based on the common occurrence of *Cornuspira*.

The stratigraphic position of these fossils indicates to the author that zone 15 is represented here, rather than zone 16i. No evidence for the presence of the Lower *Posidonia* (P_1) zone below member D has been found, and, as foraminiferal zone 15 includes the lower part of that zone (Mamet and Skipp, 1970), the base of zone 16i probably lies within member D.

Both megafaunal and microfaunal evidence indicates a late Meramec age for member C. Foraminiferal zone 15, according to Mamet and Skipp (1970), occurs also in the Ste. Genevieve Limestone in the Mississippi Valley region and does not extend downward to the base of that formation. It seems reasonable, therefore, to ascribe to member C an equivalence to at least part of the Ste. Genevieve.

MEMBER D

Eight collections of megafossils collected by Brew, seven from the measured type section on the northwest slope of Diamond Peak, are given in table 1. An additional six collections from the east slope of the Diamond Range, one made by Girty, three by Nolan and Williams, and two by Brew and the author, are given in table 2. These collections have been recorded in a

TABLE 2.—*Fossils from beds assigned to member D of the Diamond Peak Formation, on the east slope of the Diamond Range and at Conical Hill, Eureka district, Nevada*

[See register for descriptions of collecting localities]

Fauna	USGS locality						
	6567–PC	14693–PC	14694–PC	14695–PC	17172–PC	17173–PC	Conical Hill
Corals:							
Amplexizaphrentis sp	×						
Horn coral, gen and sp. indet					×	×	
Bryozoans:							
Fistuliporoid, gen. and sp. indet	×					×	*
Stenoporoid, encrusting form, indet	×			×		×	*
ramose form, indet	×				×		*
Anisotrypa sp	×						*
Fenestella sp	×	×		×		×	*
Polypora? sp				×		×	*
Cystodictya sp		?	×	×		×	*
Echinoderms:							
Crinoid columnals	×	×	×	×	×	×	*
Echinoid spines	×			×			*
Brachiopods:							
Orbiculoidea aff. *O. moorefieldana* (Girty)	×						*
Rhipidomella n. sp	×						*
Schizophoria sp	×		×			×	*
Schuchertella sp	×				?		
Orthotetes cf. *O. kaskaskiensis* (McChesney)		×		?			*
Neochonetes sp. A	×	×				×	*
sp. C	×						
Quadratia hirsutiformis (Walcott)	×		×				*
Krotovia sp	×						*
N. gen. aff. *Avonia* sp. A	×						*
sp. B	×						*
cf. *Productus subsulcatus* Girty				×			*
Inflatia sp. A	×					×	*
sp. B	×	?					*
Echinoconchus aff. *E. vittatus* (Hall)	×				?		*
aff. *E. biseriatus* (Hall)	×						*
Flexaria aff. *F. arkansana* (Girty)					×	×	
Auloprotonia n. sp.	×	×		×		×	*
Ovatia cf. *O. latior* (Snider)	×		×	×			*
Striatifera n. sp	×					×	*
Coledium therum (Walcott)	×						*
Moorefieldella eurekensis (Walcott)	×			×		?	*
Camarotoechia sp	×						*
Leiorhynchus carboniferum polypleurum Girty		×	×				
Rhynchopora sp	×						*
Spirifer cf. *S. arkansanus* Girty	×	×					*
aff. *S. haydenianus* Girty	×						*
sp	×						
Anthracospirifer cf. *A. bifurcatus* (Hall)				×			
aff. *A. pellaensis* (Weller)						×	*
Tylothyris n. sp	×	×					*
Torynifer cf. *T. internascens* (Girty)	×						*
Crurithyris sp	×						*
Martinia sp	×						*
Cleiothyridina sp. A	×						*
Composita sp	×		×				*
Punctospirifer sp	×			×			*
Spiriferellina? sp	×	×					*
Psuedosyrinx desiderata (Walcott)	×	×				×	*
Dimegalasma eurekense Linz and Lohr	×	×			×		*
Hustedia sp	×						*
Beecheria sp	×					?	*
Cranaena? sp	×						
Pelecypods:							
Nuculopsis levatiformis (Walcott)	×	×		×			*
sp	×	×					
Phestia sp	×	×	×				*
Yoldia sp	×						*
Paleoneilo sp. A	×						*
sp. B	×						
Paleoneilo? sp	×						
Parallelodon aff. *P. truncatus* (Walcott)	×						*
Pterinopecten spio Walcott				×			*
Aviculopecten affinis Walcott	×	×	?	×			*
eurekensis Walcott	×	×					*
haguei Walcott	?				×		*
pintoensis Walcott	×						
sp				×		×	
Limipecten sp				×			*
Streblopteria similis Walcott	×						*
Pernopecten sp	×						*
Posidonia becheri Bronn			×	×			*
Posidonia? sp		×					
Pelecypods—Continued							
Leptodesma sp	×						
Septimyalina sp	×						
Sulcatopinna innexpectans Walcott		×					*
Modiolus nevadensis Walcott	×			×			*
Modiomorpha? *pintoensis* Walcott?				×			
Sphenotus salteri (Walcott)	×						*
sp. A	×		×	×			
sp. B	×						
Edmondia sp. A	×						
sp. B	×						
sp. C	×						*
Solenomorpha sp			×				*
Cardiomorpha sp. A	×						
sp. B	×						
Cypricardella connata (Walcott)	×						*
aff. *C. striata* (Walcott)	×						
Cypricardinia aff. *C. moorefieldana* Girty	×			×			*
Schizodus curtiformis Walcott	×						*
sp	×						*
Conocardium sp	×						
Scaphopods:							
Dentalium sp	×						
Plagioglypta sp	×						
Gastropods:							
Straparollus (*Euomphalus*) sp. A	×	×					*
(*Euomphalus*) sp. B	×						*
Bellerophon sp	×	?					*
Knightites (*Retispira*) sp	×						*
Euphenites sp. indet			×				
Rhineoderma? sp. indet	×						
Trepospira? sp. indet	×						
Baylea? sp. indet	×						
Mourlonia sp	×						
Mourlonia? sp. indet	×						
Lunulazona sp	×			×			*
Pleurotomariacean aff. *Caliendrum* sp	×						
Glabrocingulum nevadense (Walcott)	?	×					*
sp	×						
Peruvispira? sp	×						
Pleurotomariacean aff. Nielsonia sp	×						
Worthenia? sp	×						
Gosseletina sp. A	×						
Gosseletina? sp. B	×						
Pleurotomariacean gen. indet. A	×						
gen. indet. B	×						
Yunnania sp	×						*
sp. B	×						*
Platyceras (*Orthonychia*) sp	×						*
Naticopsis (*Naticopsis*) sp. A	×						*
(*Naticopsis*)? sp. B	×						*
(*Jedria*) sp	×						*
Gen. indet. cf. *Platyzona* sp	×						*
"*Loxonema*" *bella* Walcott	×						*
Stegocoelia sp. A	×						*
sp. B	×						
Gen. indet. cf. *Stegocoelia* sp	×						
Ianthinopsis sp	×						*
Cephalopods:							
Michelinoceras? sp	×						
Cyrtothoracoceras sp	×						
Orthoconic nautiloid, gen. and sp. indet			×				
Temnocheilus sp	×						
Tylonautilus sp	×						
Goniatites? sp. indet			×				
Trilobites:							
Kaskia sp	×	?		×			*
Ostracodes:							
"*Paraparchites*" n. sp. aff. "*P.*" *cyclopeus* Girty, 1910	×						
cf. "*P.*" *nickelsi* Ulrich, 1891	×						
Graphiodactyllis sp	×						
Sansabella? sp	×						
"*Bairdia*" sp	×						
Fish:							
Cladodus sp	?					×	

separate table so as not to prejudice the faunal evidence from the measured type section. Assignments to a specific member generally are less certain on the east side of the range, owing to faulting, than on the less disturbed western side. Nevertheless, the author feels reasonably certain of the correct assignment of these collections to member D. Foraminifers found in five rock specimens collected for petrographic examination were studied by Betty A. Skipp.

Member D is the most highly fossiliferous unit of the Diamond Peak Formation. The Conical Hill fauna reaches its most prolific development in this member. Species that occur in the beds at Conical Hill and in member D on the east slope of the Diamond range are given in table 2. The fauna is varied. Several calcareous sandstone beds in this member contain as many as 25 species of megafossils, but the limestone beds are by far the most highly fossiliferous, in both numbers of individuals and species. A dark-gray limestone at Bold Bluff (USGS loc. 6567–PC) yielded 121 species of fossils. Particularly striking is the number of mollusks in this part of the section. The member D megafauna in our collections aggregates 142 species subdivided as follows: 3 corals, 7 bryozoans, 2 echinoderms, 44 brachiopods, 42 pelecypods, 2 scaphopods, 34 gastropods, 6 cephalopods, 1 trilobite, and 1 fish. Of these 142 species, 85 (60 percent) are present also in the beds at Conical Hill. In addition, the microfauna includes at least 32 foraminiferal and 5 ostracode species.

MEGAFAUNAL EVIDENCE

The base of member D in the type section is marked by a bed that contains (Helen Duncan, written commun., 1963) the colonial coral *Siphonodendron*, represented by an undescribed species having a rather strong columella, associated with the brachiopod *Auloprotonia* (USGS loc. 21285–PC). Float specimens of the same coral (USGS locs. 21273–PC, 21286–PC) were regarded by Brew as derived from this bed. *Siphonodendron* is generally regarded as restricted to the Meramec Series in the United States.

About 90 feet above the base of member D, a small collection (USGS loc. 21287–PC) contains *Posidonia becheri* Bronn. This pelecypod is particularly characteristic of the Lower *Posidonia* (P_1) zone of the British Carboniferous section and equivalent rocks at many localities in the Northern Hemisphere. *P. becheri* ranges upward and is found sparingly in the Upper *Posidonia* (P_2) zone at a few scattered localities but has not thus far been found in that zone in the east-central Nevada. Foraminiferal evidence from beds higher in member D indicates that the Diamond Peak occurrence of *P. becheri* should be assigned to the Lower *Posidonia* (P_1) zone.

Posidonia becheri is present in two other collections (USGS locs. 14694–PC, 14695–PC) from the east slope of the Diamond Range (table 2), all believed referrable to member D. A small crushed indeterminate goniatite from USGS collection 14694–PC was said by the author (Gordon, in Nolan and others, 1956, p. 61) to have surface sculpture that suggested the genus *Cravenoceratoides* of the Upper *Eumorphoceras* (E_2) zone. Although nothing is intrinsically wrong with this comment as stated, it is nevertheless misleading. The statement was made without the author's having seen the rest of the collection. The presence in the collection of such forms as *Quadratia hirsutiformis* (Walcott), *Leiorhynchus carboniferum polypleurum* Girty, and *P. becheri* Bronn shows that it cannot be younger than *Posidonia* zone. A general similarity exists between the Diamond Peak collections that contain *P. becheri* and the fauna of the Moorefield Formation of Arkansas as restricted by the author (1948), in the upper beds of which *P. becheri* is found.

In Brew's measured type section of the Diamond Peak Formation, 100 feet above the bed that contains *Posidonia becheri*, a sandy limestone bed (USGS loc. 21289–PC) is crowded with shells of a terebratuloid brachiopod identified as *Dielasma* aff. D. *bisinuatum* (Weller). This shell is distinctive in having a median fold in the pedicle valve and a corresponding median sulcus in the brachial valve. It appears to be fairly similar to Weller's species from the St. Louis Limestone.

No particularly diagnostic megafossils are known from the upper half of member D in the type section, but microfossil evidence partly fills the gap.

MICROFAUNAL EVIDENCE

Foraminifers studied by Betty A. Skipp indicate that zones 16i and 16s of Mamet and Skipp (1970) are present in the upper 150 feet of member D. Zone 16i contains foraminifers that are found also in the upper part of the Lower *Posidonia* (P_1) zone of the British Carboniferous section; zone 16s contains foraminifers commonly found associated with ammonoids of the Upper *Posidonia* (P_2) or *Goniatites granosus* zone. Both ammonoid zones are late Visean in age. The foraminiferal collections are given in table 3.

Because of the questioned identification of *Neoarchaediscus* sp. in USGS collection f21923 (table 3), 246 feet above the base of the member, Skipp (written commun., 1968) was not positive whether zone 15 or zone 16i is represented. The stratigraphic position of the collection, however, 156 feet stratigraphically

TABLE 3.—*Calcareous foraminifers from member D of the Diamond Peak Formation, Diamond Peak area, Nevada.*

[Identifications by Betty A. Skipp. See register for description of collective localities. R, rare; ×, occurrence; C, common]

Fauna	USGS foraminiferal collection				
	f21923	f21924	f21925	f21926	f21927
Glomospira sp	?C	?			×
Earlandia spp	C	×		×	
Tuberitina sp	C	×	×	×	
Palaeotextularia ex. gr. *P. consobrina Lipina* 1948	C	×			
Climacammina ex. gr. *C. prisca* Lipina 1948	C	×			
ex. gr. *C. patula* Brady 1876		R	×		
spp				×	
Tetrataxis sp		R			
Globivalvulina? sp. indet				×	
Endothyra maxima (D. Zeller) 1953	×				
pandorae (D. Zeller) 1953		×		×	
phrissa (D. Zeller) 1953		×			
ex. gr. *E. bowmani* Brady 1876 emend. CIZN 1965	C		×		×
excellens (D. Zeller) 1953				×	
tantala (D. Zeller) 1953				×	
ex. gr. *E.? prisca* Rauzer-Chernoussova and Reitlinger) 1936		×		×	
Globoendothyra sp	C	R			
Endothyranopsis crassus (Brady) 1870		×	×	×	
compressus (Rauzer-Chernoussova and Reitlinger) 1936		R			
Eoendothyrandopsis sp		R			
Archaediscus krestovnikovi Rauzer-Chernoussova 1948		×			
ex. gr. *A. krestovnikovi* Rauzer-Chernoussova			×		
ex. gr. *A. moelleri* Rauzer-Chernoussova 1948	C			×	×
sp				×	×
Neoarchaediscus sp	?R	R		C	×
Planoarchaediscus sp				R	
Brunsia spp	C	×	×	×	
Eostaffella (Paramillerella) tortula (D. Zeller) 1953		×		×	×
Pseudoendothyra sp				R	
Cornuspira sp	C	×		×	
Calcispheara sp				×	
Hedraites? sp				×	

above a bed containing *Posidonia becheri*, indicates that assignment to zone 16i is preferrable. USGS collection f21924, 265 feet above the base of the member, contains a typical zone 16i fauna, according to Skipp.

A small collection (USGS f21925), 325 feet above the base of the member, belongs in zone 16, but it does not contain sufficient diagnostic species to assign it either to zone 16i or 16s.

Two collections (USGS f21926, f21927) from a limestone bed 6 feet below the top of the member are the lowest that contain a microfauna definitely assignable to zone 16s, according to Skipp. Common *Neoarchaediscus* and *Eostaffella* are the diagnostic foraminifers.

CORRELATION

Combined macrofaunal and microfaunal evidence indicates that a large part of member D, from 90 to 265 feet above its base, can be assigned with confidence to the Lower *Posidonia* (P_1) zone of late Visean age. Rocks of similar age containing megafaunas assignable to this zone are present in the Chainman Shale on both sides of the Nevada-Utah State line, in the lower part of the Caney Shale in the northern Arbuckle Mountains region of Oklahoma, in the upper part of the Moorefield in northern Arkansas, and in the Ste. Genevieve Limestone on the east side of the Mississippi River in Illinois and Kentucky.

Precisely where the limits of the P_1 zone occur in the Diamond Peak section is not certain, but the zone appears to be contained within member D. The top 6 feet of member D, as indicated by microfossils, belongs in the Upper *Posidonia* (P_2) zone of late Visean age, which is also known as the *Goniatites granosus* zone.

MERAMEC-CHESTER BOUNDARY

The combination of macrofaunal and microfaunal evidence in member D of the Diamond Peak Formation focuses attention on a divergence of criteria for the precise location of the Meramec-Chester boundary. It has been customary for U.S. Geological Survey biostratigraphers in the Western United States to place the base of the Chester Series equivalents just above the top of the *Faberophyllum* coral zone in dominantly limestone facies where such corals are present and just below the *Goniatites granosus* (P_2) ammonoid zone in fine-grained clastic facies where corals are normally absent. Recent foraminiferal studies by Mamet (written commun., 1968) have indicated that the top of the *Faberophyllum* zone corresponds approximately with the top of foraminiferal zone 15, and the base of the *Goniatites granosus* zone with the base of zone 16s. This relation implies that the intervening zone 16i would be referred to the Chester in limestone sections where corals are present, and to the Meramec in sections composed mainly of fine-grained clastic rocks where goniatite assemblages are present.

The problem is complicated by the fact that in the type region of the Meramec Series in Missouri, the Upper Mississippian section is incomplete. Erosion has removed part of the Ste. Genevieve Limestone, the uppermost formation included in the Meramec Series. West of the Mississippi River, in the type section of the Ste. Genevieve Limestone, the upper part of zone 14 and only the lower part of zone 15 are present (Mamet and Skipp, 1970). East of the Mississippi River, the Ste. Genevieve includes the upper part of zone 14 and all of zones 15 and 16i (Mamet and Skipp, 1970). The type sections of the Aux Vases Sandstone in Missouri and of the Renault Formation in southern Illinois are referred to zone 16i by Mamet and Skipp (1970). Thus, they regard zone 16i as the basal zone of the Chester Series in the Mississippi Valley.

The author considers the brachiopod fauna of the beds on Conical Hill as very late Meramec in age. Just below these beds near the top of the Chainman Shale at Conical Hill, as mapped by Nolan (1962, pl.

1), some of the same brachiopods occur is association with a primitive species of *Faberophyllum*, identified by Helen Duncan (in Nolan and others, 1956, p. 60), indicating a fairly late Meramec age.

It is not yet known whether the Conical Hill brachiopod fauna occurs in association with zone 16i foraminifers. As far as is now evident, both the positively and tentatively identified 16i collections occur in member D above the abundantly fossiliferous beds bearing the Conical Hill megafossils. Almost no megafossils are known from the upper 150 feet of the member and no microfossils have been found in the member below that.

The Renault Formation in Illinois, of early Chester age, carries a megafauna more like that of member E of the Diamond Peak Formation than of members B–D.

Obviously, further studies are needed of the Late Mississippian megafaunas and microfaunas of both the Great Basin and the Mississippi Valley regions to resolve this area of uncertainty. The author regards the bulk of member D, including all those beds that contain the typical Conical Hill megafauna, as late Meramec in age. He concurs with Skipp in regarding the top few feet of member D, with its zone 16s foraminiferal fauna, as Chester in age but wishes to reserve judgment on the relationship of the Meramec-Chester boundary to the 16i foraminiferal zone. The rather incomplete foraminiferal evidence would place the Meramec-Chester boundary somewhat lower, probably at least 135 feet below the top of the member.

MEMBER E

Six collections were made in this member, four from Brew's measured type section and two from rocks outside the line of section (table 4). The lowest of Brew's collections (USGS loc. 21291–PC), 280 feet above the base of the member, contains species typical of the Chester Series, such as *Diaphragmus* cf. *D. cestriensis* (Worthen), and *Anthracospirifer* aff. *A. increbescens* (Hall). The same forms also occur in a collection 110 feet higher stratigraphically (USGS loc. 21293–PC).

An imprint of *Goniatites choctawensis* Shumard in siltstone (USGS loc. 21275–PC) in a small fault block on the southeast side of Diamond Peak possibly belongs stratigraphically between the two collections mentioned above. Another collection from the same general area (USGS loc. 21274–PC), which includes imprints of *Goniatites granosus* Portlock, is believed by Brew to have come from near the top of member E.

As foraminifers typical of the *Goniatites granosus* or Upper *Posidonia* (P_2) zone occur in the top few feet of member D and as *G. granosus* has been recognized somewhere near the top of member E, it would seem safe to refer this member in its entirety to the P_2 zone. The author (Gordon, in Nolan and others, 1956, p. 61), reporting on the presence of the nautiloid *Tylonautilus* sp. in the type Diamond Peak section (USGS loc. 14698–PC), pointed out that in Europe *Tylonautilus* is generally restricted to the Upper *Eumorphoceras* (E_2) zone. Subsequent study of the Diamond Peak fossils and their stratigraphic occurrence have shown that most of the specimens of *Tylonautilus* in the Diamond Peak Formation have come from the P_1 and P_2 zones. Member E is early Chester in age.

