Middle and Lower Ordovician Formations in Southernmost Nevada and Adjacent California

GEOLOGICAL SURVEY BULLETIN 1180-C

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By REUBEN JAMES ROSS, JR.

With a section on PALEOTECTONIC SIGNIFICANCE OF ORDOVICIAN SECTIONS SOUTH OF THE LAS VEGAS SHEAR ZONE

By REUBEN JAMES ROSS, JR., *and* C. R. LONGWELL

CONTRIBUTIONS TO STRATIGRAPHIC PALEONTOLOGY

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MIDDLE AND LOWER ORDOVICIAN FORMATIONS IN SOUTHERNMOST NEVADA AND ADJACENT CALIFORNIA

By REUBEN JAMES ROSS, JR.

ABSTRACT

Physical and paleontologic stratigraphy of the low Middle Ordovician strata of southern Nevada and adjoining California indicates that only the *Orthidiella* and *Anomalorthis* Zones of the Whiterock Stage have significant time value. The *Palliseria* Assemblage Zone is younger on the west of the report area than on the east. It is related to a migrating lithic facies that crosses other time zones. The *Rhysostrophia* Zone is removed from the Whiterock and is assigned to the Marmor Stage.

Whiterock, Marmor, and Porterfield strata are considered conformable with a transition zone possibly representing the Ashby Stage.

Physical stratigraphy corroborates Longwell's estimate of 25–40 miles of right lateral movement on the Las Vegas shear zone and of several thrust plates shingled to the south of the shear. In this southern area, evidence suggests that the upper sands of the Eureka Quartzite had a northerly source.

INTRODUCTION

This report summarizes the distribution of rock types and enclosed fossils of Early and Middle Ordovician age in southern Nevada and adjacent California. It is based in large part on six sections measured along an east-west line from the Arrow Canyon Range, Nev., to the Inyo Mountains, Calif., (fig. 1; table 1). The information from these sections has been supplemented by data from others both to the north and to the south.

SCOPE AND EXTENT OF INVESTIGATION

Attention has been given primarily to the upper part of the Pogonip Group and its relation to the overlying Eureka Quartzite. Several problems involve correlation of the faunas of the Antelope Valley Limestone of the Pogonip and have continentwide significance. These problems cannot be solved with the information presented here. Not only is additional collecting of fossils needed in some of the localities already visited, but additional regional data on lateral

TABLE 1.—*Location of measured sections*

[Localities, listed by States, are taken from a more extensive list covering the Basin Ranges (R. J. Ross, Jr., 1964)]

Locality (figs. 1, 11, 12)	Location						Remarks
	Sec.	T.	R. E.	Coordinates	Quadrangle	Area	
California							
2[1]		12 S.	36		Independence	Inyo Mountains, west side. Mazourka Canyon.	Measured by Langenheim and others (1956).
3				Zone 4: E. 2,428,300 ft, N. 532,100 ft.	Dry Mountain	Panamint Range, Quartz Spring area, approximately 1½ miles north of Teakettle Junction.	In part based on McAllister (1952).
4		14 S.	40		Ubehebe Peak	Ubehebe Peak area, 2½ miles due north of the Peak and Racetrack playa.	From McAllister (1952).
6		19 S.	46		Furnace Creek	Trail Canyon, south side	C. B. Hunt (oral commun., 1960).
7		21 S.	8		Stewart Valley	Nopah Range, west side, north end.	Hazzard (1937).
8[2]		12 S.	36		Independence	Inyo Mountains, west side. Mazourka Canyon.	Measured by D. C. Ross.
9		17 S.	43	Zone 4: E. 2,487,650 ft, N. 394,000 ft.	Panamint Butte	Panamint Range	Also measured by W. E. Hall and H. G. Stephens (unpub. data).
10				Zone 4: E. 2,377,700 ft, N. 375,500 ft.	Darwin	Darwin district 1,200 ft N. 41° E. from White Swan mine.	Hall and MacKevett (1962),
11		27 N.	3		Ryan	West side of ridge, west side of Red Amphitheatre.	J. F. McAllister (written commun., Aug. 23, 1962).
Nevada							
6		20 N.	51		Bartine Ranch	Lone Mountain	Nolan and others (1956).
12	30	16 N.	50		Horse Heaven Mountain.	Vicinity of Antelope Valley	Nolan and others (1956, p. 24–29).
16	5	11 N.	69		Wheeler Peak	Granite Peak, northwest side near summit; Snake Range.	
21	 25	7 N. 8 N.	62 62			Egan Range, west side. About 6 miles north of Sunnyside Ranch, on bluff south of road into Cave Valley.	Hintze (1952, p. 60–65).
24					Tonopah 2°	Tybo, west edge (not surveyed)	Ferguson (1933).

30		13–14 S.	63		Arrow Canyon	Arrow Canyon Range, Clark County.	Webb (1956 p. 52).
31		11–14 S.	53–54		Frenchman Lake and Papoose Lake.	Near Yucca and Frenchman Flats.	Johnson and Hibbard (1957, p. 345–349, 350–352).
32		12 S.	47–48		Bare Mountain	Meiklejohn Peak	Cornwall and Kleinhampl (1961).
36	5	17 S.	60		Las Vegas 2°	Black Gate Canyon, Sheep Range.	
37	3, 10	19 S.	63		Dry Lake	Apex siding.	
38		20 S.	62		Henderson and Las Vegas.	Frenchman Mountain.	
39	15	18 S.	58		Corn Creek Springs	Lucky Strike Canyon lower part.	
40		18 S.	57	E 516,000 ft N 570,300 ft	Charleston Peak	Lucky Strike Canyon upper part. Along ridge running eastward from south end of hill 6612.	
41		19 S.	56	E 470,900 ft, N 573,100 ft; E 470,350 ft, N 571,750 ft.	do	Lee Guard Station.	
42	16	20 S.	59		Blue Diamond	La Madre Mountain eastern part along crest of spur.	Approx. altitude 4,640–4,940 ft..
43	31	20 S.	58		Mountain Spring	Red Rock Canyon, west of.	
44		12 S.	55		Frenchman Lake	Aysees Peak.	
45		15 S.	54	East zone: E. 390,300 ft N. 681,900 ft.	Mercury	Spotted Range southwest end along crest of ridge.	
46	3	16 S.	52		Specter Range	Specter Range, south end. east side.	
47		15S.	63, 64	E. 698, 100 ft, N. 673,200 ft; E. 710,500 ft, N 684,200 ft; E. 723,000 ft., N. 677,000 ft.	Arrow Canyon	Arrow Canyon Range, central part.	
48		14S.	63	E. 703,400 ft, N. 720,000 ft; E. 703,000 ft, N. 714,950 ft.	do	Arrow Canyon Range, northwest part.	
49	13	5N.	49½		Tonopah 2°	Rawhide Mountain.	
50		14S.	54	Central zone E. 733,000 ft, N. 737,000 ft.	Frenchman Lake	Ranger Mountains, canyon on northwest slope.	Byers and others (1961).
Utah							
	10, 11	14N.	4		Randolph	Swan Peak and Garden City Canyon.	Ross, R. J, Jr. (1951, p. 11–13).

[1] Composite section. Main section along Lead Canyon Trail.
[2] Composite section. Same area as loc. 2.

extent of both faunas and lithologies are required. Sections are needed for the western Spring Mountains and the Pahrump area of Nevada and for the Grapevine Mountains and the area near Pyramid Peak in California.

This is, therefore, a progress report in which I have attempted to present some of the bothersome problems in regional correlation and to make available the stratigraphic data obtained to date (1962).

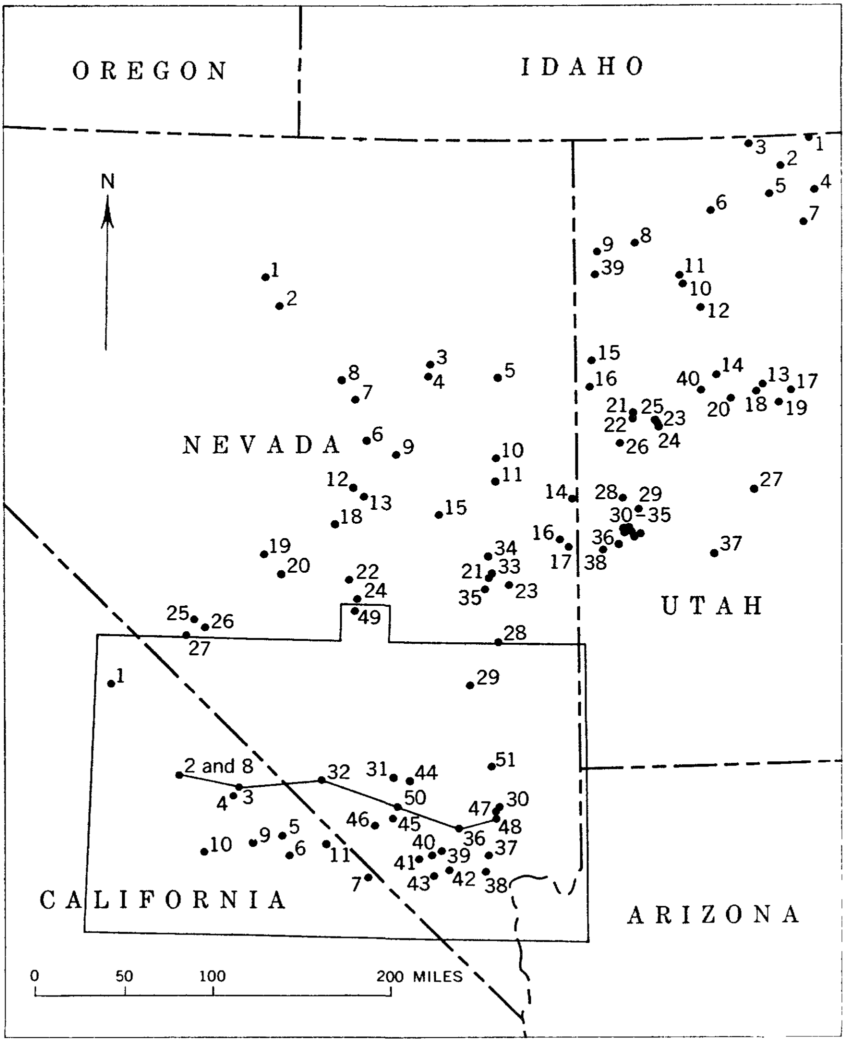


Figure 1.—Index map, showing positions of Ordovician sections in the Basin Ranges. The area covered by this report is outlined. Numbers indicate the localities discussed in this report and listed in table 1. Numbered stratigraphic localities not discussed in table 1 are discussed in another report (R. J. Ross, Jr., 1964, table 1). Line along which lie sections for plate 1 is indicated.

Without the two-volume monograph on "Chazyan and Related Brachiopods" by Cooper (1956), 155 genera and hundreds of species would have remained obscure or unknown. The availability of an authoritative work covering one of the most important elements of the fossil fauna permitted a much greater proportion of time to be devoted to stratigraphy than would otherwise have been possible. A few undescribed species have been found in this study as might be expected, but they are to be covered in a later taxonomic report.

In connection with his study, Cooper revised the old threefold division (Chazy, Black River, and Trenton) of the Middle Ordovician to accommodate several faunal zones that seemed to be intermediate between them. His revision resulted in six stages (p. C73). The Chazy was retained but renamed the Marmor, and the Whiterock was interposed between it and the Early Ordovician.

As a result of the present work, it is my belief that the uppermost zone of the Whiterock Stage is of Marmor age and that the Whiterock and Marmor Stages must be partly synonymous. The evidence is far from overwhelming. Although my conclusion must be considered tentative, it is presented to call attention to a problem that may be worth critical examination elsewhere.

ACKNOWLEDGMENTS

Jean M. Berdan examined all the ostracodes collected during this study, as well as many obtained by other field parties in Nevada and Utah. Similarly, W. A. Oliver, Jr., and Helen Duncan studied the corals which have proved particularly important in correlating the uppermost Antelope Valley beds of the Nevada Test Site with the top of the Lehman Formation of Hintze (1951) in the Snake Range, Nev.

On the Nevada Test Site in 1960, F. M. Byers, Harley Barnes, and F. G. Poole located and measured suitable sections and assisted in collecting fossils; our efforts resulted in publication of a composite section in 1961. In 1961, C. R. Longwell assisted in the work on sections southwest of the Las Vegas Valley. In early 1962, D. C. Ross and I inspected sections in the Inyo Mountains and Panamint Range of California; we were joined by H. G. Stephens in the Panamint Range and by J. F. McAllister in the Quartz Spring area, California.

At Bare Mountain, Nev., H. R. Cornwall and F. J. Kleinhampl provided valuable assistance; Kleinhampl also aided in the measurement of sections at Rawhide Mountain, Nev., in 1960. Throughout this work L. A. Wilson assisted in the field and laboratory.

POGONIP GROUP AND EUREKA QUARTZITE

In central southern Nevada it is possible to use the terminology of Nolan and others (1956), which includes the Goodwin, Ninemile, and Antelope Valley Formations of the Pogonip Group (p. 23–29), and the Eureka Quartzite (p. 29–32). Lithologies of all these units are particularly well represented at the Nevada Test Site and in the Bare Mountain quadrangle. To the east and west the Pogonip formations become increasingly difficult to differentiate.

The main problems in this study involve the Antelope Valley Limestone and Eureka Quartzite. Although there are some parts of the Eureka which may be equivalent to the upper quartzitic member of the Swan Peak Formation of Utah, no attempt is made here to separate these two quartzites.

Six geologically important Ordovician sections lie along an almost straight line from east to west across southern Nevada and adjoining California. These sections are in the Arrow Canyon Range, the Sheep Range, the Nevada Test Site, the Bare Mountain quadrangle, the Quartz Spring area, and the Inyo Mountains (fig. 1; pl. 1).

Most of the Pogonip formations are remarkably consistent in this stretch. Although Langenheim and others (1962) described the Paleozoic formations of the Arrow Canyon Range, their work did not embody faunal control and lacked the detail necessary to make close comparison of these formations with the Pogonip to the west. The present work was concentrated on the uppermost part of the Pogonip and was undertaken to fulfill this need for part of the section. The section at Black Gate Canyon in the Sheep Range is too highly dolomitized to be of more than very general stratigraphic use, but it is valuable for an overall measure of thicknesses. The sections in the Ranger Mountains and near Aysees Peak on the Nevada Test Site are complexly faulted but provide well-preserved fossils and well-exposed unaltered rocks. I have also examined limited sections in the Spotted Range and Specter Range south and west of the test site to gain increased knowledge of the transition from Pogonip rocks to Eureka rocks.

The section at Meiklejohn Peak closely parallels the composite section at the test site in lithic detail but differs drastically in the composition of the upper faunas of the Pogonip. In the Quartz Spring area, California, lithologies are again similar, but there is unsatisfactory fossil control in the high Pogonip (pl. 1). In the northern Inyo Mountains, the Mazourka Group (Ross, D. C., 1963), composed of the Al Rose Formation and the Badger Flat Limestone, seems to contain a higher percentage of detrital material throughout than does the correlative Pogonip. The equivalent of the highly detrital Ninemile

Formation is much thinner than to the northeast and east, as are equivalents of all other subunits.

Across this area, fossil control within the Goodwin Limestone and its equivalents is poor, and much of the correlation is based on position between recognizable Nopah and Ninemile correlatives. Silty and shaly rocks in the Goodwin Limestone can be mistaken easily for typical Ninemile shales.

The Ninemile Formation is remarkably persistent across almost all of central and southern Nevada although it is not everywhere recognized as a distinct unit. Predominantly it is a green fissile shale with thin interbeds of extremely fossiliferous limestone. Commonly these interbeds are nodular, particuarly in their upper parts. The gradational nature of the change from shaly beds upward into silty nodular thin-bedded limestones of the lower part of the Antelope Valley Limestone was emphasized by Nolan and others (1956, p. 27, 28). Characteristically the Ninemile Formation contains a trilobite and brachiopod fauna equivalent to fauna of zone J (*Pseudocybele nasuta* Zone) of Ross (1951) and of Hintze (1952). Ross and Berry (1963, table 1) considered this zone to be approximately equal to the graptolite zone of *Didymograptus protobifidus*, which occurs in similar lithology in the Al Rose Formation of the Mazourka Group of the Inyo Mountains (pl. 1). (This upper shaly unit probably is unit 4 of Langenheim and others (1956, fig. 3, p. 2087).)

The Antelope Valley Limestone in central southern Nevada is gradational with the underlying Ninemile shales. In dolomitized sections, as in the Spring Mountains and Desert Range, a thick middle unit of the Pogonip weathers prominently in shades of brown and orange. There is a great temptation to consider this entire "brown stripe" the Ninemile equivalent; actually the brown-weathering interval of rocks is composed of two silty or shaly units separated by a more calcareous unit. Only the lower of the two detrital units is the Ninemile equivalent, as illustrated in the Quartz Spring area (McAllister, 1952, p. 11, units 5, 6, 7) and on the Nevada Test Site (Byers and others, 1961, table 189.1).

The lower detritus-rich beds of the Antelope Valley Limestone were named the Paiute Ridge and the Ranger Mountains Members by Byers and others (1961, p. C108). Nolan and others (1956, p. 29) stated that the *Orthidiella* Zone is the lowest fossil zone found in the Antelope Valley beds and listed a fauna that is almost identical with that from the Ranger Mountains Member (USGS collns. D718 CO, D719 CO, D727 CO, D728 CO). However, collections made from limestones above the Ninemile Formation at Ninemile Canyon in the Antelope Range belong to the *Pseudocybele nasuta* fauna. I believe that the base of the Antelope Valley at the type section is correlative both faunally and lithically with the base of the Paiute Ridge Member of the Nevada Test Site.

By definition (Nolan and others, 1956, p. 28–29), the Antelope Valley Limestone is composed of three lithic types. These are "* * * a lower 150-foot unit of thinner bedded limestones, a middle unit of 600 feet of massive and cliff-forming limestone, and an upper 350-foot unit of platy and flaggy limestone." Although different in details on thickness, this description admirably fits the formation in both the Nevada Test Site and Bare Mountain quadrangle. On the test site the lower 330 feet of the Aysees Member (Byers and others, 1961, p. C108) is equivalent to the middle unit of the type area.

Also by definition (Nolan and others, 1956, p. 28–29), four faunal zones characterize the formation. These are the *Orthidiella*, the *Palliseria*, the *Desmorthis*, and the *Anomalorthis* Zones. Cooper (1956, p. 126–127; chart 1) added the *Rhysostrophia* Zone above the *Anomalorthis* Zone. The Antelope Valley Limestone has in a sense become the rock unit on which Cooper's (1956, chart 1) Whiterock Stage is based (fig. 8).

STRATIGRAPHIC SECTIONS

Stratigraphic sections, together with lists of fossils found in each are presented on the following pages. Some of these are accompanied by diagrammatic sections showing lithologies and positions at which fossil collections were made.

ARROW CANYON RANGE, NEV.

Plate 1; figure 1, localities 30, 47, 48

The Ordovician strata of the Arrow Canyon Range were mentioned briefly by Longwell (1949, p. 926; 1952, p. 32) and received detailed reporting by Webb (1956, p. 52–53) and by Langenheim and others (1962, p. 597–599).

On the west side of the range, Webb (1956, p. 52–53), who was interested in the Eureka Quartzite, measured 132 feet in that formation including about 40 feet of dolomitic sandstone and quartzite that Langenheimand others (1962, p. 598) assigned to the overlying Ely Springs Dolomite. Langenheim and others reported that conodonts from this 40-foot interval were of Maysville age according to W. C. Sweet. They considered the brachiopods to be of Eden age. On these grounds they placed the interbedded quartzites and dolomitic sandstones in the Ely Springs Dolomite. However, Sweet (oral commun., Jan. 26, 1963; written commun., Feb. 2, 1963) informed me that his original determination of the conodont fauna indicated that its age was not younger than Maysville. He further stated that, on the basis of present knowledge of conodont distribution, it might be as old as Barneveld. The name Barneveld was originated by Fisher (1962) to supplant Trenton as restricted by Cooper (1956, chart 1).

On the basis of lithic similarity, the 40-foot interval belongs in the Eureka Quartzite to which it is here reassigned. Sweet's assessment of the interval's age would tend to support the reassignment, as would brachiopods collected more recently (noted below).

Langenheim and others (1962, p. 597–599, fig. 4) summarized the Ordovician units of the range in very general terms. They divided the Pogonip Group into six informal formations totaling about 2,400 feet in thickness and designated them Opa to Opf. In addition to 103 feet of Eureka Quartzite, they fould 499 feet of Ely Springs Dolomite which included the 40 feet of dolomitic sandstone and quartzite previously placed in the Eureka by Webb (1956, p. 52–53). Few fossils were mentioned in their report, and only two or three noncritical forms were given generic designation. No species were identified.

In 1961 L. A. Wilson and I visited the Arrow Canyon Range for 2 days. Collections were made from the basal part of the Ely Springs Dolomite, the upper part of the Eureka Quartzite, and the upper beds of the Pogonip. No attempt was made to measure the entire Pogonip Group because Langenheim had originally planned to do detailed work there.

Partial sections were measured in the upper part of the Pogonip at the north on the west side of the range and in the Eureka Quartzite at two localities in the center of the range on the east side.

These sections, including positions of critical fossils or fossil collections, are given here. Locations of sections are by Nevada footage coordinates, east zone, on the Arrow Canyon quadrangle map (1:62,500).

Section of Eureka Quartzite at mine in east-central Arrow Canyon Range; Nevada footage coordinates, east zone: E. 710,500 ft, N. 684,200 ft

[Fig. 1, loc. 47; pl. 1; Silica quarry locality of Langenheim and others (1962, fig. 1)]

Ely Springs Dolomite.	
Eureka Quartzite:	*Feet*
Quartzite; thinbedded at base and finely crossbedded at top	9
Interbeds, very thin (6 in.–1 ft), of sandy dolomite, fine-grained gray quartzite, and shaly siltstone which is pale reddish purple mottled with light olive gray. Silicified brachiopods from upper part, colln. D977 CO	19
Sandstone, dolomitic, crossbedded, thin-bedded	3
Sandstone	2
Dolomite, sandy; grades upward into dolomitic, pinkish, fucoidal sandstone	1.5

Section of Eureka Quartzite at mine in east-central Arrow Canyon Range; Nevada footage coordinates, east zone: E. 710,500 ft, N. 684,200 ft—Continued

	Feet
Eureka Quartzite—Continued	
Slope covered with float	7
Sandstone, white, mottled with red; contains abundant nodules of collophane in upper 2 ft USGS colln. D1066 CO	5
Quartzite, white, vitreous; in beds 1–5 ft thick	88
Partial thickness measured	135

Section of Eureka Quartzite on the more southerly of two small hills south of road, east of central Arrow Canyon Range; Nevada footage coordinates, east zone: E. 723,000 ft, N. 677,000 ft

[Fig. 1, loc. 47; pl. 1; "Outpost Hill" locality of Langenheim and others (1962, fig. 1)]

Ely Springs Dolomite:

Dolomite, dark-gray; *Receptaculites oweni* abundant 12 ft above base.

	Feet
Eureka Quartzite:	
Dolomite, sandy, and dolomitic sandstone, seemingly transitional. Silicified fossils, USGS colln. D978 CO	3
Slope covered with soil and float	15
Sandstone, dolomitic	1
Slope covered with soil and float	12
Sandstone, dolomitic; forms low ledges	6
Slope covered	13
Sandstone, weak, peculiarly mottled; contains abundant nodules of collophane in upper part	6
Quartzite, white, vitreous	98
Total thickness, Eureka Quartzite	154

Section of upper part of the Pogonip Group on west side of Arrow Canyon Range; Nevada footage coordinates, east zone: E. 703,400 ft, N. 720,000 ft

[Fig. 1, loc. 48; pl. 1; "Illinois Gulch" locality of Langenheim and others (1962, fig. 1)]

Eureka Quartzite.

	Feet
Pogonip Group:	
Dolomite, medium-gray; in beds 6 in.–2 ft thick; forms low ledges. Fossiliferous, but most fossils recrystallized relics or incompletely silicified	37
Dolomite, medium-gray and medium-dark-gray; in 2- to 3-ft beds. Very fossiliferous, but all fossils recrystallized relics	7
Limestone, medium-gray; has abundant yellowish-orange silty partings giving crepe appearance	13
Slope covered with talus. Ledges of intraformational conglomerate and silty nodular limestone exposed	11
Limestone, aphanitic to finely crystalline; in 3- to 6-ft beds; thinly and irregularly laminated with yellowish-orange silty partings. Interbeds of bioclastic calcarenite weathering dark gray. Some silty beds appear yellowish on weathered surfaces. USGS Collns. D963 CO and D975 CO from float in middle of this unit	58

Section of upper part of the Pogonip Group on west side of Arrow Canyon Range; Nevada footage coordinates, east zone: E. 703,400 ft. N. 720,000 ft—Con.

Pogonip Group—Continued	*Feet*
Limestone, silty, aphanitic, medium-gray; weathers pale orange	2
Limestone, aphanitic to finely crystalline, medium-gray; thinly and crudely laminated with irregular yellowish-orange silty partings; in 3- to 6-ft beds which alternate between those with little silt and those with abundant silt	50
Limestone, aphanitic, light-gray; weathers light gray to yellowish orange	2
Limestone, very silty; weathers conspicuous pale yellowish orange	4
Limestone, aphanitic, medium-gray; thinly and crudely laminated with irregular silty partings	8
Limestone; interbeds of crudely laminated silty limestone medium-gray splotched with pale yellowish orange, of medium- to light-gray bioclastic limestone, and of minor intraformational conglomerate with light pebbles in darker matrix. Fossils: ostracodes in upper 1 ft	21
Slope covered with float	2
Limestone, silty, fine-grained; weathers grayish orange	1
Limestone, fine-grained, crystalline, medium-dark-gray. Laminae, 1–3 in. thick, fairly persistent; form ledges 3–5 ft high. Silty material minor but causes a few yellowish-orange splotches	11
Limestone, very silty; weathers pale yellowish orange to pinkish. Abundantly fossiliferous; contains *Palliseria, Maclurites, Receptaculites.* Forms small cliff	10
Limestone, silty, bioclastic, abundantly fossiliferous. Weathers rubbly or nodular. Light gray to medium light gray; contains much pale-yellowish-orange silt. Upper 4 ft contains base of *Palliseria* Zone with *Maclurites* and *Receptaculites* over 6 in. in diameter. USGS Colln. D974 CO	16
Limestone, very fine grained, light-gray; contains abundant bioclastic material. In irregular 1- to 2-in. laminae with silty partings weathering pale yellowish orange to grayish orange pink. Rock weathers nodular. Sponges, gastropods, and peculiar "black rings." USGS Colln. D973 CO	20
Limestone, dark-gray, bioclastic calcarenite; forms ledges 1–4 ft high. Upper 8 ft forms weaker slope than lower beds. Fossils are sponges, small *Maclurites*, cephalopods	30
Covered slope above cliff	6
Limestone, cliff-forming, medium-dark-gray; weathers dark gray to medium gray; in beds 2–4 ft thick. Crowded with "*Girvanella.*" Sponges and small *Maclurites* abundant. Some beds have irregular partings of pale-yellow-orange silty material	125+
Partial thickness measured	434+

No measurement below this point. Lowest unit is top of Langenheim's Ope (Langenheim and others, 1962, p. 598, fig. 4).