MEMBER F

Only two collections are available from member F. Both were made by Brew and the author on the slope southeast of Diamond Peak. The presence of *Diaphragmus* cf. *D. cestriensis* (Worthen) in one collection (USGS loc. 17178–PC) suggests an early to middle Chester age, as does the occurrence of *Inflatia* cf. *I. bilobata* Sadlick in the other collection (USGS loc. 17179–PC).

Absence of recognizable corals and ammonoids in member F and overlying members of the Diamond Peak Formation, as well as the present lack of foraminiferal evidence, precludes precise correlation of this part of the formation with other Mississippian sections in the United States or with well-documented Carboniferous sections in Europe. For example, evidence is not available to indicate accurately the position of the Visean-Namurian boundary of the northwest European section; however, as this boundary is based on goniatites, it must lie somewhere above the highest bed containing the ammonoid fauna of the *Goniatites granosus* zone, near the top of member E. Presumably, therefore, most of member F is Namurian in age. Whether member F is late early Chester or early middle Chester in age cannot yet be determined.

FAUNAL HIATUS

In a large part of the Cordilleran region of the American West, including the Great Basin, the middle part of the beds of Chester age is recognized in sections combining limestone and shale by the presence of the coral zone of *Caninia excentrica* Meek (and allied species), commonly known as the *Caninia* zone; this is the K zone of Dutro and Sando (1963). In the Great Basin these corals are commonly associated with an as yet undescribed species of the productoid brachiopod *Antiquatonia*, which is abundant at some localities. This brachiopod, which superficially resembles the undescribed species of *Auloprotonia* in the lower

TABLE 4.—*Fauna from members E–H of the Diamond Peak Formation, Diamond Peak area, Nevada*

[See register for descriptions of collecting localities]

Fauna	Member E						Member F		Member G								Member H				
	USGS fossil collections																				
	21274–PC	21275–PC	21291–PC	21292–PC	21293–PC	18590–PC	17178–PC	17179–PC	17177–PC	21276–PC	21294–PC	21295–PC	21296–PC	21297–PC	21298–PC	F25–59–ES	17174–PC	21299–PC	21300–PC	21301–PC	21302–PC
Corals:																					
Zaphrentoid coral																		×			
Horn Coral									×											×	
Bryozoans:																					
Fistuliporoid, gen. and sp. indet							×														
Stenoporoid, gen. and sp. indet					×		×												×		
Fenestella sp					×	×	×														
Archimedes sp. indet					×		×														
Fenestrate bryozoan, indet			×	×			×														
Pelmatozoans:																					
Crinoid columnals	×		×		×		×		×										×		
Brachiopods:																					
Orbiculoidea sp									×										×		
Rhipidomella nevadensis (Meek)									×								×			×	×
Schizophoria cf. *S. resupinoides* (Cox)									×	×			×	×	×						
Schuchertella sp							×														
Orthotetes cf. *O. kaskaskiensis* (McChesney)			×		×		×		×				×	×	×						
Strophomenoid, gen. and sp. indet						×				×		×									×
Neochonetes cf. *N. oklahomensis* (Snider)													×	×							
Tornquistia sp																					×
Prouctoid, n. gen. and n. sp							×														
Inflatia cf. *I. bilobata* Sadlick								×													
Inflatia n. sp										×			×	×				×	×		×
Inflatia sp. indet											×										
Kozlowskia n. sp																					×
Flexaria aff. *F. arkansana* (Girty)							×		×	×	×		×	×	×				?		
Flexaria? sp. indet			×																		×
Echinoconchus sp					×		×														
Diaphragmus cf. *D. cestriensis* (Worthen)			×		×		×														
"Diaphragmus" aff. *"D." phillipsi* (Norwood and Pratten)										×			×		×				×		?
Ovatia cf. *O. pileiformis* (McChesney)							×		×			×									
Ovatia n. sp. A													×	×							
Ovatia n. sp. B													×	×							
Ovatia sp. indet			×		×	×					×				×	×					×
Rhynchonelloid, gen. and sp. indet	×								×												×
Leiorhynchus carboniferum Girty																		×			
Spirifer cf. *S. brazerianus* Girty																	×				
Anthracospirifer aff. *A. increbescens* (Hall)			×		×												×				
Anthracospirifer aff. *leidyi* (Norwood and Pratten)							×		×												
Spiriferoid indet	×				×																
Cleiothyridina sp				×	×		×										×				
Composita subquadrata (Hall)?											×										
Composita sp																			×		
Composita? sp. indet			×				×						×								
Eumetria? sp. indet													×								
Beecheria sp													×	×							
Pelecypods:																					
Polidevcia sp	×																				
Paleoyoldia sp	×													×							
Aviculopecten eurekensis Walcott			×																		
Aviculopecten spp													?								
Acanthopecten? sp									×												
Pterinopecten spio Walcott														×	×						
Streblopteria similis Walcott	×						×														
Streblopteria? sp. indet			×		×				×					×							
Posidonia sp				×																	
Pteronites sp			×																		
Caneyella cf. *C. richardsoni* Girty	×																				
Promytilus? sp	×																				
Myalina sp					×		×					×		×	×						
Leptodesma pintoensis Walcott							×														
Leptodesma sp			×	×	×																
Conocardium sp	×																				
Schizodus? sp. indet			×																		
Solenomya? sp. indet									×												
Cypricardella sp			×																		
Sphenotus sp	×		×		×				×												
Wilkingia? sp. indet													×								
Pelecypod indet						×							×	×	×						
Gastropods:																					
Stegocoelia sp	×		×																		
Straparollus (Euomphalus) sp	×				×	×															
Amphiscapha sp					×																
Platyceras sp					×																
Gastropod, gen. and sp. indet														×							
Coleolus sp														×							

TABLE 4.—*Fauna from members E–H of the Diamond Peak Formation, Diamond Peak area, Nevada*—Continued

Fauna	Member E						Member F		Member G								Member H				
	USGS fossil collections																				
	21274–PC	21275–PC	21291–PC	21292–PC	21293–PC	18590–PC	17178–PC	17179–PC	17177–PC	21276–PC	21294–PC	21295–PC	21296–PC	21297–PC	21298–PC	F25–59–ES	17174–PC	21299–PC	21300–PC	21301–PC	21302–PC
Cephalopods:																					
Tylonautilus gratiosus (Girty)	×																				
Stroboceras cf. *S. sulcatum* (Sowerby)						×															
Stroboceras? sp. indet	×																				
Coiled nautiloid indet					×																
Goniatites choctawensis Shumard		×																			
Goniatites granosus Portlock	×																				
Trilobite:																					
Paladin sp					×							?									

part of the Diamond Peak Formation, is present at some localities where the corals are absent. Near the south end of Buck Mountains, 11 miles east-northeast of Diamond Peak, this *Antiquatonia* is fairly common in calcareous shale and fine-grained sandstone beds in the lower 150 feet of the exposed section of the Diamond Peak Formation. This species has not been recognized in the section at Diamond Peak.

Were the *Caninia* zone beds present in the Diamond Peak section, they should be represented somewhere in the upper part of member F, or near the base of member G. The productoid identified in member F (table 4) as *Diaphragmus* cf. *D. cestriensis* (Worthen) is common below the *Caninia* zone in other sections where this zone is present. The productoid identified from the lower part of member G (USGS loc. 17177–PC) as "*Diaphragmus*" aff. "*D.*" *phillipsi* (Norwood and Pratten) is very common above the *Caninia* zone in other Great Basin sections. These two collections were made on a spur on the east slope of Diamond Peak and are about 250 feet apart stratigraphically.

Whether an unconformity is present between these two collecting localities or whether the absence of the *Caninia* zone fauna is due to a lateral facies change accompanied by thinning is not presently known. The possibility of cutout due to faulting also exists, but it seems less likely because even in the measured type section, apparently undisturbed by faulting, this part of the beds of Chester age seems rather thin in comparison with other Great Basin sections.

MEMBER G

Eight collections from member G were studied by the author, including six from the measured type section (table 4). The most characteristic species, and one of the most abundant, is a *Diaphragmus*-like productoid brachiopod identified in table 4 as "*Diaphragmus*" aff. "*D.*" *phillipsi* (Norwood and Pratten), which has compound diaphragms that form a series of frills on the brachial valve. In the measured section this species was common in two beds of dark-gray platy shale, 27 and 97 feet above the base of the member (USGS locs. 21296–PC, 21298–PC). The species also was recognized in a bed at the crest of the range, roughly 120 feet above the base of the member (USGS loc. 21276–PC).

Forms similar to, or identical with, this species occur in the Chainman Shale in the Burbank Hills in western Utah, beginning near the top of the *Cravenoceras hesperium* ammonoid zone and extending upward approximately to the base of the Ely Limestone. *Rhipidomella nevadensis* (Meek) is also common in this part of the section in western Utah. In member G in the Diamond Peak area, *R. nevadensis* was recognized only at USGS locality 17177–PC in the lower part of the member.

Those two brachiopod species indicate that member G is late Chester in age. The observed stratigraphic position of these brachiopods in relation to ammonoids in western Utah sections indicates that part of the *Eumorphoceras bisulcatum* (E_2) zone of Namurian A age is represented by member G.

MEMBER H

Five collections from member H have been studied, of which four are from the measured type section. The lowest collection, 19 feet stratigraphically above the base of the member (USGS loc. 21299–PC), is from a gray-black limestone bed; it contains the long-ranging *Leiorhynchus carboniferum* Girty in some abundance.

The next collection, 97 feet above the base of the member (USGS loc. 21300–PC), contains "*Diaphragmus*" aff. "*D.*" *phillipsi* (Norwood and Pratten). As in the Confusion Range section in western Utah, the stratigraphically higher forms of this distinctive *Diaphragmus*-like shell are somewhat more finely costate than the stratigraphically lower specimens.

Seven feet stratigraphically above the last collection, one bed (USGS loc. 21301–PC) contains abundant *Rhipidomella nevadensis.* Roughly 75 feet higher than this bed, and 42.5 feet below the base of the Ely Limestone, another bed (USGS loc. 21302–PC) contains a more varied fauna, including *Kozlowskia* n. sp. This Mississippian *Kozlowskia* is locally abundant at the top of the Chainman Shale in the Confusion and Conger Ranges in western Utah.

Member H, therefore, carries about the same fauna, though in less abundance, as the uppermost part of the Chainman Shale in the mountain ranges that flank the Nevada-Utah border east of Ely. The age of member H is very late Chester.

DIAMOND PEAK FORMATION OF THE LOWER PLATE OF THE BOLD BLUFF THRUST FAULT

One collection was made from rocks assigned by Brew to the Diamond Peak Formation of the lower plate of the Bold Bluff thrust fault. The collection (USGS loc. 17173–PC) contains the following fauna:

Horn corals, gen. and sp. indet.
Fistuliporoid bryozoan, massive form
Fistulioporoid bryozoan, ramose form
Stenoporoid bryozoan, gen. and sp. indet.
Fenestella sp.
Polypora sp.
Crinoid columnals
Schizophoria sp.
Neochonetes sp. A
Inflatia sp. A
Buxtonia sp.
Echinoconchus aff. *E. biseriatus* (Hall)
Auloprotonia n. sp.
Ovatia cf. *O. latior* (Snider)
Striatifera n. sp.
Moorefieldella eurekense (Walcott)?
Anthracospirifer aff. *A. pellaensis* (Weller)
Tylothyris n. sp.
Pseudosyrinx desiderata (Walcott)?
Hustedia sp.
Beecheria? sp. indet.
Aviculopecten haguei Walcott?

This collection is typical of the Conical Hill fauna of the Diamond Peak Formation and could belong in either member C or D. According to Brew, the material is from rocks that may be approximately equivalent to the upper part of member C.

REGIONAL RELATIONS OF THE DIAMOND PEAK FORMATION AND THE CHAINMAN SHALE

Perhaps by now the reader who has followed the discussion finds himself wondering how the Chainman Shale can underlie the Diamond Peak Formation in the Diamond Peak area and yet be in part equivalent elsewhere in age to the highest beds of the type Diamond Peak. The correlation chart (fig. 11) was prepared primarily to explain this situation.

The type section of the Chainman Shale is in Robinson Canyon in the Egan Range, 2 miles west of Ely, Nev. Although the Chainman is less affected by alteration than the nearby type exposure of the Joana Limestone, its type section is sparsely fossiliferous and may be incomplete. *Rhipidomella nevadensis* (Meek), however, occurs near the top of the Chainman. In the Egan Range and in the Schell Creek Range, which lies to the east, the Chainman Shale is Late Mississippian (Chester) in age. Ammonoids of the *Goniatites granosus* zone (= Upper *Posidonia*, or P_2 zone) occur near the base, and brachiopods of the *Rhipidomella nevadensis* zone occur near the top of the shale. The Chainman Shale in its type region, therefore, is approximately equivalent in age to members E through H of the type section of the Diamond Peak Formation. No beds of Meramec age have been recognized in the Chainman Shale in the Egan and Schell Creek Ranges.

Farther east, in the Snake and Confusion Ranges along the Nevada-Utah State line, the Chainman Shale has approximately the same upper limit as in the Ely region, being overlain by the Ely Limestone. The lower part of the formation, however, includes beds of Meramec age, identified by their ammonoid-faunas content. These stratigraphically lower beds of the Chainman Shale are equivalent, at least in part, to members C and D of the type Diamond Peak section, and unfossiliferous beds beneath the ammonoid-bearing beds may correlate with even lower parts of the Diamond Peak section.

Beds of Meramec age are also present in the lower part of the Chainman Shale west of Ely, in the White Pine and Pancake Ranges, but in that region tongues of Diamond Peak type clastic rocks extend eastward into the upper part of the Chainman. Where the Diamond Peak facies is well developed, the top of the Chainman Shale locally lies at different levels. Nevertheless, in parts of the White Pine Range, beds of dominantly Chainman lithology contain all the major ammonoid assemblages of late Meramec and Chester age and locally extend upward to the base of the Ely Limestone.

Some geologists have used the term "Illipah Formation" (Christiansen, 1951, p. 76; Bissell, 1960, p. 1427, 1433–1435) to designate coarse-grained clastic sedimentary rocks at the top of the Chainman Shale in the White Pine Range and in areas to the east. Others have suggested dropping the name "Illipah" because they regard it as synonymous to the Scotty Wash Quartzite of the Pioche district (Steele, 1960, p. 99) or to the Diamond Peak Formation (Sadlick, 1960, p. 81–84). In the western part of the White Pine Range and in the Pancake Range, most coarse-grained clastic beds are lenses and tongues of Diamond Peak rocks. In much of eastern Nevada, however, quartzites and some limestone beds are fairly commonly intercalated with the upper part of the Chainman Shale.

Usage of the name "Illipah" for a stratigraphic unit of Carboniferous age has never been properly formalized by designation of a type section and identification of the delimiting strata. Christiansen's original usage of the term "Illipah Formation" was merely passing mention in a guidebook article. The same name, however, has been formalized for an Eocene formation in northeast Nevada (Eakin, 1960, p. 26; Humphrey, 1960, p. 41–42, pl. 1). The name should therefore not be used for any part of the Carboniferous.

In the Pancake Range the Upper Mississippian sections exhibit a general merging of Chainman and Diamond Peak lithologies. Stewart (1962, p. C59) found it impossible to differentiate the two formations in the north-central part of the range, but divided the undifferentiated sequence into four informal units. Fossils collected by Stewart during his study and by the writer subsequently show that Stewart's lower two units, and at least the lower part of the third, are Meramec in age.

In the Eureka district the Chainman Shale, in the two areas where it can be differentiated, is considered to underlie the Diamond Peak Formation (Nolan and others, 1956), but an intertonguing relationship exists between the upper beds of the Chainman and the bulk of the Diamond Peak Formation as represented by its type section, in the Diamond Mountains and also near Eureka. Near Eureka, bodies of Chainman Shale have been mapped beneath the Diamond Peak Formation in the vicinity of Conical Hill in Windfall Canyon (Nolan, 1962, p. 11, pl. 1). The stratigraphic equivalence of these beds to part of the type Diamond Peak section is indicated by fossils from the Chainman Shale listed by Nolan and others (1956, p. 60). These fossils are relisted below, as originally identified and as given in table 2 of the present report:

Nolan and others (1956, p. 60)	*This report (table 2)*
Rhipidomella nevadensis (Meek)	*Rhipidomella* n. sp.
Chonetes cf. *C. oklahomensis* Snider	*Neochonetes* sp. A
Dictyoclostus n. sp.	*Auloprotonia* n. sp.
Linoproductus "ovatus" (Hall)	*Ovatia* cf. *O. latior* (Snider)
Spirifer mortonananus Miller	*Spirifer* aff. *S. haydenianus* Girty
Brachythyris sp.	*Brachythyris* sp.
Dimegalasma cf. *D. neglectum* (Hall)	*Dimegalasma eurekense* Linz and Lohr

In the opinion of the author, all the fossils from both the Chainman Shale and the Diamond Peak Formation in the immediate vicinity of Conical Hill occur in beds considered stratigraphically equivalent to member D and perhaps to the uppermost part of member C of the type Diamond Peak section, a few miles to the north. The presence of *Faberophyllum* in beds mapped as Chainman, recognized by Helen Duncan (Nolan and others, 1956, p. 60), indicates that these beds are rather late Meramec in age.

True *Rhipidomella nevadensis* (Meek) is restricted to members G and H of the Diamond Peak Formation, its uppermost subdivisions, and to the lower beds of the Ely Limestone. This species, associated with a late Chester fauna, has been found in typical Chainman Shale lithology on the east slope of the Diamond Mountains north of Pinto Creek Ranch. Thus, age determinations and biostratigraphic relations based upon contained fossils indicate that in some parts of the Eureka district the base of the Diamond Peak Formation lies at considerably different levels and that tongues of Chainman-like shale interfinger with coarse-grained clastic rocks of the Diamond Peak Formation almost as high as the base of the Ely Limestone.

North of the Diamond Peak area, in the Pinyon Range in the Pine Valley and Carlin quadrangles, as mapped by Smith and Ketner (1968, p. I12–I13), the Chainman Shale is of Early Mississippian age. On the west slope of the range in the Pine Valley quadrangle, where the so-called Chainman is locally overlain unconformably by rocks of Late Permian age, it consists of a dominantly shale, siltstone, and sandstone sequence that contains the ammonoid genus *Protocanites* in the lower part, indicating late Kinderhook age, and a coral-brachiopod assemblage (including *Trochophyllum*) in the upper part, indicating early Osage age (Gordon and Duncan, 1962, p. C233). Ely Limestone caps the main ridge of the range. The so-called Chainman Shale in this area is a temporal equivalent of roughly the upper two-thirds of the Joana Limestone of the Ely district.

In the Carlin quadrangle, including the northern part of the Pinyon Range, the Mississippian section probably is without a stratigraphic break of any consequence. The upper part of the co-called Chainman Shale includes beds of late Osage age. In the lower part of the overlying Diamond Peak Formation, a yellow siltstone contains a fauna that can be placed at, or near, the Osage-Meramec boundary. The upper part which contains the colonial corals *Siphonodendron* (not the Diamond Peak species) and *Diphyphyllum*, is Meramec in age (Gordon and Duncan, 1962, p. C234). The lower part of the Diamond Peak Formation contains species of genera that cross the Osage-Meramec boundary—such as the bryozoan *Worthenopora* and the brachiopods, *Leptagonia*, *Setigerites*, *Spirifer*, *Cleiothyridina*, *Composita*, and *Dimegalasma*, which may belong in either series. These forms are associated, however, with ostracodes that, according to I. G. Sohn (written commun., 1962), are more typical of Late than of Early Mississippian age.

Higher in the Diamond Peak Formation of the Carlin region, limestone beds contain the coral *Faberophyllum* associated with the productoid brachiopod *Striatifera;* just beneath these beds, dark-gray shales contain brachiopods that occur also in the Moorefield Formation of Arkansas—such as *Quadratia hirsutiformis* (Walcott), *Leiorhynchus carboniferum* Girty, "*Spirifer*" *martiniiformis* Girty, and *Echinocœlia* cf. *E. pilosa* (Girty). These beds are very late Meramec in age and roughly equivalent to member D of the type Diamond Peak section. Even higher in the section, beds that contain abundant brachiopods constituting a fauna of late Chester age are probably equivalent to member H or to the upper part of member G. The uppermost beds of the Diamond Peak Formation in Carlin Canyon are Early Pennsylvanian in age and carry a very early Morrow fauna; they are therefore equivalent in age to part of the Ely Limestone of the Diamond Mountains and other areas (see fig. 1).