The occurrence of *Receptaculites oweni* in the lower 15 feet of the Ely Springs Dolomite is of special significance here. Not only does it suggest a late Middle Ordovician age, but it is particularly valuable as a marker in this zone for purposes of correlation with other sections in the Spring Mountains where the Eureka Quartzite is absent.

Geological Survey collections D977 CO and D978 CO from the upper dolomitic sandstones of the Eureka Quartzite include *Paucicrura* sp., *Chaulistomella* sp., *Platystrophia* sp., *Sowerbyella* sp., *Strophomena* sp., and abundant conodonts. This is presumably the same conodont assemblage reported by Langenheim (Langenheim and others, 1962, p. 598–599) as Maysville in age. Most of the brachiopod genera have long ranges within the Middle and Upper Ordovician. *Platystrophia* does not occur before Trenton time, and *Chaulistomella* has not been reported later than Wilderness (early Trenton) time. This suggests that the upper beds of the Eureka are of Trenton age.

Although there is a high dolomite content in the transitional sandstones and quartzites, I consider this 40-foot unit a part of the Eureka Quartzite. Only above it is found the characteristic dark-gray dolomite of the Ely Springs. Other sections to the west also suggest that the contact is gradational. The occurrence of Middle Ordovician fossils both above and below the Eureka-Ely Springs contact indicates that a major unconformity is not necessarily present.

In the Eureka Quartzite approximately 90 feet above its base, abundant nodules of collophane are present in a 5- to 6-foot bed of quartzite, mottled with red and purple. Attention is called to this stratum because it seems to mark a zone that is present also near Apex siding to the south and at sections to the west in the Spring Mountains at Lee Canyon and lower Lucky Strike Canyon.

The presence of the *Anomalorthis* fauna immediately beneath the Eureka Quartzite indicates that the Pogonip-Eureka boundary in the Arrow Canyon Range is in the same position as at Lone Mountain in central Nevada.

Fossils collected from the Arrow Canyon Range are listed below by USGS collections:

D962 CO. Highest bed of Pogonip Group beneath Eureka Quartzite. Nevada coord., east zone: E. 698,100 ft, N. 673,000 ft.

Anomalorthis sp.
Conodonts, abundant and well preserved

D963 CO. Pogonip Group, 70 ft below top. On measured section. Nevada coord., east zone: E. 703,400 ft, N. 720,000 ft.

Anomalorthis lonensis (Walcott)
A. nevadensis Ulrich and Cooper
Ctenodonta sp.
Conodonts, abundant

D970 CO. Pogonip Group, 35 ft below top. Nevada coord., east zone: E. 698,100 ft, N. 673,200 ft.

Bathyurid pygidium
Conodonts

J. M. Berdan reported as follows concerning ostracodes in this collection: "*Eoleperditia* sp. cf. *E. bivia* (White), and small ostracodes, possibly *Schmidtella.* Although the specimens in this collection are poorly preserved and almost impossible to get out of the matrix, the general association appears similar to that found in the upper part of the Antelope Valley elsewhere in Nevada. It does not seem to be the same as collection D825 CO."

D971 CO. Pogonip Group, approximately 850 ft below top. Nevada coord., east zone: E. 703,000 ft, N. 714,950 ft.

Presbynileus? sp.
Gastropods, small
Conodonts, few, simple

D972 CO. Pogonip Group, approximately 780 ft below top. Nevada coord., east zone: E. 703,000 ft, N. 714,950 ft.

Sponges

D973 CO. Pogonip Group, approximately 265 ft below top. Included in measured section. Nevada coord., east zone: E. 703,400 ft, N. 720,000 ft.

Sponges

E. L. Yochelson identified the following from this collection: *Palliseria, Maclurites?*, and Gastropod, indet.

D974 CO. Pogonip Group, approximately 240 ft below top. Included in measured section. Nevada coord., east zone: E. 703,400 ft, N. 720,000 ft.

Maclurites sp. (large)
Palliseria sp.

(D1066 CO. Above *Palliseria* beds, west side of Arrow Canyon Range, Nev. Approximate Nevada coord., east zone: E. 703,400 ft, N. 720,000 ft. J. M. Berdan reported as follows concerning ostracodes in this collection: "This collection contains *Eoleperditia bivia* (White), and small, smooth ostracodes which are too poor to be generically determined. Presumably this represents the same ostracode association that occurs in the Lehman Formation and the Swan Peak(?) of Hintze in the Crystal Peak section, Utah and the upper part of the Antelope Valley in Nevada."

D975 CO. Pogonip Group, from float 85 ft below top. Included in measured section. Nevada coord., east zone: E. 703,400 ft, N. 720,000 ft.

Cephalopod siphuncle

D977 CO. Eureka Quartzite, transition beds above lower massive quartzite, 20 ft below base of Ely Springs Dolomite. Nevada coord., east zone: E. 710,-500 ft, N. 684,200 ft.

Platystrophia sp. (narrow-hinged species)
Chaulistomella? sp.
Sowerbyella sp.
Strophomena sp.
Paucicrura sp.

D978 CO. Eureka Quartzite, upper 3 ft. Nevada coord., east zone: E. 723,000 ft, N. 677,000 ft.

Chaulistomella? sp.
Paucicrura sp.

733-029—64——2

BLACK GATE CANYON, SHEEP RANGE, NEV.

Plate 1; figure 1, locality 36

A good section of Ordovician rocks is exposed along the headward part of Black Gate Canyon in the Sheep Range. Unfortunately the calcareous rocks are all dolomitized to such a degree that very few fossils have been collected from the vicinity. Large forms like *Palliseria* and *Maclurites* are readily recognized in place.

Because of lack of faunal control, correlation with other sections is possible only in the most generalized manner. Attempts to divide the Pogonip Group into the Goodwin, Ninemile, and Antelope Valley equivalents have proved very unsatisfactory. Approximately 540 feet of Ely Springs Dolomite overlies 170 feet of Eureka Quartzite. The Pogonip totals about 2,360 feet in thickness.

Section of Ordovician formations, Black Gate Canyon, Sheep Range, sec. 5, T. 17 S., R. 60 E., Las Vegas 2° quadrangle, Nevada

[Pl. 1]

	Feet
Silurian(?).	
Ordovician:	
Ely Springs Dolomite:	
Dolomite, dark-gray; massive to more thinly bedded at top	484
Dolomite, light-gray; weathers with dark-gray splotches. Very thin bedded	36
Dolomite, sandy and partly brecciated, dark-gray	23
Thickness, Ely Springs Dolomite	543
Fault; displacement probably slight.	
Eureka Quartzite:	
Sandstone, very fine, quartzitic	15
Quartzite, vitreous, white	59
Shale, black; weathers grayish red	3
Quartzite, light-brown	2.5
Sandstone, very fine, fucoidal; mottled moderate red to pale red (5*R* 5/4–5*R* 6/2)	2
Quartzite, light-brown, vitreous	2.5
Sandstone, very fine, yellowish-gray	2
Quartzite, vitreous, light-brown	3
Interlensed medium-gray dolomite and crossbedded quartzite	18
Quartzite, crossbedded, white; weathers brown	17
Dolomite, medium-gray, sandy	3
Quartzite, vitreous, white; weathers brown	7
Dolomite, medium-gray	1
Quartzite, vitreous, white; weathers brown	35
Thickness, Eureka Quartzite	170

Section of Ordovician formations, Black Gate Canyon, Sheep Range, sec. 5, T. 17 S., R. 60 E., Las Vegas 2° quadrangle, Nevada—Continued

	Feet
Ordovician—Continued	
Pogonip Group:	
Shale, silty, splintery, light-olive-brown; weathers yellowish orange, except that top 2–3 ft is dark gray	16
Dolomite, fine-grained, massive, light-gray	20
Dolomite, very sandy; crossbedded sandy streaks, weather brown	55
Dolomite, fine-grained, silty; coated with light brown. Very fine laminae defined only on weathered surface by silt	6
Fault; displacement probably not great.	
Ely Springs Dolomite; a small wedge lies in this position here and in 3 ridges to north, 32 ft thick.	
Fault.	
Pogonip Group—Continued	
Slope covered with float; a few ledges of light-gray dolomite exposed	56
Dolomite; silty light-gray dolomite alternates with very silty and sandy light-brown to grayish-orange dolomite; in 5- to 10-ft layers	58
Dolomite, medium-gray to medium-light-gray, fine-grained, thin- and even-bedded; beds 2–12 in. thick. Minor coarsely crystalline beds	13
Dolomite, thinly laminated, silty, light-olive-gray to medium-gray. Weathers light brown to moderate yellowish brown. Partly sandy	25
Dolomite, dark-gray, resistant, thick-bedded. "*Girvanella*," *Maclurites*, and *Palliseria*	13
Dolomite, thin-bedded, dark-gray, nonresistant. "*Girvanella*"	19
Dolomite, dark-gray, resistant. "*Girvanella*," *Palliseria*, and *Maclurites* throughout	78
Dolomite, breccia; blocks as much as 1 ft across composed of all lower units of the Pogonip. Matrix is sandsized and bedded. Seems sedimentary	15
Slope masked by float	12
Dolomite, dark-gray, thin-bedded; nonresistant but forms conspicuous ledges. Crowded with "*Girvanella*"	107
Dolomite, dark-gray, thin-bedded, resistant, cliff-forming. "*Girvanella*"	78
Dolomite, dark-gray, thick-bedded, resistant, cliff-forming	200
Sandstone, dolomitic, lensing	2
Dolomite, dark-gray, very resistant, thick-bedded. Crowded with "*Girvanella*"	40
Dolomite, thin-bedded, slabby, nonresistant	32
Dolomite, light-medium-gray; with relict crenulated silt partings. Massive, resistant	79
Dolomite, very fine grained, massive; weathers grayish orange. Only very slight indication of bedding	27
Dolomite, light-medium-gray, only slightly silty. Forms resistant ledges	49
Slope masked by float	42

Section of Ordovician formations, Black Gate Canyon, Sheep Range, sec. 5, T. 17 S., R. 60 E., Las Vegas 2° quadrangle, Nevada—Continued

	Feet
Ordovician—Continued	
Pogonip Group—Continued	
Dolomite with relict crenulated silty partings highly silicified to produce "crepe" effect. Very resistant	33
Dolomite, massive, resistant; in 2- to 4-ft beds with closer spaced relict silty partings	53
Slope covered with calcareous siltstone chips weathering pale to moderate brown	100
Dolomite, resistant; weathers light olive gray	106
Slope masked by chips of calcareous siltstone weathering grayish orange to light brown	93
Limestone, dolomitized, fine-grained, resistant	43
Limestone, dolomitized; in thin interbeds of fine-grained and intraformational conglomerate	28
Limestone, dolomitized; as intraformational conglomerate	64
Fault?—Breccia zone.	
Pogonip Group—Continued	
Dolomite, massive, with irregular silt partings, ledge-forming, light-brownish-gray	38
Limestone, dolomitized, thin-bedded	57
Limestone, dolomitized; as intraformational conglomerate	8
Slope covered with float	38
Limestone, dolomitized; as intraformational conglomerate	3
Slope masked by dolomitic-siltstone float; weathers light grayish orange	50
Limestone, dolomitized; as interbeds of thinly laminated and intraformational conglomerate, USGS colln. D852 CO	111
Limestone, dolomitized, finely laminated; in thin beds, forming thick resistant ledges. Cherty, but chert content decreases upward. A few very thin insignificant beds of intraformational conglomerate	330
Slope, mostly masked. Thin protruding ledges composed of light-gray and light-medium-gray dolomitized limestone as intraformational conglomerate. Slightly cherty 79 ft above base	158
Thickness, Pogonip Group	2,355
Cambrian:	
Nopah Formation:	
Dolomite, black, thick-bedded, cherty.	

NEVADA TEST SITE

Plate 1; figure 1, localities 31, 50

Because of structural complexities it is difficult if not impossible to find a complete section of the Pogonip Group on the Nevada Test Site. Byers and others (1961, p. C106–C110) compiled a composite section from three main localities and compared it with a similar section compiled by Johnson and Hibbard (1957, p. 345–350).

The lower part of the Goodwin Limestone is best exposed on Pahute Ridge in the southwest part of the Papoose Lake quadrangle (Nevada coord., central zone: E. 702,000 ft, N. 845,000 ft.). The Ninemile Formation is best exposed in the range south-southwest of Aysees Peak (Nevada coord., central zone: E. 749,800, N. 775,000 ft), as are the lower beds of the Antelope Valley Limestone. Although the entire Antelope Valley is well exposed in this area, its upper beds are offset by several faults. The apparent thickness of the Antelope Valley at this place is 1,600 feet. The beds above the *Palliseria* Zone seem to be about 300 feet thicker than the beds in the Ranger Mountains south of Frenchman Flat (Nevada coord., central zone: E. 728,000 ft, N. 741,000 ft). However, the lower beds of the Antelope Valley are badly faulted in the Ranger Mountains. As a result, thicknesses of all units are subject to error.

Measurement of the Eureka Quartzite by Byers and others (1961, table 189.1) is accurate. However, a change needs to be made in the Ely Springs Dolomite. Although poorly silicified brachiopods from the upper 170 feet (informal unit E) (USGS colln. D788 CO) include *Orthambonites* of a Middle Ordovician aspect, *Resserella?* (formerly *Parmorthis*) sp. is also present in new collections, and it is a Silurian genus. Probably this unit as well as the next lower 275 feet of informal unit D belong in the Silurian and should be removed from the Ely Springs Dolomite.

The age of the supposedly Late Ordovician brachiopod fauna reported for unit B (Byers and others, 1961, table 189.1) of the Ely Springs (USGS colln. D715 CO) can be revised slightly. *Holtedahlina*, a Middle and Upper Ordovician genus, is not correctly identified; *Furcitella*, a Middle Ordovician (Wilderness and Trenton) form, is the correct designation. The only genus lending a Late Ordovician aspect to this assemblage is *Austinella*, and Sinclair (1956, p. 127) questioned its value in differentiating between Middle and Late Ordovician ages. Therefore, contrary to recent custom, a Middle Ordovician age for a large part of the Ely Springs must be considered in the Ranger Mountains as in the Arrow Canyon Range, Spring Mountains and Quartz Spring area (California).

A most critical stratigraphic problem involves the correlation of and facies interrelation between the upper strata of the Pogonip and the lower strata of the Eureka. Preceding the discussion of the problem is a list of the fossil collections in stratigraphic order from top to bottom; not all collections are from the same measured section, but they can be pieced together without much difficulty in this area.

Fossils from Eureka Quartzite follow, listed by USGS collections:

D680 CO. Sandy limestone 60–90 ft above base of Eureka Quartzite. Nevada coord., central zone: E. 733,000 ft, N. 738,000 ft. Ranger Mountains, Frenchman Lake quadrangle, Nevada.

Valcourea cf. *V. Plana* Cooper
Plectambonitid
Illaenopsis sp.
Lonchodomas sp.
Ampyx sp.
Isotelus cf. *I. spurius* Phleger
Schmidtella n. sp. (identified by J. M. Berdan)
Eurychilina sp. (identified by J. M. Berdan)

This fauna correlates with that of the Barrel Spring Formation of the Inyo Mountains and with that of some of the lower part of the Copenhagen Formation. Jean M. Berdan (written commun., May 18, 1962) stated that the same species of *Schmidtella* occurs in USGS collection D844 CO from the *Orthidiella* Zone at Rawhide Mountain and in another collection from the Kanosh Shale of Hintze (1951) near Crystal Peak, Utah.

Fossils from Pogonip Group follow, listed by USGS Collections:

Several of the following collections are located stratigraphically relative to lettered units of Johnson and Hibbard (1957, p. 345–347). See Byers and others (1961, table 189.1).

D713 CO. Upper 10 ft of Antelope Valley Limestone, beneath Eureka Quartzite. Nevada coord., central zone: E. 732,000 ft, N. 741,000 ft. Ranger Mountains, Frenchman Lake quadrangle, Nevada.

"*Lichenaria*" cf. sp. B, with rather large corallites. W. A. Oliver, Jr. (written commun., 1963) stated that this is the same species as is found in USGS collection D378 CO.
Macrocoelia? sp.

Collection D378 CO is from the highest beds of the Lehman Formation of Hintze (1951) on Granite Peak, southern Snake Range, Nev. The genus *Macrocoelia* is known from Marmor and Porterfield rocks.

D731 CO. Antelope Valley Limestone, 5 ft below base of Eureka Quartzite. One mile south of Aysees Peak, Nevada coord., central zone: E. 755,200 ft, N. 775,900 ft. Frenchman Lake quadrangle, Nevada.

"*Lichenaria*" sp. (identified by W. A. Oliver, Jr.)
Macrocoelia? sp.

D711 CO. Antelope Valley Limestone, highest bed exposed at top of ridge, 412 ft above base of unit I of Johnson and Hibbard (1957). (This bed is stratigraphically below that containing collns. D713 CO and D731 CO.) Nevada coord., central zone: E. 728,000 ft, N. 741,000 ft. Ranger Mountains, Frenchman Lake quadrangle, Nevada.

Eofletcheria cf. sp. A (identified by W. A. Oliver, Jr.)
Favositoid corals, indet.
Bryozoan, undet.

D712 CO. Antelope Valley Limestone, in same stratigraphic position as collection D710 CO, approximately 30 ft below base of Eureka Quartzite. Exposed on dip slope to northwest of constricted wash. Nevada coord., central zone: E. 731,350 ft, No. 740,550 ft. Frenchman Lake quadrangle, Nevada.

Orthambonites cf. *O. swanensis* Ulrich and Cooper
Bryozoans, indet.
Conodonts, undet.

D710 CO. Antelope Valley Limestone, approximately 30 ft below base of Quartzite; 395 ft above base of unit I of Johnson and Hibbard. Nevada coord., central zone: E. 729,300 ft, N. 741,350 ft. Ranger Mountains, Frenchman Lake quadrangle, Nevada.

Orthambonites cf. *O. swanensis* Ulrich and Cooper
Bryozoans, indet.
Conodonts, undet.

Insoluble residues of collections D710 CO and D712 CO contain much fine quartz sand and a minor amount of coarse well-rounded and frosted quartz sand.

D709 CO. Antelope Valley Limestone, from float slightly more than 375 ft above base of unit I of Johnson and Hibbard. Nevada coord., central zone: E. 729,300 ft, N. 741,350 ft. Ranger Mountains, Frenchman Lake quadrangle, Nevada.

Orthambonites cf. *O. swanensis* Ulrich and Cooper
O. cf. *O. dinorthoides* Cooper

The species identified as *O.* cf. *O. swanensis* in collections D704 CO, D710 CO, and D711 CO was originally assigned to *O. paucicostatus.* Careful study of scores of silicified shells shows that it is closer to specimens of *O. swanensis* from the type area in the Logan quadrangle of Utah, not to specimens from the Ibex area. It is also identical to forms from Rawhide Mountain, 160 ft below a thick black shale below the Eureka Quartzite (colln. D835 CO).

D708 CO. Antelope Valley Limestone, 376 ft above base of unit I of Johnson and Hibbard. Nevada coord., central zone: E. 729,150 ft, N. 741,450 ft. Ranger Mountains, Frenchman Lake quadrangle, Nevada.

Bryozoan, undet.

D707 CO. Antelope Valley Limestone, 315 ft above base of unit I of Johnson and Hibbard. Nevada coord., central zone: E. 729,150 ft, N. 741,450 ft. Ranger Mountains, Frenchman Lake quadrangle, Nevada.

Anomalorthis sp.

D706 CO. Antelope Valley Limestone, 245 ft above base of unit I of Johnson and Hibbard. Nevada coord., central zone: E. 729,150 ft, N. 741,450 ft. Ranger Mountains, Frenchman Lake quadrangle, Nevada.

Anomalorthis nevadensis Ulrich and Cooper
A. oklahomensis Ulrich and Cooper
Bryozoan, undet.
Conodonts, undet.

D705 CO. Antelope Valley Limestone, approximately 80 ft above base of Unit 1 of Johnson and Hibbard. Nevada coord., central zone: E. 728,700 ft, N. 741,700 ft. Ranger Mountains, Frenchman Lake quadrangle, Nevada.

Desmorthis? sp.

In the lower 60 ft of unit I and most of unit H of Johnson and Hibbard, *Palliseria* is abundant, as are large *Maclurites* and small *Receptaculites*?. *Palliseria* does not seem to occur as low as *Maclurites.*

D729 CO. Antelope Valley Limestone, approximately 35 ft above base of Unit I of Johnson and Hibbard. Nevada coord., central zone: E. 753,650 ft, N. 776,350 ft. South of Aysees Peak, Frenchman Lake quadrangle, Nevada.

Anomalorthis oklahomensis Ulrich and Cooper
Bryozoans, undet.

Fossils from the Ranger Mountains Member follow, listed by USGS collections:

D719 CO. Antelope Valley Limestone, upper 100 ft of Ranger Mountains Member (unit G of Johnson and Hibbard). Nevada coord., central zone: E. 726,700 ft, N. 740,700 ft. Along both sides of broad wash at its exit from Ranger Mountains, Frenchman Lake quadrangle, Nevada. (This locality supplied most of the fauna of the *Orthidiella* Zone as originally conceived. It was here that G. A. Cooper and Josiah Bridge made collections in the early 1930's. For excellence of silicified brachiopods, few localities can better this one.) At the outset 13 collections were made from this locality to study vertical distribution of species within the 50-foot zone. To date I have not made full use of these detailed collections. A composite faunal list follows:

Small ball-shaped algae?
Orthidiella longwelli Ulrich and Cooper
O. extensa Ulrich and Cooper
O. costellata Ulrich and Cooper
O. carinata Ulrich and Cooper
?*Trematorthis tenuis* Ulrich and Cooper
Orthambonites eucharis Ulrich and Cooper
Ingria cloudi Ulrich and Cooper
Liricamera nevadensis Cooper

Near the base of this interval:

Remopleurides sp.
Cybelid pygidium
Carolinites n. sp.

D720 CO. Antelope Valley Limestone, Ranger Mountains Member (unit G of Johnson and Hibbard). Nevada coord., central zone: E. 731,000 ft, N. 744,100 ft. On point east of most easterly canyon on north front of Ranger Mountains, Frenchman Lake quadrangle, Nevada.

Orthidiella, two spp.
Orthambonites eucharis Ulrich and Cooper
Anomalorthis sp.
Ingria cloudi Ulrich and Cooper

D728 CO. Antelope Valley Limestone, 35 ft above base of Ranger Mountains Member (unit G of Johnson and Hibbard). Nevada coord., central zone: E. 750,900 ft, N. 775,300 ft. On east wall of valley, near top, 1¼ miles southwest of Aysees Peak, Frenchman Lake quadrangle, Nevada.

Orthidiella sp.
Orthambonites eucharis Ulrich and Cooper
Trinodus
Cheirurinid? cranidium
Calymenid, with a single pair of glabellar furrows
Carolinites n. sp.
Nileus sp.

D727 CO. Antelope Valley Limestone, 25 ft above base of Ranger Mountains Member (unit G of Johnson and Hibbard). Nevada coord., central zone: E. 750,900 ft, N. 775,300 ft. On east wall of valley, near top, 1¼ miles southwest of Aysees Peak, Frenchman Lake quadrangle, Nevada.

Small ball-shaped algae?
Orthidiella sp.
Orthambonites eucharis Ulrich and Cooper

Ectenonotus n. sp.? (only 11 axial rings in pygidium)
Ectenonotus cf. *E. westoni* (Billings)
Bathyurellus feitleri (Holliday)
Carolinites n. sp.
Remopleurides sp.
Cybelid, aff. "*Cybele*" *mira* (Billings)
Odontopleurid
Trinodus sp.

Concerning the ostracodes from this collection, Jean M. Berdan (written commun., 1962) reported as follows: "*Leperditella*? sp. These specimens are not too well preserved, but seem to be close to the form identified as *Leperditella*? sp. from USGS collection D821 CO, 250 ft below the *Palliseria* zone, Bare Mountain quadrangle. However, they differ in having a semicircular rather than a subtriangular lateral outline."

D718 CO. Antelope Valley Limestone, 15 ft above base of Ranger Mountains Member (unit G of Johnson and Hibbard). Nevada coord., central zone: E. 750,900 ft, N. 775,300 ft. On east wall of valley, near top, 1¼ miles southwest of Aysees Peak, Frenchman Lake quadrangle, Nevada.

Orthidiella sp.
Nileus sp.
Carolinites sp.

The faunas of the Ranger Mountains Member are believed to correlate approximately with those of zone L of Ross (1951) although there are no species in common.

Fossils from the Paiute Ridge Member follow:

D726 CO. Antelope Valley Limestone, 50 ft below top of Paiute Ridge Member (unit F of Johnson and Hibbard). Nevada coord., central zone: E. 750,850 ft, N. 775,300 ft. On east wall of valley, 1¼ miles southwest of Aysees Peak, altitude 5,600 ft, Frenchman Lake quadrangle, Nevada.

Orthambonites cf. *O. subalata* Ulrich and Cooper

D725 CO. Antelope Valley Limestone, 170 ft above base of Paiute Ridge Member. Nevada coord., central zone: E. 750,450 ft, N. 775,200 ft. On east wall of valley, 1¼ miles southwest of Aysees Peak, Frenchman Lake quadrangle, Nevada.

Hesperonomia antelopensis Ulrich and Cooper
Diparelasma? cf. *D. typicum* Ulrich and Cooper
Kirkella sp.
Lachnostoma latucelsum Ross
Goniotelina? sp.
Megalaspidella? sp.