Deposition of the Diamond Peak Formation in the Carlin region therefore began earlier and ended later than in the type region (Smith and Ketner, 1968, p. I13). None of the faunas recorded from the so-called Chainman Shale and the basal part of the Diamond Peak Formation of the Carlin region has been found in the Diamond Peak area, or anywhere else in the Eureka district.

ELY LIMESTONE

The study of 18 fossil collections (table 5) made by Brew from the Ely Limestone demonstrates that the Mississippian-Pennsylvanian boundary lies within the lower member of this formation, a little more than 80 feet above its base. Only the lower part of the Ely Limestone is exposed in that part of the Diamond Peak area where Brew's section was measured. No beds later than Early Pennsylvanian in age were recognized in the section. Elsewhere in the Eureka quadrangle, however, along the southwest edge of the mapped area, Ely Limestone beds of Middle Pennsylvanian (Atoka) age have been reported (Nolan and others, 1956, p. 63).

TABLE 5.—*Fauna of the Ely Limestone, Diamond Peak area, Nevada*

[See register for descriptions of collecting localities]

Fauna	Upper Mississippian							Lower Pennsylvanian										
	Lower member										Upper member							
	USGS collecting localities																	
	17176–PC	21303–PC	21304–PC	21305–PC	21306–PC	21307–PC	21308–PC	21309–PC	21310–PC	21311–PC	21312–PC	21313–PC	21314–PC	21315–PC	21316–PC	21317–PC	21318–PC	ES–57–2F
***Rhipidomella nevadensis* assemblage:**																		
Corals:																		
Amplexizaphrentis? sp			×															
Horn coral indet	×																	
Bryozoans:																		
Stenoporoid, gen. and sp. indet						×												
Pelmatozoans:																		
Crinoid columnals			×															
Brachiopods:																		
Rhipidomella nevadensis (Meek)	×	×	×	×	×		×											
Schizophoria cf. *S. texana* Girty		×	×		×													
Krotovia? sp		×																
Inflatia sp			×															
Echinoconchus sp						×												
Buxtonia aff *B subcircularis* Sutton and Wagner						×												
Diaphragmus? sp				×	×													
Ovatia sp. B	×	×																

TABLE 5.—*Fauna of the Ely Limestone, Diamond Peak area, Nevada*—Continued

Fauna	Upper Mississippian								Lower Pennsylvanian									
	Lower member										Upper member							
	USGS collecting localities																	
	17176–PC	21303–PC	21304–PC	21305–PC	21306–PC	21307–PC	21308–PC	21309–PC	21310–PC	21311–PC	21312–PC	21313–PC	21314–PC	21315–PC	21316–PC	21317–PC	21318–PC	ES–57–2F
Brachiopods—Continued																		
Anthracospirifer cf. *A. leidyi* (Norwood and Pratten)								×										
Anthracospirifer sp		×		×		×	×											
Anthracospirifer sp. indet			×															
Crurithyris? sp. indet					×													
Torynifer cf. *T. setiger* (Hall)			×		×	×												
Cleiothyridina sp	×																	
Composita subquadrata (Hall)?		×																
Composita sp				×	×	×												
Reticulariina campestris (White)		×		×														
Beecheria? sp			×															
Girtyella sp		×																
Pelecypods:																		
Aviculopecten sp. indet		×																
Streblopteria? sp			×															
Schizodus sp		×																
Sphenotus? sp. indet		×																
Pelecypod indet. (concentrically ribbed)							×											
Fish:																		
Bone fragment	×																	
***Rugoclostus* n. sp. assemblage:**																		
Corals:																		
Caninoid, *gen.* and *sp. indet*												×		×				
Zaphrentoid, gen. and sp. indet												×						
Horn coral indet															×	×		
Bryozoans:																		
Stenoporoid, gen. and sp. indet												×				×		×
Stenoporoid, gen. and sp. indet (ramose)															×	×		
Fenestella sp																×		
Rhomboporoid, gen. and sp. indet																×		×
Pelmatozoans:																		
Crinoid columnals								×				×						×
Echinoid spines														×				
Brachiopods:																		
Orbiculoidea sp																	×	
Strophomenoid, gen. and sp. indet												×						
Schizophoria cf. *S. texana* Girty									×					×				
Neochonetes sp															×			
Rugoclostus n. sp								×								×		
Flexaria sp										×					×			
Antiquatonia sp													×					
Linoproductus sp											×		×		×	×		
Dictyoclostid, gen. and sp. indet														×	×			
Wellerella sp																×		
Anthracospirifer occiduus (Sadlick)								×		×			×			×		
Anthracospirifer opimus (Hall)									×		×							
Anthracospirifer rockymontanus (Marcou)																×		
Neospirifer cf. *N. cameratus* (Morton)															×			
Cleiothyridina cf. *C. orbicularis* (McChesney)																×		
Cleiothyridina sp								×		×								
Composita sp								×	×		×			×		×		
Punctospirifer transversus (McChesney)												×						
Reticulariina campestris (White)												×		×		×		
Hustedia cf. *H. miseri* Mather																×		
Beecheria sp. indet																×		
Pelecypods:																		
Pelecypod indet													×					

LOWER MEMBER

The fauna of the lower part of this member is a continuation of the fauna of member H of the Diamond Peak Formation. The uppermost Mississippian fauna contains abundant *Rhipidomella nevadensis* (Meek). This species is present in collections from levels 2, 31, 36, 46, and 81 feet above the base of the member. *Torynifer cf. T. setiger* (Hall), a characteristic Mississippian form, was found from 31 to 55 feet above the base.

The fauna takes on a Pennsylvanian aspect 90 feet above the base of the member, where productoid brachiopods referrable to *Rugoclostus* and spirifers identifiable as *Anthracospirifer occiduus* (Sadlick) appear. Although the two collections from the upper part of the lower member are meager, the fossils in them are similar to those from the upper member; *Rhipidomella nevadensis* was not found in these higher beds.

CRITERIA FOR RECOGNIZING THE MISSISSIPPIAN-PENNSYLVANIA BOUNDARY

In most of the Great Basin it is possible to recognize the Mississippian-Pennsylvanian boundary within a few feet, or at worst, within a few tens of feet, by means of the brachiopod faunas. The author places the boundary above the beds with a predominance of *Rhipidomella nevadensis* (Meek) and below the first appearance of the productoids of the *Rugoclostus* assemblage. *Rhipidomella nevadensis* has been found locally in the *Rugoclostus* beds but is always rare. Characteristic of very Late Mississippian beds in the Great Basin is a proliferation of medium-sized productoids—particularly of the genera *Inflatia*, *Flexaria*, *Ovatia*, and related forms—along with *Torynifer*. These forms are succeeded in the basal Pennsylvanian rocks by generally larger productoids of the genera *Rugoclostus*, *Flexaria?*, *Echinoconchus*, *Antiquatonia*, and *Linoproductus*. The location of the boundary by these criteria seems to agree rather closely with where Girty placed the same boundary, as recorded in various earlier U.S. Geological Survey publications on the Great Basin.

Some geologists have recommended locating the base of the Pennsylvanian at the first appearance of *Rhipidomella nevadensis*, but this would introduce numerous difficulties. For one thing, there is no obvious faunal break at that level among the rest of the brachiopods. Also, as *R. nevadensis* in the Conger Range, Utah, has been found about 20 feet below a bed containing the ammonoid *Cravenoceras merriami* Youngquist, part of the Upper *Eumorphoceras* (E_2) zone would have to be included in the Pennsylvanian. This step is not likely to be recommended by any ammonoid specialist.

REGIONAL DISTRIBUTION OF THE MISSISSIPPIAN PART OF THE ELY LIMESTONE

The Mississippian beds at the base of the Ely have been recognized also in the Confusion, Schell Creek, and Egan Ranges. This part of the section has not been studied in detail in the Snake, White Pine, and Pancake Ranges. Normally, the thickness of these beds is nearer to 50 feet than to the 80-odd feet measured in the section on Diamond Peak. This thickness is consistent with the greater overall thickness of the Upper Mississippian section in the Diamond Mountains.

CORRELATION WITH *HOMOCERAS* ZONE

In the Confusion and Schell Creek Ranges a distinctive and, as yet, undescribed species of *Diaphragmus* has been recognized in this Mississippian interval at the base of the Ely Limestone. From beds containing this species on the east slope of the Schell Creek Range, near Majors Place at the Junction of U.S. Highways 6–50 and 93 (fig. 1), Mamet (written commun., 1969) has recognized his foraminiferal zone 19 fauna in one, and probably a second, of four specimens provided by the author. This is the first record of zone 19 foraminifers in the Great Basin. Mamet has previously recognized this fauna in Idaho (W. J. Sando, written commun., 1698). A suite of specimens from the same interval on Diamond Peak failed to yield any foraminifers.

Zone 19 foraminifers occur in the northwest European Carboniferous section in the *Homoceras* (H) zone. The ammonoid genus *Homoceras* has not been recognized in the United States. The *Homoceras* (H) zone in northwest Europe is suceeded by the Lower *Reticuloceras* (R_1) zone, which also can be recognized in the lower part of the type section of the Morrow Series in northwest Arkansas.

Zone 20 foraminifers are fairly widespread in lower Morrow deposits, according to Mamet (written commun., 1968). Zone 18 foraminifers occur in the type sections of the Clore and Kinkaid Limestones in Illinois (Mamet and Skipp 1970). Zone 19 seems to correspond in the American midcontinent to a hiatus at the Mississippian-Pennsylvanian (Chester-Morrow) boundary in the type areas of both series.

The beds at the base of the Ely Limestone, therefore, are post-type-Chester and pre-type-Morrow in age. As the fauna of this interval is overwhelmingly similar to fauna those of the Mississippian beds below, we are including these beds in the Mississippian.

UPPER MEMBER

Nine collections were studied from the upper member of the Ely Limestone; eight are from the measured section (table 5). Characteristic of these higher cherty limestone beds of the Ely are *Rugoclostus* n. sp., *Antiquatonia* sp., *Anthracospirifer occiduus* (Sadlick), *A. opimus* (Hall), and *Hustedia* cf. *H. miseri* (Mather). As in other parts of the Great Basin, the Chester spiriferinids *Punctospirifer transversus* (McChesney) and *Reticulariina campestris* (White) range upward through beds of Early Pennsylvanian age. As far as could be determined, no beds of Middle Pennsylvanian (Atoka) age occur in the measured section on Diamond Peak.

CONCLUSIONS

The author's biostratigraphic studies in the west-central part of the Great Basin, and particularly in the Eureka district, permit the following conclusions to be drawn regarding the age and correlation of the Carboniferous formations. These conclusions have already been supported in this discussion and are briefly summarized here.

1. The earliest Mississippian (Kinderhook) beds in the Eureka district occur in the upper part of the Pilot Shale.
2. The Joana Limestone in its type area in the Ely district is late Kinderhook and Osage in age.
3. In the Eureka district, including the Diamond Peak area, the Joana Limestone contains no beds of Osage age.
4. The Chainman Shale in its type area in the Ely district is Chester in age.
5. In the Confusion Range of Utah and the White Pine Range of Nevada the Chainman is late Meramec and Chester in age.
6. In parts of the White Pine and Pancake Ranges the upper part of the Chainman Shale and the Diamond Peak Formation intertongue.
7. In the Pancake Range, the undifferentiated Chainman-Diamond Peak sequence of Stewart (1962) is late Meramec and Chester in age.
8. In the Eureka district, including the Diamond Peak area, the Chainman Shale, which is overlain by, or intertongues with, the lower part of the Diamond Formation, is Meramec in age.
9. In the Carlin region the rocks called Chainman Shale are very late Kinderhook and Osage in age and are temporally equivalent to the Joana Limestone.
10. The Diamond Peak Formation at its type locality is Meramec (mostly late Meramec) and Chester in age.
11. Within the type Diamond Peak Formation:
    a. The Meramec-Chester boundary is located within and near the top of member D;
    b. The Visean-Namurian boundary probably occurs near the contact between members E and F; and
    c. A faunal hiatus that represents much of middle Chester time probably occurs at or near the contact between members F and G.
12. No beds of Pennsylvanian age are present in the Diamond Peak Formation of the type area, but the uppermost beds of the formation in the Pinyon Range (north) area of the Carlin quadrangle are Early Pennsylvanian in age.
13. The Mississippian-Pennsylvanian boundary lies within the lower part of the Ely Limestone in the Eureka district, as well as in the Ely district and the Confusion Range.
14. The uppermost beds of the Ely Limestone in the Diamond Peak area are Early Pennsylvanian, but elsewhere in the Eureka area the formation includes beds as young as Middle Pennsylvanian (Atoka).

REGISTER OF FOSSIL COLLECTING LOCALITIES IN THE DIAMOND PEAK AREA, NEVADA

USGS locality	*Description and collectors*
6567–PC	Eureka 15-min quadrangle, White Pine County. Apparently just west of Bold Bluff and just east of fault—south of Diamond Peak. Limestone occurring in black shale in lower part of Diamond Peak Formation. Seemingly the one mentioned (Walcott, 1884) as 200 ft above the base. G. H. Girty and H. G. Ferguson, June 1928.
14690–PC	Eureka 15-min quadrangle, White Pine County. Highest zone of black shale on east slope of Bold Bluff, in the SW¼ sec. 6, T. 19 N., R. 55 E., White Pine [now Chainman] Shale, from a lenticular siliceous limestone near the top—bed 24 of Bold Bluff section. J. S. Williams, July 17, 1938.
14693–PC	Eureka 15-min quadrangle, White Pine County. Section up ridge trending southward from east end of Diamond Table, well below top. [Probably in SW¼NW¼ sec. 32 (unsurveyed), T. 20 N., R. 55 E.] Diamond Peak Formation—bed 11 of measured section. J. S. Williams, T. B. Nolan, and T. A. Broderick, July 14, 1938.
14694–PC	Eureka 15-min quadrangle, White Pine County. About 800 ft below top on southeast side of Diamond Table Peak. Diamond Peak Formation, from float below a quartzite which is the upper part of bed 13 of measured section. J. S. Williams and others, July 14, 1938.
14695–PC	Eureka 15-min quadrangle, White Pine County. Top of second massive ledge of quartzite below top of southeastern part of Diamond Table. Diamond Peak Formation—fossils from olive-brown siltstone—bed 17 of measured section. J. S. Williams and others, July 15, 1938.
16680–PC	Eureka 15-min quadrangle, White Pine County. On east slope of Diamond Mountains not far below main crest, 3,900 ft S. 33° E. of VABM 9358 above Black Point. Diamond Peak Formation, member B. D. A. Brew, 1956.
16681–PC	Eureka 15-min quadrangle, White Pine County. A little higher on slope than last, 3,900 ft S. 28½° E. of VABM 9358 above Black Point.

USGS locality	Description and collectors
	Diamond Peak Formation, member B. D. A. Brew, 1956.
16682–PC	Eureka 15-min quadrangle, White Pine County. On main crest, 4,250 ft S. 22½° E. of VABM 9358 above Black Point. Diamond Peak Formation, member B. D. A. Brew, 1956.
16683–PC	Eureka 15-min quadrangle, White Pine County. High on east slope of Diamond Mountains, 6,100 ft S. 27° E. of VABM 9358 above Black Point. Diamond Peak Formation, member B. D. A. Brew, 1956.
16684–PC	Eureka 15-min quadrangle, White Pine County. Near top of main ridge directly upslope from USGS loc. 16683–PC, 5,950 ft S. 16° E. of VABM 9358 above Black Point. Diamond Peak Formation, member B. D. A. Brew, 1956.
16685–PC	Eureka 15-min quadrangle, White Pine County. On top of main ridge, 10,700 ft S. 8½° E. of VABM 9358 above Black Point Diamond Peak Formation, member B. D. A. Brew, 1956.
17172–PC	Eureka 15-min quadrangle, White Pine County. Limestone blocks in minor drainage on slope at about 8,400 ft elev, about one-eighth mile due north of Bold Bluff in the NW¼SW¼ sec. 6, T. 19 N., R. 55 E. Diamond Peak Formation. Mackenzie Gordon, Jr., and D. A. Brew, July 15, 1957.
17173–PC	Eureka 15-min quadrangle, White Pine County. On crest of ridge that extends in general south-southeast direction from main divide of Diamond Mountains to Water Canyon, between two west tributaries of Water Canyon, in NE¼ SW¼ sec. 31 (unsurveyed), T. 20 N., R. 55 E.; approximate elev 7,950 ft. Diamond Peak Formation, limestone and calcareous shale, 50 ft thick, above fourth massive conglomerate on ridge, perhaps 1,000 ft above base of formation. Mackenzie Gordon, Jr., and D. A. Brew, July 15, 1957.
17174–PC	Eureka 15-min quadrangle, White Pine County. East slope of Diamond Mountains, about 70 ft below top of main ridge, near middle of NE¼ NE¼ sec. 36, T. 20 N., R. 54 E. Diamond Peak Formation; *Rhipidomella nevadensis* bed in upper part. Mackenzie Gordon, Jr., and D. A. Brew, July 15, 1957.
17176–PC	Eureka 15-min quadrangle, on Eureka-White Pine County line. Fossils in shaly nodular limestone on main ridge directly upslope from USGS loc. 17174–PC, in NE¼NE¼ sec. 36, T. 20 N., R. 54 E. Ely Limestone, 7 to 10 feet above base of formation. Mackenzie Gordon, Jr., and D. A. Brew, July 16, 1957.
17177–PC	Eureka 15-min quadrangle, White Pine County. On top of ridge that extends southeastward from south shoulder of Diamond Peak, the fairly level part of which ridge is known as Diamond Table; at local base of slope on ridge-crest, at a point 3,200 ft S. 8° E. of summit of Diamond Peak, in SE¼NE¼ sec. 30 (unsurveyed), T. 20 N., R. 55 E.; at elev of about 9,900 ft. Diamond Peak Formation; *Diaphragmus* bed in upper part. Mackenzie Gordon, Jr., and D. A. Brew, July 16, 1957.
17178–PC	Eureka 15-min quadrangle, White Pine County. On same ridge as USGS loc. 17177–PC but about 1,000 ft to south-southeast, at about elev 9,800 ft, and roughly 250 ft lower in section. Diamond Peak Formation, upper part. Mackenzie Gordon, Jr., and D. A. Brew, July 16, 1957.
17179–PC	Eureka 15-min quadrangle, White Pine County. Same general locality as USGS loc. 17177–PC, but about 100 yd to northeast and 70 ft lower stratigraphically. Mackenzie Gordon, Jr., and D. A. Brew, July 16, 1957.
18590–PC	Eureka 15-min quadrangle, Eureka County. Within Diamond Peak measured section. (See p. 67 for details). Diamond Peak Formation, member E; 2,559 ft above base of formation and 967 ft below base of Ely Limestone. D. A. Brew, July 6, 1959. (Appears to be same level as USGS loc. 21293–PC.)
21269–PC	Eureka 15-min quadrangle, White Pine County. On ridge at south side of Sadler Canyon, 7,100 ft N. 77½° W. of B.M. 5927, in NW¼NW¼ sec. 34 (unsurveyed), T. 20 N., R. 55 E. Chainman Shale—deformed here, but best estimate places collection 300 ft below base of Diamond Peak Formation. D. A. Brew, June 29, 1958.
21270–PC	Eureka 15-min quadrangle, Eureka County. 4,700 ft N. 18° W. of summit shown as elev 10,375 on topographic map, on crest of range, north of Diamond Peak. Diamond Peak Formation, probably member B; perhaps 390 ft above base of formation and 3,136 ft below base of Ely Limestone. D. A. Brew, August 15, 1957.
21271–PC	Eureka 15-min quadrangle, White Pine County. On ridge trending eastward from southeast end of Diamond Table, 9,600 ft N. 78° E. of B.M. 5927, in NE¼ sec. 34 (unsurveyed), T. 20 N., R. 55 E. Diamond Peak Formation, perhaps from member C, about 1,000 above base of formation. D. A. Brew, June 29, 1958.
21272–PC	Eureka 15-min quadrangle, White Pine County. On slope above (west of) Robinson Springs; rubble pile, 4,000 ft N. 87° E. of elev 9,271 shown on topographic map on crest of range south of Minoletti Creek. Diamond Peak Formation, probably from member C, about 1,550–1,650 ft above base of formation and 1,876–1,976 ft below base of Ely Limestone, although member assignment is very questionable. M. K. Hubbert and D. A. Brew, July 29, 1957.
21273–PC	Eureka 15-min quadrangle, White Pine County. On crest of range south of Minoletti Creek;

USGS locality	Description and collectors
	3,580 ft S. 22½° E. of elev 9,271. Diamond Peak Formation, member D; about 1,788 ft above base of formation and 1,738 ft below base of Ely Limestone. From same unit as USGS colln. 21285–PC. D. A. Brew, July 25, 1957.
21274–PC	Eureka 15-min quadrangle, White Pine County. On southeast-trending ridge between Adobe and Sadler Canyons: 3,370 ft S. 77° E. of summit of Diamond Peak. Diamond Peak Formation, member E(?), probably 1,400–1,550 ft below base of Ely Limestone and 1,980–2,126 ft above base of formation. D. A. Brew, June 20, 1958.
21275–PC	Eureka 15-min quadrangle, White Pine County. On east-trending ridge just north of Adobe Canyon, in fault-bounded block 3,800 ft S. 88½° E. of elev 10,365 on main ridge north of Diamond Peak. Diamond Peak Formation, member E(?), stratigraphic position thought to be similar to that of USGS loc. 21274–PC. D. A. Brew, June 25, 1958.
21276–PC	Eureka 15-min quadrangle, White Pine County. Almost on crest of range at head of intermittent drainage that descends eastward to Newark Valley School, 700 ft S. 4½° E. of elev 9,951 on main ridge west of Circle Ranch. Diamond Peak Formation, member G; 3,152.5 ft above base of formation and 373.5 ft below base of Ely Limestone, from same unit as USGS locs. 21297–PC and 21298–PC. D. A. Brew, Aug. 22, 1957.