This fauna belongs to zone J of Ross (1951) and indicates that the lower part of the Paiute Ridge Member (unit E of Johnson and Hibbard) is linked more closely by fossil assemblage to the underlying Ninemile Formation than to the overlying beds of the Antelope Valley Limestone.

D717 CO. Antelope Valley Limestone, 60 ft above base of Paiute Ridge Member (unit E of Johnson and Hibbard). Nevada coord., central zone: E. 750,850 ft, N. 775,850 ft. On east side of valley, 1¼ miles southwest of Aysees Peak, Frenchman Lake Quadrangle, Nevada.

Orthoconic cephalopods, indet.
Conotreta sp.
Conodonts, undet.

Fossils from the Ninemile Formation follow, listed by USGS collections:

D716 CO. Ninemile Formation, top 10 ft. Nevada coord., central zone: E. 750,850 ft, N. 775,850 ft. On east side of valley, 1¼ miles southwest of Aysees Peak, Frenchman Lake quadrangle, Nevada.

Orthidiella sp.
Hesperonomia sp.
Lachnostoma latucelsum Ross

This may be a mixed collection resulting from mixing of float with the sample.

D724 CO. Ninemile Formation, 180 to 195 ft above base. Nevada coord., central zone: E 750,220 ft, N. 775,200 ft. On east side of valley, 1¼ miles southwest of Aysees Peak, Frenchman Lake quadrangle, Nevada.

Hesperonomia sp.
Archaeorthis elongata Ulrich and Cooper
Kirkella sp.
Presbynileus? sp.
Pseudocybele nasuta Ross

D722 CO. Ninemile Formation, 80 ft above base. Nevada coord., central zone: E. 749,800 ft, N. 775,300 ft. On east side of valley, 1¼ miles southwest of Aysees Peak, Frenchman Lake quadrangle, Nevada.

Archaeorthis elongata Ulrich and Cooper
Trigoncerca? sp.
Hintzeia sp.
Trinodus sp.

This fauna probably correlates with zone H of Ross (1951).

D723 CO. Ninemile Formation, 10 ft above base. Nevada coord., central zone: E. 749,800 ft, N. 775,000 ft. On east side of valley, 1¼ miles southwest of Aysees Peak. Frenchman Lake quadrangle, Nevada.

Archaeorthis elongata Ulrich and Cooper
Hintzeia sp.
Trinodus sp.

Fauna of the Goodwin Limestone follows, listed by USGS collections:

D721 CO. Goodwin Limestone, 15 ft below top. Nevada coord., central zone: E. 749,800 ft, N. 775,000 ft; 1¼ miles southwest of Aysees Peak, Frenchman Lake quadrangle, Nevada.

Ampyx sp.
Protopresbynileus sp. (some pygidia as much as 5 cm long)
Asaphid, unident.

D735 CO. Goodwin Limestone, 540 ft above base. Nevada coord., central zone: E. 701,900 ft, N. 845,300 ft. West side of Pahute Ridge, Papoose Lake quadrangle, Nevada.

Clelandia or *Pseudoclelandia* sp.

D732 CO. Goodwin Limestone, in calcareous siltstones 420 ft above base. Nevada coord., central zone: E. 701,750 ft, N. 845,950 ft. West side of Pahute Ridge, Papoose Lake quadrangle, Nevada.

Nanorthis sp.

D733 CO. Goodwin Limestone, 200 ft above base. Nevada coord., central zone: E. 701,950 ft, N. 845,800 ft. West side of Pahute Ridge, Papoose Lake quadrangle, Nevada.

Xenostegium cf. *X. franklinense* Ross
Symphysurina sp.
Parabellefontia cf. *P. concinna* Hintze

This collection is equivalent to zone B of Ross (1951) and marks the base of the Ordovician through much of Utah and Nevada.

The uppermost Pogonip faunas on the Nevada Test Site are of particular significance. The positions of the *Anomalorthis*, *Palliseria*, and *Orthidiella* Zones of the Antelope Valley Limestone are obvious. These belong in Cooper's (1956) Whiterock Stage. Above the *Anomalorthis* Zone is about 100 feet of strata in which occur *Lichenaria*, *Eofletcheria*, *Macrocoelia*? sp., abundant bryozoa, and *Orthambonites* cf. *O. swanensis* Ulrich and Cooper (excluding forms from the Ibex area assigned to *O. swanensis* by Ulrich and Cooper (1938, pl. 14, figs. 25–29)).

In the area of the Confusion Range and southern Snake Range, *Lichenaria* and *Eofletcheria* were used by Hintze (1952, p. 23) as the basis for a faunal zone he designated zone O; this zone is younger than the *Anomalorthis*-bearing zones M and N. In fact, the corals of one collection (USGS D713 CO) correlate with *Lichenaria* found in the upper few feet of the so-called Lehman Formation (USGS colln. D378 CO) (uppermost Pogonip) on Granite Peak (southern Snake Range, Wheeler Peak quadrangle). This may be the place referred to by Webb (1958, p. 2351–2352).

The presence of *Macrocoelia*? sp. suggests that these highest beds at the test site are at least as young as Marmor (Chazyan).

There is no marked physical evidence for an unconformity between the *Anomalorthis* Zone and these highest beds. In between them, the presence of *Orthambonites* cf. *O. swanensis* Ulrich and Cooper suggests correlation with the lower beds of the Swan Peak Formation and with the Kanosh Shale of Hintze. It is exactly the same species of *Orthambonites* found to the north at Rawhide Mountain (p. C66, C68) (south of Tybo, Nev.); there, it is associated with *Anomalorthis* in beds of dolomitic limestone about 135 feet below the top of the Pogonip.

Originally I identified *Orthambonites* at both of these localities as *O. paucicostata* Ulrich and Cooper, a species characteristic of Cooper's *Rhysostrophia* Zone. Closer examination of about 50 specimens showed close affinities with *O. swanensis* Ulrich and Cooper.

In the Ranger Mountains on the Nevada Test Site, the *Anomalorthis*-bearing beds are succeeded conformably by beds of probable Marmor age or younger. If the *Rhysostrophia* Zone is represented, it includes the upper 30 feet of Antelope Valley strata in this area.

The fossils (USGS colln. D680 CO) from the lower part of the Eureka Quartzite correlate with beds assigned by Cooper (1956, chart 1) to his Ashby Stage. But according to Jean M. Berdan (written commun., May 18, 1962), ostracodes from this unit are very similar to those from both the Kanosh Shale in Utah and the *Orthidiella* Zone (colln. D844 CO) at Rawhide Mountain. There is an obvious relationship with presumably older ostracode faunas.

MEIKLEJOHN PEAK, BARE MOUNTAIN QUADRANGLE, NEVADA

Plate 1; figure 1, locality 32

The Bare Mountain quadrangle was mapped by Cornwall and Kleinhampl (1961). Ross and Cornwall (1961, p. 231–233) described an impressive biohermal mass in the Antelope Valley Limestone on the west side of Meiklejohn Peak.

Holliday (1942, p. 472–477) made several collections of trilobites from this peak. On the basis of present knowledge on the stratigraphy, it is probable that all the trilobites he described from the area came from the *Orthidiella* Zone of the Antelope Valley. They include *Ectenonotus* and *Bathyurellus*.

On its west and north sides, Meiklejohn Peak provides significant sections of the Pogonip Group. The three formations—Goodwin, Ninemile, and Antelope Valley—are well developed. Their development at Bare Mountain and on the Nevada Test Site is very similar. So similar is the lithic comparison between the two areas that the strong contrast in faunas of the upper 500 feet of the Antelope Valley beds is startling. No *Anomalorthis* Zone fauna has been found. Instead, above the *Palliseria* Zone is a great thickness of strata with such Marmor, Ashby, and Porterfield fossils as *Skenidioides*, *Atelelasma*, *Leptellina*, *Ptychopleurella*, *Anisocyamus*, and large *Isotelus*.

In transitional sandy beds at the top (USGS collns. D824 CO, D833 CO, D820 CO) are *Oxoplecia monitorensis*, *Sowerbyella perplexa*, and *Laticrura*. This fauna is a mixture of Ashby and Porterfield species.

As at the Nevada Test Site, there is no obvious physical unconformity between the highest Whiterock fauna (here, the *Palliseria* Zone) and the lowest Marmor and Ashby forms. The change from limestone to quartzite at the top of the Pogonip is a gradational one.

On the southwest face of Meiklejohn Peak, Cornwall and Kleinhampl's original section was remeasured, and fossils were collected from it. Above the *Palliseria* Zone, brecciation and dolomitization indicates the possible presence of a fault.

A second section, measured north of the peak, exposes 350 more feet above the *Palliseria* Zone than does the section on the west side. Furthermore, a fauna including *Skenidioides* (USGS colln. D829 CO) is present on the north side of the peak but not on the west. I believe that the section on the north is complete, although it may have been lengthened by faulting. Possibly the fault that shortens the section on the west side of the mountain extends into the north side and cuts out the *Anomalorthis* Zone, but I have failed to recognize such an extension.

Measured sections follow and are in turn followed by fossil lists. The section at Meiklejohn Peak is basically the same section as that measured by Cornwall and Kleinhampl (1961). However, for the present report the lower 600 feet was measured about 200 yards east of their section.

Because of topography and a very large bioherm (Ross and Cornwall, 1961, p. B231–B233), the upper part of the section was measured over essentially the same route. This course was unfortunate inasmuch as it closely parallels a conspicuous fault (see Cornwall and Kleinhampl 1961, geologic map); a second partial section was measured in NW¼SE¼ sec. 13, T. 12 S., R. 47 E., to get away from this fault. Although less than a mile away, this partial section seems to indicate a greater thickness than that measured on Meiklejohn Peak itself.

Section of the Pogonip Group on southwest side of Meiklejohn Peak, Bare Mountain quadrangle, Nevada, SW¼ NE¼ sec. 24, T. 12 S., R. 47 E.

[Fig. 1, loc. 32; pl. 1]

	Feet
Ely Springs Dolomite (approx. 150 ft).	
Eureka Quartzite (approx. 300 ft):	
Calcareous sandstone and quartzite	32
Pogonip Group:	
Antelope Valley Limestone:	
Limestone, very sandy. *Sowerbyella* abundant at top of this unit. Colln. D820 CO from top	6
Limestone, slabby; very sandy with interbeds of siltstone; yellowish brown, calcareous	25
Limestone, dark-gray, silty, thin-bedded, partly nodular. Silicified brachiopods, part of USGS colln. D819 CO from float 41–60 ft above base of this interval	75
Limestone, dark-gray, thin-bedded; silty with interbeds of less silty nodular fossiliferous limestone. Part of USGS colln. D819 CO from float 19 ft above base	74
Dolomite, light-gray, brecciated. Fault(s) may cut the section in this interval	124
Limestone, resistant, dolomitic, dark-gray; faint irregular laminations suggested in otherwise massive rock. *Palliseria* 10 ft below top. "*Girvanella*" common 48–170 ft above base. Numerous cephalopod siphuncles in lower 50 ft	181
Limestone, nodular, silty, weak, slope-forming. Silt and siliceous content increases upward. *Orthidiella* in USGS colln. D818 CO is 85 ft above base. USGS colln. D821 CO is 60 ft above base	99

Section of the Pogonip Group on southwest side of Meiklejohn Peak, Bare Mountain quadrangle, Nevada, SW¼ NE¼ sec. 24, T. 12 S., R. 47 E.—Continued

	Feet
Pogonip Group—Continued	
Antelope Valley Limestone—Continued	
Limestone, silty, nodular, resistant; forms low ledge	20
Limestone, knobby, silty, very weak	7
Limestone, massive; dark-gray splotched with lighter silty areas; partly fine grained with a few layers, 8 in. thick, composed of coarse bioclastic debris	18
Limestone, ledge-forming, bioclastic, coarsely crystalline, abundantly fossiliferous	16
Limestone, nodular, silty, thin-bedded	32
Limestone, aphanitic to fine-grained, light-gray, biohermal; poor, if any, bedding	163
Limestone, fine-grained bioclastic; in lower part, interbedded with thinly irregularly bedded nodular silty limestone. *Hesperonomia* sp. and *Archaeorthis* sp. present	32
Limestone, impure; has irregular silty partings; forms massive 1- to 3-ft ledges	5
Limestone with abundant siliceous silty partings interlaced to give "crepe" effect on weathered surface	31
Thickness, Antelope Valley Limestone	908
Ninemile Formation:	
Siltstone, with limestone nodules, and nodular silty limestone. More resistant than underlying unit	77
Shale, papery; weathers olive green; interlayered in equal parts with nodular silty limestone beds. USGS Colln. D828 CO taken 2 ft above base of this unit	84
Shale, greenish-black, very fissile, papery; in 3- to 6-in. beds, interlayered with medium-gray limestone in 1-in. layers	71
Thickness, Ninemile Formation	232
Goodwin Limestone:	
Limestone, composed of intraformational conglomerate in beds 1–7 ft thick. USGS collns. D739 CO and D827 CO 6 ft below top. This unit forms cliffy ledge	79
Limestone, silty; with interbeds of limestone and intraformational conglomerate. Silt tends to be silicified in upper 30 ft	49
Limestone, fine-grained; in massive 2- to 15-ft beds composed of 1- to 2-in. irregular laminae welded together. These laminae delineated by silt content. Limestone weathers medium light gray	27
Limestone, very silty; with silt partially silicified and more resistant than underlying unit. Pure limestone interbeds not conspicuous	51
Limestone, nodular, silty; in 2- to 4-in. layers interbedded with fine-grained limestone in 3-in. to 2-ft layers. Silt weathers conspicuous yellowish orange (10*YR* 7/6)	53
Limestone, fine-grained to aphanitic, resistant, thinly laminated (½- to 2-in. layers). Silty content increases upward. USGS colln. D702 CO from lower 10 ft	27
Limestone, slightly cherty; irregularly laminated with siliceous partings between laminae	19

Section of the Pogonip Group on southwest side of Meiklejohn Peak, Bare Mountain quadrangle, Nevada, SW¼ NE¼ sec. 24, T. 12 S., R. 47 E.—Continued

	Feet
Pogonip Group—Continued	
Goodwin Limestone—Continued	
Limestone, in 1- to 2-in. laminae separated by silty material. Laminae lensing. USGS colln. D826 CO taken 5 ft above base of this unit	33
Limestone and dolomite interbedded; both composed of 1-in. laminae, in part interlensed. Limestone is medium light gray with a faint blue cast	11
Dolomite, light-gray, in 1- to 6-in. beds, slightly cherty. USGS colln. D817 CO	9
Thickness, Goodwin Limestone	358
Nopah Formation:	
Dolomite, massive, light-gray.	

Fossil collections from the section on the southwest side of Meiklejohn Peak are listed below by USGS collections:

D820 CO. Antelope Valley Limestone, from upper 6 ft. Meiklejohn Peak, SW¼NE¼ sec. 24, T. 12 S., R. 47 E. Bare Mountain quadrangle, Nevada.
Glyptorthis sp.
Sowerbyella cf. *S. perplexa* Cooper
Macrocoelia? sp.
Protozyga? sp.

D819 CO. Antelope Valley Limestone, from float collected 100–210 ft below base of main body of Eureka Quartzite. This collection correlates with collection D831 CO from the section north of Meiklejohn Peak.
Valcourea sp.
Ptychopleurella n. sp.
Hesperorthis cf. *H. antelopensis* Cooper (immature)
Atelelasma n. sp.
Leptellina occidentalis Ulrich and Cooper
cf. *L. occidentalis* Ulrich and Cooper
Two unidentified orthid species
cf. *Parastrophina*? sp.

Valcourea, Hesperorthis, and *Atelelasma* are not known as genera in rocks older than the Marmor Stage according to Cooper (1956, p. 138–146). Previously *Leptellina occidentalis* was reported from the *Rhysostrophia* zone of the Whiterock Stage, but only in the Toquima Range. The possible age of the collection is Marmor to Porterfield with a single Whiterock species. Because the *Leptellina occidentalis* came from the same block of limestone as the supposedly younger species, its presence cannot be attributed to the fact that the collection is from float.

D818 CO. Antelope Valley Limestone, 340 ft above base of biohermal limestone. West side of Meiklejohn Peak. Bare Mountain quadrangle, Nevada.
Orthidiella longwelli Ulrich and Cooper
cf. O costellata Cooper
Agnostid trilobite
Dimeropygid trilobite
Dasycladacean algae

D821 CO. Antelope Valley Limestone, 315 ft above base of biohermal limestone. West side of Meiklejohn Peak. Bare Mountain quadrangle, Nevada.

Orthidiella cf. *O. longwelli* Ulrich and Cooper
Anomalorthis cf. *A. lonensis* (Walcott)
Orthambonites sp.
Dasycladacean algae

Concerning the ostracodes from this collection, Jean M. Berdan (written commun., 1962) reported: "This collection contains *Eoleperditia* sp. aff. *E. bivia*, *Leperditella*?, *Aparchites*?, ?*Ballardina simplex* Harris, and unidentified small smooth ostracodes. *Eoleperditia* sp. aff. *E. bivia* and *Ballardina simplex*? occur in the lower part of the Antelope Valley Formation in Goodwin Canyon, in the Eureka District. The other forms listed here also occur in the Antelope Valley Formation elsewhere in Nevada, but seem to have longer ranges. The form listed as *Eoleperditia* sp. aff. *E. bivia* is not *E. bivia* s.s., but a closely related species, which may prove to have stratigraphic value."

D740 CO. Antelope Valley Limestone, from thin lens composed almost entirely of a single species of brachiopod. Approximately 100 feet above base of bioherm.

Idiostrophia nuda Cooper

Cooper (1956, p. 126) listed this species in his *Orthidiella* zone.

D828 CO. Ninemile Formation, approximately 85 ft above base.

Hesperonomia sp.
Lachnostoma sp.
Kirkella sp.
Dimeropygiella sp.
Carolinites sp.
Protopresbynileus sp.
Ampyx? sp.

This is a typical Ninemile assemblage correlating with zone J of Ross (1951.)

D703 CO. Ninemile Formation, approximately 40 ft above base.

Trinodus sp.
Ampyx sp.

D739 CO. Goodwin Limestone, upper 10 ft.

Protopresbynileus sp.
Conodonts, undet.

D827 CO. Goodwin Limestone, upper 10 ft.

Aulacoparia sp.
Protopresbynileus sp.
Conodonts, undet.

D702 CO. Goodwin Limestone, approximately 70 ft above base.

Bellefontia sp.
Symphysurina sp.

D826 CO. Goodwin Limestone, approximately 20 ft above base.

Xenostegium sp.

D817 CO. Goodwin Limestone, approximately 10 ft above base.

Conotreta sp.
Apatokephalus sp.

A partial section was measured for comparison with the section southwest of Meiklejohn Peak, which could have been affected by proximity to a large fault. This section shows a seemingly greater thickness of about 350 feet. The faunal zone represented by USGS collection D829 CO (*Desmorthis*, *Skenidioides*, and *Leptellina*) was not found in the section west of the peak but should be present in a zone now occupied by brecciated dolomite. USGS collection D831 CO of this section correlates with USGS collection D819 CO of the western section. There is a very large stratigraphic spread between the site of collection of D831 CO and the Eureka Quartzite in the northern section, but the spread is much shorter in the western section. It is possible that the western section has been shortened by two faults, although the northern section may have been lengthened by a fault above collection D832 CO that was not observed.

Section of Eureka Quartzite and Antelope Valley Limestone north of Meiklejohn Peak, measured upward from top of the Palliseria *Zone. Eastward and upward diagonally across ridge in N½SE¼ sec. 13, T. 12 S., R. 47 E. Nevada coord., central zone: E. 500,100 ft, N. 779,000 ft; E. 500,700 ft, N. 778,950 ft*

[Fig. 1, loc. 32; pl. 1]

	Feet
Eureka Quartzite (approx. 360 ft thick):	
Quartzite, massive	300±
Limestone, very sandy; weathers light medium gray	7
Quartzite, vitreous	6
Siltstone, calcareous	11
Sandstone, calcareous, fine-grained	4
Thickness, Eureka Quartzite	328
Pogonip Group:	
Antelope Valley Limestone:	
Siltstone, calcareous, and silty limestone, interbedded. USGS colln. D824 CO	13
Limestone, silty, fossiliferous. USGS colln. D833 CO	4
Siltstone and very fine sandstone, both calcareous	12
Siltstone, calcareous, weak	19
Sandstone, fine-grained, very-calcareous, light-medium-gray. Looks like a limestone	3
Limestone, slabby, nodular, very thin bedded; largely covered with float	280
Limestone, dark-gray, thin-bedded, slabby; interspersed with thick (3 ft) beds of resistant limestone. Resistant-limestone ledges thin in lower 50 ft. Prominent ledges 70, 94, and 167 ft above base. Fossils collected 25–50 ft above base, USGS colln. D829 CO; 55–75 ft above base, colln. D825 CO; 138 ft above base, colln. D830 CO; 207 ft above base, colln. D831 CO; and 247 ft above base, colln. D832 CO	247
Limestone, massive, dark-gray. "*Girvanella*" in lower 75 ft. Top of *Palliseria* Zone used arbitrarily as base of this interval, although *Palliseria* and this lithology continue lower	141
Partial thickness, Antelope Valley Limestone	719

Fossils from the section on the north side of Meiklejohn Peak are listed below by USGS collections:

D824 CO. Antelope Valley Limestone, transition beds, approximately 35 ft below base of massive quartzite of the Eureka. Correlates with collection D820 CO.

Oxoplecia monitorensis Cooper
Sowerbyella cf. *S. perplexa* Cooper
Laticrura cf. *L. heteropleura* Cooper
Illaenus cf. *I. utahensis* Hintze
Bryozoans, unident.

This fauna is of Porterfield age although the trilobite suggests Whiterock equivalence.

D833 CO. Antelope Valley Limestone, transition beds, approximately 43 ft below base of massive quartzite of the Eureka.

Stromatoporoid?, undet.

D832 CO. Antelope Valley Limestone, approximately 360 ft below base of massive quartzite of the Eureka and 385 ft above *Palliseria* Zone.

Sowerbyella?
Calliops sp.
Pseudomera? sp.

Concerning the ostracodes from this collection, Jean M. Berdan (written commun., 1962) reported: "Collection D832 CO contains small ostracodes preserved as internal molds of calcite. Because of the type of preservation, they cannot be identified, and they do not break out of the rock. The general shape suggests *Leperditella*, but they could equally well be several other genera."

D831 CO. Antelope Valley Limestone, approximately 40 ft lower than collection D832 CO.

Atelelasma sp.
Leptellina occidentalis Ulrich and Cooper
Skenidioides sp. (immature)
Orthambonites sp. (immature)
Conodonts, undet.

This fauna is a mixture of Porterfield and Marmor elements.

D830 CO. Antelope Valley Limestone, 70 ft lower than collection D831 CO.

Orthambonites? sp.
Valcourea? sp.
Leptellina? sp.
Remopleurides cf. *R. similus* Whittington
Calliops sp.
Isotelus sp.

D825 CO. Antelope Valley Limestone, 70 ft below collection D830 CO and 30 ft above collection D829 CO.

Isotelus sp. (large with stout genal spines)
Remopleurides sp.
Conodonts, undet.

Concerning ostracodes in this collection, Jean M. Berdan (written commun., 1962) reported as follows:

"*Anisocyamus* sp.
Winchellatia? sp.

These genera suggest an age younger than Whiterock, as neither genus occurs below the McLish in Oklahoma."

D829 CO. Antelope Valley Limestone, 530–550 ft below base of massive quartzite of the Eureka. Approximately 180 ft above highest occurrence of *Palliseria*.

Paterula sp.
Leptellina occidentalis Ulrich and Cooper
Strophomena? sp.
Desmorthis? sp.
Skenidioides oklahomensis Cooper
Lophospira? sp.
Calliops sp.
Remopleurides sp.
Isotelus? sp.
Conodonts, undet.

Concerning the ostracodes from this collection, Jean M. Berdan (written commun., 1962) reported as follows: "Aparchitid? ostracodes. These specimens are crudely silicified, and the marginal structures are not certainly determinable. Although in general outline they resemble *Anisocyamus*, there are no heteromorphic valves in this collection, and the free margins appear to be different. Therefore, they are tentatively placed with the aparchitids rather than the primitiopsids such as *Anisocyamus*." This fauna is composed of a mixture of Porterfield and high Whiterock forms.

Of the collections listed above, D832 CO, D831 CO, D830 CO, D829 CO, and D825 CO are puzzling for two reasons. They hold a stratigraphic position in which one might expect to find the *Anomalorthis* Zone fauna of the Whiterock Stage, and yet no faunal element of that zone is present in them. Their fauna is composed of genera and species, particularly *Atelelasma* and *Skenidioides*, which are not known below the Porterfield or Marmor Stages.

One species, *Leptellina occidentalis*, was listed by Cooper (1956, p. 127) in his *Rhysostrophia* Zone of the Whiterock Stage; he (chart 1) indicated that Whiterock strata are separated in Nevada from overlying rocks of Ashby and Porterfield age by an unconformity representing all of Marmor and most of Ashby time. The mixture of these species suggests that *L. occidentalis* is long ranging or that no unconformity exists.

QUARTZ SPRING AREA, CALIFORNIA

Plate 1; figure 1, locality 3

Composite section of Ely Springs Dolomite, Eureka Quartzite, and Pogonip Group north of Teakettle Junction, Dry Mountain quadrangle

[Information presented by J. F. McAllister (1952, p. 10–15) (in quotation marks below) is supplemented and modified by measurements made by him, D. C. Ross, and me in April 1962. Modifying measurements were made along three ridges, the California, zone 4, coordinates of which follow: Lower part of the Ely Springs Dolomite, E. 2,428,-100 ft, N. 535,000 ft; transition beds between Eureka Quartzite and Pogonip Group, E. 2,429,000 ft, N. 533,000 ft; equivalent of the Goodwin Limestone, E. 2,425,700 ft, N. 532,650 ft and E. 2,424,800 ft, N. 533,850 ft]

	Feet
Ely Springs Dolomite:	
Dolomite, light-gray grading downward into conspicuously dark-gray. Lower part cherty. Brachiopods from approximately 200 ft above base in USGS colln. D1014 CO; from 25 ft above base in USGS colln. D1013 CO; from 10 ft above base in USGS colln. D1012 CO	910
Quartzite, dolomitic, resistant; weathers brownish	10
Dolomite, dark-gray. *Maclurites* sp. (large)	18
Thickness (rounded) Ely Springs Dolomite	940
Eureka Quartzite:	
Quartzite, vitreous, thick-bedded, coarsely jointed	250
Quartzite, interbedded dark hematitic, light vitreous, and platy. Crossbedded	79
Quartzite; weathers dusky brown. A distinct marker bed in this area	20
Quartzite, vitreous	2
Quartzite, crossbedded in 3- to 6-in. thick beds	12
Sandstone, dolomitic; weathers pale yellowish orange to dusky brown	3
Quartzite, crossbedded, lensing; beds very variable in thickness	31
Quartzite, vitreous, "*Scolithus*" tubes	3
Thickness, Eureka Quartzite	400
Pogonip Group:	
Antelope Valley Limestone:	
Covered interval	17
Dolomite, silty, soft; weathers dark yellowish orange. USGS colln. D1022 CO taken for possible conodonts	5
Dolomite, medium-gray to medium-dark-gray; in thin 1-ft beds; mottled with coarse and fine dolomite in network pattern	8
Fault present but displacement easily compensated. Dolomite, sandy; weathers grayish orange to moderate brown	4
Dolomite, dark-gray in beds 1–3 ft thick, each composed of layers 1–6 in. thick	3
Dolomite, mottled; nodular with silty partings. Silt weathers yellowish. Layers vary from 1 in. to 2 ft	23
Dolomite, fine-grained, light-brownish-gray; weathers yellowish gray	9
Dolomite, laminae ¼–1 in. thick; weathers yellowish gray. Chert nodules in middle of interval	19
Dolomite; forms ledges 3–4 ft thick; chert nodules in crude layers about 6 in. apart; weathers medium gray	7
Sandstone, fine-grained, dolomitic; weathers grayish orange to grayish brown. Weak, slope forming. Silicified bryozoans, stromatoporoids	9

Composite section of Ely Springs Dolomite, Eureka Quartzite, and Pogonip Group north of Teakettle Junction, Dry Mountain quadrangle—Continued

	Feet
Pogonip Group—Continued	
Antelope Valley Limestone—Continued	
Dolomite, medium-gray; forms ledges 3–12 in. thick. Abundant pelmatozoan debris	26
Dolomite, medium-light gray, splotched with pale yellowish orange along sandy streaks. Forms 2- to 3-ft ledges composed of 6- to 12-in. layers with ½-in. laminae or with fine compact dolomite	21
Limestone, dolomitic, silty, weak; forms masked slope	22
Dolomite, dark-gray, thick- to thin-bedded. Abundant *Girvanella, Palliseria,* and *Maclurites.* These forms absent from lower 50–100 ft, which is evenly bedded, resistant. Fossil USGS colln. D1009 CO from 75 feet above base. Lower 40 ft composed of dolomite weathering yellowish-orange. USGS colln. D1011 CO from this interval	315
"Light-buff or yellowish shaly limestone, sparsely fossiliferous; very poorly exposed; forms shoulders on spur"	50
"Brown-weathering siliceous beds, largely chert, tend to predominate over the gray limestone, which remains in nodules and lenses where the thin siliceous layers touch at undulations, producing a crepe structure. The proportion of siliceous material decreases gradually upward; and decreases abruptly at the base, where the lowest 35 ft is a platy gray limestone with ocherous irregular partings, and contains fragments of poorly preserved fossils. The shaly rock at the base emphasizes the cliff-forming quality of the unit, which makes it one of the most conspicuous of the Pogonip." *Kirkella* occurs at top of this interval. USGS colln. D1010 CO from upper 50 ft	185
Total, Antelope Valley Limestone	723
Ninemile Formation (McAllister's (1952, p. 11) unit 7):	
"Float of light-brown shale containing fossil fragments; does not crop out along line of section." This unit contains an abundant and typical Ninemile fauna	145
	145
Goodwin Limestone (McAllister's (1952, p. 11) units 1–4 modified):	
"Light-gray limestone and dolomite, weathering brownish gray, contains many siliceous beds, up to 4 in. thick, that tend to merge at crenulations making a crepe structure especially in lower half, which from a distance is browner than the mouse gray of the upper half. About 70 ft from the base of the unit, some intraformational breccia of particles about one-half inch thick in a clastic matrix some cross-bedding; numerous veinlets of white calcite"	190
"Buff-weathering shaly dolomite crops out poorly." This interval locally composed of slabby interlaminated limestone and yellowish-orange siltstone	60
Dolomite, medium-gray; forms resistant ledges 1–2 ft thick	26
Dolomite, fine-grained; in 2- to 3-ft beds interlayered with thinly laminated silty dolomite	10

Composite section of Ely Springs Dolomite, Eureka Quartzite, and Pogonip Group north of Teakettle Junction, Dry Mountain quadrangle—Continued

	Feet
Pogonip Group—Continued	
Goodwin Limestone—Continued	
Dolomite, fine-grained; forms resistant ledges 2–3 ft thick	11
Limestone, dolomitic, silty, thinly laminated; weathers with yellowish streaks	18
Dolomite, granular, even-bedded; probably derived from bioclastic limestone	17
Dolomitized intraformational conglomerate in 2- to 3-ft beds. Cherty near top	28
Fault; displacement unknown.	
Limestone, slabby, thin-bedded, silty. Weathers with yellow-orange streaks where silty	19
Dolomite, thin-bedded; in layers 1–12 in. thick. Abundant chert stringers 10–30 ft above base and in top 7 ft. Weathers light medium gray with yellowish-brown streaks	69
Total thickness, Goodwin Limestone	448
Nopah Formation:	
Dolomite, dark-gray.	

Fossils from the Quartz Springs sections are listed here by USGS collections:

D1014 CO. Ely Springs Dolomite, approximately 230 ft above base. Preservation poorly silicified.
Rhychonellid brachiopod
Sowerbyellid brachiopod

D1013 CO. Ely Springs Dolomite, 55 feet above base. California coord., zone 4: E. 2,428,100 ft, N. 535,000 ft.
Paucicrura cf. *P. subplana* Cooper
Sowerbyella sp.

D1012 CO. Ely Springs Dolomite, 34 ft above base. California coord., zone 4: E. 2,428,100 ft, N. 535,000 ft.
Paucicrura cf. *P. subplana* Cooper
Sowerbyella sp.

The fossils in collections D1014 CO, D1013 CO, and D1012 CO are probably of Middle Ordovician, Trenton age. The presence, in the lower 20 ft of the formation, of *Maclurites* similar to *M. magna* is a further indication of a Middle Ordovician age at least for the lower part of the Ely Springs.

D1022 CO. Antelope Valley Limestone, approximately 20 ft below top. California coord., zone 4: E. 2,429,200 ft, N. 533,000 ft.
Conodonts, undet.

D1009 CO. Antelope Valley Limestone, 310 ft above base and approximately 70 ft above base of cliff-forming unit below *Palliseria* Zone. California coord., zone 4: E. 2,429,000 ft, N. 533,000 ft.
Orthambonites subalata Ulrich and Cooper
Orthidiella sp.
Anomalorthis sp.

This collection is in the *Orthidiella* Zone and correlates with zone L of Ross (1951).

D1011 CO. Antelope Valley Limestone, 70 ft lower than colln. D1009 CO at same locality. Equals base of McAllister's unit 8.
Conodonts, undet.

D1010 CO. Antelope Valley Limestone, 165 ft above base, 20 ft below top of McAllister's unit 6. Same locality as colln. D1009 CO.
Archaeorthis? sp.
Kirkella sp.
Presbynileus? sp.

The Ninemile Formation is limited lithically to the 145 feet of greenish shale and siltstone that McAllister called unit 5 (1952, p. 11). Its fauna includes *Hesperonomia*, *Archaeorthis*, *Dimeropygiella*, *Kirkella*, *Lachnostoma*, and *Pseudocybele*.

As at the Nevada Test Site, some of the overlying limestones of McAllister's units 6 and 7 should be included in the Ninemile because several of these genera or genera with correlative ranges occur in them. The possibility of this inclusion must be considered seriously but requires additional regional investigation on geographic changes in lithology.

This section is particularly important in providing both stratigraphic and faunal evidence for the Middle Ordovician age of the lower part of the Ely Springs. I do not feel that the pure 10-foot quartzite bed found locally in the lower 30 feet of the formation can be the result of the reworking of Eureka sands after a long period of erosion or nondeposition; instead, I believe that it indicates unstable conditions during a change from sand to carbonate deposition with little or no unconformity.

NORTHERN INYO MOUNTAINS, CALIF.

Plate 1; figure 1, localities 2, 8

The Ordovician section of the northern Inyo Mountains was first described by Kirk (1918, p. 22, 34–36) and compared very loosely with correlative rocks in central Nevada. Phleger (1933) named the Mazourka and Barrel Spring Formations in this area and reported on the faunas of each briefly. Cooper (1956, p. 129–130, chart 1) reinterpreted some of Phleger's fauna and correlated the Mazourka with his Whiterock Stage and the Barrel Spring with the Ashby or Porterfield. Langenheim and others (1956) measured Phleger's type sections and published a fairly detailed stratigraphic column. They placed all beds between the top of the Mazourka and base of uninterrupted dark Ely Springs Dolomite in a Eureka Group. In 1960 Pestana named and described the Johnson Spring Formation based on the interbedded quartzites and dolomites above the Barrel Spring and below the Ely Springs beds. Pestana described several corals and a single brachiopod from the Johnson Spring and Barrel Spring Formations.

D. C. Ross (1964) mapped the Independence quadrangle, and in conjunction with that study he made a detailed comparison of the Ordovician rocks from north to south in the northern Inyo Mountains. Here I present a composite section compiled by him. As a result of his studies he recently (1963) revised the terminology of the Mazourka Formation of Phleger (1933).

In the Inyo Mountains section the Barrel Spring Formation, particularly its upper half, is composed of "Western-facies" lithology. The occurrence of *Dicellograptus sextans* Hall in the formation indicates correlation with the early Caradoc zones of *Nemagraptus gracilis* and *Climacograptus bicornis* (zones 9–10 of Elles and Wood, 1914, p. 514–526). These zones are probably equivalent to the Porterfield or Wilderness Stages (Ross and Berry, 1963, table 1).

Palliseria occurs high in the Badger Flat Limestone above and associated with *Rhysostrophia*. Both are significant zone fossils according to Cooper's (1956, table 1) scheme, in which, however, *Palliseria* is shown to occur considerably below *Rhysostrophia*.

Composite section of Ordovician formations, Independence quadrangle, Inyo County, Calif.

[California, zone 4, coordinates follow: Ely Springs Dolomite, E. 2,273, 400 ft, N. 574,700 ft; Johnson Spring Formation, E. 2,273,740 ft, N. 575,750 ft; Barrel Spring Formation, E. 2,274,000 ft, N. 571,150 ft; Badger Flat Limestone, E. 2,272,800 ft, N. 586,000 ft; Al Rose Formation, E. 2,272,800 ft, N. 586,000 ft. Compiled by D. C. Ross]

	Feet
Ely Springs Dolomite:	
Chert, dark-gray to black, massive, brecciated	10
Dolomite, medium-gray. Weathers light gray; weathered surface has varied gray-banded appearance. Very thin irregular bedding	13
Dolomite, dark-gray, weathering dark to light gray, and black chert in regular to nodular interbeds of 1–4 in	15
Dolomite, medium-gray; weathers light gray; thin to thick bedded; but massive outcrop. Scattered plematozoan fragments	64
Dolomite, dark-gray; weathers medium dark gray; massive. Scattered black chert in nodules and thin nodular beds	57
Dolomite, dark-gray, nodular beds from 1–5 in. thick interlayered with nodular black chert beds from 1–3 in. thick. Scattered pelmatozoan fragments	22
Dolomite, dark-gray; massive layers several feet thick that contain some irregular dark lenses and wispy layers that are laminated to thin bedded	19
Total thickness, Ely Springs Dolomite	200
Johnson Spring Formation:	
Quartzite, white to gray, fine-grained, massive. (Langenheim's unit 27)	17
Dolomite, dark-gray; weathers medium light gray; massive to poorly bedded, scattered black-chert nodules, some fossil debris	20

Composite section of Ordovician formations, Independence quadrangle, Inyo county, Calif.—Continued

	Feet
Johnson Spring Formation—Continued	
Limestone, dark-gray; scattered black-chert nodules and gastropod fragments	4
Limestone, dark-gray; irregular nodular bedding accentuated by dark-gray argillaceous layers that weather medium gray. Dark-gray mudstone about 20 ft below top. Corals and bryozoans (USGS colln. D1008 CO) about 10 ft above base	43
Quartzite, very light gray to white; locally weathers shades of red and yellow; calcareous cement in part. (Langenheim's unit 21)	34
Limestone, dark-gray; weathers medium to light gray in thin nodular beds. Minor reddish-brown-weathering lenses. Coral and other fossile fragments (USGS colln. D1025 CO)	20
Calcareous quartz sandstone, reddish-brown-weathering thin-bedded siltstone, medium-gray fossiliferous limestone, dark-medium-gray dolomite, and minor white quartzite in interbedded sequence; overall appearance is reddish-brown	26
Quartzite, white, massive	2
Dolomite, sandy(?), light-medium-gray, massive to thick-bedded; considerable pelmatozoan debris	5
Silty siliceous layer, light-olive-gray to medium-light-gray; weathers light brown to moderate reddish brown, is laminated to very thin bedded. Colln. D1023 CO from equivalent unit to north	6
Quartzite, white to yellowish-gray; in part well bedded and crossbedded; coarser than overlying quartzite units, calcareous cement near base	35
Total thickness (rounded), Johnson Spring Formation	212
Barrel Spring Formation:	
Shale and mudstone, grayish-black; weathers moderate to dark reddish brown or, less commonly, silvery gray; thinly laminated in part with shaly to flaggy parting. Sandy and silty layers near top. Brachiopods, trilobites, graptolites, and ostracodes (USGS colln. D1005 CO) in lower 5 ft. Brachiopods (USGS colln. D924 CO, D1017 CO) also common 60 ft from top	78
Limestone, medium-dark-gray; weathers medium gray to medium bluish gray, irregular nodular beds from ½ to 3 in. thick. Interbedded with light-brown-weathering lenticular layers that weather out in relief	29
Impure mixture of sand and carbonate; much now calchornfels. Thin bluish-gray limestone beds near base and impure quartzite near top	50
Total thickness, Barrel Spring Formation	157

Composite section of Ordovician formations, Independence quadrangle, Inyo county, Calif.—Continued

	Feet
Mazourka Group:	
Badger Flat Limestone:	
Limestone, medium-gray, very thinly irregularly bedded, interlayered with nodular beds and lenses of brown-weathering silty material. Rare black-chert layers as much as half an inch thick. Abundant pelmatozoan fragments and some bryozoan and brachiopod fragments; USGS colln. 1002 CO from top 10 ft	41
Quartzite, dark-gray to light-gray; weathers to knobby brownish surface in beds 6 in.–1 ft thick. Some calcareous cement	5
Siltstone(?), somewhat calcareous, medium-gray; weathers dark yellowish orange to light brown. Scattered crinoidal debris. (A very distinctive "yellow" layer in outcrop.)	12
Limestone, medium-gray; very thin irregular bedding, abundant yellowish argillaceous or silty lenses and nodules, scattered pelmatozoan fragments	23
Quartzite, medium-gray; weathers brownish and knobby. Some calcareous cement, also lenticular limestone in this layer	8
Limestone, medium-gray to dark-gray. Irregular lenses of yellowish- to brownish-weathering argillaceous and silty material give outcrops the nodular bedded appearance so typical of the upper part of the Pogonip (or upper part of the Mazourka). Fossils locally very abundant: large gastropods including *Palliseria*? and straight cephalopods at upper contact, cystid plates a few feet down, *Receptaculites*, *Rhysostrophia* and gastropods about 100 ft below top; about 40 ft farther down are more brachiopods and trilobite fragments. USGS colln. D1003 CO approximately 85 ft below top; USGS colln. D1004 CO about 125 ft below top; USGS colln. D922 CO about 155 ft above base	489
Limestone, gray, very thin bedded; minor black chert	8
Total thickness, Badger Flat Limestone	586
Al Rose Formation:	
Shale and mudstone, medium-dark-gray to olive gray—weathers light brown to moderate reddish brown—in layers 2 in. thick interbedded with gray limestone in beds as much as half an inch thick. *Didymograptus protobifidus* Elles a few feet from top (USGS colln. D811 CO). Regularly bedded unit, which is probably equivalent to Langenheim's (Langenheim and others, 1956) unit 4	52

Composite section of Ordovician formations, Independence quadrangle, Inyo county, Calif.—Continued

	Feet
Mazourka Group—Continued	
Al Rose Formation—Continued	
Argillaceous and silty layers, medium-gray—weathers dark yellowish orange to light brown—interlayered with medium-gray limestone in very thin irregular beds. Percentages vary, but generally silty material predominates over limestone in eyelike lenses ("crepe" effect). Outcrops have an overall brownish cast in contrast to the bluish color of the upper part of the Pogonip. Brachiopod and trilobite fragments locally 100–200 ft above base USGS colln. D1024 CO) and 63 ft above base USGS colln. D919 CO)	300–400?
Limestone, medium-gray, very thin bedded to laminated; minor black chert near base. Edgewise conglomerate layer about 6 in. thick associated with bioclastic layers about 3 ft below top	13
Thicgness, Al Rose Formation	500?

Fossil collections from the northern Inyo Mountains sections include the following:

D1008 CO. Johnson Spring Formation, approximately 140 ft above base in lithology similar to that of Ely Springs. California coord., zone 4: E. 2,273,750 ft, N. 575,750 ft.

Streptelasmid corals, small
Palaeophyllum sp.
Lichenaria sp.
Dinorthid, smooth, indet. (fragment)
aff. *Nicollella* sp. (immature)
Zygospira sp.
Sowerbyella merriami Cooper

This fauna correlates with the upper part of the Copenhagen Formation and may be of Wilderness age.

D1025 CO. Johnson Spring Formation, approximately 85 ft above base in lithology similar to that of the Ely Springs. California coord., zone 4: E. 2,273,750 ft, N. 575,750 ft.

Small streptelasmid corals
Zygospira sp.
Sowerbyella sp.

D1023 CO. Johnson Spring Formation, approximately 25 ft above base. California coord., zone 4: E. 2,281,000 ft, N. 584,700 ft.

Conodonts, undet.
Asteroid

D1017 CO. Barrel Spring Formation, type section, approximately 60 ft below top. California coord., zone 4: E. 2,274,000 ft, N. 571,150 ft.

Orthambonites decipiens (Phleger)
Orthambonites sp.
Valcourea cf. *V. plana* Cooper
Valcourea sp.
Bryozoans, indet.
Lonchodomas sp.
Ampyx? sp.
Isotelus? *spurius* Phleger

D924 CO. Barrel Spring Formation, type section, approximately 8 ft above base of upper argillite unit, 72 ft below top.

Isotelus? *spurius* Phleger

D1005 CO. Barrel Spring Formation, type section, approximately 75 ft below top. California coord., zone 4: E. 2,273,900 ft, N. 571,200 ft.

Orthambonites cf. *O. decipiens* Phleger
Remopleurides sp.
Dicellograptus sextans Hall

D1002 CO. Badger Flat Limestone, upper 20 ft. California coord., zone 4: E. 2,271,300 ft, N. 584,900 ft.

Sponge?
Cystid plates
Bryozoans, two genera but indet.

D923 CO. Badger Flat Limestone, approximately 100 ft below top. California coord., zone 4: E. 2,269,800 ft, N. 587,700 ft.

Cephalopod siphuncle
Conodonts, undet.

D1003 CO. Badger Flat Limestone, approximately 190 ft below top. California coord., zone 4: E. 2,271,500 ft, N. 585,100 ft.

Sponges
Rhysostrophia nevadensis Ulrich and Cooper
Gastropods

D1004 CO. Badger Flat Limestone, 230 ft below top. California coord., zone 4: E. 2,271,500 ft, N. 585,100 ft.

Calycocoelia sp.
Orthambonites patulus (Phleger)
Orthambonites? cf. *O. mazourkaensis* (Phleger)
Rhysostrophia occidentalis Ulrich and Cooper
Rhysostrophia n. sp.

D1006 CO. Badger Flat Limestone, approximately 300 ft below top. California coord., zone 4: E. 2,274,000 ft, N. 575,700 ft.

Orthambonites cf. *O. mazourkaensis* (Phleger)
Conodonts, undet.

D1007 CO. Badger Flat Limestone, approximately 350 ft below top. California coord., zone 4: E. 2,274,000 ft, N. 575,700 ft. The following were identified by Dr. Rousseau H. Flower.

Ruedemannoceras sp.
Rossoceras sp.

D922 CO. Badger Flat Limestone, approximately 420 ft below top. California coord., zone 4: E. 2,271,800 ft, N. 585,400 ft.

Cephalopod, indet.
Pseudomera? sp. (pygidium only)

D917 CO. Al Rose Formation, shaly beds approximately 10 ft below top of formation. California coord., zone 4: E. 2,270,900 ft, N. 587,700 ft.

Phyllograptus anna Hall

D811 CO. Al Rose Formation, shaly beds approximately 10 ft below top of formation. California coord., zone 4: E. 2,274,000 ft, N. 575,700 ft.

Didymograptus protobifidus Elles

D1054 CO. Al Rose Formation, shaly beds in top 10 ft. California coord., zone 4: E. 2,266,100 ft, N. 593,800 ft.

Didymograptus artus Elles and Wood (1 specimen)
D. protobifidus Elles (more than 30 specimens)
Tetragraptus bigsbyi Hall
Phyllograptus anna Hall
Ampyxinid trilobite
Olenid aff. *Parabolinella*
Asaphid?, indet.

The three collections D811 CO, D917 CO, and D1054 CO are of late Arenig age and probably correlate with trilobite zone J of Ross (1951), equivalent to the Ninemile Formation.

D920 CO. Al Rose Formation, approximately 350 ft below top. California coord., zone 4: E. 2,267,300 ft, N. 593,800 ft.

Trigonocerca? sp. (a large pygidium)

D1024 CO. Al Rose Formation, approximately 430 ft below top. California coord., zone 4: E. 272,800 ft, N. 586,000 ft.

Indet. asaphid trilobite thorax and pygidium

D919 CO. Al Rose Formation, 75 ft above base. California coord., zone 4: E. 2,267,900 ft, N. 593,800 ft. Independence quadrangle.

Shumardia sp.
Trilobite pygidium, kainellid or apatokephalid, poorly preserved.

This collection is tentatively considered correlative with some part of the Goodwin Limestone.

PANAMINT BUTTE QUADRANGLE, CALIFORNIA

Figure 1, locality 9

The Panamint Butte quadrangle was mapped geologically by W. E. Hall and H. G. Stephens. The Ordovician stratigraphic section was measured by Stephens, L. A. Wilson, and me. However, few fossils were collected from the Ordovician section. Intense dolomitization not only has destroyed most of the fossils in the Ordovician but also has made close comparison of lithic details with other areas difficult.

About 130 feet of interbedded quartzose rocks and dolomites are between definite Eureka Quartzite and known Antelope Valley beds. Whether this unit should be considered as part of the Eureka or as part of the Pogonip Group is difficult to know at present. For purposes of mapping it is more convenient to restrict the Eureka to the overlying thick quartzite, thus leaving the interbeds in the Pogonip, which is the arbitrary course followed here. However, regional stratigraphy suggests that at least part of the transitional unit is probably correlative with the lower part of the Eureka of the Nevada Test Site and the

Barrel Spring Formation in the Inyo Mountains. Fossil evidence for or against this suggestion is lacking.

The only fossils obtained to date (1964) are silicified and are from thick dolomites 130 feet below the Eureka Quartzite (USGS colln. D1015 CO). These fossils indicate the presence of the *Anomalorthis* Zone.

Section of Lower and Middle Ordovician formations, Panamint Butte quadrangle, 2¼ miles south-southeast of Panamint Butte and 3¾ miles east-northeast of Lake Hill. Coordinates of two ends of section, California coord., zone 4: E. 2,487,650 ft, N. 394,000 ft; E. 2,490,500 ft, N. 393,600 ft

	Feet
Ely Springs Dolomite:	
Dolomite, dark-gray (not measured).	
Eureka Quartzite:	
Quartzite, white, vitreous	40
Quartzite, medium-gray, vitreous	12
Siltstone, black, very fine grained	2
Quartzite, medium-gray, mottled; abundant reddish faces along joints	8
Quartzite, white, thin-bedded, vitreous	34
Quartzite, vitreous, impure; mottled brown	1
Quartzite, very fine grained, calcareous, very dark gray	1
Thickness, Eureka Quartzite	98
Pogonip Group:	
Antelope Valley Limestone (upper 130 ft probably includes equivalents of lower parts of the Eureka and Barrel Spring strata elsewhere):	
Dolomite, silty; weathers yellowish gray	36
Dolomite, very silty; with coarse sandy streaks weathering moderate reddish brown	18
Quartzite, very fine sand sized, dolomitic; weathers yellowish gray at base	9
Dolomite, increasingly fine grained and closely laminated upward; medium gray, weathers light gray mottled medium gray	19
Quartzite, medium-gray, dolomitic; with well-rounded quartz grains. Weathers light olive gray with conspicuous moderate reddish-brown (10*R* 4/6) streaks and mottling	11
Dolomite, silty, very fine grained; weathers very pale orange (10*YR* 8/2)	12
Siltstone, quartzitic, massive, dolomitic; weathers grayish orange (10*YR* 7/4)	11
Covered slope. Weak zone	5
Siltstone, quartzose, massive, dolomitic	6
Sandstone, very fine grained, finely laminated; weathers grayish orange (10*YR* 7/4)	2
Dolomite, light-brownish-gray; weathers yellowish-gray (5*Y* 8/1)	2
Limestone, dolomitic, silty; weathers yellowish gray along silty streaks. Abundant silicified fossils in upper half. USGS colln. D1015 CO	38

Section of Lower and Middle Ordovician formations, Panamint Butte quadrangle, 2 miles south-southeast of Panamint Butte and 3 miles east-northeast of Lake Hill. Coordinates of two ends of section, California coord., zone 4: E. 2,487,650 ft, N. 394,000 ft; E. 2,490,500 ft, N. 393,600 ft—Continued

	Feet
Pogonip Group—Continued	
Limestone, dark-gray, silty; in part nodular. *Palliseria*	16
Limestone, dolomitic; weathers yellowish orange (10*YR* 7/6)	4
Dolomite, dark-gray, resistant	44
Limestone, dolomitic, black; thin beds 6–12 in. thick	2
Dolomite, massive, dark-gray; abundant "*Girvanella*"	41
Dolomite, medium-gray, thick-bedded, cliff-forming. Weathers light olive gray (5*Y* 6/1) to yellowish gray (5*Y* 7/2)	161
Dolomite, weak, silty, slight crepe effect. Chert stringers between 1-ft layers. Weathers grayish orange	10
Dolomite, silty, thin-bedded; weathers grayish orange to dusky yellow	8
Dolomite, medium- to dark-gray, thin-bedded to laminated, in 1- to 2-ft beds interbedded with ¼- to ½-in. chert laminae in 3- to 6-in. layers. Weathers grayish orange changing upward to light olive gray (5*Y* 6/2)	48
Thickness, Antelope Valley Limestone	503
Ninemile(?) Formation equivalent:	
Dolomite, silty, grayish-orange weathering, in 3-ft beds interlayered with gray-weathering dolomite in 1-ft beds	22
Dolomite, very thinly laminated; in 1- to 6-in. layers; very silty; has white chert stringers in upper 15 ft. Weathers grayish orange (10*YR* 7/4)	44
Thickness, Ninemile(?) Formation equivalent	66
Goodwin(?) Limestone (probably not an exact correlative):	
Dolomite, medium-gray, cherty; with a few orange-weathering silty streaks which increase upward in the top half	67
Dolomite, light-gray, massive "marbelized"	16
Dolomite, light- to medium-gray; in general fine grained; thin bedded with a few massive intervals. Chert stringers parallel bedding at following distances above base: 39–50 ft, 150–165 ft, 220–240 ft, 250–302 ft, 311–337 ft. Thickness of entire interval	337
Thickness, Goodwin Limestone	420
Possible bedding-plane fault. Displacement probably small.	
Nopah Formation:	
Dolomite, dark-gray.	