COLLECTIONS FROM DIAMOND PEAK MEASURED SECTION

Eureka 15-minute quadrangle, Eureka County, Nevada

The section was measured by D. A. Brew in the summer of 1959 on the northwest slopes of Diamond Peak; it is the type locality of Diamond Peak Formation. The section includes 1,077 feet of Chainman Formation, 3,526 feet of Diamond Peak Formation, and 432 feet of Ely Limestone. The base of the section is a point 3,940 feet N. 39°40′ E. of the conical hill shown on the topographic map with elevation 7,887 feet, three-quarters of a mile north-northeast of Cottonwood Spring. (This hill is in SW¼SE¼ sec. 12, T. 20 N., R. 54 E.) The top of the section is at an elevation 10,000 feet on the northward-extending summit ridge of Diamond Peak, at a point about 5,550 feet N. 12° E. of the summit of Diamond Peak. The section includes USGS fossil localities 18590–PC, 21277–PC through 21318–PC, and f21922 through f21927 (foraminiferal collections).

USGS locality	Description and collectors
21277–PC	Black Point facies of Chainman Formation, 20 ft below top. D. A. Brew, June 29, 1959.
21278–PC	Diamond Peak Formation, member B; 317.5 ft above base of formation and 3,208.5 ft below base of Ely Limestone. D. A. Brew, June 29, 1959.
21279–PC	Diamond Peak Formation, member B; 403 ft above base of formation and 3,123 ft below base of Ely Limestone. D. A. Brew, June 29, 1959.
21280–PC	Diamond Peak Formation, member B; 410.5 ft above base of formation and 3,115.5 ft below base of Ely Limestone. D. A. Brew, June 30, 1959.
21281–PC	Diamond Peak Formation, member B; 567.5 ft above base of formation and 2,958.5 ft below base of Ely Limestone. D. A. Brew, June 30, 1959.
21282–PC	Diamond Peak Formation, member C; 1,673 ft above base of formation and 1,853 ft below base of Ely Limestone. D. A. Brew, July 1, 1959.
21283–PC	Diamond Peak Formation, member C; same horizon as USGS loc. 21282–PC. D. A. Brew, July 1, 1959.
21284–PC	Diamond Peak Formation, member C; 1,736 ft above base of formation and 1,790 ft below base of Ely Limestone. D. A. Brew, July 1, 1959.
21285–PC	Diamond Peak Formation, member D; 1,788 ft above base of formation and 1,738 ft below base of Ely Limestone. D. A. Brew, Aug. 14, 1959.
21286–PC	Diamond Peak Formation, member D; probably same horizon as USGS loc. 21285–PC but found loose on member C, 1,663.5 ft above base of formation and 1,862.5 ft below base of Ely Limestone. D. A. Brew, July 1, 1959.
21287–PC	Diamond Peak Formation, member D; 1,880 ft above base of formation and 1,646 ft below base of Ely Limestone. D. A. Brew, July 3, 1959.
21288–PC	Diamond Peak Formation, member D; 1,889 ft above base of formation and 1,637 ft below base of Ely Limestone. D. A. Brew, July 3, 1959.
21289–PC	Diamond Peak Formation, member D; 1,980.5 ft above base of formation and 1,545.5 ft below base of Ely Limestone. D. A. Brew, July 4, 1959.
21290–PC	Diamond Peak Formation, member D; 2,031 ft above base of formation and 1,495 ft below base of Ely Limestone. D. A. Brew, July 4, 1959.
21291–PC	Diamond Peak Formation, member E; 2,449.5 ft above base of formation and 1,076.5 ft below base of Ely Limestone. D. A. Brew, July 6, 1959.
21292–PC	Diamond Peak Formation, member E; 2,500 ft above base of formation and 1,026 ft below

USGS locality	*Description and collectors*
	base of Ely Limestone. D. A. Brew, July 6, 1959.
21293–PC	Diamond Peak Formation, member E: 2,559 ft above base of formation and 967 ft below base of Ely Limestone. D. A. Brew, July 6, 1959.
21294–PC	Diamond Peak Formation, member G: [float] 3,095.5 ft above base of formation and 430.5 ft below base of Ely Limestone. D. A. Brew, July 13, 1959.
21295–PC	Diamond Peak Formation, member G; 3,101.5 ft above base of formation and 424.5 ft below base of Ely Limestone. D. A. Brew, July 13, 1959.
21296–PC	Diamond Peak Formation, member G: from same unit as USGS loc. 21295–PC? D. A. Brew, July 11, 1959.
21297–PC	Diamond Peak Formation, member G; 3,152.5 ft above base of formation and 373.5 ft below base of Ely Limestone. D. A. Brew, July 13, 1959.
21298–PC	Diamond Peak Formation, member G: same horizon as USGS loc. 21297–PC. D. A. Brew, July 13, 1959.
21299–PC	Diamond Peak Formation, member H: 3,325 ft above base of formation and 201 ft below base of Ely Limestone. D. A. Brew, July 17, 1959.
21300–PC	Diamond Peak Formation, member H; 3,403 ft above base of formation and 123 ft below base of Ely Limestone. D. A. Brew, July 17, 1995.
21301–PC	Diamond Peak Formation, member H; 3,410 ft above base of formation and 116 ft below base of Ely Limestone. D. A. Brew, July 17, 1959.
21302–PC	Diamond Peak Formation, member H; 3,483.5 ft above base of formation and 42.5 ft below base of Ely Limestone. D. A. Brew, July 17, 1959.
21303–PC	Ely Limestone, lower member; 2 ft above base. D. A. Brew, July 18, 1959.
21304–PC	Ely Limestone, lower member; 31 ft above base. D. A. Brew, July 18, 1959.
21305–PC	Ely Limestone, lower member; 36 ft above base. D. A. Brew, July 18, 1959.
21306–PC	Ely Limestone, lower member; 45.5 ft above base. D. A. Brew, July 18, 1959.
21307–PC	Ely Limestone, lower member; 52.5 ft above base. D. A. Brew, July 18, 1959.
21308–PC	Ely Limestone, lower member; 80.5 ft above base. D. A. Brew, July 19, 1959.
21309–PC	Ely Limestone, lower member; 90 ft above base. D. A. Brew, July 19, 1959.
21310–PC	Ely Limestone, lower member; 106.5 ft above base. D. A. Brew, July 19, 1959.
21311–PC	Ely Limestone, upper member; 138 ft above base of formation. D. A. Brew, July 19, 1959.
21312–PC	Ely Limestone, upper member; 144.5 ft above base of formation. D. A. Brew, July 19, 1959.
21313–PC	Ely Limestone, upper member; 150.5 ft above base of formation, D. A. Brew, July 20, 1959.
21314–PC	Ely Limestone, upper member; 166.5 ft above base of formation, D. A. Brew, July 20, 1959.
21315–PC	Ely Limestone, upper member; 169 ft above base of formation, D. A. Brew, July 20, 1959.
21316–PC	Ely Limestone, upper member; 176.5 ft above base of formation, D. A. Brew, July 20, 1959.
21317–PC	Ely Limestone, upper member; 252.5 ft above base of formation. D. A. Brew, July 20 and 23, 1959.
21318–PC	Ely Limestone, upper member; 432 ft above base of formation. D. A. Brew, July 23, 1959.

FORAMINIFERAL COLLECTIONS

All the following collections are from the Diamond Peak measured section (see p. 67 for details).

f21922	Diamond Peak Formation, member C; 1,711 ft above base of formation and 1,815 ft below base of Ely Limestone. D. A. Brew, 1959.
f21923	Diamond Peak Formation, member D; 2,036 ft above base of formation and 1,490 ft below base of Ely Limestone. D. A. Brew, 1959.
f21924	Diamond Peak Formation, member D; 2,053 ft above base of formation and 1,473 ft below base of Ely Limestone. D. A. Brew, 1959.
f21925	Diamond Peak Formation, member D; 2,115 ft above base of formation and 1,411 ft below base of Ely Limestone. D. A. Brew, 1959.
f21926	Diamond Peak Formation, member D; 2,164 ft above base of formation and 1,362 ft below base of Ely Limestone. D. A. Brew, 1959.
f21927	Diamond Peak Formation, same locality and horizon as USGS loc. f21926. D. A. Brew, 1959.

STRUCTURE

The rocks of the Diamond Mountains have been deformed by folding and faulting. The folds consist of a series of north-trending gently plunging anticlines and synclines of probably latest Paleozoic or Mesozoic age. They have been overturned to the east and tightly appressed in the northern part of the Eureka quadrangle and the southern part of the Diamond Springs quadrangle to the north (Larson and Riva, 1963). In addition to these major folds, warps of lesser magnitude occur; some of the warps are the same age as the major folds, and some are probably Tertiary in age. Near Diamond Peak the folded rocks are cut by a low-angle thrust that is interpreted to be slightly younger than the folds. It is probable that more thrusts are present in the range than were mapped. Younger high angle faults, largely, if not all normal, have displaced the axial surfaces of the major folds, defined the present north-trending boundaries of the mountain range, and caused adjustments between different blocks of the range proper. These faults are Tertiary in age.

Structures pertinent to the deciphering of the stratigraphic relations near Diamond Peak are shown on plate 1 and are discussed in the following section. The structures in the area covered by figure 4 have already been described in detail by Brew (1963).

FOLDS

The folds of the south-central Diamond Mountains can be classified in three groups: (1) major folds, (2) lesser open folds and warps, most of which may be associated with differential movement within individual fault blocks, and (3) very small flexures occurring near, and related to, thrust planes. The first group is represented only by the Cold Creek syncline, the second group by numerous gentle warps in the vicinity of Diamond Peak and elsewhere, and the third group by very small folds mapped in two localities near the base of the upper plate of the Bold Bluff thrust fault.

COLD CREEK SYNCLINE

The major fold of the Eureka quadrangle is a syncline belonging to the series of north-trending folds that characterizes the northern and central parts of the Diamond Mountains. In the northern part of the area of figure 4 all formations up to, and including, the Ely Limestone are folded about a gently north-plunging axis; the axial surface dips steeply to the west. This structure is here called the Cold Creek syncline.

The western overturned limb of the Cold Creek syncline is traceable as far south as the latitude of Black Point (fig. 4). South of that latitude the western limb is upright (except locally), and the dips lessen. About 2½ miles west-northwest of Circle Ranch (pl. 1) a southwest-trending open syncline is exposed on the north slope of Diamond Peak; it extends to the west flank of the range south of Cottonwood Spring. This gently plunging open structure is interpreted to be the southern continuation of the Cold Creek syncline beyond the limits of its overturned segment.

The precise age of the deformation that produced the Cold Creek syncline is not known. Riva (1957) and Larson and Riva (1963) did not describe or depict any extreme structural discordance between the rocks of Pennsylvanian age and those of Permian, although local angular unconformities and considerable local relief is present. It therefore seems likely that the major episode of folding postdated the deposition of the Permian rocks. The youngest bedrock unit mapped and described by Riva (1957) and Larson and Riva (1963) is unconformable over all the older rocks and probably is correlative with the Newark Canyon Formation of Early Cretaceous age (p. 31). This unit is definitely younger than the folding that formed the major north-trending folds of the range. On this basis the folding of the Cold Creek syncline can be dated as post-Permian (post-Leonard) and pre-Early Cretaceous.

LESSER FOLDS AND GENTLE WARPS

A minor anticlinal axis can be traced from the edge of bedrock on the west side of the range not far north of the divide at the head of Mau Creek (fig. 4) southeastward through that divide and then southwestward and southward almost as far as Cottonwood Spring. The limbs dip as much as 35°, but generally about 20°. The southern extent of the axis lies entirely within partially concealed dominantly fine-grained rocks assigned to the Black Point facies of the Chainman Formation, so that the position of the axis is known only approximately.

Not far to the southeast of these anticlinal folds is the open syncline that has been previously suggested as a possible southern extension of the Cold Creek syncline. The dips of its limbs average about 20°, but local variations are common. The fold plunges very gently to the northeast, east of the crest of the range, and is horizontal on the west side.

To the south and southeast of this syncline are several open folds whose axes can be traced for not more than 2 miles. Perhaps the most significant of these is a west-dipping anticlinal bend of the monocline that occurs on the east side of Alpha Peak ridge, on the east limb of the syncline discussed above. This axis has been purposely omitted from plate 1 and figure 4. The beds east of the axis dip an average of 25° to the west, and those to the west, dip an average of 50° in the same direction. Section B–B of plate 1 shows this steepening and also shows the apparent similar configuration of the Bold Bluff thrust fault; the similarity suggests that the folding may have deformed the thrust.

In the area east of Diamond Peak there are several gentle warps, all but one of which occur in the downfaulted blocks that adjoin the high part of the range.

These slightly sinuous warps are difficult to trace and die out abruptly. Their lack of continuity, the flatness of their limbs, and their tendencies to converge —all suggest formation not as a result of regional stresses, but rather from differential tilting along very minor faults during the downfaulting of the blocks on the flanks of the range.

FAULTS

LOW-ANGLE FAULTS

The only significant low-angle faults recognized occur south and southeast of Diamond Peak, where the Bold Bluff and associated thrust faults have been mapped, and on the lower slopes of Black Point (fig. 4). Only the Bold Bluff thrust fault is critical to the stratigraphic interpretation of the Diamond Peak area.

BOLD BLUFF THRUST FAULT

The Bold Bluff thrust fault (pl. 1) has already been described briefly in relation to the contrasting facies of the Chainman Formation in its upper and lower plates (Brew, 1961b). It has been mapped for about 6 miles in a generally northeasterly direction from Poison Spring to the base of the range at a point about 1 mile north of the mouth of Sadler Canyon. The thrust surface has been displaced by later high-angle normal faulting. Structure contours and three-point solutions on the surface show that it dips about 10° W. along Alpha Peak ridge from its high point in the headwaters of Water Canyon; to the east of this area the surface is about horizontal (fig. 12), and then to the north and northeast the generalized dip is about 15° N.

The thrust surface is delineated by the truncation of lithologic units within both plates (pl. 1). It is also marked by several springs in the Water Canyon area.

FIGURE 12.—South side of Diamond Table, showing nearly horizontal bedding in very thick conglomerates of Diamond Peak Formation above the Bold Bluff thrust fault. The thrust surface is located about 100 feet below the base of the prominent cliff in the middle of the picture.

Structural features associated with it include slickensides, minor thrusts and folds which are described briefly below, and local areas of large irregular competent blocks "swimming" in finer grained rock. The available evidence indicates that the upper plate moved southeastward relative to the lower plate.

RELATED MINOR THRUSTS AND FOLDS

In the vicinity of Diamond Table, which is just north of Water Canyon (pl. 1), two areas of relatively small-scale folds and associated minor thrusts were mapped in the upper plate of the Bold Bluff thrust fault, not far above the thrust plane. The faults are too small to show on plate 1, but the small folds are shown.

A complexly thrusted and folded small overturned anticline with a horizontal axis was mapped on the southwest side of Diamond Table. It is related to the presence of a resistant 10-foot-long wedge of silicified conglomerate that acted as a rigid mass along an auxiliary thrust plane. The conglomerate was not only an active element, but a separate small lens some 50 feet to the northwest of the fold acted as a dam against which the less competent beds were piled up and, in part, underthrust along high-angle surfaces. The direction of movement inferred from these features is northwest to southeast.

An anticline and reverse-faulted complementary syncline were mapped at the east end of Diamond Table, south of Sadler Canyon. The horizontal anticlinal axis trends about northeast, and the eastern limb is appreciably steeper than the western. These folds could not be seen lower on the hill and appeared to die out within a few tens of feet along strike.

EXTENT AND SIGNIFICANCE

Although the Bold Bluff thrust fault has not been recognized in the Diamond Range north of the area of plate 1, there is one enigmatic locality just southeast of Pedrioli Creek (fig. 4) where an exceptionally large apparent thickness of Chainman rocks has been interpreted to be due to high-angle faulting. Some of the poorly exposed Chainman there consists of "pencil-weathering" black clayrock, and it is conceivable that a fenster exposing the lower plate Chainman occurs in this area. The questionable exposures are bounded on the northwest by the vertical Pedrioli Creek fault and are obscured by colluvium to the east and south.

In the Diamond Mountains north of the Eureka quadrangle (Dott, 1955; Riva, 1957; Larson and Riva, 1963), the Bold Bluff thrust fault is apparently not exposed. As a purely speculative regional hypothesis it is tempting to extend the fault beneath Newark

Valley (fig. 1) to join the thrust fault in the southern Ruby Mountains which Sharp (1942) mapped as separating several thousand feet of clastic Carboniferous rocks from underlying older Paleozoic strata. Willden, Thomas, and Stern (1967) have established that the age of this thrusting is Oligocene or younger. One can infer connections of these faults with the thrusts mapped in the area north of Buck Mountain and south of Overland Pass by Rigby (1960). Dott (1955, p. 2266) has suggested generally similar connections, primarily on the basis of facies contrasts in the Diamond Peak and overlying rocks on the opposite sides of Newark Valley.

The recognition of the Bold Bluff thrust fault provides an essential clue to the understanding of the stratigraphy of the southern Diamond Range because contrasting facies of Mississippian rocks have been juxtaposed along it. These relations have been summarized previously (Brew, 1961b), and also elsewhere in this report.

Figure 13 shows the generalized thickness and character of the rocks in the upper and lower plates of the Bold Bluff thrust fault. In addition to the contrasting Mississippian stratigraphy in the two plates, there are also minor differences in thickness and lithologic character of the other formations. The most significant of these are the lithologic and thickness differences in the Devils Gate Limestone (Nolan and others, 1956, p. 49).