Fossils from the section in the Panamint Butte quadrangle are listed below:

D1015 CO. Antelope Valley Limestone, approximately 130 ft below main mass of Eureka Quartzite. California coord., zone 4: E. 2,490,500 ft, N. 393,600 ft. Located 2¼ miles south southeast of Panamint Butte, 3¾ miles east northeast of Lake Hill.[1]

Bryozoans, silicified, make up most of insoluble residue of rock
Syntrophopsis? sp.
Anomalorthis sp.
Desmorthis? sp.
Gastropods, undet.
Cystids, indet.

This fauna is from the *Anomalorthis* Zone.

APEX SIDING, NEVADA

Figure 1, locality 37; figure 2

[Outcrop area shown as DS on Clark County map (Bowyer and others, 1958), Nevada, in T. 19 S., R. 63 E.]

The section at Apex siding provides a measure of the thinning Eureka Quartzite in which the top beds contain collophane nodules like those in the sections at Arrow Canyon Range, lower Lucky Strike Canyon, and Lee Guard Station.

The base of the Pogonip Group is not exposed. Therefore, only a minimum thickness is provided here.

Partial section of Lower and Middle Ordovician formations south of Apex siding, center of S½ sec. 3, and N½ sec. 10, T. 19 S., R. 63 E., Dry Lake quadrangle, Nevada (fig. 1, loc. 37; fig. 2)

	Feet
Ely Springs Dolomite:	
Top not exposed. Thickness estimated as 500 ft.	
Eureka Quartzite:	
Quartzite with scattered nodules of collophane	6
Quartzite, white, vitreous	31
Sandstone, very fine grained, dolomitic, very light gray	2
Thickness, Eureka Quartzite	39
Pogonip Group:	
Dolomite, light-gray; laminated with silty partings weathering yellowish orange	3
Covered with float	22
Dolomite, silty; weathers light olive gray	5
Covered with float	8
Dolomite, light-gray; weathers light olive gray	6
Dolomite, very silty; weathers yellowish orange	3
Dolomite, dark-gray	1
Dolomite, dark-gray, silty. Weathers dark-gray coated with yellowish orange	5
Covered with float	27
Dolomite, very silty and cherty; weathers yellowish gray to yellowish orange. Breaks with conchoidal fracture, very fine grained	9

Partial section of Lower and Middle Ordovician formations south of Apex siding, center of S½ sec. 3, and N½ sec. 10, T. 19 S., R. 63 E., Dry Lake quadrangle, Nevada (fig. 1, loc. 37; fig. 2)—Continued

	Feet
Pogonip Group—Continued	
Dolomite, dark-gray, fine-grained; in 3-ft beds interspersed with less resistant thinner silty beds	53
Dolomite, dark-gray to medium-light-gray; weathers brownish gray; in beds 2–3 ft thick. Partly covered with float. "*Girvanella*"	148
Dolomite, medium-light-gray to dark-gray; weathers brownish gray; in beds 2–5 ft thick. Abundant "*Girvanella*"	43
Covered with float and rubble	47
Dolomite, massive, medium-light-gray (*N* 6); weathers light brownish gray (5*YR* 6/1)	37
Dolomite, weak, silty; leaves yellowish-brown (10*YR* 6/4) chips in float	14
Limestone, coarse, bioclastic; in 1- to 2-ft beds. Trilobites and brachiopods. USGS colln. D984 CO	4
Limestone, intraformational conglomerate with light-colored pebbles in darker medium-light-gray matrix. Beds thicken upward, ranging from 3 in. to 3 ft	20
Slope masked by float	36
Dolomite, very silty, slabby, nonresistant. Much intraformational conglomerate. Weathers orange brown (10*YR* 6/4)	61
Dolomite, very thin bedded, very cherty; intraformational conglomerate weathering medium gray	7
Dolomite, very thin bedded, cherty; weathers medium gray	10
Dolomite, thin-layered (1 in.–1 ft); forms beds 6 in.–4 ft thick; fine grained, resistant, cherty except for bottom 35 ft. Weathers medium gray	115
Dolomite, silty, irregularly laminated; with a few thin beds of intraformational conglomerate. Weathers pale yellowish brown. Lower 10 ft very cherty	15
Slope covered with float	7
Dolomite, even-textured, cryptocrystalline; weathers pale yellowish brown	13
Dolomite; coarse intraformational conglomerate; in massive beds. Weathers pale yellowish brown	19
Dolomite, in beds 1–4 ft thick composed of 1- to 3-in. layers. Weathers medium gray. Slightly cherty. Fossils from middle, USGS colln. D1058 CO	15
Slope covered with float	10
Dolomite, medium light-gray, slightly silty, fine-grained. Weathers light olive gray (5*Y* 6/1) to very pale yellowish brown (10*YR* 7/2)	13
Dolomite, in beds 1–4 ft thick, composed of layers 1–3 in. thick. Medium gray weathers brownish gray (5*YR* 5/1); interbedded with a few thinner beds of light-gray dolomite weathering very light olive gray (5*Y* 7/1). Three zones of large chert stringers 5 ft above base, 25 ft above base, and at top of this interval	35
Slope masked by float	4

Partial section of Lower and Middle Ordovician formations south of Apex siding, center of S½ sec. 3, and N½ sec. 10, T. 19 S., R. 63 E., Dry Lake quadrangle, Nevada (fig. 1, loc. 37; fig. 2)—Continued

	Feet
Pogonip Group—Continued	
Dolomite, interlaminated irregularly with silty dolomite. Silty laminae weather grayish orange (10*YR* 7/4)	2
Dolomite, medium-light-gray; in beds 6 in.–3 ft thick; weathers light olive gray (5*Y* 6/1)	12
No lower beds exposed.	
Thickness measured, Pogonip Group	829

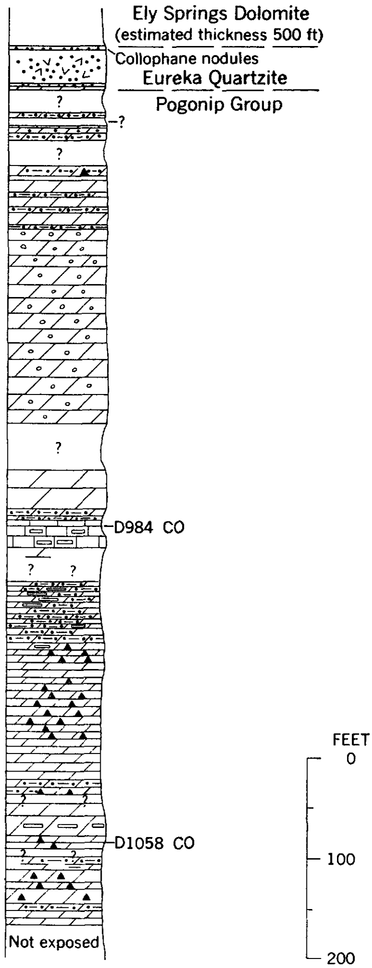


FIGURE 2. — Diagrammatic stratigraphic section south of Apex siding, center of S½ sec. 3, and N½ sec. 10, T. 19 S., R. 63 E., Dry Lake quadrangle, Nevada. For explanation of lithic types see plate 1.

A collection of gastropods made 80 feet above the lowest exposure of this section yielded a species which is also found in USGS collection D1055 CO at upper Lucky Strike Canyon. E. L. Yochelson (written commun., 1963) reported as follows:

"D1058 CO. Pogonip Group. South of Apex siding, center S½ sec. 3, and N½ sec. 10, T. 19 S., R. 62 E., Dry Lake quadrangle, Nevada.

?*Eccyliopterus* cf. *E. gyroceras* (Roemer) (abundant) very low spired gastropod aff. *Dirhacopea* sp.

This collection was intentionally not etched to completion. It is possible that further etching might yield a larger fauna comparable to D1055 CO.

"Ulrich and Bridge (1932, p. 735) suggest that the form here called ?*Eccyliopterus* occurs approximately in the middle Gasconade equivalent. *Dirhacopea* occurs in slightly older beds. Early Ordovician seems a reasonable age for this sample."

SPOTTED RANGE, NEV., SOUTHWEST END

Figure 1, locality 45; figure 3

This section was examined in hopes of obtaining information on the higher beds of the Pogonip Group and their relation to the Eureka Quartzite. The Antelope Valley Limestone of the Pogonip Group is cut by several faults in this area, which makes measurement impractical.

The Ely Springs Dolomite was not measured. It is overlain by a Silurian dolomite that is very pale grayish yellow, has a sugary texture and contains large pentamerid brachiopods.

The Eureka Quartzite is far less resistant that it is in most places and includes many dolomitic beds. A collection of conodonts (USGS colln. D991 CO) from the lower part of the formation includes an assemblage of high Middle Ordovician aspect.

Limestones 35 feet below the base of the Eureka contain trilobites (USGS colln. D990 CO) very similar to those 300–500 feet below the quartzite at Meiklejohn Peak to the west. However, the massive *Palliseria*-bearing limestones are only 240 feet below the Eureka beds in the Spotted Range and 600 feet below at Meiklejohn Peak.

Section of Eureka Quartzite and upper part of the Antelope Valley Limestone along crest of ridge in the southwest end of the Spotted Range, Nevada footage coord., east zone: E. 390,300 ft, N. 681,900 ft

Ely Springs Dolomite.	
Eureka Quartzite:	*Feet*
Sandstone, dolomitic, medium-gray, medium-grained, mottled, fucoidal. Grades downward into dolomitic quartzite	15
Quartzite and sandstone interbedded in 1- to 6-ft layers. White. Forms an even slope	90
Quartzite, white, resistant, ledge-forming	11
Quartzite, mottled light-brown	3

Section of Eureka Quartzite and upper part of the Antelope Valley Limestone along crest of ridge in the southwest end of the Spotted Range, Nevada footage coord., east zone: E. 390,300 ft, N. 681,900 ft—Continued

	Feet
Eureka Quartzite—Continued	
Quartzite, mottled light-gray, dark-grayish-pink (5*R* 7/2), and dark-reddish-brown (10*R* 3/4. Beds 1–2 ft thick interbedded with less resistant dolomite quartzite. Dolomite increases in content downward	17
Quartzite, very pale grayish orange (10*YR* 8/4), grading downward to light gray. Weak	10
Quartzite, mottled light-gray	5
Quartzite, dolomitic, fucoidal, light-brown and light-gray	2
Quartzite; the same as the overlying units but without fucoidal markings	9
Quartzite, very pale grayish orange	4
Quartzite, dolomitic, light-gray	3
Quartzite, very pale grayish orange	12
Fault?	
Brecciated quartzite	3
Quartzite, mottled pink and gray; weathers moderate yellowish brown and red	17
Quartzite, thin-bedded, fucoidal, mottled yellowish-brown, light-gray, and pink. Dolomitic	10
Quartzite, moderate brown (10*YR* 6/4), dolomitic	11
Quartzite, white; weathers very pale yellowish orange	16
Fault?	
Jasper and quartzite breccia	1
Quartzite, very pale grayish orange; mottled with reddish splotches	27
Quartzite, reddish-brown (10*YR* 4/4)	1
Quartzite, light-brown	9
Sandstone, dolomitic, and sandy dolomite. Unit is massive, cross-bedded, pale-yellowish-orange	16
Dolomite, bioclastic; light-gray fossil relicts; conodonts (D991 CO)	16
Quartzite, dolomitic, very pale grayish orange	4
Dolomite and quartzite interlensed, medium-gray	3
Quartzite, thin-bedded, weak, very pale yellowish orange	22
Sandstone, very dolomitic, and quartzite; interbedded forming a prominent ledge	14
Quartzite, vitreous, thin-bedded, very light brown	9
Sandstone, dolomitic, medium-gray, and quartzite interbedded	6
Thickness, Eureka Quartzite	366
Pogonip Group:	
Antelope Valley Limestone:	
Dolomite, calcarenite, very slightly silty. Medium light gray on fresh and on weathered surfaces	5
Siltstone, dolomitic, pale-olive; weathers to pale yellowish orange. Forms ledged slope	15
Limestone, medium-light-gray, mottled with irregular silt partings that weather pale yellowish orange. Fairly resistant	9

Section of Eureka Quartzite and upper part of the Antelope Valley Limestone along crest of ridge in the southwest end of the Spotted Range, Nevada footage coord., east zone: E. 390,300 ft, N. 681,900 ft—Continued

	Feet
Pogonip Group—Continued	
Antelope Valley Limestone—Continued	
Limestone, slabby, weak, medium-gray, fine-grained, silty; weathers mottled light gray and medium gray. A few trilobites and silicified brachiopods on the weathered surfaces. Colln. D990 CO	9
Limestone, dark-gray; beds 1–2 ft thick; very fine grained with many fossils relict and not recoverable	17
Limestone, microlaminated, light-gray, slightly silty	1
Limestone, dark-gray, irregularly laminated; beds 1–2 ft thick; slightly silty partings between irregular laminae produce "crepe" appearance on vertical weathered surfaces	15
Limestone, dolomitic, microlaminated; weathers dusky yellow (5Y 6/4)	2
Limestone, dark-gray; irregularly laminated in beds 2 ft thick	24
Dolomite, dark-gray, thin-bedded (1- to 4-ft beds) interbedded with light-gray, dusky-yellow-weathering microlaminated or aphanitic limestone in beds 1–2 ft thick	35
Limestone, silty, slightly dolomitic, light-gray; weathers pale yellowish orange to light gray	15
Limestone, aphanitic, pale-reddish-purple to grayish-red; weathers medium light gray to pale yellowish orange. Beds 1–4 ft thick	11
Limestone, silty, light-gray, aphanitic; weathers yellowish orange	5
Limestone, aphanitic, light-gray; weathers light gray to yellowish orange at the base. Beds 3 ft thick	8
Limestone, medium-gray, weathers medium gray, slightly silty; in beds 6 in.–1 ft thick, forming ledges	25
Limestone, medium-gray, thin-bedded; abundant silty and cherty beds. Silty beds weather brown to light brown	35
Covered interval	10
Total Antelope Valley Limestone measured	241

Top of resistant massive dark-gray *Palliseria*-bearing limestone that forms the main cliff of the Antelope Valley Limestone. No measurement below this point.

Collection from Eureka Quartzite follows:

USGS colln. D991 CO. Dolomite in Eureka Quartzite, approximately 60 ft above base. Identifications by L. A. Wilson.

Phragmodus undatus Branson and Mehl
Ozarkodina sp.
Belodina cf. *B. disponsa*

Fauna probably Trenton in age.

Collection from Antelope Valley Limestone follows:

USGS colln. D990 CO. Slabby limestone approximately 35 ft below top of Antelope Valley Limestone.

Goniotelina? cf. *G. williamsi* Ross

Isotelus? sp. (like *Asaphus canalis* as illustrated by Billings (1865, fig. 255) and by Whitfield (1886, p. 295, 336–339, pl. 34, figs. 2, 3, 6))
Calliops aff. *C. troosti* (Safford and Vogdes)
Ceraurinella? sp.
Ostracodes
Conodonts

Fauna is a mixture of Whiterock and Porterfield or younger elements; the Porterfield or younger elements predominate.

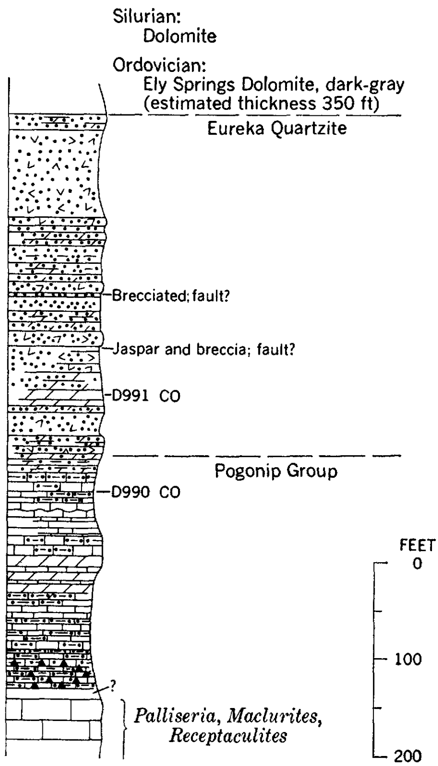


Figure 3.—Partial stratigraphic section in the Spotted Range, southwest end, along crest of ridge. Nevada coordinates east zone: E. 390,300 ft, N. 681,900 ft. For lithic explanation see plate 1.

SOUTHERN SPECTER RANGE, NEV.

Figure 1, locality 46; figure 4

Structurally the Specter Range is exceedingly complex, and complete stratigraphic sections of Ordovician formations are difficult to find. A partial section of the uppermost Pogonip beds and Eureka Quartzite was measured in an attempt to learn more of the interrelation of the two.

Conspicuous pink beds 120–170 feet below the top of the Pogonip can probably be correlated very roughly with similar layers in the Spotted Range at about the same stratigraphic position and in the Ranger Mountains (Nevada Test Site) approximately 280 feet below the Eureka Quartzite.

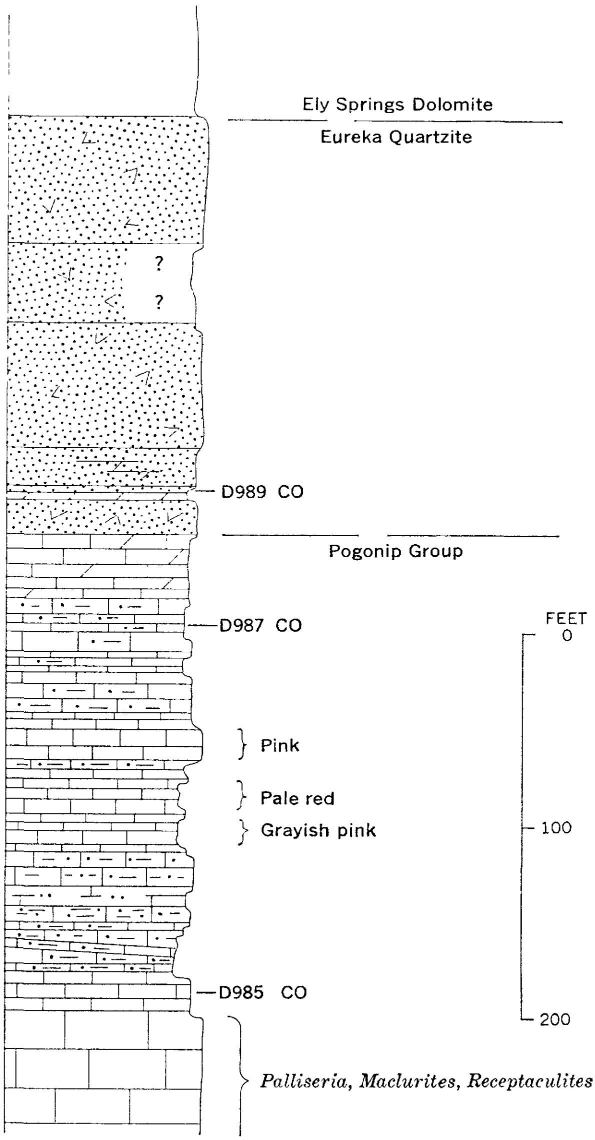


FIGURE 4.—Partial stratigraphic section in the southern Specter Range, south end, east side, NW¼SW¼ sec. 3, T. 16 S., R. 52 E., Specter Range quadrangle, Nevada. For explanation of lithic types see plate 1.

Partial section in Eureka Quartzite and highest Pogonip beds above massive unit H of Johnson and Hibbard (1957), NW¼ SW¼ sec. 3, T. 16 S., R. 52 E., Specter Range quadrangle, Nevada

Ely Springs Dolomite (not measured).	
Eureka Quartzite (probably shortened by faulting):	*Feet*
Quartzite, white, vitreous	65
Quartzite, vitreous, mottled brown and red; mostly float	43
Quartzite, vitreous, mottled light-brown	63
Quartzite, dolomitic, light-brown	20
Sandstone, dolomitic, crossbedded	3
Dolomite, light-medium-gray, abundant relict fossils. Colln. D989 CO	3
Quartzite, vitreous; becomes sandstone in upper few feet. Base brecciated	18
Thickness, Eureka Quartzite	215
Pogonip Group:	
Limestone, dolomitic, thin-bedded and microlaminated. Weathers medium light gray to light olive gray	35
Limestone, slabby, very silty; weathers yellowish orange to light gray. Fossil bryozoan 9 ft above base	11
Limestone, fine-grained; in 1- to 2-in. laminae; medium light gray, with silty partings weathering yellowish orange. Slope forming. USGS colln. D987 CO, cephalopod	13
Limestone, cherty dark-gray; weathers dark gray	2
Limestone, fine-grained, medium-gray; in beds 1–4 ft thick. Weathers light gray with a few silty partings	11
Limestone, dark-gray; in 1- to 2-in. laminae, in thin flat layers	2
Limestone, aphanitic, mottled light-gray; in beds 3–4 ft thick	4
Limestone, very fine grained, very irregularly laminated; silty partings between laminae weather yellowish. Limestone is medium dark gray, weathers dark gray	18
Limestone, light-pinkish-gray to light-gray; aphanitic flecked with coarser calcite crystals	7
Limestone, thinly laminated, pink; weathers pinkish gray, except for 2–3 ft in middle which may be gray laterally. Fairly coarse grained in upper one-third. Silty partings present in lower one-third	20
Limestone, silty; weathers light brown	4
Limestone; weathers pinkish gray	5
Limestone, aphanitic, pale-red; weathers light brown. Very silty	5
Limestone, aphanitic, pale-red; weathers pinkish gray	4
Limestone, aphanitic, very silty, pale-red; marked by red silty lines. Weathers grayish orange (10*YR* 7/4) to light brown (5*YR* 6/4)	3
Limestone, aphanitic, grayish-pink; weathers pinkish gray	15
Limestone, medium-crystalline, of uniform texture, in even 1- to 2-in. laminae. Thin bedded, light-gray, weathers light gray	4
Limestone, silty, cryptocrystalline, light-gray; irregularly mottled and parted by silt. Silt forms about 30 percent of rock, weathers pale yellowish orange	18
Limestone; like unit above but silt forms 50 percent of rock. In 8-in. to 1-ft beds	10

Partial section in Eureka Quartzite and highest Pogonip beds above massive unit H of Johnson and Hibbard (1957), NW¼ SW¼ sec. 3, T. 16 S., R. 52 E., Specter Range quadrangle, Nevada—Continued

	Feet
Pogonip Group—Continued	
Limestone, dark-gray, interlayered with silty partings approximately 6-in. apart; thin bedded silty material weathers pale yellowish orange	8
Limestone, dark-gray; like units above and below except that about 1 ft separates silty partings	14
Limestone; like two units above, but thin bedded. Gastropods, but not *Palliseria* or *Maclurites*	15
Limestone, dark-gray, coarsely crystalline, bioclastic; in beds 6 in.–1 ft thick. Some irregular silty partings weather pale yellowish orange. Abundant fossils: *Pseudomera* (large species), "*Girvanella*," and *Palliseria* collected 17 ft above bottom of unit. USGS colln. D985 CO	18
Top of massive cliff-forming dark-gray limestone bearing abundant *Palliseria*, *Maclurites*, and *Receptaculites*.	
Total Pogonip Group measured	246

Fossils from the Specter Range section listed by USGS collections include:

D989 CO. From dolomite 18–21 ft above base of Eureka Quartzite.
Small gastropod steinkerns, not identifiable

D987 CO. From limestone 37 ft below base of Eureka Quartzite.
Adamsoceras? (Sent to R. H. Flower for identification)

D985 CO. From limestones at top of *Palliseria* Zone, 230 ft below base of Eureka Quartzite.
Pseudomera sp.
Bryozoans

EASTERN LA MADRE MOUNTAIN, NEV.

Figure 1, locality 42

[Outcrop area shown on Clark County map (Bowyer and others, 1958) in T. 20 S., R. 59 E.]

No beds were positively identified as Ordovician in this section although a thin interval may be equivalent to the Pogonip beds. The Ely Springs Dolomite and Eureka Quartzite are absent or have lost their identity as far as I have been able to determine. The beds overlying those that tentatively have been considered Pogonip are Devonian on the basis of bryozoans and corals.

The Ordovician thickness given for this section is only tentative. Trilobites collected by C. R. Longwell below this unit have been identified by A. R. Palmer as equivalent to the Upper Cambrian Dunderberg Shale; therefore, the strata below the Devonian may be Late Cambrian post-Dunderberg in age, rather than Ordovician. No fossils were found in the beds of questionable age.

Section of formations of Devonian and Ordovician(?) age, NW¼ sec. 16, T. 20 S., R. 59 E., along crest of spur between approximate altitudes of 4,640 ft and 4,940 ft, Blue Diamond quadrangle, Nevada

	Feet
Devonian:	
Dolomite, light-gray, massive. Not measured.	
Dolomite, dark-gray; weathers pale grayish brown (5*YR* 4/2), Carbonate-filled vugs alined parallel to bedding in layers 3 in. apart. Post-Ordovician corals from base	87
Dolomite, light-gray; weathers pale yellowish brown	17
Dolomite, light-gray; weathers light gray	5
Dolomite, medium-gray; weathers medium brownish gray	13
Dolomite, light-gray; weathers light gray	3
Dolomite, medium-gray; weathers medium light gray (*N*6) to light brownish gray (5*YR* 7/1); in beds 1–2 ft thick. One bed 13 ft above base weathers yellowish olive gray (5*YR* 7/2)	19
Dolomite, cryptocrystalline, pinkish-gray (5*YR* 8/1); weathers very pale orange (10*YR* 8/2); in beds 3 in.–1 ft thick	15
Dolomite, fine-grained, light-gray; weathers medium light gray; in beds 3–18 in. thick	18
Dolomite, coarsely crystalline (possibly bioclastic), medium-gray	3
Dolomite, medium-grained; in part vuggy; weathers light brownish gray to medium gray	6
Dolomite, silty, very thin bedded; in 1- to 2-in. layers	14
Dolomite, medium-light-gray, thin-bedded, resistant	1
Dolomite, very coarse grained, light-gray; weathers pinkish along strike	6
Dolomite, light-gray, coarsely crystalline; weathers with slight orange cast	4
Dolomite, bioclastic, medium-grained, dark-gray; in 1-ft beds; weathers pale grayish brown (5*YR* 4/2). Abundant relict fossils in top bed. *Thamnopora*	5
Slope mantled with float	9
Total Devonian measured	225
Ordovician(?):	
Ely Springs and Eureka Formations: Absent.	
Lower Ordovician (Pogonip(?)) or Upper Cambrian:	
Dolomite; beds of both thinly laminated and massive mottled dolomite, beds 1–2 ft thick. Weathers medium light gray	31
Dolomite, light-gray; in beds 6 in.–4 ft thick, formed of fine-grained laminae 1–2 in. thick. Weathers yellowish oliver gray (5*Y* 7/1)	35
Dolomite, coarse-grained, markedly crossbedded, light-gray; in beds 6 in.–2 ft thick	24
Dolomite, thin-bedded, resistant, medium-light-gray. Weathers light gray with yellowish-orange streaks along silty laminae. Scattered chert stringers	10
Dolomite in interbeds that are slabby, nodular, and silty. Weathers pale yellowish brown (10*YR* 7/1)	12
Dolomite, slabby, very thin bedded, light-gray. Weathers very pale brownish gray (5*YR* 7/1). Nonresistant	23

Section of formation of Devonian and Ordovician (?) age, NW¼ sec. 16, T. 20 S., R. 59 E., along crest of spur between approximate altitudes of 4,640 ft and 4,940 ft, Blue Diamond quadrangle, Nevada—Continued

	Feet
Ordovician (?)—Continued	
Dolomite, light-gray, granular, weathers yellowish gray (5*Y* 7/2); in beds 2–6 ft thick. Very thin white chert stringers	13
Dolomite, massive, light-gray. Top 12 ft with dark-brown silicified patches and light-gray chert stringers. Forms prominent ledge	37
Dolomite, light-gray; in beds 2–4 ft thick; weathers yellowish gray. Very little chert	16
Dolomite, light-gray, granular; in beds increasing in thickness upward from 2 to 4 ft. Very thin white chert stringers parallel bedding. Relict structures suggest irregular silt partings. Forms base of small cliff	21
Dolomite, light-gray; like unit above but lacking chert	21
Dolomite, light-gray; glauconitic in lower 15 ft. Finely granular. Weathers yellowish gray. Forms weak slope between two small cliffs	28
Dolomite, light-gray, coarse-grained; in beds up to 8 ft thick, composed of relict laminae 1–2 in. thick. Problematical relict intraformational conglomerate. Weathers yellowish gray (5*Y* 7/2). Cliff-forming	37
Covered slope	9
Dolomite, light-gray; in 1- to 2-in. laminae forming 1⅓- to 2-ft beds. Weathers very pale yellowish brown (10*YR* 7/2)	5
Covered slope	15
Total Lower Ordovician Pogonip (?) Group or Upper Cambrian	337
Upper Cambrian:	
Top of light-gray massive very vuggy dolomite.	

WEST OF RED ROCK CANYON, NEV.

Figure 1, locality 43

[Outcrop area shown on Clark County map (Bowyer and others, 1958) in sec. 31, T. 20 S., R. 58 E.]

The section measured high on the west side of Red Rock Canyon proves the presence of the Ordovician Ely Springs and the complete absence of Eureka Quartzite. The beds here considered Pogonip yielded no fossils and are so identified on lithic grounds. Actually the Pogonip may be absent at this locality.

Sections of formations of Ordovician age, west of Red Rock Canyon, Nev. Measured on high spur in NW¼SW¼ sec. 31, T. 20 S., R. 58 E., Mountain Springs quadrangle, altitude 6,000–6,400 ft

Ely Springs Dolomite:

Dolomite, light-gray; thick bedded, except for lower 4 ft. *Receptaculites oweni* approximately 15 ft above base. Estimated thickness, 50 ft.

Eureka Quartzite: Absent.

Sections of formations of Ordovician age, west of Red Rock Canyon, Nev. Measured on high spur on NW¼ SW¼ sec. 31 T. 20 S., R. 58 E., Mountain Springs quadrangle, altitude 6,000–6,400 ft—Continued

	Feet
Pogonip(?) Group:	
Dolomite, medium-gray; beds 3 in.–2 ft thick. Weak compared to Ely Springs	18
Dolomite, very silty, slabby, weak; weathers yellowish orange	53
Dolomite, gray; with some yellowish-weathering silt; in beds 3 in.–1 ft thick. Slightly more resistant than unit above	44
Dolomite, thick-bedded, cliff-forming, very slightly silty	103
Dolomite, fairly resistant; in beds 2 in.–2 ft thick	45
Dolomite; in beds 3–4 ft thick, alternating fairly pure and finely laminated silty. Silty beds weather yellowish	45
Dolomite, light-gray; in 3-in. to 1-ft beds. Many beds finely laminated	100
Dolomite, massive	10
Dolomite; thin slabby beds interlayered with finely laminated dolomite	76
Dolomite, very silty; weathers yellowish orange; less resistant than unit above	23
Dolomite, massive; in beds 6–8 ft thick	44
Dolomite, brownish-gray, mottled; beds 1–2 ft thick	35
Dolomite, coarsely crystalline, equigranular. Problematical "*Girvanella*" or relict intraformational conglomerate	28
Dolomite, thin-bedded, slabby, weak; weathers yellowish orange	35
Total Pogonip(?) Group	658
Upper Cambrian(?) dolomite:	
Dolomite, massive, very light gray.	

UPPER PART OF LUCKY STRIKE CANYON, NEV.

Figure 1, locality 40

[Outcrop area shown on Clark County map (Bowyer and others, 1958) in T. 18 S., Rs. 57–58 E.]

No strata of the Ely Springs Dolomite or Eureka Quartzite are recognized as such at this section although units of Pogonip lithology are present. Devonian beds overlie rocks similar to the Pogonip on a fault. However, the extent and stratigraphic offset of this fault are not known.

Whether or not the Ely Springs and Eureka strata are cut out evenly by faulting along the ridge for a mile to the northeast needs to be investigated.

That one or both of these two units have changed facies to resemble Pogonip lithology is a strong possibility. Abundant in USGS collection D982 CO, 380 feet below the fault, is *Paucicrura*, a brachiopod not previously reported in beds older than the base of the Eureka Quartzite (Porterfield Stage). Such a change in facies might explain why the Eureka Quartzite is not recognized in this section, in the section west of Red Rock Canyon, and in the eastern La Madre Mountain.

Although Ordovician rocks here resemble Pogonip lithology in a general way, it is not practical to subdivide them into the formations of the group.

Section of Pogonip(?) Group near head of Lucky Strike Canyon along ridge running eastward from southern end of hill 6612; coordinates at upper end of section: E. 516,000 ft, N. 570,300 ft, Charleston Peak quadrangle, Nevada

[The upper end of the section is at an approximate altitude of 6,250 ft where the ridge is crossed by a fault. The rocks above this fault seem to be of Devonian age. The only fossils obtained are from the ridge at considerably higher altitude, 6,360 ft, where *Amphipora* is present with Late Devonian *Thamnophyllum*]

Fault.

Ordovician:

Pogonip(?) Group:

	Feet
Dolomite, dark-gray, mottled—weathers dark gray—interbedded with finely laminated dark-gray dolomite, that weathers dark gray and is in beds from 2 to 6 ft thick. Lower 130 ft partly covered with float; small sponges are present in the lower half of the unit but are not well exposed. A few beds of intraformational conglomerates about 2 ft thick are also present in the middle of the unit	309
Dolomite, medium-light-gray; in beds 6 in.–3 ft thick composed of much relict bioclastic material, possible "*Girvanella*" remains, and rarely sponges	35
Slope covered with float except for a few ledges of protruding dolomite	32
Dolomite ledge, moderate-gray; very silty in irregular splotches. Silty parts weather yellowish orange. Brachiopods silicified and abundant Pelmatozoan columnals. USGS Colln. D982 CO	10
Dolomite, thin-bedded, silty, bady shattered; weathers pale orange 10*YR* 7/2)	23
Slope mantled with float except for a few ledges of protruding dolomite. Ledges and float weather yellowish orange on a gray background	43
Dolomite, very silty, slabby, and thinly laminated; in beds as much as 2 ft thick interbedded with a few beds as much as 4 feet thick composed of more resistant silty dolomite. Dolomite throughout light gray with silty portions weathering pale yellowish orange. Fossil sponges were collected 45 ft above the base; USGS Colln. D983 CO	87
Limestone, dark-gray, coarsely bioclastic	38
Dolomite, thin-bedded, silty, light-gray; with silt weathering yellowish orange. More resistant than overlying unit	11
Dolomite, resistant; in beds 2–4 ft thick, many silt partings in the upper portion, abundant white chert stringers except in the bottom 30 ft. Dolomite weathers light gray and silty portions weather yellowish orange. Fossil gastropods 2 ft above the base; USGS colln. D1056 CO	88
Dolomite, dark-gray, mottled; very large "*Girvanella*"-like bodies	5

Section of Pogonip (?) Group near head of Lucky Strike Canyon along ridge running eastward from southern end of hill 6612; coordinates at upper end of section: E. 516,000 ft, N. 570,300 ft, Charleston Peak quadrangle, Nevada—Continued

	Feet
Ordovician—Continued	
Pogonip (?) Group—Continued	
Dolomite, resistant, cherty; mostly medium grained and crossbedded; in beds approximately 2 ft thick with interbeds of silty dolomite occurring at 4-ft intervals	27
Dolomite, composed of intraformational conglomerate, with cobbles and large pebbles that are very striking; cherty. Fossil gastropods collected at base of this unit; USGS colln. D1055 CO	4
Dolomite, like the unit above but with silty and slabby beds interspersed	41
Slope covered with float. A very few ledges appear. These suggest that unexposed rock is similar to that in unit above	98
Slope almost entirely covered with float and rubble. Thin ledges of dolomite—thin-bedded and well-laminated, slightly cherty—suggest that this is the material composing most of the interval	184
Dolomite, intraformational conglomerate; weathers medium light gray, cherty, grades downward into resistant homogeneous dolomite that is thinly laminated but without silt partings	48
Dolomite, silty; weathers yellowish orange	51
Dolomite, thick-bedded, light-medium-gray, granular, slightly mottled. Some relics of circular structures which look like "*Girvanella*"	57
Dolomite, thin-bedded, thinly laminated, cherty	5
Total Pogonip (?) Group	1,196
Cambrian:	
Nopah Formation:	
Dolomite, very dark gray to black, massive. Fossils collected include Cambrian *Matthevia* (USGS colln. D1057 CO).	

Fossils from upper part of Lucky Strike Canyon were examined by E. L. Yochelson and W. J. Sando (written commun., 1963) as well as by me. USGS collections include:

D982 CO. Approximately 380 ft below top of seeming Ordovician rocks. On crest of ridge.

Paucicrura sp. (a small species)
Pelmatozoan columnals

This collection is no older than Porterfield and therefore may correlate with either the Eureka Quartzite or the Ely Springs Dolomite.

D1057 CO. Nopah Formation. Near head of Lucky Strike Canyon in the Charleston Peak quadrangle. Along ridge running east from the south end of hill 6612. Nevada coord., east zone: E. 516,000 ft, N. 570,000 ft. E. L. Yochelson reported as follows:

Matthevia variabilis Walcott (abundant)
Matherella n. sp.

"D1056 CO. Approximately 530 ft above top of Nopah Formation. Fossils dissolved away and remaining matrix is a relatively soft silt. The few impressions left are not satisfactory. I can make out:

cf. *Lophospira*

Moderately low spired gastropod, indet.

This is too little evidence to support any conclusions. My guess is that this may be more likely younger Early Ordovician than earlier Early Ordovician."

DI055 CO. Approximately 490 ft above top of Nopah Formation. From this collection W. J. Sando identified:

Ribieria sp.

Yochelson identified:

Echinoderm columnal
Sponge spicule?
Hyolithes sp.
Pelagiella cf. *P. paucivolvata* (Calvin)
Bellerophontacean-bellerophontiform, with narrow shallow slit
cf. *Bucanella* sp. (abundant)
"*Helicotoma*" aff. "*H*" *uniangulata* (Hall)
?*Eccyliopterus* cf. *E. gyroceras* (Roemer) (abundant)
Clisospira or, less likely, *Mimospira*
Ophileta cf. *O. complanata* Vanuxem (common)
Low-spired gastropods, indet. (Two or more genera) (common)
Moderately high spired gastropod, indet.
high-spired gastropod, indet.
Nautiloid, undet. (possibly indet.)

Yochelson reported, "Parts of this fauna are typical of the 'Gasconade' of central Texas. The bellerophontaceans and *Clisospira* appear to be new in terms of the Early Ordovician faunas of the United States. In addition to the ?*Eccyliopterus*, there may be another openly coiled gastropod in the collection, but the material is not sufficient to resolve this problem.

"Even though almost all the material is steinkerns, this locality is extremely important and should be re-collected in connection with any thorough investigation of Early Ordovician mollusks.

"Preliminary identifications were not clear as to age. This seems to be early Early Ordovician. It is possible that this collection and D1058 CO may be from the same horizon but too little is known of the ranges of openly coiled gastropods to do more than suggest this as a possibility."

LOWER PART OF LUCKY STRIKE CANYON, NEV.

Figure 1, locality 39

[Outcrop area shown on Clark County map (Bowyer and others, 1958) in T. 18 S., R. 58 E.]

Because of faulting, this section is not entirely satisfactory, but it does give a good measure of the Ely Springs Dolomite and Eureka Quartzite. Because of obvious regional changes in these two units southward, this is an important locality. Although the Eureka is well developed to the southwest, west, and north, it is not known south of this spot.

Nodules of collophane are present in the Eureka as they are at sections in the Arrow Canyon Range, at Apex siding, and near Lee Guard Station.

Composite section of Ordovician formations south side of lower part of Lucky Strike Canyon, Nev., sec. 15, T. 18 S., R. 58 E., Corn Creek Springs quadrangle

Fault?	
Ely Springs Dolomite:	*Feet*
Dolomite, medium-gray; in 2- to 4-ft beds; weathers medium light and dark gray in alternating layers	92
Dolomite, medium-gray; weathers dark gray and medium dark gray; in 2- to 8-ft. beds	60
Dolomite composed almost entirely of "*Girvanella*" with a few corals	4
Dolomite, medium-gray; weathers dark gray to medium dark gray. *Catenipora* sp., 79 ft above base; colln. D981 CO. *Receptaculites oweni* abundant in 5-ft zone, 32 ft above base	196
Total Ely Springs Dolomite	352
Eureka Quartzite:	
Sandstone, dolomitic, light-gray to reddish-gray, mottled	6
Quartzite, weak, not vitreous	7
Sandstone, quartzitic. Nodules of collophane (colln. D980 CO)	4
Total Eureka Quartzite	17
Pogonip Group:	
Covered slope	6
Dolomite, light-gray; weathers light gray	3
Dolomite, light-olive-gray, fine-grained; in beds 6 in.–2 ft thick. Weathers from grayish orange at bottom to light gray toward top	21
Covered slope	9
Dolomite, medium-gray, mottled	1
Slope covered except for ledges of dolomite; very thin-bedded and thinly laminated (¼–6 in.). Breaks with conchoidal fracture. Light olive gray; weathers grayish orange to yellowish gray. Chert rare	7
Covered	2
Dolomite, medium-gray; weathers light olive gray, in 6- to 8-in. beds. Scattered chert nodules	2
Dolomite, medium-gray, medium-grained; weathers pale yellowish brown. Abundant cystid plates, bryozoans, gastropods, all silicified. USGS colln. D979 CO	5
Dolomite, very cherty, granular	3
Dolomite, very coarsely crystalline, bioclastic. Abundant cystid columnals. Small sponges	10
Dolomite, dark-gray, resistant, ledge-forming	50
Fault. Dolomite brecciated. Displacement not known. Not thought to be great, although there is shattering through this entire thickness. "*Girvanella*"	34
Dolomite, coarsely crystalline, silty, pale-grayish-brown; weathers striking grayish orange. Beds about 3 ft thick	47
Dolomite, medium-light-gray, in beds 6 in.–3 ft thick. Chert in irregular scattered stringers, particularly in upper part of this unit. Many beds with silt partings forming irregular patterns. Unit weathers yellowish	57

Composite section of Ordovician formations south side of lower part of Lucky Strike Canyon, Nev., sec. 15, T. 18 S., R. 58 E., Corn Creek Springs quadrangle—Continued

	Feet
Pogonip Group—Continued	
Dolomite, medium-dark-gray, weathers medium light gray. Coarsely granular, showing some crossbedding and rare patches of quartz sand. Beds 1–3 ft thick	36
Dolomite, thin-bedded; olive gray, weathering light olive gray, or medium dark gray weathering medium gray. The medium-dark-gray dolomite forms one in five beds. Beds 6–18 in. thick, except a few beds 3 ft thick. Rock contains irregular silty partings weathering yellowish orange	37
Base not exposed.	
Total Pogonip Group measured	330

Fossil collections from lower Lucky Strike Canyon include:

USGS colln. D981 CO. Approximately 75 ft above the base of the Ely Springs Dolomite.

Catenipora? sp. (identified by W. A. Oliver, Jr.)

USGS colln. D979 CO. Approximately 40 ft below the top of the Pogonip Group.

Palliseria robusta Wilson (identified by E. L. Yochelson.) Silicified brachiopod fragments, indet. Large plates of echinodermata.

WEST-NORTHWEST OF LEE GUARD STATION, NEV.

Figure 1, locality 41

[Area of outcrop indicated on Clark County map (Bowyer and others, 1958) in T. 19 S., R. 56 E., west of Lee Canyon]

This section is significant because it establishes the presence of a normal thickness of Eureka Quartzite in close proximity to areas where that formation is either very thin or absent. A layer rich in collophane nodules is present at the top. Abundant cystid plates (USGS colln. D994 CO) concentrated 170 feet below the base of the Eureka may correlate with similar forms only 40 feet below the quartzite in lower Lucky Strike Canyon (USGS colln. D979 CO). Sandy interbeds are present in the higher limestones of the Pogonip Group above the Zone of *Anomalorthis* (USGS colln. D993 CO, 200 feet below base of massive quartzite). The correlative of the Ninemile Formation is more calcareous than is typical.

Section of Lower and Middle Ordovician formations west-northwest of Lee Guard Station, sec. 3, T. 19 S., R. 56 E., on south side of peak 10,197, approximate altitude 8,700–9,340 ft, Charleston Peak quadrangle, Nevada. Coordinates of components of section, Nevada, east zone: Eureka Quartzite, E. 470,900 ft, N. 573,100 ft; upper part of the Pogonip Group, E. 470,350 ft, N. 571,750 ft.

	Feet
Ely Springs Dolomite:	
A weak masked interval below the thick dark-gray dolomite; this might be equivalent to sandstone, siltstone, and quartzite units of the Eureka to the east in Arrow Canyon Range.	
Eureka Quartzite:	
Sandstone, mottled reddish; with abundant nodules of collophane	1
Quartzite and dolomitic sandstone in thin interbeds	11
Quartzite, thin-bedded	11
Quartzite, thick-bedded, cliff-forming, vitreous	109
Total Eureka Quartzite	132
Pogonip Group:	
Antelope Valley Limestone:	
Dolomite, medium light-gray, fine-grained at bottom and very coarsely crystalline at top. No quartz sand present.	
Weathers light gray	5
Slope covered	3
Dolomite, medium-dark-gray, very fine grained, silty; weathers mottled medium dark gray	10
Slope covered with float	16
Dolomite, aphanitic, massive, dark-gray; weathers mottled medium dark gray	8
Sandstone, dolomitic; as matrix of intraformational conglomerate with large pebbles and cobbles composed of silty dolomite	8
Dolomite, fine-grained, silty, light-gray	1
Sandstone, dolomitic; contains well-rounded quartz grains	3
Dolomite, silty, very fine grained, medium-light-gray	3
Slope covered with float	20
Dolomite, light-gray; weathers light gray to pale yellowish orange	9
Dolomite, silty, fucoidal, crudely laminated, light-gray; weathers mottled light olive gray	7
Slope mostly covered with float. A few ledges of silty aphanitic light-gray dolomite protrude. Weathers moderate orange pink to very pale orange	29
Slope covered with float	4
Dolomite, light-gray, very fine grained in beds 1–2 ft thick	6
Dolomite, microlaminated, silty; weathers reddish to orange. Fossil brachiopods; colln. D994 CO	4
Dolomite, aphanitic, light-gray	1
Siltstone, dolomitic; weathers pale yellowish gray	2
Dolomite, very silty, very fine grained, in 1-in. laminae	4
Dolomite, silty, medium-grained; forms low ledges	18
Dolomite, nodular, silty; weathers with tinges of red and olive in silty partings. Silicified fossils in colln. D993 CO	12
Dolomite, medium light-gray, fine-grained, in beds 1–3 ft thick	9
Limestone, bioclastic, dark-gray	12

Section of Lower and Middle Ordovician formations west-northwest of Lee Guard Station, sec. 3, T. 19 S., R. 56 E., on south side of peak 10,197, approximate altitude 8,700–9,340 ft, Charleston Peak quadrangle, Nevada. Coordinates of components of section, Nevada, east zone: Eureka Quartzite, E. 470,900 ft, N. 573,100 ft; upper part of the Pogonip Group, E. 470,350 ft, N. 571,750 ft—Continued

Pogonip Group—Continued	
Antelope Valley Limestone—Continued	*Feet*
Dolomite, crudely laminated, slightly silty	16
Dolomite, medium-light-gray; weathers medium dark gray; massive ledges composed of compact 6-in. to 1-ft beds forming resistant ledges and cliffs. "*Girvanella*" one of the main, if not the main, constituent of this unit. Small sponges fairly abundant 130 ft above the base. Small gastropods, having the general form of *Palliseria* but far too small for that genus, common 200 ft above the base	234
Dolomite, thin-bedded, light-gray	16
Dolomite, light-gray, resistant, homogeneous, medium-grained; abundant relict fossils. "*Girvanella*" abundant	53
Total Antelope Valley Limestone	513
Ninemile Formation:	
Limestone, resistant; in 1- to 2-in. laminae with irregular silty partings. Coherent. Some layers very fine grained, others bioclastic and coarse	11
Limestone, thin-bedded, very silty; forms low ledges	10
Limestone, fine-grained, slightly silty, mottled; ledges masked by float for the most part	24
Limestone, bioclastic, fossiliferous, dark-gray; trilobites and brachiopods abundant but badly broken. Include *Hesperonomia, Archaeorthis, Kirkella.* Thin bedded and interbedded with flaky green shale	40
Limestone, bioclastic, partly dolomitized	11
Limestone, entirely dolomitized, slabby, bioclastic	3
Limestone, medium-gray, slabby, bioclastic; composed partly of intraformational conglomerate. Fossils in USGS colln. D992 CO	8
Slope covered with float. Float composed of silty dolomite chips weathering grayish orange to very pale yellowish brown (10*YR* 7/2). A few dolomite ledges protrude through float	52
Total Ninemile Formation	159
Goodwin Limestone:	
Dolomite, resistant, very cherty, thin-bedded, light-gray	44
Slope covered with float	6
Dolomite, thick-bedded, resistant	8
Slope almost entirely covered with float. Float composed of chips of dolomite which is silty and weathers very pale brown	84
Dolomite, light-gray; weathers light gray with pinkish splotches	18
Slope almost completely covered with float composed of chips of light-gray dolomite	106
Dolomite, light-gray; forms resistant cliffs and ledges in massive beds composed of thin laminae. Slightly cherty	5

Section of Lower and Middle Ordovician formations west-northwest of Lee Guard Station, sec. 3, T. 19 S., R. 56 E., on south side of peak 10,197, approximate altitude 8,700–9,340 ft, Charleston Peak quadrangle, Nevada. Coordinates of components of section, Nevada, east zone: Eureka Quartzite, E. 470,900 ft, N. 573,100 ft; upper part of the Pogonip Group, E. 470,350 ft, N. 571,750 ft—Continued

	Feet
Pogonip Group—Continued	
Goodwin Limestone—Continued	
Limestone, fine- to medium-grained, partly bioclastic; in beds 1–3 ft thick interbedded with thinly laminated silty limestone in beds 1 ft thick; medium gray	12
Dolomite, thin-bedded, cherty, thinly laminated, silty; interlayered with more massive beds. In upper half many beds are microlaminated. Part of this interval is partly masked by float	87
Total Goodwin Limestone measured	370

(This is the lowest practical point at which measurements could start. It is not the base of the Goodwin Limestone, however.)

Fossils follow, listed by USGS collections:

D992 CO. Pogonip Group, 630 ft below base of Eureka Quartzite, in probable Ninemile Formation, west-northwest of Lee Guard Station, on ridge on south side of peak 10197. Approximate coord., Nevada east zone: E. 470,350 ft, N. 571,750 ft.