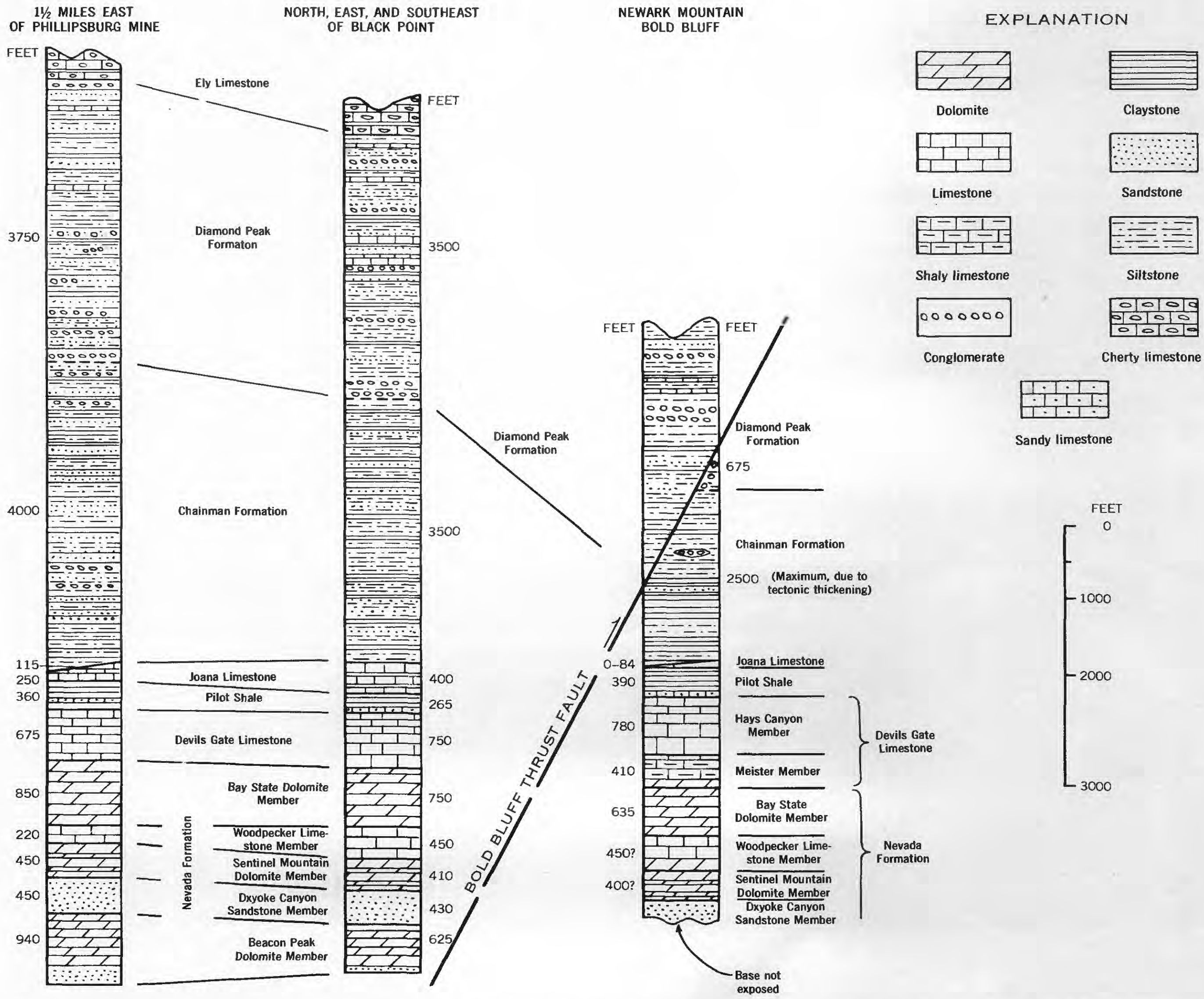


FIGURE 13.—Generalized thickness and lithologic character of rocks in the upper and lower plates of the Bold Bluff thrust fault. Modified in part from Nolan, Merriam, and Williams, 1956.

HIGH-ANGLE NORMAL FAULTS

High-angle normal faults occur on both sides of the Diamond Mountains and within the range itself. A third group, comprising faults that are in part boundary and in part internal, is also present. Faults belonging to all these categories are discussed briefly below; more detailed descriptions were given by Brew in 1963.

BOUNDARY FAULTS

The term "boundary fault," as used, refers to a fault (either inferred or mapped) along which movement or erosion has at least, in part, defined a portion of the present boundaries of the range (pl. 1; fig. 4). Triangular facets characteristically truncate the spurs on both sides of the elevated central block; on the west side of the range there is evidence for several thousand feet of stratigraphic throw on the boundary fault. About 2 miles southeast of the summit of Newark Mountain, downdropped blocks of Devonian limestone establish the existence of about 2,500 feet of stratigraphic throw on one of the boundary faults on the east side of the range. E. R. Larson (in Dott, 1955, p. 2261; Larson and Riva, 1963) has suggested that most of the boundary faults on the west side of the Diamond Mountains north of the Eureka quadrangle are of the reverse type. The evidence from the Eureka quadrangle does not directly refute this interpretation, but the configuration of the inferred folds and the shape of the scarp suggest that a normal origin is more likely.

Alpha Fault

The Alpha fault was named by Hague (1892, p. 28) in the area due west of Alpha Peak (pl. 1). The name is extended to cover the northward continuation of that fault to its inferred juncture with the Pedrioli Creek fault. It forms the western boundary of the mapped area of plate 1.

In its northern exposure (fig. 4) the fault separates the Black Point facies of the Chainman Formation from similar downdropped rocks and from several large masses of Ely Limestone. To the south, near Cottonwood Spring, the downdropped block includes rocks of the Newark Canyon Formation and Tertiary(?) fanglomerates. Near the south edge of the mapped area, vertically dipping rocks of the Carbon Ridge Formation make up the western block, and steeply west-dipping Ely Limestone, the eastern block.

The stratigraphic throw on the Alpha fault at its north end is difficult to estimate because key horizons are not exposed, and the rocks on both sides belong to the Black Point facies of the Chainman Formation. Where the Ely Limestone has been dropped against the Black Point facies the throw is estimated to be as much as 8,000 feet. Farther to the south, not far from Cottonwood Spring, the minimum total stratigraphic throw on the main branch of the fault is 3,500 feet. The throw probably decreases steadily to the south and some is taken up on the northern continuation of the Newark fault, but the steep attitudes of the units on both sides of the fault make any estimate highly suspect.

The map pattern indicates that the Alpha fault dips in general moderately, but locally very steeply, to the west. Three-point solutions show that due west of Alpha Peak the fault dips about 55° W. and at the latitude of Cottonwood Spring 62° W.

Newark Valley Fault

The Newark Valley fault is inferred to border all the various subblocks of the Diamond Mountains on the east side (pl. 1; fig. 4). It is entirely concealed by alluvium, and the evidence for its existence consists of the steep east-facing scarps of Rattlesnake and Cedar Mountains (north and south of Strawberry Ranch, respectively, fig. 4) and the very steep triangular-faceted scarp which extends from Circle Ranch south along the face of Newark Mountain. A branch of the fault is exposed at the foot of Newark Mountain south of the area mapped. There it separates Lower Devonian rocks from a downdropped block made up of Upper Devonian rocks.

At this latter locality the apparent stratigraphic throw on the branch fault is about 2,500 feet, and the cumulative throw of the fault system is correspondingly greater. No direct evidence of the dip of the fault is available. The faceted spurs in the area between Mining Canyon and Adobe Canyon dip between 28° and 40°, but they have been considerably modified by erosion and their steepness represents only the minimum limit of dip.

FAULTS WITHIN THE RANGE (INTERNAL FAULTS)

Internal faults are defined as those which occur within the main block of the range and whose topographic significance is much less than that of the boundary faults.

The block-to-block adjustments along these faults within the range indicate the complicated nature of the high-angle faulting. All the internal adjustments are probably related to the main mid-Tertiary episode of Basin and Range block faulting, but they could conceivably be in part earlier. T. B. Nolan (oral commun., 1957) has suggested that some of the faulting may be

Pliocene or even younger on the basis of the faulted remnants of gravel deposits which overlie various older units near Newark Summit.

Newark Fault

The Newark fault was named by Hague (1892, atlas, sheet XIII) in Tollhouse Canyon, just south of the mapped area, where it separates the Ely Limestone on the west from Water Canyon facies of the Chainman and underlying Mississippian units on the east. The name is here extended to cover the northern continuation of the fault west of Alpha Peak and along Alpha Peak ridge as well as the related faulting on Alpha Peak ridge due east of Torre Flat (pl. 1). This Newark fault system is closely related to the Alpha fault, and the two systems actually merge about 1 mile northeast of Torre Flat.

The Newark fault truncates the Bold Bluff thrust fault, the Chainman and Diamond Peak Formations of the lower plate, and members of the Diamond Peak of the upper plate near Poison Spring (pl. 1) and in the area west of Alpha Peak (pl. 1, section C–C′). The downfaulted block consists of steeply dipping Ely Limestone. The fault dies out to the north on Alpha Peak ridge in a locality where high-angle cross faults are predominant.

The stratigraphic throw near Poison Spring must be at least 2,000 feet and it decreases northward. Near altitude 8,966 northwest of Alpha Peak the Newark fault dips 45° W., as determined by three-point solution.

Farther to the north along Alpha Ridge, near altitude 9,345 due east of Torre Flat, are faults which can also be considered part of the Newark fault system (pl. 1, section B–B′). In this area a downdropped wedge of Ely Limestone is adjacent to the also downfaulted western block made up of Diamond Peak members G and H and the Ely Limestone. Member F makes up the eastern block, and the overall stratigraphic throw is about 300–400 feet. The throw on the Ely wedge may be 600–800 feet. These faults strike northwest to join the Alpha fault about 1 mile west-southwest of the summit of Diamond Peak and dip in general about 50°–60° W., as determined by three-point solutions.

Sadler Canyon Fault Complex

High-angle faulting in the upper part of Sadler Canyon and on to the south on Diamond Table has resulted in differential elevation and depression of several fault-bounded blocks (pl. 1, section A–A″, B–B′; fig. 14). Among the faults involved in the mosaic are the previously described Bold Bluff thrust and Newark Valley high-angle fault; the Water Canyon, Sadler Canyon, and Sadler Ridge faults, which are described here; and the Adobe Canyon fault, which is described on page 61.

The Water Canyon fault (pl. 1) has been mapped from near the summit of Diamond Peak south through the saddle where Diamond Table joins the main ridge of Diamond Peak and down into Water Canyon. The east side is upfaulted about 200–300 feet. The fault dips about 70° E. at its north end and is about vertical south of Diamond Table.

The vertical Sadler Canyon fault (pl. 1) has been mapped for about 2,500 feet in the main branch of Sadler Canyon. It is entirely covered by alluvium, but its existence is demonstrated by the presence of the Water Canyon facies of the Chainman on the southwest side of the fault and downfaulted member D of the Diamond Peak Formation in the upper plate of the Bold Bluff thrust fault on the northeast side. The throw on the fault is estimated, only approximately, as 500 feet.

The Sadler Ridge fault (pl. 1; fig. 14) follows a ridge of highly fractured rock from the edge of Newark Valley into the steep cliffs of member D of the Diamond Peak Formation near the head of Sadler Canyon. The fault is for the most part vertical throughout its length and has the Diamond Peak of the upper plate of the Bold Bluff thrust fault and the Chainman of the lower plate on both sides. In the southeastern half of its extent the southwest side has been downfaulted about 400 feet, and the northwest half the same side has been raised a few hundred feet relative to the north side.

The greater part of the Adobe Canyon fault is discussed below, but because of its importance in the Sadler Canyon complex, the southern part is discussed here. On the south and east sides of Diamond Table the

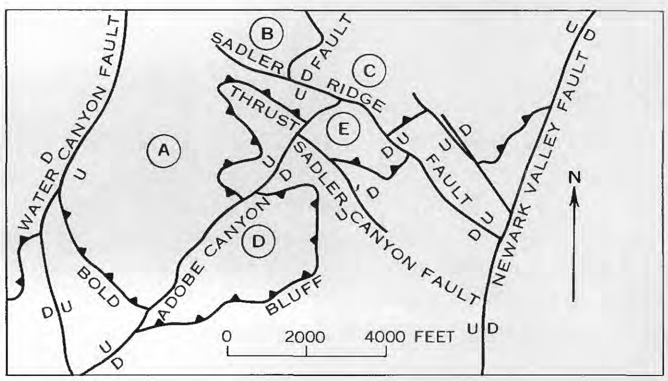


FIGURE 14.—Generalized fault map of the Sadler Canyon-Water Canyon area, showing movement on principal faults. Circled letters indicate blocks referred to in text.

Adobe Canyon fault dips steeply to the east (pl. 1, section B–B′) and the throw, as indicated by the position of the Bold Bluff thrust in both blocks, is about 280 feet with the southeast side down. This relatively simple relationship continues northward into the south branch of Sadler Canyon.

Between the south branch of Sadler Canyon and the Sadler Ridge fault the Adobe Canyon fault dips as much as 70° W., as shown by three-point solution, and the sense of movement is reverse. North of the Sadler Ridge fault the dip is again moderate to the east and the movement sense normal. This local change in attitude is enigmatic.

The sequence of movements on this complex of faults has been interpreted from the observed throw on each fault; the principal blocks and the movement senses are shown on plate 1 and in figure 14. Block A is up relative to B, C, D, and E. Block B is up relative to C, D, and E and down to A. Block C is up relative to D and E and down to A and B. Block D is up relative to E and down to A, B, and C. Block E is down relative to A, B, C, and D.

The sequence of movements, as shown by these relations, is as follows: (1) Movement on the Bold Bluff thrust fault; (2) C, D, and E down with respect to A and B by movement on the whole Adobe Canyon fault; (3) B and C down relative to A, D, and E by movement on the Sadler Ridge fault; (4) D and E down relative to A, B, and C by movement on parts of the Adobe Canyon and Sadler Ridge faults; and (5) E down with respect to the rest of the blocks by movement on the Sadler Canyon and parts of the Adobe Canyon and Sadler Ridge fault. The movement of the Newark Valley fault could either follow this sequence or occur anywhere within it. Likewise, the movement on the Water Canyon fault could have occurred at any time after (2).

This sequence is not of great importance, except that it illustrates that fault-bounded blocks were differentially jostled during the main faulting episodes.

COMBINATION BOUNDARY AND INTERNAL FAULTS

The term "combination boundary and internal faults" is used to denote faults that are located in part along the edge of the main mountain block and in part within the range. As far as is known, most of the valley-side blocks are downfaulted, and in this way they are more closely related to the boundary faults than to the more complicated internal faults.

Robinson Springs Fault

The Robinson Springs fault branches off the southern continuation of a large fault to the north near Mau Creek (fig. 4). For a short distance south of Robinson Springs it parallels the front of the range, and then it enters the range about 2½ miles northwest of Circle Ranch (pl. 1) and swings southwestward toward the crest. Near the crest it splits into two branches, both of which have their northwestern sides downfaulted, as does the main fault.

The fault dips steeply west for most of its length, but it is vertical near the range crest. The stratigraphic throw is estimated at about 200 feet near the range front where abruptly overturned dips and apparent tight folding make structural interpertation difficult. Farther to the south the throw is perhaps slightly greater, and the northern branch of the fault shows 340 feet of throw. The southern branch may have 200 feet where it intersects the Ely Limestone. Everywhere else the Diamond Peak Formation occurs on both sides of the fault.

Adobe Canyon Fault

The Adobe Canyon fault (pl. 1, section A–A′) extends from Robinson Springs due south for more than 3 miles to the Sadler Canyon fault complex. Its role in the complex has been described previously.

The Adobe Canyon fault dips moderately to the east, and three-point solutions at three different places gave 42°–45° dips. Near altitude 9,045 the Ely Limestone has been faulted against members E and F of the Diamond Peak Formation (fig. 15), and the stratigraphic throw is about 2,800 feet. South of altitude 9,045 the Ely is faulted out against a subsidiary fault in the bottom of the north fork of Adobe Canyon, and the throw on the southward continuation of the fault is much less. Exact determination of the amount is not

FIGURE 15.—Ely Limestone downfaulted against the Diamond Peak Formation along Adobe Canyon fault. Cliffs in center are part of member F of the Diamond Peak, and slopes at upper right are the Ely Limestone.

possible because of lack of marker beds in member D through which the fault passes, but about 400 feet seems probable. This figure is similar to that determined for the Adobe Canyon fault in the Sadler Canyon fault complex. The remainder of the throw at present at hill 9,045 is taken up on the subsidiary fault in the north fork of Adobe Canyon. This fault could not be traced very far to the southeast.

An associated fault extends from Robinson Springs to near the Newark Valley School site and has dropped the Ely Limestone of Mississippian and Pennsylvanian age and the Carbon Ridge Formation of Permian age against members E and F of the Diamond Peak Formation (pl. 1). This fault dips in general very steeply to the northeast. The maximum stratigraphic throw represented must be 5,000–6,000 feet. This throw is divided between two branches of the fault near altitude 7,815, northwest of the Circle ranch.

The southeastern terminus of this fault is an abrupt right-angle corner not far from the edge of the range. The northeast-striking fault that terminates the main fault could not be traced more than a couple of hundred feet southwest of the corner.

SUMMARY

The boundary, internal, and combination faults described above are (in addition to the Cold Creek syncline and the Bold Bluff thrust fault) the main structural features of the Diamond Mountains in the Eureka quadrangle. As presently interpreted, the overall effect of the faulting has been to elevate the main block of the range relative to the valley blocks. In areas where good stratigraphic control is available, however, the overall result is seen to have involved differential movements on and within various blocks of the fault mosaic. The highest standing block in the southern part of the area is the one that includes Diamond Table (pl. 1) and the area on the east side of Diamond Peak.

The age of the main episode of this faulting cannot be more accurately determined than post-Early Cretaceous and pre-Pleistocene. However, weak evidence points to an early, middle, and possible late Tertiary age. This evidence is based primarily on the relation of the Tertiary(?) megabreccia unit to the main blocks of the mountain range. The megabreccia unit dips uniformly away from the range and its distribution along the flank implies a close genetic relation to the range, as do the compositional and textural features of the unit (p. 33–34); the uplift of the range must have predated the deposition of this unit. To the west of the mapped area, in and around Palmer Ranch, the megabreccia unit unconformably overlies vertically dipping conglomerate, sandstone, and shale of the Newark Canyon Formation of Early Cretaceous age, thus establishing the maximum age of the unit. At this same locality the fanglomerate and megabreccia have been locally displaced along a system of high-angle faults that strike south-southwest toward Richmond Mountain (just northeast of the town of Eureka) where the capping andesite and basalt of probable late Tertiary age (Nolan, 1962, p. 17) are faulted (T. B. Nolan, written commun., 1968).

The tenuous minimum age of pre-Pleistocene is in accord with the evidence from the alluvial fans and pediments on the east side of the range. The Pleistocene lakes postdated the extensive fan deposits and caused much reworking of their materials, as in the area near Circle Ranch. Inasmuch as the fans formed after the major uplift of the mountain block, a pre-Pleistocene minimum age is indicated.

GEOLOGIC HISTORY

The purpose of this section is to present a general outline of the sedimentation and subsequent deformation of the upper Paleozoic and younger rocks in the Eureka quadrangle. The Chainman, Diamond Peak, and Ely Formations are treated at somewhat greater length than are the older and younger formations.

LATE DEVONIAN AND EARLY MISSISSIPPIAN SEDIMENTATION

The youngest Devonian and oldest Mississippian rocks exposed in the south-central Diamond Mountains are calcareous and noncalcareous dark clayrock and minor siltrock assigned to the Pilot Shale. Deposition of these shaly strata followed a long period during which dominantly carbonate sediments were deposited (fig. 16*A*). These shaly strata were laid down under quiet conditions and the silt-size clasts are wholly quartz, suggesting that, although the Antler orogeny may have already been affecting areas to the west, no chert clasts were contributed from the rocks involved in that orogeny. In contrast, similar fine-grained rocks of the Water Canyon facies of the Chainman Formation contain appreciable amounts of chert that are inferred to have been derived from rocks in the orogenic belt.

Deposition of calcareous sediments of the Joana Limestone followed the deposition of fine-grained sediments of the Pilot Shale, apparently without any interruption, in the Eureka quadrangle. The textures of the Joana suggest much more reworking than for the Pilot, caused, perhaps, by shoaling. Chert grains are present, indicating that the provenance terrane that furnished the great volume of the Chainman and Diamond Peak sediments had already been tapped.