Sponge?

Presbynileus sp.

Fossils 25 ft higher were identified in the field as *Hesperonomia* sp., *Archaeorthis* sp., and *Kirkella* sp.

D993 CO. Pogonip Group, 160 ft below base of Eureka Quartzite in probable Antelope Valley Limestone.

Cystid plates, abundant

Anomalorthis sp.

D994 CO. Pogonip Group, 132 ft below base of Eureka Quartzite in probable Antelope Valley Limestone.

Orthambonites sp. (possibly *O. occidentalis* but poorly preserved)

Conodonts

RAWHIDE MOUNTAIN, NEV.

Figure 1, locality 49; figure 5

[T. 5 N., R. 49 and 49½ E., Tonopah 2° quadrangle]

Rawhide Mountain is 6 miles south of the abandoned mining town of Tybo, Nev. (fig. 1, loc. 24). In his report of the Tybo district, Ferguson (1933, p. 16–20) indicated that no Upper Ordovician carbonate was present between the Eureka Quartzite and the Silurian. Because the Tybo area is much disturbed structurally, F. J. Kleinhampl and I visited Rawhide Mountain in 1961 to determine whether the Ely Springs Dolomite was absent for structural or for stratigraphic reasons. We concluded that 75 feet of dark-gray dolomite, but no more than that thickness, may belong to the Ely Springs.

In addition we found a thick black shale unit beneath the Eureka (Ferguson, 1933, p. 18); this unit contains a trilobite and ostracode fauna. Lower in the section the Ninemile Formation is far thicker than at any place south.

The section provides a possible link between those sections to the south and those in the general vicinity of Eureka, Nev.

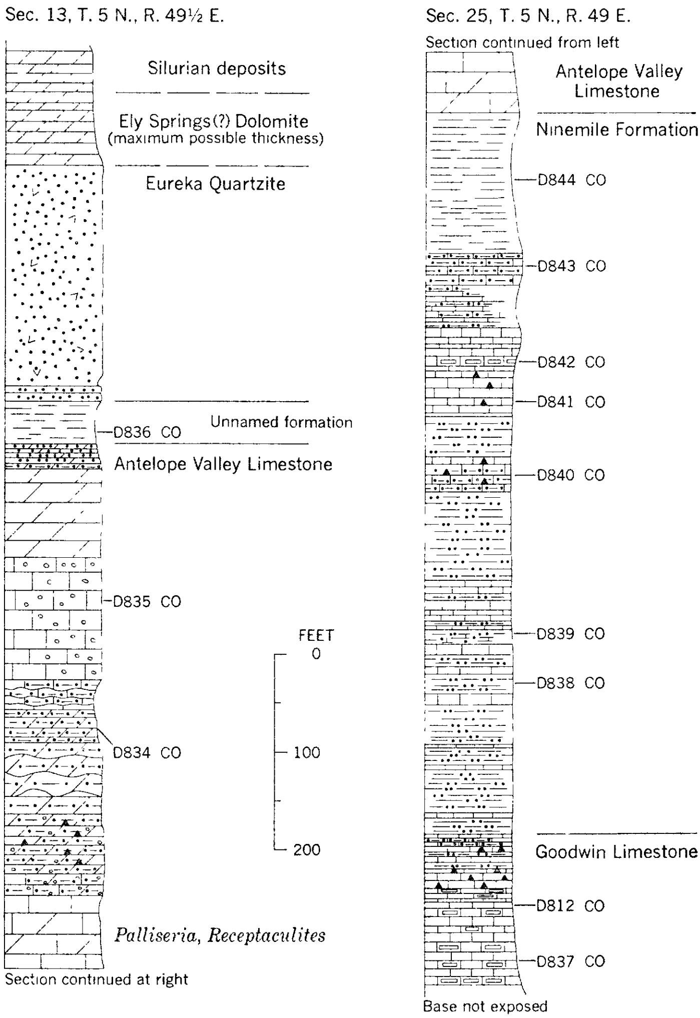


Figure 5.—Diagrammatic stratigraphic section at Rawhide Mountain, sec. 13, T. 5 N., R. 49½ E., and sec. 25, T. 5 N., R. 49 E., Tonopah quadrangle, Nevada. For explanation of lithic types see plate 1.

The upper part of the section is best exposed on the southeast front at the northeast end of Rawhide Mountain (sec. 13, T. 5 N., R. 49½ E.), whereas the Ninemile Formation and top of the Goodwin Limestone are best exposed at the south end of the mountain (sec. 25, T. 5 N., R. 49 E.). The following section is a composite from these two localities. Unfortunately, in the time available, we were unable to link the upper and lower parts of the section together with certainty. The lower part of the Goodwin Limestone is not exposed.

Composite section of Ordovician formations at Rawhide Mountain, sec. 13, T. 5 N., R. 49½ E. and sec. 25, T. 5 N., R. 49 E., Tonopah 2° quadrangle, Nevada.

	Feet
Ordovician:	
Ely Springs Dolomite:	
Dolomite, dark-medium-gray, badly brecciated. No fossils	75
Eureka Quartzite:	
Quartzite, vitreous, crossbedded in part, thick- to thin-bedded; basal 10 ft are weak sandstone	226
Sandstone, dolomitic, crossbedded	15
Total Eureka Quartzite	241
Unnamed formation:	
Shale, black, fissile, fossils rare. *Remopleurides*, *Isotelus*?, small ostracodes. Colln. D836 CO	44
Pogonip Group:	
Antelope Valley Limestone:	
Dolomite, sandy; well-rounded quartz grains	3
Sandstone, dolomitic, crossbedded	13
Dolomite, silty, sandy; weathers pale grayish orange	9
Dolomite, massive, light-gray	92
Limestone, dolomitic; crudely laminated but cemented into massive beds as much as 3 ft thick, forming ledges 6–20 ft high. "*Girvanella*" abundant in many beds throughout interval. A few beds in upper 70 ft weather pale grayish orange. Most beds alternate between medium light and medium dark gray. *Orthambonites* and *Anomalorthis* 77 ft above base. Colln. D835 CO	122
Limestone, nodular, silty, thin-bedded, nonresistant	33
Dolomite, silty; thinly laminated, but laminae show only on weathered surface. Weathers pale grayish orange. Colln. D834 CO about 10 ft above base. Bryozoans, ostracodes	33
Limestone, dolomitic, massive; medium light gray with yellowish-orange splotches arranged in 1- to 2-in. layers, crudely laminated	75
Dolomite, silty, siliceous, light-olive-gray; weathers grayish orange	63
Dolomite, massive, light-gray; bedding faintly suggested by silty streaks	36
Limestone, dolomitic, massive, silty; with very fine laminae weathered into relief. "*Girvanella*" abundant	19
Limestone, dolomitic, dark-gray, massive. *Palliseria*, *Receptaculites*	75
Total Antelope Valley Limestone	573

Composite section of Ordovician formations at Rawhide Mountain, sec. 13, T. 5 N., R. 49 ½ E. and sec. 25, T. 5 N., R. 49 E., Tonopah 2° quadrangle, Nevada—Continued

	Feet
Pogonip Group—Continued	
Ninemile Formation:	
Shale, black and green; weathers dark yellowish orange. *Orthidiella* 71 ft above base (USGS colln. D844 CO). Ostracodes	143
Limestone, thinly laminated, silty. *Orthambonites*, abundant small ostracodes (USGS colln. D843 CO)	30
Slope covered with silty calcareous float that weathers grayish orange and is fossiliferous	47
Limestone, fine-grained, light-gray; in 6-in. to 3-ft beds. A few beds of intraformational conglomerate in 2-ft interbeds. Fossils from base (USGS colln. D842 CO)	45
Limestone, gray, slightly silicified. Fossils in lower 28 ft (USGS colln. D841 CO). *Hesperonomia, Lachnostoma*	47
Siltstone, calcareous	41
Limestone, resistant; partly very silty; in 6-in. to 3-ft beds. Fossils in lower half (USGS colln. D840 CO)	35
Siltstone, calcareous. A few 6-in. to 1-ft beds of limestone	91
Limestone, light-gray, crystalline; in thin beds, 3 in.–1 ft thick, with minor amount of interbedded siltstone	50
Siltstone and limestone interbedded. Limestone at top in beds as much as 12 in. thick. Lower interbeds of both lithologies equal and about 1–2 in. thick. Fossils common on surfaces of chips slabs. USGS colln. D839 CO, 82 ft above base; USGS colln. D838 CO *Kirkella*, 33 ft above base. Unit forms 24° slope	91
Siltstone, calcareous, black to dark-gray; weathers dark yellow orange to light brown. Generally 6-in. beds of siltstone alternate with 1-ft beds of nodular limestone. One graptolite fragment, dichograptid	112
Total Ninemile Formation	732
Goodwin Limestone:	
Limestone, light-gray; with silty and siliceous interbeds forming a little less than 50 percent of the interval. Intraformational conglomerate and fine interbeds	44
Limestone, highly silicified nodular; "crepe" effect where weathered	15
Limestone, light-gray, slightly siliceous. Some intraformational conglomerate	10
Limestone, silicified; "crepe" effect where weathered	2
Limestone, light-gray to medium-gray; intraformational conglomerate and fine-grained interbeds, 3 in.–2 ft thick. Some poorly developed silicification is light olive gray to grayish orange. Fossils 21 ft above base (colln. D837 CO); *Trigonocerca?* 66–83 ft above base (colln. D812 CO)	88
Total Goodwin Limestone measured	159

Covered below this point in wash.

Fossils from Rawhide Mountain follow, listed by USGS collections:

D836 CO. Black shale, beneath Eureka Quartzite.

Remopleurides sp. (compares with species in colln. D831 CO at Meiklejohn Peak, not with species from Barrel Spring Formation).

Isotelus? sp. (small, may be dwarfed by environment).

Ostracoda (two genera)

Concerning the ostracodes from this collection, Jean M. Berdan (written commun., 1962) reported as follows: "Collection D836 CO contains molds of ostracodes which appear to be a fairly large species of *Schmidtella*. Although drawing any conclusions from ostracodes with this type of preservation is risky, this species appears similar to the species of *Schmidtella* identified from the Eureka in the Ranger Mountains (colln. D680 CO) and also to previously reported *Schmidtella* from the Kanosh Shale in Utah. However, the specimens in this collection seem closer to the specimens from the Ranger Mountains than to those in the Kanosh, as they do not have a pronounced an umbo, a feature which would be apparent even in molds."

D835 CO. Antelope Valley Limestone from dolomitic limestone 206 ft below base of Eureka Quartzite.

Anomalorthis oklahomensis Ulrich and Cooper

Orthambonites cf. *O. swanensis* Ulrich and Cooper (same species as that from collns. D709 CO, D710 CO, and D711 CO, from Ranger Mountains, Nevada Test Site.)

D834 CO. Antelope Valley Limestone, 339 ft below base of Eureka Quartzite.

Eoleperditia cf. *E. bivia*

Leperditella sp.

Other small, smooth ostracodes

According to Berdan these ostracodes correlate with the Lehman Formation, (not with the Kanosh Shale of Hintze, 1951).

D844 CO. Ninemile Formation, 70 ft below top, in black and green shale. (Top 143 ft here is correlative with lower beds of the Antelope Valley elsewhere.)

Orthidiella sp.

Leperditella sp. (large gibbous species)

Schmidtella sp. (large species)

According to Berdan these ostracodes are found in the Kanosh Shale of Hintze, thus suggesting that the upper part of the Ninemile Formation at this locality is also a lithic equivalent of the Kanosh.

D843 CO. Ninemile Formation, 188 ft below top, in silty limestone.

Orthambonites sp.

Archaeorthis? sp.

Pseudocybele? sp.

Ostracodes, abundant

D842 CO. Ninemile Formation, 264 ft below top.

Nileid?

Lichnocephala sp.

Kirkella sp.

Pilekia? sp.

Diparelasma? sp.

Hesperonomiella? sp. (very doubtful)

D841 CO. Ninemile Formation, 285–310 ft below top.

Hesperonomia antelopensis Ulrich and Cooper

Orthidiella? sp.

Kirkella vigilans (Whittington)

Lachnostoma latucelsum Ross

D840 CO. Ninemile Formation, 368–388 ft below top.
Hesperonomia sp.
Hesperonomiella? sp.
Indet. asaphid pygidium

D839 CO. Ninemile Formation, 538 ft above base.
Hesperonomia cf. *H. crassa* Ulrich and Cooper
Notopeltis orthometopa Harrington
Lachnostoma latucelsum Ross
Unidentified asaphid
Pseudocybele? n. sp.

D838 CO. Ninemile Formation, 585 ft below top.
Kirkella sp. (field identification)
Maclurites, not *M. magnus* (according to E. L. Yochelson)

D837 CO. Goodwin Limestone, 138 ft below top.
Syntrophiid brachiopod
Nanorthis? sp.
Trilobite fragments, indet.

D812 CO. Goodwin Limestone, 95–175 ft below top.
Scinocephalus aff. *S. solitecti* Ross
Leiostegium sp.
Asaphellus sp.
Trigonocerca sp.
Illaenid?

Some elements of this fauna are found in the uppermost Goodwin in Ninemile Canyon, Antelope Range, Nev.

WEST SIDE OF ANTELOPE VALLEY, NEV.

Figure 1, locality 12; figure 6.

[Type section of the Antelope Valley Limestone (Nolan and others, 1956, p. 28)]

On the west side of Antelope Valley, the upper part of the Pogonip Group is exposed beneath strata to which Nolan and others (1956, p. 28) gave the name Copenhagen Formation. At the base of that unit is a quartzitic sandstone (Kirk, 1933, p. 28–29). In 1957 R. J. Ross Jr., made three small collections from Pogonip beds immediately underlying the sandstone.

The upper 5 feet of the Antelope Valley beds is very sandy and seems to be overlain conformably, possibly gradationally, by the sandstone, although Cooper (1956, chart 1) indicated that a disconformity of considerable magnitude exists between them.

Because of the faulted nature of the east side of Martin Ridge, the three collections came from three different localities indicated below by Nevada footage grid coordinates, east zone.

The collections are from the upper platy and argillaceous part of the typical Antelope Valley Limestone and provide the only place so far reported by anyone where brachiopods possibly assignable to the so-called *Rhysostrophia* Zone (Cooper, 1956, p. 127) can be shown to rest above those of the *Anomalorthis* Zone.

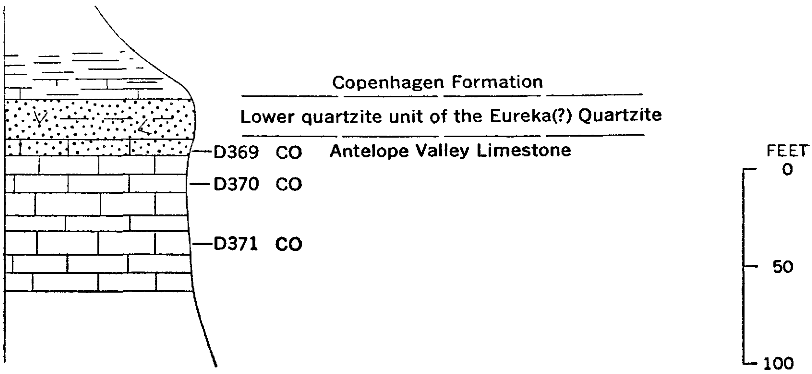


FIGURE 6.—Partial stratigraphic section on the east side of Martin Ridge, west side of Antelope Valley. Composite of three localities, Nevada coord., east zone: E. 273,100 ft. N. 1,628,700 ft: E. 274,300 ft, N. 1,627,560 ft: E. 274,250, N. 1,626,300. Horse Heaven Mountain quadrangle, Nevada. For explanation of lithic types see plate 1.

D369 CO. Antelope Valley Limestone, 5 ft below base of overlying sandstone, east side of Martin Ridge, altitude 6,880 ft. Coord., east zone, E. 273,100 ft, N. 1,628,700 ft, Horse Heaven Mountain quadrangle, Nevada.

Leptellina sp.
Valcourea sp.
Calliops? sp.
Goniotelina? sp. (pygidium without spine)
Bryozoans
Ostracodes

D370 CO. Antelope Valley Limestone, 25 ft below top. East side of Martin Ridge, altitude 6,710 ft. Coord., east zone: E. 274,300 ft, N. 1,627,560 ft, Horse Heaven Mountain quadrangle, Nevada.

Anomalorthis sp.
Illaenus cf. *I. utahensis* Hintze
Goniotelina sp. (with terminal spine)
Leperditiid ostracodes
Conodonts

D371 CO. Antelope Valley Limestone, from float 60 ft below top. East side of Martin Ridge. Coord., east zone: E. 274,250 ft, N. 1,626,300 ft, Horse Heaven Mountain quadrangle, Nevada.

Anomalorthis cf. *A. oklahomensis* Ulrich and Cooper
Illaenus sp.

BEAVER CREEK, UTAH

Figure 7; figure 1, near locality 1

[East side of creek, south of Utah-Idaho State line, E½ sec. 35, T. 15 N., R. 4 E., Logan quadrangle, Utah]

To correct and supplement previous information (Ross, 1951, p. 13) on this section which has bearing on the correlation of the boundary between the Garden City and Swan Peak Formations, the fossils collected below the boundary are listed here.

USGS collection D190d CO was made 105 feet below the lowest thin quartzite of the lower part of the Swan Peak Formation as used by Williams (1948, p. 1136) and Ross (1951, p. 6–7). It includes:

Orthambonites subalata Ulrich and Cooper
Anomalorthis oklahomensis Ulrich and Cooper
Syntrophopsis transversa Ulrich and Cooper
Goniotelina n. sp.
Bathyurellus n. sp.

This collection sugests a correlation between zone L of Ross (1951, p. 27) and the high *Orthidiella* Zone or low *Anomalorthis* Zone of Cooper (1956, p. 126–127, chart 1). This tends to support Cooper's (1956, p. 130) correlation of zone M in the lowest Swan Peak and in the Kanosh Shale of Hintze (1951) with the *Anomalorthis* Zone of the Antelope Valley Limestone.

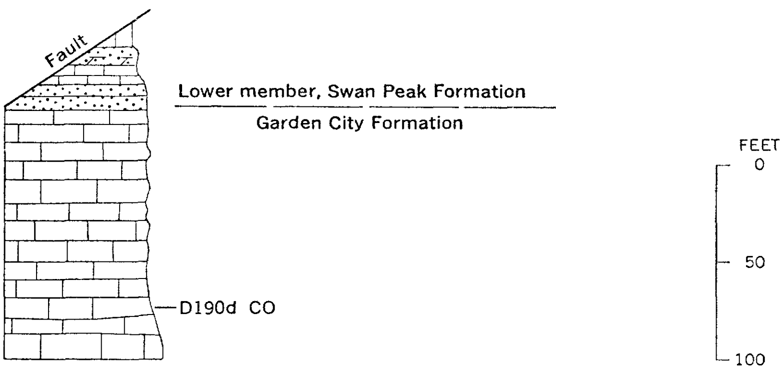


FIGURE 7.—Partial stratigraphic section on Beaver Creek, immediately south of the Idaho-Utah State line, E½ sec. 35, T. 15 N., R. 4 E., Logan quadrangle, Utah. Supplements locality 2 of Ross (1951). For explanation of lithic types see plate 1.

It is therefore significant that the vitreous quartzite of the upper part of the Swan Peak Formation and the Eureka Quartzite at its type area at Lone Mountain, Nev., hold similar stratigraphic positions and rest on the same faunal zone.

At the Beaver Creek locality (fig. 7), brachiopods correlating with those of the Ninemile Formation of central Nevada occur 150 feet below the base of the lower member of the Swan Peak. The intervening 45 feet of section between the two collections is less than one might expect in central Nevada for the same interval.

Two collections of ostracodes from the Swan Peak beds were studied by Jean M. Berdan (written commun., 1962), who reported as follows:

D629 CO. "From the lower part of the upper quartzite member of the Swan Peak Formation; consists of molds and casts of ostracodes, which are difficult to identify. However, a species of *Schmidtella* seems to be present, and probably some sort of leperditellid. The *Schmidtella* is smaller than the species previously mentioned from the Kanosh, but not as small as the one in the Antelope Valley."

D681 CO. "From the limy beds beneath the upper quartzite member of the Swan Peak Formation at Green Canyon, near Logan, Utah. Contains quantities of '*Paraschmidtella.*' The same genus though possibly not the same species, occurs in the lower part of the Kanosh Shale in the Heckethorn Hills, between Hintze's Ibex sections J and K, and also in one of the collections from Spors Mountain, in the Thomas Range. This ostracode is probably not true *Paraschmidtella*, which is a Lower Devonian genus, hence I have put the name in quotes. It is coarsely punctuate, and may well be what Hintze identified as *Macronotella*, although it certainly does not belong in that genus as currently interpreted. The specimens from the Logan area seem to be less punctuate than those from the Ibex area."

STRATIGRAPHIC SUMMARY

CONTINUITY OF LITHIC UNITS

Lower and Middle Ordovician lithic units are fairly continuous across southern Nevada and adjacent California.

The shales of the Ninemile Formation or its equivalent are easily recognized in the western half of the area and are probably represented by dolomitized siltstones and silty limestones east of the Nevada Test Site. This formation is considered to form the top of the Lower Ordovician.

The lower impure limestone of the Antelope Valley is recognized without much difficulty between the Arrow Canyon Range and the Quartz Spring area but seems to have lost its identity in the Inyo Mountains, perhaps because of metamorphism. This unit is in most places characterized by a fauna transitional from that of the Ninemile Formation and by the *Orthidiella* Zone. In addition, dasycladacean algae are abundant near the flanks of large reeflike bodies in a wide area from Bare Mountain to the test site. These indicate deposition in an environment of warm, shallow seas (P. E. Cloud, written commun., June 9, 1961).

The massive to thick-bedded "*Girvanella*"-rich middle member of the Antelope Valley Limestone is recognized without great difficulty in all areas studied except in the northern Inyo Mountains. On the Nevada Test Site where members somewhat different (Byers and others, 1961) from those in the type area (Nolan and others, 1956) have been designated, these rocks form the lower part of the upper or Aysees Member.

The upper thin-bedded silty and sandy limestone is well developed in all areas except in the Inyo Mountains and Sheep Range. In the Inyo Mountains, sandstones and sandy siltstones interbedded with the highest limestones seem to represent this interval. In the Sheep Range sandy and silty dolomites are its equivalent. On the Nevada Test Site this unit forms the upper part of the Aysees Member (Byers and others, 1961). The continuity of these lithic units is indicated on plate 1. Like the underlying units, the Eureka Quartzite and Ely Springs Dolomite persist across most of the area studied. The Eureka is absent in the eastern part of the La Madre Mountain (figs. 1, 12, loc. 42), on the west of Red Rock Canyon (figs. 1, 12, loc. 43), and in the upper reaches of Lucky Strike Canyon (figs. 1, 12, loc. 40), whereas the Ely Springs is either very thin or absent at Rawhide Mountain (fig. 1, loc. 49).

MIDDLE ORDOVICIAN STAGES

The Middle Ordovician stratigraphy of North America has for years been the subject of much disagreement, particularly in regard to the Chazy and Black River Stages (Twenhofel and others, 1954, p. 253–255). Cooper in 1956 completed a monumental work, on the brachiopods of the Middle Ordovician, in which he set forth a new scheme of Middle Ordovician Stages (fig. 8) (1956, p. 6–9) to get away from the confines, prejudices, and misunderstandings of the traditional Chazy, Black River, and Trenton subdivisions.

In this new scheme, Chazy was restricted to its type area in New York, and the Marmor Stage was named for a stratigraphic section near Friendville, Tenn., believed to be the correlative of the restricted Chazy Group (Day Point, Crown Point, and Valcour Formations of New York (Cooper, 1956, p. 8, chart 1)). The name Whiterock Stage was coined (Cooper, 1956, p. 7–8, chart 1) for a sequence of rocks exposed in central Nevada that are younger than Early Ordovician and yet seem to contain brachiopods more primitive than those of the Marmor strata. Similarly, the Black River was restricted to its type area and equated to the lower part of the Wilderness Stage which has a reference section in West Virginia. The Ashby and Porterfield Stages were interjected between the Marmor and Wilderness on the basis of sections in Tennessee and Virginia (Cooper, 1956, p. 8, chart 1). The Trenton Stage was restricted to units equivalent to those of the type area southwest of the Adirondack Arch (Cooper, 1956, p. 9, chart 1); the restriction was well illustrated by Kay (1937, fig. 10, column on southwest Adirondack Arch).

The history of usage of Ordovician stages in New York State and current interpretations there were published on a new correlation chart by Fisher (1962).

In the present report the Whiterock, Marmor, Ashby, and Porterfield Stages are involved in the discussion of the upper part of the Pogonip Group and overlying Eureka Group. Of these, the Whiterock deserves special note here because it is based on several sections in the Antelope, Monitor, and Toquima Ranges, Nev. (Cooper, 1956, p. 7–8).

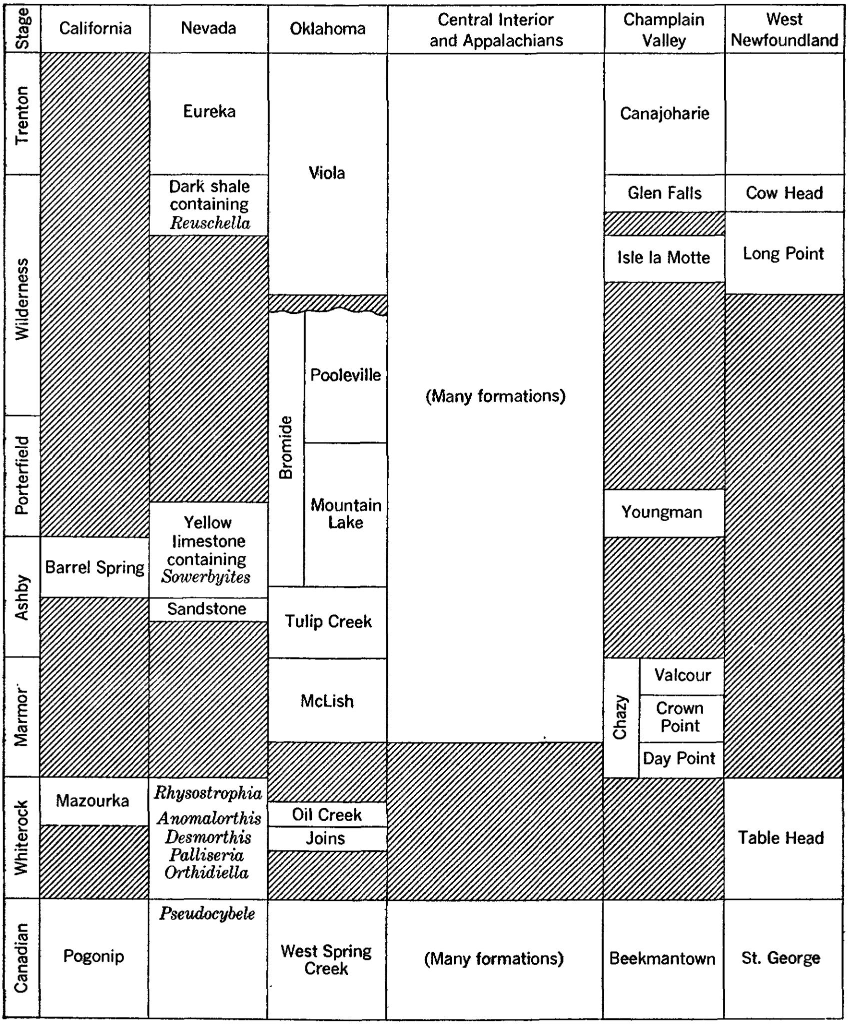


FIGURE 8.—Correlations within the Middle Ordovician according to Cooper (1956).