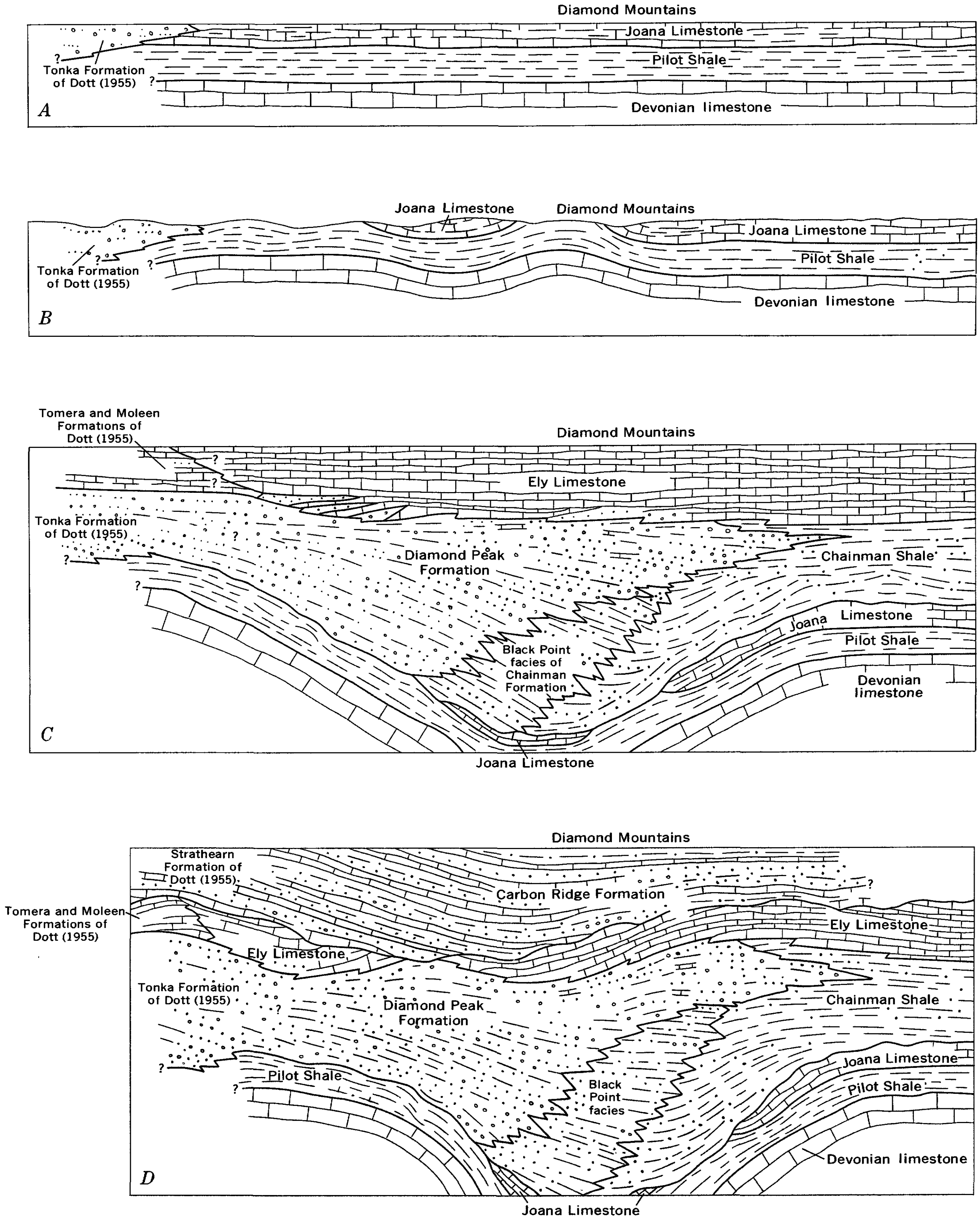


FIGURE 16.—Inferred evolution of part of the western edge of the Chainman-Diamond Peak depositional basin. *A*, After deposition of the Lower Mississippian Joana Limestone; *B*, After uplift and erosion of the Joana Limestone; *C*, After deposition of the Chainman, Diamond Peak, and Ely Formations; and *D*, After deposition of the Carbon Ridge Formation of Permian age. Vertical scale greatly exaggerated and horizontal relations diagrammatic.

EARLY MISSISSIPPIAN DEFORMATION

Uplift, probably minor tilting, and erosion followed the deposition of the Joana Limestone, causing it to be completely removed in some parts of the Eureka quadrangle (fig. 16*B*). Lack of key beds in the Joana and the Pilot prevent a more exact estimate of the amount removed, but a few hundred feet of relief existed on the surface before the deposition of the lower part of the Chainman Formation. There is no evidence that folding accompanied the uplift.

This phase of deformation (probably within the Early Mississippian Kinderhook and Osage) is the only one clearly recorded in the Mississippian of the Eureka quadrangle. If other unconformities are present they are obscured by the local variations in lithic types that are common in the Diamond Peak. This deformation is considered part of the Antler orogenic episode as defined by Roberts, Hotz, Gilluly, and Ferguson. (1958, p. 2817, 2820) even though it was perhaps only local and far removed from the main part of the orogenic belt.

LATE MISSISSIPPIAN THROUGH MIDDLE PENNSYLVANIAN SEDIMENTATION

Most of the rocks considered in detail in this report were deposited in the interval bounded by the post-Joana and the pre-Carbon Ridge unconformities, and the changes in depositional environment and in the provenance terrane during that time can be traced from the relatively quiet sedimentation during early Chainman time through the period of most rapid sedimentation and subsidence into the abruptly unstable and changeable conditions that persisted until the provenance terrane practically ceased to provide terrigenous debris. At that time the generally slow and continuous subsidence characterizing the deposition of the Ely Limestone platform sediments began. This subsidence continued until uplift and deformation occurred in Late Pennsylvanian time. Realizing the continuity of the whole sequence, it is still convenient to discuss it formation by formation, as possible facies relationships are thereby emphasized.

CHAINMAN FORMATION

The relationships of the Water Canyon and Black Point facies of the Chainman Formation are interpreted to indicate that the Black Point facies, which occurs in the upper plate of the Bold Bluff thrust fault, probably is a sourceward equivalent of the typical Chainman Shale, of which the Water Canyon facies is a part. This interpretation, together with the evidence regarding the later thrusting, puts the source terrane for both facies to the west of the Diamond Mountains. The regional evidence suggests that the formation is thinner to the east and south (fig. 5). The available evidence indicates that the greatest accumulation of sediment in the Chainman basin formed the rocks now exposed in the Diamond Mountains, but this interpretation may be disproved by detailed study of adjacent areas.

Into this subsiding basin (the part represented by the Black Point facies) were transported large volumes of poorly sorted silt-, clay-, and sand-size detritus derived from a provenance terrane to the west which apparently was elevated as the basin subsided (fig. 16*C*). Periods of shallow-water conditions were apparently short lived and gave way to continued subsidence and continued rapid deposition. Farther from the provenance terrane the sediments consisted only of fine material carried beyond the area of maximum accumulation plus a few scattered tongues and lenses of the coarser Black Point facies. Increases in the amount of pebble- and cobble-size debris, which probably resulted from intensified tectonic activity in the Antler orogenic belt, presaged the greater influxes of pebble-size debris which differentiate the Diamond Peak Formation from the Chainman Formation.

DIAMOND PEAK FORMATION

In the area of maximum accumulation, the sediments of the Diamond Peak Formation began accumulating sometime in the Meramec. The sediments of the lower part of the Diamond Peak were deposited in virtually the same environment as was the Black Point facies of the Chainman Formation. The formations differ only in the greater frequency of conglomeratic and sandy strata in the Diamond Peak. The provenance terrane was about the same for both, and the depositional basin continued to subside. Not much is known of the geometry of the Diamond Peak deposits, but the evidence at hand indicates that they form a prism with its long axis oriented about north-south. In profile the prism was originally a nearly triangular lens, with its longest side forming the upper surface of the deposit and the oblique apex located near the western edge of the basin (fig. 16*C*).

As interpreted here, the coarsed sediments which characterize the Diamond Peak interfinger with the Black Point facies and perhaps with the Water Canyon facies of the Chainman Formation. As pointed out in the section on "Stratigraphy," the Diamond Peak has been defined by the relatively greater proportion of coarse clastics it contains. The fact that it is classified as a separate formation should not obscure its lithogenetic ties with the finer grained rocks that are also parts of the same tectonic and depositional pattern. It should also be emphasized that there are many details of the Chainman and Diamond Peak stratigraphy which have not yet been studied.

The influxes of coarser debris are considered to be the result of intensified orogenic activity in the Antler orogenic belt to the west. R. J. Roberts (oral commun., 1963) has suggested that the orogeny involved movement of the upper plate of the Roberts Mountains thrust toward the Chainman-Diamond Peak trough. The present report and the petrographic data (Brew, 1963) support the orogeny as the cause of the influx of detritus, and it is likely, from petrologic evidence, that the provenance terrane was not more than a few tens of miles away. The Roberts Mountains thrust probably was the mechanism by which the provenance terrane was brought to the edge of the trough, and the terrigenous clastics were probably derived from the upper plate during or after its movement. There is no clear evidence in the Diamond Mountains that the Roberts Mountains thrust actually overrode its own debris as an erosion thrust.

The bedding and textures of the interbedded sandstone and siltrock in the Diamond Peak suggest that turbidity currents may have carried much of the sand-size material well out into the basin.

The transportation of the gravel-size material far out into the basin is more difficult to explain. Some may have been dislodged from coalescing deltas at the edge of the basin and carried into deeper water by subaqueous slides. The absence of crossbedding, definite channeling, or small-scale scours makes river transport unlikely, although these features could have been destroyed when the sea transgressed fluvial deposits. Their sorting characteristics, however, appear to preclude such extensive reworking.

The problem of transporting gravel-size debris into the basin is even more apparent when the sedimentation history of the upper members of the Diamond Peak is considered. During their deposition a pattern of small-scale fluctuation in sediment influx and shoaling replaced the pattern of more constant deposition evident in the lower part of the section. In the upper members, which range from early to late Chester in age, the conglomerate is closely associated with fossiliferous marine limestone in some places and with fossiliferous clayrock and siltrock in others. In still a third situation (that typified by member F) the conglomerate occurs with sediments which were apparently deposited very near the lower limit of effective wave action in what seems to have been a very abruptly fluctuating environment. The conglomerate associated with the fossiliferous marine limestone apparently was introduced to a locale of carbonate sedimentation where marine organisms existed and the conglomerate debris must have been moved by strong marine bottom currents of some type.

The overall pattern of sedimentation in the upper part of the Diamond Peak indicates general shallowing of the trough, longer periods during which agitation of the bottom took place and ripple marks formed, and possibly even temporarily emergent episodes. Dominantly unreworked terrigenous clastic sediments continued to be deposited, but interspersed with these phases occurred times when little terrigenous debris reached the depositional site and carbonate deposits accumulated. This trend increased, and the terrigenous clastics of the Diamond Peak gradually gave way to the limestone of the Ely.

ELY LIMESTONE

The deposition of the lower member of the Ely Limestone followed the trend indicated by the uppermost member of the Diamond Peak Formation. About at the Mississippian-Pennsylvanian systemic boundary the amount of terrigenous debris reaching the depositional site began to drop off markedly, and deposition of slightly to moderately reworked limestone became dominant. Thereafter, only very minor amounts of pebble- through silt-size terrigenous debris were transported from the quiescent orogenic belt eastward into the slowly subsiding basin.

The evidence from the Eureka quadrangle shows only that the edge of the Ely depositional basin was somewhere to the west. In the northern Diamond Mountains and the Elko area Dott (1955, 1958) found that the provenance terrane continued to shed clastic debris into the basin during much of Early Pennsylvanian time; those areas must have still been close to the edge of the active source area (fig. 16*C*). To the east, the carbonate deposition extended well into what is now Utah, and the whole area was apparently a stable, but slowly subsiding, shelf. The fossil record in the northern Diamond Mountains (Dott, 1955) and elsewhere near Eureka (Nolan and others, 1956) indicates that this situation persisted until the Late Pennsylvanian.

POST-MIDDLE PENNSYLVANIAN DEFORMATION

No direct evidence of post-Ely Limestone deformation occurs in the part of the Eureka quadrangle considered in this report. Although both the Ely and the younger Carbon Ridge Formation are exposed in the area, their original contact is not exposed. West of Newark Summit the Carbon Ridge unconformably overlies 1,500 feet of Ely Limestone on a surface with slight relief (Nolan and others, 1956, p. 62). Here, at least, post-Ely uplift and erosion was slight to moderate. According to Riva (1957) and Dott (1955), the situation in the northern Diamond Range is similar; as much as several hundred feet of their Tomera and Moleen Formations were eroded before deposition of the Permian strata. The Ely Limestone was completely eroded in the vicinity of Secret Canyon before Permian time (Nolan and others, 1956, p. 64–65).

Nowhere in the area noted above is there evidence of tight folding during the deformation that caused the uplift and erosion.

EARLY PERMIAN SEDIMENTATION

During the Early Permian the coarse clastics, mudstone, limy sandstones, and fossiliferous limestones of the Carbon Ridge Formation were deposited throughout the area. These rocks are lithogenetically similar to the Diamond Peak Formation and are inferred to have been deposited in an actively subsiding trough adjacent to the rejuvenated Antler orogenic belt. The alternations of lithic types indicate many minor fluctuations in detritus and in the water depth. Riva (1957) discovered several unconformities within the Permian section just north of the Eureka quadrangle, suggesting that the depositional trough was apparently even more unstable than was the Diamond Peak trough (fig. 16*D*).

POST-EARLY PERMIAN DEFORMATION

Permian and underlying strata near the mapped area were folded and faulted together before the uplift and erosion which formed the surface upon which the Newark Canyon Formation of Early Cretaceous age was unconformably deposited (Nolan and others, 1956, p. 65). Inasmuch as the Cretaceous rocks are not known to be involved in any thrusting in the Eureka area, it is likely that all thrust faulting occurred during this latest Paleozoic pre-Cretaceous interval (Nolan, 1962, p. 28). It likewise seems apparent from reinterpretation of Riva's mapping (Riva, 1957) that the main folding of the rocks in the Diamond Mountains predated the deposition of the Newark Canyon rocks.

The forces that caused the folding and low-angle faulting in the Diamond Mountains were in an east-west direction and tectonic transport by both folding and faulting was to the east or southeast. It seems unlikely that these forces were related to the original movement of the Roberts Mountains thrust sheet, because they occurred much later than the thrust's first activity in Mississippian time. A reasonable interpretation is that the Roberts Mountains thrust was active when coarse clastics from the upper plate were shed into the Diamond Peak trough, but that it did not then reach the longitude of the Diamond Mountains, nor did any associated folding. Long after, following deposition of the Permian clastics derived from the rejuvenated Antler provenance terrane, the orogenic belt migrated eastward and the renewed stresses caused the overturned folds and thrusts in the Diamond Mountains. There is still no proof that the Roberts Mountains thrust ever extended to the Diamond Mountains.

EARLY CRETACEOUS SEDIMENTATION

The continental deposits of the Newark Canyon Formation were laid down unconformably across many of the older rock units. These sandstones, conglomerates, and shales appear to have been derived from wholly local source areas and deposited in an intermittently subsiding environment that Nolan (1962, p. 28) interprets to be part of the final stages of a deformational episode that was most intense at the beginning of Early Cretaceous time. The regional distribution of these rocks is at present poorly known.

The presence of abundant locally derived lithic clasts and textures resulting from rapid erosion, transport, and deposition indicates that they may have been deposited in separate local troughs. This may, in part, explain their spotty distribution.

LATER EVENTS

The Newark Canyon Formation was in most places only gently folded by later structural events. In the area south of Black Point and west of the main block of the Diamond Mountains, the Newark Canyon was strongly folded and truncated by erosion before the formation of the fanglomerates and megabreccias which rim the west side of the mountain range. The outcrop pattern indicates that the fold axes probably trend about north or northeast parallel to the range front and to the high-angle boundary faults. T. B. Nolan has suggested (oral commun., 1958) that the deformation may have resulted from gravity sliding into a graben created by an early episode of high-angle faulting. This folding cannot be dated more exactly than post-Early Cretaceous and prefanglomerate and megabreccia unit.

Erosion truncated the folded Cretaceous strata before the megabreccias were deposited, and since the megabreccias probably either accompanied or postdated the main high-angle faulting, the relation of the erosion and the faulting is not known. The generally even nature of the erosion surface suggests that it might have been either part of a pediment formed adjacent to the fault block mountain range or part of a larger pediplane. The former possibility seems more likely in view of its apparent limited extent; if so, the major high-angle faulting interpreted to have given the mountain range its present general form must have predated the truncation of the upturned Cretaceous strata.

Accompanying and following the high-angle faulting, the fanglomerate and megabreccias formed along the west base of the range. Their present absence on the east side is perhaps due to more recent faulting and resultant erosion in that area. These deposits were subsequently modified and dissected by erosion that may have been caused by changes in base level related to younger minor faulting. The high-angle faulting continued at reduced intensity throughout most of the Tertiary and perhaps into the Holocene.

The well-developed alluvial fans on the east side of the range have no counterpart where the megabreccia and fanglomerate are exposed on the west side, and the time relations of the two are not known, although it is likely that the fans are younger. Beach deposits formed at the edges of Pleistocene lakes modified the fans to a certain extent and also affected the alluvial debris that mantles the pediment near Robinson Springs.

CONCLUSIONS

The Mississippian rocks of this part of the Basin and Range province were deposited along the tectonically active western edge of an extensive marine basin. The older Mississippian strata exposed are in part black shales interpreted to have been deposited in the offshore parts of the basin, but correlative rocks deposited west of the black shales show intertonguing of that facies with a more sandy, shoreward facies. This synorogenic shoreward facies includes interbedded sandstone, siltrock, minor clayrock, and coarse pebble and cobble conglomerate, all of which were derived from older eugeosynclinal sedimentary rocks of the Antler orogenic belt. These older rocks are inferred to have been moved into the provenance terrane as the upper plate of the Roberts Mountains thrust fault. At about the end of the Mississippian the source area ceased to shed coarse clastics into the elongate trough and limestones were deposited over a large area in a slowly subsiding basin.

The Mississippian sediments deposited closest to the orogenic belt were at first "poured" into the trough and few well-sorted strata are present. The younger sediments were deposited under virtually similar conditions, but reworking became intermittently greater because of fluctuations in the subsidence. During this later part of the Mississippian the provenance terrane spasmodically provided significant volumes of conglomeratic debris which were transported into the marine environment. As the abrupt movements typical of the latest part of the Mississippian diminished and gradual subsidence took over in the Pennsylvanian, more and more of the sediments were reworked before burial.

The rocks of Paleozoic age were folded about north-trending axes, and eastward-directed thrusting occurred after deposition of another prism of synorogenic clastics during the Early Permian. This deformation produced overturned folds in part of the Diamond Range, but less shortening took place elsewhere and the folds produced there are upright and open. During the Tertiary, high-angle faulting outlined the main block of the mountain range and caused differential movement of individual fault-bounded blocks within the range.

STRATIGRAPHIC SECTION OF THE UPPER PART OF THE BLACK POINT FACIES OF THE CHAINMAN FORMATION, THE TYPE SECTION OF THE DIAMOND PEAK FORMATION, AND THE LOWER PART OF THE ELY LIMESTONE[1]

Eureka 15-minute quadrangle, Nevada: Base of section (alt 8,130) is 3,940 ft N. 39°40' E. of conical hill alt 7,887 in sec. 12, T. 20 N., R. 54 E. (¾ mile north-northeast of Cottonwood Spring); section extends about 3,500 ft S. 56° 30' E. up spur to crest of range at alt 9,780, then south along crest ending 5,550 ft N. 12 E. of Diamond Peak summit; section is in secs. 7 and 18 (unsurveyed), T. 20 N., R. 55 E.

Top of measured section; alt about 10,000 ft

Ely Limestone:

Upper member:	*Feet*
29. Limestone, medium-gray (weathering light-bluish-gray), chert nodules, very fossiliferous locally; interbedded sandstone (ES–59–165: calcareous quartz arenite), gray (weathering brown), fine-grained, poorly sorted; unit is medium bedded. Fossil colln. F45–59–ES (=USGS loc. 21318–PC) at top of section	71.0
28. Limestone, gray (weathering brownish-gray), sandy, poorly exposed; interbedded limy brown-weathering sandstone; unit forms low saddle	12.0
27. Limestone, dark-gray (weathering bluish-gray), poorly exposed, local "fossil hash," scattered chert nodules near base, more chert at top than at base; unit is a medium-bedded slope-former; sparse beds contain clastic chert pebbles	3[illegible].5
26. Limestone (ES–59–164: biomicrite), medium-gray (weathering light-bluish-gray), abundant "fossil hash" locally,	

[1] Petrographic classifications of rocks are given in parentheses with specimen numbers (see Brew, 1963, for details of classification).

Ely Limestone—Continued

Upper member—Continued	Feet
sparse chert beds as much as 15 cm thick; unit is thick bedded at base, becomes medium bedded and platy weathering at top	14.5
25. Limestone, medium-gray (weathering lighter bluish-gray than unit 24), sparsely fossiliferous, abundant tan-weathering chert in 15-cm beds and nodules, latter having "bullseye" form in some cases; unit is medium bedded	15.5
24. Limestone, dark-gray (weathering bluish-gray), abundant dark chert in nodules and 0.1- to 0.5-ft beds (weathering "honey" color), very abundant crinoidal and brachiopod debris; unit is medium to thick bedded, forms cliff	15.5
23. Limestone, poorly exposed, unit is probably thin bedded and similar to unit 22; forms debris-covered slope	31.0
22. Limestone, medium-gray (weathering light-gray and pinkish-gray), abundant chert in irregular masses as much as 0.4 ft thick, abundant brachiopods and corals; unit is thin to medium bedded, forms saddle. Fossil colln. F44–59–ES (=USGS loc. 21317–PC)	3.5
21. Limestone, medium-gray (weathering bluish-gray), chert abundant in irregular masses and beds as much as 0.5 ft thick, fossiliferous towards top; unit is medium bedded; gradational with unit 20	9.0
20. Limestone (ES–59–159: biomicrite), medium-gray (weathering medium-gray), sparsely fossiliferous (brachiopods), locally cherty; unit is medium bedded	5.0
19. Siltstone, gray (weathering light-brown), calcareous; interbedded limestone, gray (weathering mottled-brown and gray), few fossils, local chert nodules; unit is thin bedded	1.0
18. Limestone (ES–59–157: biomicrite), dark-gray (weathering bluish-gray), some beds coarser grained, locally fossiliferous, chert nodules and beds as much as 12 cm thick irregularly distributed and locally abundant; unit is thin to thick bedded (most medium bedded). Fossil colln. F42–59–ES (=USGS loc. 21315–PC) (2.0 ft above base) and F43–59–ES (=USGS loc. 21316–PC) (8.5 ft above base)	47.5
17. Siltstone, gray (weathering light-olive-gray), fossiliferous, calcareous, some pyrite; grades into unit 18. Fossil colln. F41–59–ES (=USGS loc. 21314–PC)	2.5
16. Limestone (ES–59–154: biomicrite), dark-gray (weathering bluish-gray), locally fossiliferous, local nodules of dark chert as much as 10 cm in maximum dimension, spare chert pebbles; unit is medium to thick bedded. Fossil colln. F40–59–ES (=USGS loc. 21313–PC) (7.0 ft above base)	19.0
15. Limestone (ES–59–152: cherty sandy biosparite, and ES–59–153: biosparite or biosparrudite), dark-gray (weathering bluish-gray), cherty, fossiliferous; unit is medium to very thick bedded; lower 0.5 ft is platy and weathers yellowish gray. Fossil colln. F38–59–ES (=USGS loc. 21311–PC) (0.5 ft above base) and F39–59–ES (= USGS loc. 21312–PC) (7 ft above base)	9.0
Total upper member	295.5

Lower member:	Feet
14. Sandstone, weathering brownish-gray and brown, fine-grained, scattered 1-cm chert pebbles throughout; grades upward to conglomerate, calcareous matrix (ES–59–150: calcareous lithic chert conglomerate), with chert clasts as much as 5 cm in maximum dimension in matrix of calcareous sandstone, fine-grained, moderately sorted	3.5
13. Conglomerate (ES–59–148: calcareous silicified lithic chert-quartz conglomerate), gray clasts of chert as much as 5 cm in maximum dimension in matrix of sandstone, medium-grained, moderately sorted	5.5
12. Sandstone (ES–59–147: calcareous silicified quartz-chert conglomerate), gray, clasts of chert as much as 5 cm in maximum dimension in matrix of sandstone, medium-grained, moderately sorted	8.5
11. Limestone (ES–59–146: cherty recrystallized silty limestone), gray and yellow (weathering light-yellowish-brown and gray), locally fossiliferous; distinctive mottled appearance, very cherty	8.5
10. Limestone (ES–59–145: sandy biomicrite), gray (weathering brownish-gray), becoming bluish gray upwards, pyritiferous, scattered chert pebbles and granules, fossiliferous; grades into limy sandstone. Fossil colln. F37b–59–ES (=USGS loc. 21310–PC) from middle of unit	8.0
9. Conglomerate (ES–59–144: silicified lithic chert conglomerate), white (weathering light-brown and pale-green), clasts as much as 1.8 cm in	

Ely Limestone—Continued

Lower member—Continued

	Feet
maximum dimension, possible biomodal sorting, firmly cemented with silica; contact with unit 8 is irregular, probably a scour surface	3.5
8. Claystone-matrix limestone-phenoplast conglomerate (ES–59–143: hematitic(?) silty claystone-matrix dismicrite nodule rock), gray (weathering olive-gray and dark-greenish-gray); grades upward into siltstone similar to the matrix	4.5
7. Limestone, dark-gray (weathering dark-bluish-gray), chert beds as much as 15 cm thick show minor contortions, some "fossil hash"	3.5
6. Limestone, gray (weathering yellowish-gray); interbedded sandstone, weathering brown and yellowish-brown, calcareous; limestone-matrix limestone-phenoplast conglomerate (ES–59–141); silty micrite-matrix dismicrite nodule rock), and minor shale, weathering dark-green, fossiliferous. Fossil colln. F36–59–ES (=USGS loc. 21308–PC) (7.0 ft above base) and F37a–59–ES (=USGS loc. 21309–PC) (13.0 ft above base)	18.0
5. Claystone (ES–59–140: chloritized silty (lithic quartz-chert) claystone), gray (weathering dark-greenish-gray), lightens in color upwards; grades into siltstone of same aspect; gradational with unit 6	3.0
4. Limestone (ES–59–139: intrasparite), gray (weathering yellowish-gray); and subequal amount of sandstone, weathering brown and yellowish-brown, calcareous, at base. Contact with unit 3 is irregular, probably a diastem	9.5
3. Limestone (ES–59–138: cherty oosparite), bluish-gray (weathering gray), fossiliferous (mostly crinoid stems and brachiopods), platy-weathering, some nodules of gray chert near top; interbedded sandy siltstone and sandstone, weathering brown and olive-gray, near base. Fossil colln. F33–59–ES (=USGS loc. 21305–PC) (5.5 ft above base), F34–59–ES (=USGS loc. 21306–PC) (14.5 ft above base), and F35–59–ES (=USGS loc. 21307–PC) (21.0 ft above base)	29.5
2. Siltstone, dark-purple (weathering dusky-red-purple); grades upwards into limestone, weathering purplish-gray (ES–59–137: silty intramicrite), fossiliferous. Fossil colln. F32–59–ES (=USGS loc. 21304–PC) at top of unit	9.0
1. Limestone (ES–59–135: silty biomicrite, and ES–59–136: biomicrite), gray (weathering greenish-gray and gray), fossiliferous (mainly crinoidal debris), platy-weathering; interbedded siltstone, weathering light-brown; and minor sandstone, brown, very fine grained. Fossil colln. F31–59–ES (=USGS loc. 21303–PC) about 2.0 ft above base	22.5
Total lower member	137.0
Total Ely Limestone	482.5

Diamond Peak Formation:

Member H:

	Feet
104. Siltstone, dark-gray (weathering dark-grayish-green with purplish hue), sandy at base; interbedded with sandstone light-gray (weathering light-greenish-gray), very fine grained; and claystone with sparse limestone clasts [ES–59–134: ferruginous limestone nodule-bearing silty (quartz-chert) claystone], weathering dark-purplish-gray. Contact with unit 103 is a diastem, with minor scours about 1 ft deep	6.0
103. Conglomerate (ES–59–132: silicified lithic chert conglomerate), weathering white and pale-green, clasts of white and pale-green chert as much as 2 cm in maximum dimension in matrix of sandstone, medium-grained, poorly sorted; interbedded subequal amount of conglomeratic sandstone (ES–59–133: calcareous silicified conglomeratic quartz-chert arenite), gray (weathering olive-gray)	27.5
102. Sandstone, light-gray (weathering light-grayish-green), very fine grained, dense; interbedded subequal amounts of siltstone, weathering dark-grayish-green, like unit 100, with scattered 2-cm limestone clasts; and siltstone-matrix limestone-phenoplast conglomerate, gray (weathering olive-gray), near middle of unit. Fossil colln. F30–59–ES (=USGS loc. 21302–PC) (22.0 ft above base)	39.5
101. Siltstone-matrix limestone-phenoplast conglomerate, like unit 100, but limestone clasts are larger (greater than 2 cm); grades upward into limestone, gray, nonfossiliferous	4.0

Diamond Peak Formation—Continued

Member H—Continued

	Feet
100. Siltstone-matrix limestone-phenoplast conglomerate (ES–59–131: chloritized limestone nodule-bearing clayey quartz-chert siltstone), dark-gray (weathering dark-greenish-gray), scattered nodules less than 2 cm in maximum dimension; grades into siltstone like the matrix; and sandstone, light-gray (weathering light-greenish-gray), very fine grained, firmly cemented with silica	30.5
99. Conglomerate (ES–59–130: silicified lithic chert conglomerate), light-gray (weathering white); clasts of light-gray chert and quartzite as much as 6.5 cm in maximum dimension in matrix of sandstone, fine- to medium-grained, poorly sorted	5.0
98. Limestone (ES–59–129: silty intrasparrudite), gray, abundant brachiopods, horn corals; interbedded equal amounts of siltstone, gray (weathering olive-gray), fossiliferous; and siltstone-matrix limestone-phenoplast conglomerate, gray (weathering olive-gray). Fossil colln. F28–59–ES (=USGS loc. 21300–PC) (9.5 ft above base) and F29–59–ES (=USGS loc. 21301–PC) (17.5 ft above base)	21.5
97. Conglomerate, white, pebbles of light-gray chert as much as 5 cm in maximum dimension in matrix of sandstone, calcareous; grades upward to conglomeratic sandstone	3.0
96. Limestone (ES–59–128: sandy biosparite(?)), gray (weathering medium-gray); interbedded equal amount of conglomerate (ES–59–127: calcareous lithic chert conglomerate), gray, fine-grained, calcareous	39.0
95. Limestone (ES–59–125: intrasparrudite), dark-gray (weathering medium-gray), fossiliferous, dense, thick-bedded; interbedded sandstone (ES–59–126: sideritic quartz-chert arenite), dark-gray (weathering brown), fine- to medium-grained, well-sorted; limy cement, Fe stain, thick-bedded. Fossil colln. F27–59–ES (=USGS loc. 21299–PC) (near middle of unit)	45.0
Total member H	221.0

Member G:

	Feet
94. Covered, probably mostly siltstone, some fossiliferous float; forms saddle	117.5
93. Conglomerate (ES–59–123: calcareous lithic chert conglomerate), gray (weathering dark-gray), clasts of light and dark chert as much as 3.5 cm in maximum dimension in matrix of poorly sorted fine-grained sandstone; interbedded sandstone of two types: (ES–59–123: silicified lithic chert-quartz arenite), greenish-gray, fine-grained, poorly sorted; and (ES–59–124: calcareous silicified lithic quartz-chert arenite), brown, fine-grained, moderately sorted	29.0
92. Siltstone, gray (weathering olive-gray and brown), sparse worm trails, abundant pyrite(?) casts, poorly preserved brachiopods; grades upwards into subequal amount of limestone-phenoplast conglomerate; grades locally into very fine grained sandstone; and shale (ES–59–121: calcareous clay shale) near top; minor faults. Fossil colln. F25–59–ES (13.5 ft above base), and F26–59–ES (=USGS loc. 21297–PC) (25.5 ft above base), also approximate location of colln. F21–59–ES (=USGS loc. 21296–PC) and F22–59–ES (=USGS loc. 21298–PC) from fault-duplicated part of section	30.5
91. Conglomerate (ES–59–120: silicified lithic chert-quartz conglomerate), light-gray (weathering light-gray); clasts of pale-green, light- and dark-gray chert as much as 12.5 cm in maximum dimension in matrix of silicified sandstone; some Fe stain	27.5
90. Sandstone (ES–59–119: calcareous quartz-chert arenite), light-brown (weathering brown), fine-grained, poorly sorted, calcareous cement at base, local silica cement higher; fossiliferous locally. Fossil colln. F24–59–ES (=USGS loc. 21295–PC) (1.0 ft above base)	17.5
89. Shale (ES–59–118: gypsiferous silty clay shale), gray (weathering olive-gray), locally pyritiferous and poorly fossiliferous, worm trails. Fossil colln. F23–59–ES (=USGS loc. 21294–PC) (from float)	10.0
88. Limestone (ES–59–117: sandy intramicrudite), gray (weathering gray and light-olive-gray); resembles limestone-phenoplast conglomerate which it probably grades into laterally; sparse chert pebbles locally	13.0
87. Sandstone (ES–59–116: calcareous silicified quartz-chert arenite), light-brown (weathering light-brown), fine-grained, poorly sorted, some Fe stain	6.0
Total member G	251.0

Diamond Peak Formation—Continued

Member F:	Feet
86. Siltstone, purple and grayish-green; grades into sandstone and interbedded subequal amounts of siltstone-matrix limestone-phenoplast conglomerate (ES–59–102: silty claystone-matrix dismicrite(?) nodule rock, purple); and sandstone chert arenite, purple and greenish-gray very fine grained, with sparse pebbles, silicified; and sandstone (ES–59–101: barite-bearing calcareous silicified quartz-chert arenite), fine-grained, moderately to well-sorted, thick-bedded	85.0
85. Siltstone-matrix limestone-phenoplast conglomerate, weathering greenish-gray (becoming dusky purple upwards), limestone nodules as much as 20 cm in maximum dimension	26.0
84. Siltstone- and claystone-matrix limestone-phenoplast conglomerate, like unit 82; interbedded siltstone, as in matrix, dusky-purple, some green; and sandstone (ES–59–99: chloritized clayey lithic quartz-chert arenite), dark-gray (weathering greenish-gray), fine-grained, poorly sorted, some cross-bedding	59.5
83. Conglomerate, light-gray (weathering white and pale-green), pebbles subangular, like units 76 and 78	1.5
82. Siltstone, weathering greenish-gray; interbedded sandstone, weathering greenish-gray, very fine grained, firmly cemented with silica; clayrock, weathering purple; siltstone-matrix limestone-phenoplast conglomerate, weathering green; and minor chert-pebble conglomerate (ES–59–98: silicified lithic chert-quartz conglomerate)	23.0
81. Claystone-matrix limestone-phenoplast conglomerate [ES–59–95: claystone-matrix micrite nodule rock; ES–59–96: silty (quartz-chert) claystone, matrix micrite nodule rock, and ES–59–97: clayey lithic quartz-chert silt shale], weathering dusky-purple and green; irregular color boundary	4.5
80. Siltstone, weathering dusky-purple, grades to claystone; near middle of unit a very thick claystone-matrix limestone-phenoplast conglomerate (ES–59–94: chloritized silty claystone matrix micrite nodule rock) bed	18.5
79. Sandstone, gray (weathering greenish-gray), like that of unit 71, scattered white chert pebbles, firmly cemented with silica	3.0
78. Conglomerate, like unit 76, but slightly coarser	12.5
77. Siltstone, weathering red-purple and grayish-green; interbedded sandstone, weathering greenish-gray and purple siltstone-matrix limestone-phenoplast conglomerate	20.5
76. Conglomerate (ES–59–93: silicified lithic chert-quartz conglomerate), weathering white and pale-green, clasts of light-gray and pale-green chert as much as 7.5 cm in maximum dimension in matrix of sandstone, fine-grained, poorly to moderately sorted	11.0
75. Siltstone (ES–59–92: chloritized clayey quartz-chert siltstone), weathering dusky-red-purple, color more intense at top, and grayish-green; grades into minor claystone; gradational from unit 74	18.5
74. Siltstone-matrix limestone-phenoplast conglomerate [ES–59–91a (matrix): chloritized clayey chert-quartz siltstone, and ES–59–91b (nodule): micrite]; interbedded siltstone, like the matrix, weathering red-purple and light-green, and claystone; color boundaries irregular	25.0
73. Siltstone (ES–59–90: clayey quartz-chert siltstone), weathering dusky-red-purple and green; less clayey parts tend to be green; grades into claystone	9.0
Total member F	317.5

Member E:	Feet
72. Conglomerate (ES–59–88: chloritized silicified lithic chert-quartz conglomerate), weathering white and pale-green, clasts of pale-green and light-gray chert as much as 6.5 cm in maximum dimension in matrix of sandstone, medium-grained, poorly sorted; grades upward into sandstone (ES–59–89: chloritized silicified lithic quartz-chert arenite), weathering light-green, fine-grained, poorly sorted	13.0
71. Sandstone (ES–59–87: clayey lithic chert-quartz arenite), dark-greenish-gray (weathering dark-greenish-gray), fine-grained, poorly sorted, pyritiferous; interbedded siltstone of same aspect; and 1 thin bed of siltstone-matrix limestone-phenoplast conglomerate	63.0

Diamond Peak Formation—Continued

Member E—Continued

	Feet
70. Sandstone (ES–59–83: silicified(?) clayey chert-quartz arenite), weathering brownish-green, very fine grained, poorly sorted; grades into siltstone and upwards into clay shale with worm trails, and minor siltstone-matrix limestone-phenoplast conglomerate	45.5
69. Conglomerate (ES–59–82: calcareous lithic chert-quartz conglomerate), gray (weathering white), chert and quartzite clasts as much as 10 cm in maximum dimension in moderately to poorly sorted medium-grained matrix; interbedded subequal amount of sandstone, gray (weathering white), firmly cemented; forms ledge	16.0
68. Sandstone (ES–59–81: clayey lithic chert-quartz arenite) gray (weathering brown), medium-grained, poorly sorted; grades upward into siltstone, gray (weathering dark-greenish-gray)	15.0
67. Conglomerate, light-gray (weathering white); fine pebbles, well-sorted, abundant Mn stain; interbedded subequal amount of sandstone (ES–59–80: silicified conglomeratic quartz arenite), weathering white, fine-grained, well-sorted	3.0
66. Siltstone (ES–59–78: clayey quartz-chert siltstone), gray (weathering light-olive-gray), fossiliferous, some pyrite; grades into sandstone (ES–59–79: clayey lithic quartz-chert arenite), very fine grained, poorly sorted, and clayrock locally; at base, siltstone-matrix limestone-phenoplast conglomerate, thick-bedded. Fossil colln. F19–59–ES (=USGS loc. 21293–PC) (18.5 ft above base) and F20–59–ES (=USGS loc. 18590–PC) (same)	38.0
65. Siltstone (ES–59–77: silicified(?) clayey quartz-chert siltstone), gray (weathering greenish-gray); grades into sandstone, very fine grained; interbedded minor shale	14.5
64. Conglomerate (ES–59–76: silicified lithic chert-quartz conglomerate), gray (weathering brownish-gray), poorly to moderately sorted, light-colored quartzite and chert pebbles and cobbles with maximum dimension of 7.5 cm in matrix of medium-grained sandstone; interbedded sandstone, brown	15.5
63. Shale, gray (weathering olive-gray), fossiliferous, nonresistant; grades into subequal amount of siltstone of similar aspect. Fossil colln. F18–59–ES (=USGS loc. 21292–PC) is from float	32.5
62. Mudstone-matrix limestone-phenoplast conglomerate (ES–59–75: silty claystone-matrix dismicrite nodule rock), matrix medium-gray, weathering medium-greenish-gray, nonresistant	3.5
61. Siltstone, gray (weathering olive-gray); grades to clayrock and minor sandstone; siltstone-matrix limestone-phenoplast conglomerate, medium-bedded, near middle	3.5
60. Sandstone (ES–59–74: calcareous conglomeratic quartz-chert arenite), gray (weathering brown), medium-grained, poorly sorted, firmly cemented, abundant Fe stain	5.5
59. Siltstone, gray (weathering light-olive-gray), abundant worm trails, some brachiopods; interbedded shale (ES–59–73: silty clay shale), gray, also fossiliferous, and minor sandstone, very fine grained, and silstone-matrix limestone-phenoplast conglomerate, thick-bedded. Fossil colln. F17–59–ES (=USGS loc. 21291–PC) (4.0 ft above base)	21.5
58. Limestone (ES–59–72: silty biomicrite), gray, nonfossiliferous at base, scattered chert granules; grades upward to siltstone-matrix limestone-phenoplast conglomerate with sparse crinoidal debris and back to limestone	7.5
57. Siltstone (ES–59–71: silicified chert-quartz siltstone), gray (weathering olive-gray), grades into very fine grained sandstone	6.5
56. Siltstone, gray, locally fossiliferous; interbedded minor clayrock and siltstone-matrix limestone-phenoplast conglomerate; nonresistant slope-former	49.0
55. Sandstone (ES–59–70: silicified chert-quartz arentite), gray (weathering brown), fine-grained, poorly sorted, locally conglomeratic, firmly cemented with silica, some pyrite; forms resistant ledge	2.5
54. Sandstone (ES–59–69: clayey quartz-chert arenite), gray (weathering olive-gray and dark-greenish-gray), fine-grained, poorly sorted; forms resistant ledges; interbedded siltstone, gray (weathering dark-greenish-gray and dusky-purple), and minor medium-bedded limestone, conglomerate, and moderately sorted silicified brown sandstone	15.5
53. Limestone (ES–59–68: clayey biosparite), gray, thick-bedded lens	2.0

Diamond Peak Formation—Continued

Member E—Continued

	Feet
52. Sandstone (ES–59–67: calcareous silicified chert-quartz arenite), gray (weathering brown), fine-grained, moderately to poorly sorted, dense, firmly cemented with silica(?); interbedded subequal amount of conglomerate, and minor gray limestone, and minor siltstone-matrix limestone-phenoclast conglomerate; unit is medium bedded	16.5
51. Siltstone, medium-gray (weathering brown), sandy, thick- to very thick bedded; interbedded conglomerate, gray, firmly cemented with silica, thick-bedded, and sandstone, gray (weathering brown), very fine grained, limestone (ES–59–66: sandy intrasparite), gray, crinoidal debris, and minor siltstone-matrix limestone-phenoclast conglomerate. Unit forms slope	181.0
Total member E	570.5

Member D:

	Feet
50. Limestone (ES–59–65: sandy biomicrite, =USGS loc. f 21926), gray, chert clast content increases upwards; grades to unit 51	5.0
49. Siltstone, gray (weathering olive-gray), some chert pebbles, otherwise similar to siltstone of unit 48	7.0
48. Limestone, gray, crinoidal debris, some crossbedding; sparse chert pebbles; interbedded minor siltstone, gray (weathering light-olive-gray)	19.5
47. Conglomerate (ES–59–64: silicified lithic chert-quartz conglomerate), weathering brown, chert clasts as much as 1.5 cm, in maximum dimension poorly sorted, firmly cemented with silica: interbedded lesser amount of silt shale (ES–59–63: quartz-chert silt shale), gray (weathering olive-gray)	17.5
46. Limestone (ES–59–62: silty biosparite, =USGS loc. f21925), gray, crinoidal debris; interbedded subequal amount of siltstone, gray (weathering olive-gray); and minor siltstone-matrix limestone-phenoclast conglomerate	20.0
45. Conglomerate (ES–59–61: silicified lithic chert-quartz conglomerate), gray (weathering brown), angular chert and quartzite clasts as much as 10 cm in maximum dimension, poorly sorted; lowest 0.5 ft is brown-weathering sandstone	9.0

Diamond Peak Formation—Continued

Member D—Continued

	Feet
44. Limestone (ES–59–60: foraminiferal biomicrite, =USGS loc. f21924), dark-gray (weathering medium-gray), fossiliferous; interbedded minor conglomeratic sandstone, weathering brown, dense	53.0
43. Shale (ES–59–59: calcareous clay shale), gray (weathering brown), some pyrite; interbedded with lesser amount of limestone, gray, fossiliferous. Fossil colln. F15–59–ES (=USGS loc. 21290–PC) from middle of unit	3.5
42. Limestone (ES–59–58: foraminiferal biosparite, =USGS loc. f21923), gray, fossiliferous, contact with unit 41 is irregular and could be a diastem; very minor shale interbeds; forms prominent cliff. Fossil colln. F14–59–ES near middle of unit	15.5
41. Siltstone, like unit 38, at base; grades upward into conglomeratic sandstone (ES–59–57: calcareous conglomeratic quartz-chert arenite), weathering brown, medium-grained, moderately to poorly sorted, chert pebbles as much as 1 cm in maximum dimension; and sandstone	8.5
40. Limestone, gray, abundant chert pebbles; a 0.5-ft siltstone bed like unit 38 near base	3.5
39. Conglomerate (ES–59–56: calcareous lithic chert conglomerate), weathering brownish-white, pebbles of chert and quartzite as much as 2.1 cm in maximum dimension; moderately to poorly sorted, becomes silty upwards (like unit 38) and grades into unit 40	3.5
38. Siltstone (ES–59–55: calcareous silicified quartz-chert siltstone), light-brown (weathering light-olive-gray), dense	7.0
37. Limestone, gray, crossbedded, crinoids and brachiopods; interbedded with minor pebble beds and sandstone, gray (weathering olive-gray)	4.0
36. Sandstone, light-brown (weathering light-olive-gray), dense	2.0
35. Limestone (ES–59–54: sandy intrasparite), gray (weathering gray), almost 5 percent chert pebbles, brachiopod fragments. Fossil colln. F13–59–ES (=USGS loc. 21289–PC) (near middle unit)	7.0
34. Shale (ES–59–53: clay shale), gray (weathering light-olive), calcareous in part, some pyrite cubes	5.5

Diamond Peak Formation—Continued

Member D—Continued

	Feet
33. Limestone, dark-gray (weathering blue-gray), some crinoidal debris; grades upward into minor conglomeratic and sandy beds (ES-59-52: sandy intramicrite), gray, very thin bedded to thin-bedded; interbedded with very minor clay shale, gray (weathering light-olive-gray); local lenses pinch and swell, some are thick bedded	28.0
32. Conglomerate (ES-59-51: calcareous lithic chert conglomerate), variegated, moderately to poorly sorted; red, gray, black, and white chert clasts as much as 7.5 cm in maximum dimension; 85 percent pebbles and cobbles	3.0
31. Conglomeratic sandstone (ES-59-50: calcareous conglomeratic lithic chert-quartz arenite), coarse-grained, poorly sorted; grades into minor conglomerate; less resistant than unit 30	17.5
30. Conglomerate, gray, rounded chert (some red) and quartzite clasts as much as 7.5 cm in maximum dimension, firmly cemented with silica; interbedded with lesser amount of sandstone (ES-59-49: silicified conglomeratic quartz-chert arenite), gray (weathering brown), medium-grained, moderately sorted; forms resistant ledge	12.0
29. Shale (ES-59-48: silty clay shale), gray (weathering light-olive-gray), abundant small brachiopods; becomes sandy in upper 5 ft with sparse chert pebbles. Fossil colln. F11-59-ES (=USGS loc. 21287-PC) (15.5 ft above base) and F12-59-ES (=USGS loc. 21288-PC) (24.5 ft above base)	49.0
28. Sandstone (ES-59-47: silicified conglomeratic quartz-chert arenite), gray (weathering brown), fine-grained, moderately sorted, some pebbly layers, firmly cemented with silica	9.0
27. Sandstone (ES-59-43: calcareous quartz-chert arenite), gray (weathering brownish-gray), fine-grained, moderately sorted to well-sorted, very dense, abundant pyrite cubes; interbedded with lesser amount of limestone (ES-59-44: sandy biosparite), gray (weathering gray), very dense, some pyrite cubes; and siltstone (ES-59-45: calcareous chert-quartz siltstone) like that in unit 26; near top some sandstone (ES-59-46: silicified quartz-chert arenite), gray, very fine grained, moderately to poorly sorted; tightly cemented with silica	47.5
26. Limestone (ES-59-40: cherty biomicrite), medium-gray (weathering medium- to light-gray), medium- to thick-bedded, fossiliferous: horn corals, crinoid fragments, bryozoans, and brachiopod fragments; interbedded with siltstone (ES-59-42: quartz-chert siltstone), gray (weathering olive-gray), and minor limestone nodule rock with matrix of silty limestone, which grades upward into silty limestone (ES-59-41: silty bryozoan biomicrite). Fossil ES-57-6F and colln. (original position of) F6-59-ES (=USGS loc. 21286-PC) are from 1.0 ft above base and F10-59-ES (=USGS loc. 21285-PC) is from middle of unit	22.5
Total member D	379.5

Member C:

	Feet
25. Siltstone (ES-59-39: clayey quartz-chert siltstone), gray (weathering lighter gray), pyrite casts, thin-bedded; interbedded with gradational very fine grained sandstone; and clayrock, gray (weathering olive-gray). Possibly some limy nodules in siltstone at base of unit	19.5
24. Conglomerate (ES-59-38: silicified lithic chert-quartz conglomerate), light-gray (weathering white and light-brown), clasts of chert and quartzite with maximum dimension of 7.5 cm in matrix of silicified poorly sorted sandstone	6.5
23. Siltstone (ES-59-37: chert-quartz silt shale), dark-gray (weathering gray and olive-gray), carbonaceous, fossiliferous; grades into subequal amount of clay shale. Fossil colln. F9-59-ES (=USGS loc. 21284-PC) is from float near middle of unit	49.0
22. Limestone (ES-59-36: foraminiferal biosparite, =USGS loc. f21922), dark-gray (weathering medium-gray), dense, fossiliferous	.5
21. Siltstone, dark-gray (weathering light-olive-gray), abundant bryozoan casts; grades into sandstone (ES-59-34: clayey chert-quartz arenite), gray (weathering light-olive-gray), very fine grained, moderately to poorly sorted; interbedded with minor clayrock (ES-59-35: silty claystone) gray (weathering olive-gray), with abundant bryozoan casts. Fossil colln. F6-59-ES (=USGS loc. 21286-PC) (float 10.0 ft above base and is from unit	

Diamond Peak Formation—Continued

Member C—Continued *Feet*

26), F7–59–ES (=USGS loc. 21282–PC) (17.5 ft above base), and F8–59–ES (=USGS loc. 21283–PC) (same level as F7, but float) 55.0

20. Conglomerate (ES–59–32: silicified lithic quartz-chert conglomerate), gray (weathering brownish-gray and gray), chert, quartzite, and other lithic clasts as much as 15 cm in maximum dimension in matrix of poorly sorted sandstone, firmly cemented with silica; interbedded with lesser amount of sandstone (ES–59–33: silicified quartz-chert arenite) gray, fine-grained, moderately sorted, firmly cemented with silica, sparse chert pebbles; unit forms prominent ledge 106.5

Total member C 237.0

Member B:

19. Covered; float is mostly sandstone like that of unit 18 .... 176.5

18. Sandstone (ES–59–31: silicified chert-quartz arenite, and ES–59–29: clayey lithic quartz-chert arenite), gray (weathering gray and olive-gray), individual beds very fine grained to coarse-grained, poorly sorted; silica cement; thin-bedded, abundant pyrite, sparse (more near top) worm trails; interbedded with lesser amount of conglomerate and conglomeratic sandstone (ES–59–30: silicified conglomeratic lithic chert-quartz arenite), gray, chert clasts as much as 3 cm in maximum diameter in matrix of poorly sorted sandstone, silica cement. Unit forms ledges 19.0

17. Covered; probably similar to unit 16 .... 339.0

16. Siltstone, gray (weathering light-olive-gray), partially covered; interbedded with sandstone, weathering olive-gray, thin-bedded 74.0

15. Conglomerate (ES–59–28: silicified lithic chert conglomerate), gray (weathering gray), pebbles of quartzite and chert as much as 5 cm in maximum dimension in matrix of poorly sorted sandstone, firmly cemented with silica; a local lens 3.0

14. Sandstone (ES–59–26: silicified quartz-chert arenite), gray (weathering olive-gray to brown), very fine grained, moderately to poorly sorted, very thick bedded, cemented with silica, some pyrite; interbedded with subequal amount of siltstone, gray (weather-

Diamond Peak Formation—Continued

Member B—Continued *Feet*

ing olive-gray), some pyrite; and shale (ES–59–27: silty clay shale), dark-gray (weathering light-olive-gray), abundant pyrite 44.5

13. Siltstone, gray (weathering olive-gray), some pyrite(?) casts, sparse worm trails and concretions; interbedded with lesser amount of sandstone, gray, very fine grained to medium-grained, poorly sorted, medium-bedded; and minor clayrock; and minor sandstone (ES–59–25: silicified quartz-chert arenite), gray, fine- to medium-grained, moderately sorted, firmly cemented with silica, thick-bedded 258.5

12. Conglomeratic sandstone (ES–59–24: conglomeratic lithic chert-quartz arenite), gray (weathering olive-gray); maximum pebble size 3.5 cm in maximum dimension in matrix of silty sandstone; interbedded with siltstone (weathering olive-gray), some fossil casts; and conglomerate, gray, cobbles and pebbles of chert in silicified matrix, forms resistant ledges 44.5

11. Siltstone (ES–59–23: chert-quartz siltstone), gray (weathering olive-gray), thin-bedded, hematite cubes after pyrite(?), local concentrations of brachiopods, horn corals, crinoid columnals, and bryozoans, sparse concretions; interbedded with sandstone (ES–59–22: lithic quartz-chert arenite), gray, very fine grained to medium-grained, moderately to poorly sorted, thin-bedded, forms resistant ledges; and clayrock, gray. Fossil colln. F5–59–ES (=USGS loc. 21281–PC) (42.0 ft above base) 65.0

10. Siltstone (ES–59–21: quartz-chert silt shale), gray (weathering olive-gray), abundant worm trails and pyrite casts and hematite cubes after pyrite, weathers to 1-cm thick fragments 5–10 cm across, some carbonaceous debris and wood, crinoid, brachiopod, and coral casts; interbedded with clayrock, gray (weathering olive-gray); and sandstone (ES–59–20: clayey lithic chert-quartz arenite) weathering olive-gray, very fine grained, thin-bedded, abundant pyrite casts. Fossil colln. F2–59–ES (=USGS loc. 21278–PC) (39.0 ft above base), F3–59–ES (=USGS loc. 21279–PC) (115.0 ft above base), and F4–59–ES (=USGS loc. 21280–PC) (130.0 ft above base) 245.0

Total member B 1,269.0

Diamond Peak Formation—Continued

Member A:

	Feet
9. Conglomerate (ES-59-19: silicified lithic chert-quartz conglomerate), gray, clasts of chert and limestone and quartzite as much as 10 cm in maximum dimension, some pyrite, firmly cemented with silica; interbedded with lesser subequal amounts of siltstone like unit 8 (ES-59-18: chert-quartz silt-shale), but contorted and disrupted, and clay shale, gray (weathering olive-gray); minor sandstone also	44.0
8. Siltstone and shale (ES-59-17: sandy clay shale), grayish-black (weathering grayish-brown), thin- to medium-bedded; some pyrite, "slaty" appearance	8.5
7. Conglomeratic sandstone (ES-59-16: conglomeratic lithic chert-quartz arenite), clasts as much as 10 cm in maximum dimension, thick-bedded; interbedded with sandstone, gray, medium-grained, poorly sorted, firmly cemented with silica, some pyrite; suggestion of grading	6.0
6. Covered; probably mostly siltstone interbedded with thin sandstone beds	151.5
5. Conglomeratic sandstone (ES-59-15: conglomeratic clayey lithic chert-quartz arenite), weathering olive-gray, fine- to medium-grained, poorly sorted, chert and quartzite pebbles as much as 5 cm in maximum dimension in matrix of sandstone; some pyrite(?) and poor fossil casts	9.5
4. Siltstone (weathering olive gray), some pyrite, very thin bedded to thin-bedded; some fossil casts	9.5
3. Sandstone (ES-59-14): calcareous lithic chert-quartz arenite), gray weathering brown), fine- to medium-grained, calcareous cement; interbedded with subequal amount of siltstone, weathering olive-gray, and minor pebble conglomerate; thin- to medium-bedded, abundant pyrite	7.5
2. Siltstone, some conglomeratic beds, (weathering olive-gray); worm trails, casts of crinoid columnals and bryozoans	35.0
1. Conglomerate (ES-59-12: lithic chert conglomerate; ES-59-13: clayey(?) lithic chert conglomerate), maximum clast size 15 cm in maximum dimension; pebbles are chert, quartzite, limestone, siltstone, volcanic fragments,, most are disk shaped; interbedded with thin beds of siltstone weathering olive-gray	9.0
Total member A	280.5
Total Diamond Peak Formation	3,526.0

Chainman Formation:

Black Point facies:

	Feet
21. Conglomeratic sandstone (ES-59-11: conglomeratic clayey lithic chert-quartz arenite), chert pebbles in matrix of sandstone, weathering olive-gray and brown, very fine grained to medium-grained, some casts of crinoid columnals and bryozoans; grades upwards into siltstone	12.0
20. Siltstone, gray (weathering olive-gray), poor casts of crinoids, bryozoans, and brachiopods; interbedded with lesser amount of conglomerate, gray, pebbles of chert in matrix of sandstone, gray (weathering olive-gray), very fine grained to fine-grained; some worm trails. Fossil colln. F1-59-ES (=USGS loc. 21277-PC) near middle of unit, mostly float	15.5
19. Covered; float is lithic conglomerate from upslope	94.0
18. Conglomerate (ES-59-9: lithic chert conglomerate), gray, maximum pebble size about 1 cm in maximum dimension, matrix is sandstone, fine- to coarse-grained, poorly sorted, pebbles are chert and quartzite, casts of crinoid columnals and bryozoans; interbedded with sandstone (ES-59-10: clayey chert-quartz arenite), gray (weathering olive-gray), very fine grained, moderately to poorly sorted, abundant pyrite(?) casts	6.5
17. Covered; probably same as unit 16	15.0
16. Siltstone, gray (weathering olive-gray), pyrite(?) casts	4.5
15. Covered; float is mostly brown-weathering sandstone, but inferred to be generally similar to unit 14	188.0
14. Clay shale and clayey silt shale, dark-gray (weathers olive-gray), some worm trails, weathers to 2.5- to 8-cm diameter flakes. Similar to unit 4 in part	61.5
13. Sandstone (ES-59-8: lithic chert-quartz arenite), gray (weathering grayish-brown), fine- to medium-grained, firmly cemented with silica, thin- to thick-	

Chainman Formation—Continued

Black Point facies—Continued

	Feet
bedded (some beds are graded), abundant pyrite(?) casts and crinoid columnal casts, sparse carbonaceous (woody) debris; interbedded with subequal amount of siltstone, grayish-black (weathering olive-gray), worm trails	32.0
12. Covered; probably similar to unit 11, but float is mostly brown-weathering sandstone	159.0
11. Siltstone, dark-gray (weathering olive-gray and grayish-brown); interbedded with subequal amount of clay shale (ES-59-7: silty clay shale), dark-gray; and minor sandstone, very fine grained, medium-bedded; grades from unit 10, worm trails and pyrite(?) casts throughout; weathers to 5- to 15-cm-diameter plates	69.0
10. Siltstone, gray (weathering olive-gray); interbedded with lesser amount of gray clay shale; grades from unit 9; weathers to 2- to 5-cm-diameter flakes; worm trails and sparse cubic pyrite(?) casts; coarsens upwards	155.5
9. Siltstone (ES-59-5: quartz-chert siltstone) dark-gray (weathering olive-gray); interbedded with sandstone, medium-gray (weathering brown), very fine grained to fine-grained; sandstone beds irregularly spaced, medium- to thick-bedded, form resistant ledges; abundant worm trails and pyrite(?) casts in siltstone and sandstone. At 56.0 above base a 35-cm bed of sandstone (ES-59-6: chert-quartz arenite), medium-grained, moderately sorted; noticeable lithic fragments	81.5
8. Siltstone, same as unit 6, grades upward into unit 9	21.5
7. Covered; probably siltstone, same as unit 4	82.5
6. Siltstone, same as unit 4; not so highly fractured, sparse cubic pyrite(?) casts and worm trails in upper part	26.5
5. Covered, probably siltstone, same as unit 4	13.0
4. Siltstone (ES-59-4: clayey quartz-siltstone), grayish-black (weathering olive-gray); weathering and fracture cleavage about 1 ft deep	7.0
3. Sandstone (ES-59-3: quartz arenite), gray (weathering brown), fine-grained, well-sorted, sparse pyrite; interbedded with similar sandstone, medium- to coarse-grained, friable, abundant pyrite; some quartz veinlets	6.5
2. Sandstone (ES-59-2: quartz arenite), gray (weathering brown), very fine grained to medium-grained, moderately to poorly sorted; abundant pyrite in coarser parts; probably a local lens	7.5
1. Siltstone (ES-59-1: quartz siltstone), dark-gray and black (weathering olive-gray); pencil weathering in part, contains "worm trails" and cubic casts of pyrite(?)	18.5
Total Black Point facies of Chainman Formation	1,077.0

Base of section; not base of exposure.

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