THE WHITEROCK STAGE

The Whiterock Stage is based on five fossil zones (Cooper, 1956, chart 1, Nevada column; p. 126–127). Collections on which the five zones are based came from strata of the Antelope Valley Limestone. Although no type section was designated for this formation, its type area is in the Monitor and Antelope Ranges on either side of Antelope Valley (Nolan and others, 1956, p. 28).

The *Orthidiella*, *Palliseria*, *Desmorthis*, and *Anomalorthis* Zones were designated by Cooper in 1954 (in Twenhofel and others, 1954, chart 2, col. 64) and placed within the early Chazy Stage. Two years later the *Rhysostrophia* Zone was added on the basis of collections from the Toquima Range, and all five were grouped to form the Whiterock Stage (Cooper, 1956).

The reference section for the stage is composite. The *Orthidiella* Zone was located in the Monitor Range but the best collections were obtained from "the first ridge east of Frenchman Flat" (Cooper, 1956, p. 126), the same locality as USGS collection D719 CO of this report (p. C20).

The *Palliseria* Zone is ubiquitous in much of Nevada. Its reference section was not indicated although its position below the *Desmorthis* and *Anomalorthis* Zones was probably established at Lone Mountain north of Antelope Valley (fig. 1, Nevada loc. 6). As indicated elsewhere in this report it is known that the *Palliseria* Zone does not hold a constant stratigraphic position.

The *Desmorthis* Zone is typically developed at Lone Mountain where silicified shells of this genus form a large percentage of the bulk of a thin rock unit. Original references to this zone (Cooper, in Twenhofel and others, 1954, column 64; Cooper, 1956, chart 1, p. 126–127) indicated that it lies below the *Anomalorthis* Zone although two species of *Anomalorthis* were stated to occur in it. My own collections made on Lone Mountain (Bartine Ranch quadrangle) (collns. D372 CO, D374 CO, D375 CO, D375a CO) show that the *Desmorthis* Zone is, in fact, a thin unit within the *Anomalorthis* Zone.

According to its definition (Cooper, 1956, p. 127), the *Anomalorthis* Zone is based on fossils from thin-bedded limestones which, as Bassler (1941) noted, contain a remarkable assemblage of sponges. These beds are near Ikes Canyon in the Toquima Range (fig. 1, 20 miles west of Nevada loc. 12), and in them *Anomalorthis* is an extremely rare find. The trilobite *Pseudomera* is stated to be typical of the zone. It seems unfortunate that the *Anomalorthis* Zone is not based on a section wherein *Anomalorthis* itself is a characteristic fossil. Such a section is available at Lone Mountain, where the zone is present in highest Antelope Valley strata beneath the Eureka Quartzite. In fact, if the "sponge beds" of the Toquima Range are correlative with the *Anomalorthis*-bearing beds in the ranges surrounding Antelope Valley, then a striking change in faunal facies has taken place over a distance of approximately 20 miles.

The highest zone of the Whiterock Stage is the *Rhysostrophia* Zone, which is based on collections made south of Ikes Canyon at the same locality as the aforementioned sponge beds. It is represented there by 12 genera of brachiopods. On the basis of two of these, *Orthidium* and *Rhysostrophia*, the zone is believed to be represented also in a part of the Table Head Formation of Newfoundland. *Orthidium* and *Rhysostrophia* together are known only in the Toquima Range, Nev., and in Newfoundland; *Rhysostrophia* is found also in boulders of the Mystic Conglomerate near Quebec.

Although not previously reported in the Monitor Range, the *Rhysostrophia* Zone seems to be present in the upper 10 feet of the Antelope Valley Limestone on the east flank of Martin Ridge (Horse Heaven Mountain quadrangle), where *Leptellina*, *Valcourea*, *Calliops?*, and *Goniotelina?* are present (USGS colln. D369 CO). Although the first two of these, both brachiopods, are characteristic of the *Rhysostrophia* Zone fauna (Cooper, 1956, p. 127), they are far more characteristic of Marmor and younger stages. Only 15 feet lower, 25 feet below the top of the Antelope Valley Limestone, the *Anomalorthis* Zone is well represented (USGS colln. D370 CO). Therefore, not more than 25 feet of strata can belong in the *Rhysostrophia* Zone at this locality. The *Leptellina* and *Valcourea*-bearing beds are silty and slightly sandy, becoming increasingly so at the top. They are overlain with seeming conformity by sandstone and quartzite which Kirk (1933, p. 28–29) considered the base of the Eureka Quartzite and which Cooper (1956, p. 127–128, chart 1, Nevada column) placed at the base of his Eureka Group and dated as Ashby.

The collections from Martin Ridge provide the best evidence available from the type area of the Antelope Valley Limestone that the *Rhysostrophia* Zone does occur above the *Anomalorthis* Zone. Although *Anomalorthis* is abundant here, *Rhysostrophia* has not been found. In the Toquima Range on the other hand, where *Rhysostrophia* is abundant, *Anomalorthis* is almost unknown. So rare is the genus that G. A. Cooper (written commun., Feb. 7, 1962) was under the impression that it was absent in the Toquima Range but later found one or two specimens in collections from the sponge beds (oral commun., Jan. 22, 1963).

Of the 12 genera of brachiopods composing the *Rhysostrophia* Zone (Cooper, 1956, p. 127), 5 are monotypic and are known only from the Toquima Range. Although they may be considered phylogenetically more primitive than other genera of Marmor age, lack of outside distribution prevents their objective use in correlation, and they must be ignored for this purpose. By the same token, one species might suggest an age younger than Marmor if it were not referred questionably to *Porambonites*. *Orthambonites* is a long-ranging genus not known in rocks older than Whiterock but present throughout the younger Ordovician. The distribution of *Orthidium* and *Rhysostrophia* itself is noted above.

Therefore, dating of the *Rhysostrophia* Zone rests on three genera. Each is represented by a single species in the beds at Ikes Canyon.

There is 1 species of *Leptellina* listed in the Crown Point Formation of Marmor age; 11 species are listed in formations of Porterfield or younger ages. *Sowerbyella* is represented by 2 species in Ashby beds, 13 in Porterfield, 12 in Wilderness, and 3 in Trenton units. *Valcourea* is known to have two species in Marmor beds (one of these in the Crown Point), seven species in Ashby units, and six species in Porterfield strata.

On the basis of these data presented by Cooper (1956, p. 147–186), the *Rhysostrophia* Zone should be at least as young as the Marmor Stage and might be as young as Ashby.

Kay (1962, tables 1, 2) published a stratigraphic section for the Toquima Range in which he showed that *Leptellina* and *Sowerbyella* occur together stratigraphically above *Valcourea* and *Rhysostrophia* (fig. 9). This suggests that the fauna of the *Rhysostrophia* Zone can be subdivided. The suggestion is supported by the fact that in many sections *Rhysostrophia* is either absent or unrecognized where *Leptel-*

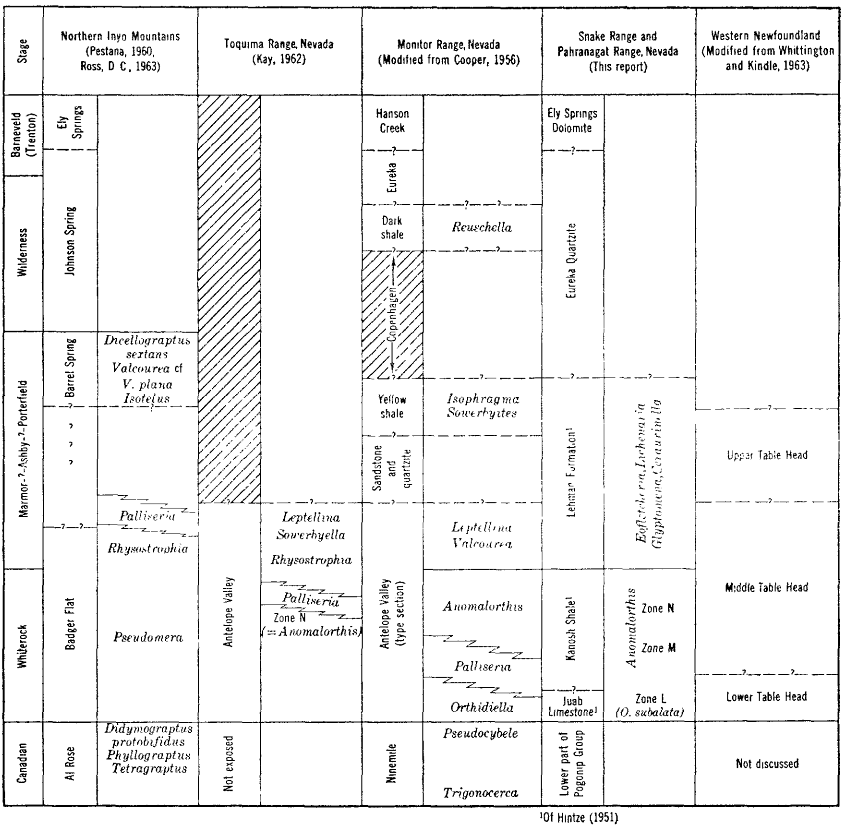


Figure 9.—Revised correlations within the Middle Ordovician of central Nevada.

lina and *Sowerbyella* are present. However, the association of *Valcourea* and *Leptellina* at Martin Ridge and at Bare Mountain shows that such a simple subdivision of the *Rhysostrophia* Zone is not consistently tenable.

The position of the *Rhysostrophia* Zone is significant. As noted above, *Leptellina* and *Valcourea* are now known in the top 10 feet of the Antelope Valley Limestone at Martin Ridge. These limestone beds are sandy and are overlain by about 25 feet of sandstone and quartzite. There is no reason to suppose that a major unconformity exists beneath the sandstone unit, nor to believe there is an unconformity below the 10-foot *Leptellina*-bearing unit. It seems evident that the uppermost Antelope Valley beds belong not only to the Whiterock Stage but also to the Marmor or younger beds as these stages are now constituted; the boundary between these stages needs to be redefined or abolished. A suggested revision is shown in figure 9.

FAUNAL ZONES AND ANOMALIES IN THE ANTELOPE VALLEY LIMESTONE

The faunal zones of the Antelope Valley Limestone exemplify three different kinds of zones and demonstrate varying degrees of persistence within lithic units across the southern Basin Ranges.

DESMORTHIS ZONE

The *Desmorthis* Zone, as noted above, is locally developed on Lone Mountain in central Nevada and is here considered a peak zone (Am. Comm. Strat. Nomenclature, 1961, art. 20(g)). It has been recognized only questionably to date in southern Nevada (USGS colln. D705 CO, Nevada Test Site).

ORTHIDIELLA ZONE

The *Orthidiella* and *Anomalorthis* Zones are range zones (Am. Comm. Strat. Nomenclature, 1961, art. 22). The *Orthidiella* Zone has been found in the sections at the Nevada Test Site (USGS collns. D719 CO, D720 CO, D728 CO, D727 CO, D718 CO), at Meiklejohn Peak (USGS collns. D818 CO, D821 CO, D740 CO), and in the Quartz Spring area (USGS colln. D1009 CO). Its position in the Inyo Mountains is uncertain; possibly the zone is represented by USGS collection D922 CO, a large poorly preserved trilobite pygidium. However, this specimen also suggests correlation with the *Anomalorthis* Zone. Positions of these collections are shown on plate 1.

ANOMALORTHIS ZONE

The *Anomalorthis* Zone is well represented in the Arrow Canyon Range (USGS collns. D962 CO, D963 CO, D970 CO, D1066 CO) directly beneath the Eureka Quartzite, and in the Nevada Test Site (USGS collns. D707 CO, D706 CO, D729 CO), several hundred feet below the Eureka. Collections characterized by *Orthambonites* cf *O. swanensis* Ulrich and Cooper (USGS collns. D712 CO, D710 CO, D709 CO) were made within 35 feet of the basal quartzites. This same species of *Orthambonites* is associated with *Anomalorthis oklahomensis* Ulrich and Cooper at Rawhide Mountain (USGS colln. D835 CO) and may represent the upper limits of the *Anomalorthis* Zone at the test site.

No indication of the *Anomalorthis* Zone has been found at Meiklejohn Peak. To be sure, a species of *Anomalorthis* is found (USGS colln. D821 CO) in the upper *Orthidiella* Zone, but this is also true at the Nevada Test Site (USGS colln. 720 CO) and in northeast Utah (Ross, 1951, zone L, p. 27). The expected position of the *Anomalorthis* Zone on Meiklejohn Peak is occupied either by the *Palliseria* Zone fauna or by a fauna presumed to be of markedly younger age (USGS collns. D829 CO, D819 CO, D831 CO, D930 CO, D825 CO). Stratigraphic evidence from the southwest side of the peak suggests that the zone may have been removed by faulting, but I failed to see such evidence on the north side. This seeming absence of the *Anomalorthis* Zone provides one of the anomalies of this study.

The zone is similarly absent from the Quartz Spring sections. Although it may be represented in the Inyo Mountains by cephalopods and a trilobite (USGS collns. D1007 CO, D922 CO), its presence there is also far from established.

PALLISERIA ZONE

The *Palliseria* Zone is an assemblage zone (Am. Comm. Strat. Nomenclature, 1961, art. 21) with limited time significance. It is characterized by the association of *Palliseria*, *Maclurites*, and "*Girvanella*" and is best developed in massive resistant dark-gray limestones and dolomites, which are the main constituents of the middle member of the typical Antelope Valley Limestone (Nolan and others, 1956, p. 29).

As indicated on plate 1, in the Arrow Canyon Range this zone occurs below the *Anomalorthis* Zone. The bottom of the *Anomalorthis* Zone and top of the *Palliseria* Zone overlap slightly on the Nevada Test Site. On Meiklejohn Peak and in the Quartz Spring area the "*Girvanella*"-rich limestones of the *Palliseria* Zone hold the position of the *Anomalorthis* Zone; and in the Inyo Mountains, *Palliseria* occurs in and above the *Rhysostrophia* Zone.

Relative to brachiopod zones the *Palliseria* Zone seems to be considerably younger on the west of the report area than on the east. Although it is not limited to the massive "*Girvanella*"-rich limestone, it is more common therein. I therefore conclude that its presence is linked closely to a facies which seemingly migrated westward (fig. 10).

If a westward shift occurred, it may have resulted in the coinciding of the *Palliseria* Zone and *Anomalorthis* Zone at Meiklejohn Peak and the Quartz Spring area by producing an environment unsuitable for the development of the *Anomalorthis* Zone fauna. Such an hypothesis may explain why brachiopod fauna were not found at either of these localities. It is not, however, the only possible explanation for the zone's absence.

RHYSOSTROPHIA ZONE

The *Rhysostrophia* Zone is an assemblage zone with great potential, but as yet indefinite, time significance. As discussed above, the *Rhysostrophia* Zone should be considered Chazy (or Marmor) in age rather than Whiterock. It is represented in the Inyo Mountains by three species of the genus *Rhysostrophia* (USGS collns. D1003 CO, D1004 CO), all associated with fossil sponges. These sponges bear a strong resemblance to those of the Ikes Canyon area where, according to Bassler (1941, p. 92), they likewise are associated with *Rhysostrophia*. On the other hand, Cooper (1956, p. 127) and Kay (1962, tables 1, 2) indicated that the sponge beds of Ikes Canyon are below *Rhysostrophia* and correlative with the upper *Anomalorthis* Zone.

The marked similarity of lithologies and stratigraphic positions of the *Anomalorthis*-bearing beds at the test site and the *Leptellina*-bearing beds at Meiklejohn Peak led me to assume them correlative until very different faunas were removed from collections by acid treatment in the laboratory. The stratigraphic similarity is so strong that one can hardly avoid the possibility that the rocks are contemporaneous and that their faunas may differ because of some unknown ecologic control such as temperature or salinity. Such a possibility would require that the Whiterock *Anomalorthis* Zone, like the *Rhysostrophia* Zone, should be of Marmor age. Because of evolutionary stages of development of the faunas (G. A. Cooper, written commun., May 31, 1962), this seems unlikely. The report by Kay (1962, tables 1, 2) of trilobites of zone N (high *Anomalorthis* Zone equivalent) below *Rhysostrophia* also discourages it. Yet, *Pseudomera*, typically a Whiterock genus, occurs above the Marmor fauna at Meiklejohn Peak (USGS colln. D832 CO). To this may be added the fact that

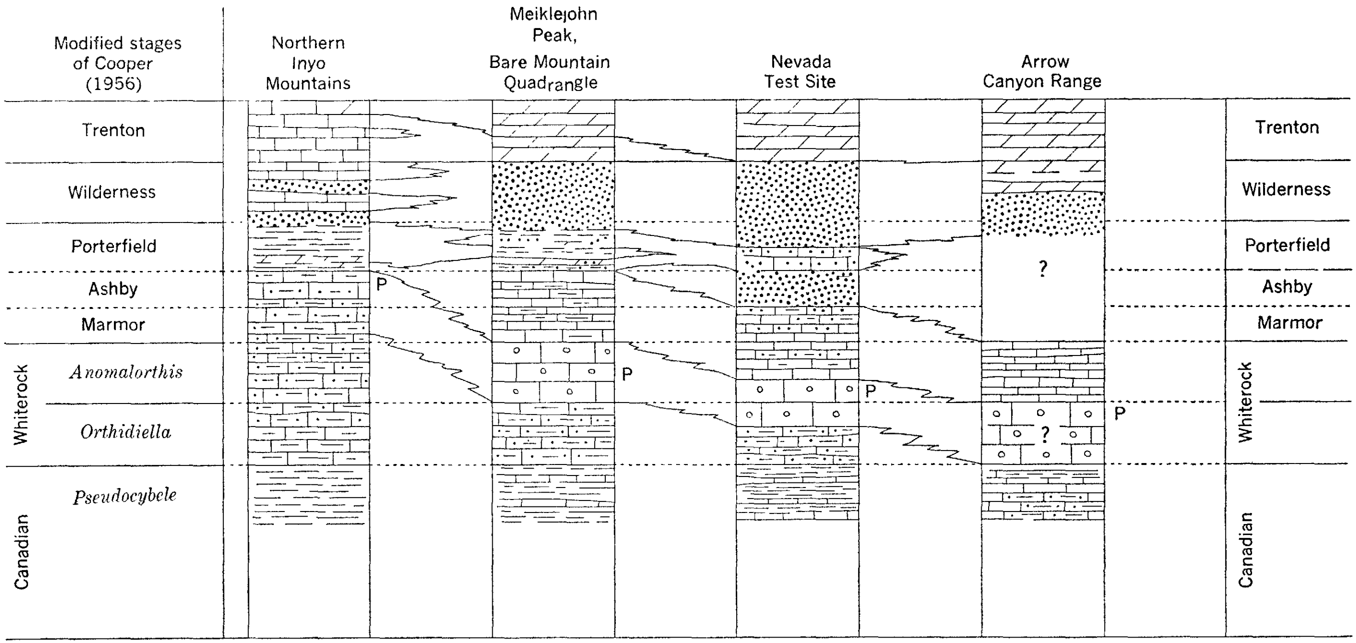


FIGURE 10.—Hypothetical representation of the shift of Middle Ordovician facies across southern Nevada and adjacent California. Based on lithic types and data shown on plate 1. Thicknesses are only roughly relative for each locality. Position of *Palliseria* Assemblage Zone indicated by P. Marmor Stage includes *Rhysostrophia* Zone. Ashby Stage is considered merely transitional between Marmor and Porterfield.

Anomalorthis and *Rhysostrophia* rarely occur in the same locality or mountain range.

Finally, it is possible that strata of the *Anomalorthis* Zone either were never deposited in or were eroded from the area surrounding Meiklejohn Peak, although they were deposited and remain in surrounding areas. Further, beds of Marmor or younger age, of essentially the same lithology, may have been deposited unconformably in that area to a considerable thickness while remaining thin or nonexistent in its surroundings. Such conditions would be interpreted to indicate instability in the area of Meiklejohn Peak while surrounding areas remained relatively stable.

Which of these possible explanations is correct cannot be ascertained until more detailed information on faunas and structure is obtained. Sections in the Grapevine Mountains and at Pyramid Peak, Calif., and at Pahrump and in the western Spring Mountains, Nev., need to be studied. The relations of the lower part of the Copenhagen Formation and its fauna to the underlying Antelope Valley Limestone also require clarification over a wide area.

Leptellina occidentalis of the *Rhysostrophia* Zone fauna occurs at Meiklejohn Peak in strata that, on the basis of position and lithic similarity, can be correlated with most of the upper beds of the Antelope Valley of the Nevada Test Side. In each USGS collection (D819 CO, D829 CO, D831 CO, D830 CO) this species is associated with other genera and species considered to be of Marmor or Porterfield age. This evidence suggests either that *L. occidentalis* is very long ranging or that the *Rhysostrophia* zone is actually correlative with Marmor or younger faunas, as is indicated in central Nevada (above, p. C75–C77).

Farther east at the Nevada Test Site, the top 30 feet of Antelope Valley strata contain an *Eofletcheria*–"*Lichenaria*"–*Macrocoelia* fauna (USGS collns. D711 CO, D713 CO, D731 CO), which I consider to be of Marmor (Chazy) age.

No evidence for the *Rhysostrophia* Zone in the Quartz Spring area has been found. It may be represented in the Spotted, Pahranagat, and Snake Ranges by the fauna of Hintze's (1952, p. 23) zone O. In the southern Spotted Range (USGS colln. D990 CO), trilobites from the upper 40 feet of the Antelope Valley beds include a mixture of Whiterock and younger forms among which are poorly preserved cranidia probably referable to *Ceraurinella*. A single slab from the upper part of the Lehman Formation of the Pahranagat Range (USGS colln. D1065 CO, collected by D. E. Park, Jr., under direction of A. Reso, Rice Univ.) contains "*Lichenaria*" and *Ceraurinella* and provides another possible mixture of Marmor (Chazy) and Porterfield forms directly beneath the Eureka Quartzite.

In the Wheeler Peak quadrangle at Granite Peak (fig. 1, loc. 16), the highest Pogonip fauna (uppermost Lehman Formation) includes *Eofletcheria*, "*Lichenaria*" sp., *Orthambonites* cf. *O. swanensis* Ulrich and Cooper, *Glyptomena?* sp., ostracodes, and *Bathyurus?* sp. (USGS collns. D378 CO, D379 CO). *O. swanensis* is known from the *Anomalorthis* Zone (zone M of Ross, 1951) while *Glyptomena* ranges from Marmor to Porterfield.

To the southwest of Wheeler Peak, P. E. Playford in 1961 made collections in the southern Egan Range (fig. 1, near loc. 21). The author identified from one of these (USGS colln. D802 CO), from 100 feet below the top of the Lehman Formation, a large species of *Bathyurus* (aff. *B. extans*), a form which one would expect to find in beds of Ashby or younger age. It is there associated with *Pseudomera* and *Illaenus*.

A Marmor (Chazy) fauna equivalent to the *Rhysostrophia* Zone therefore seems to be present in much of Nevada. Physical stratigraphic evidence is lacking for unconformity between the *Anomalorthis* Zone and this younger zone, and in some places conformity is indicated. However, it should be noted that during the present study no collections were made that include *Rhysostrophia* as well as the other components of its assemblage zone. It is therefore possible that the conception of this assemblage (Cooper, 1956, p. 127) needs revision. Such a required revision may not be the one proposed by Kay (1962, tables 1, 2), about which my own work raises questions.

ANOMALIES IN FAUNAL ZONES

The most difficult faunal anomaly to explain is the absence of the *Anomalorthis* Zone at Meiklejohn Peak. There are several possible explanations for this anomaly, all lacking satisfactory factual basis; at least one of these involves the *Rhysostrophia* Zone.

Probably the simplest explanation for absence of the *Anomalorthis* Zone at Meiklejohn Peak is its possible removal from view by faulting. It was because of possible faulting that two sections were measured at the peak. The section on the southwest side seems to be faulted in the position of the zone in question; that on the north side may be faulted above the Marmor fauna and again below the Eureka Quartzite. But faulting does not seem to explain the absence of the *Anomalorthis* Zone from both sections.

In both central and southern Nevada the physical stratigraphic evidence for continuous deposition between strata classed as Whiterock and Porterfield suggests that no unconformity exists between them. This suggestion is strongly supported by the faunas in the upper part of the Antelope Valley Limestone composed of both Marmor and Porterfield elements.

At Meiklejohn Peak, for instance, USGS collection D819 CO includes *Valcourea*, *Ptychopleurella*, *Atelelasma*, and *Hesperorthis*, all Marmor and younger. Associated is *Leptellina occidentalis* of the *Rhysostrophia* zone. In addition to trilobites USGS collection D829 CO includes *Leptellina occidentalis* associated with *Strophomena*? sp. and with *Skenidioides oklahomensis*, both Porterfield or younger. *Atelelasma* (Marmor to Porterfield) and *Skenidioides* (Porterfield and younger) are associated with *Leptellina occidentalis* in USGS collection D831 CO. From these collections alone it becomes obvious that the ranges of several genera and species must be extended or that the formations from which they are described are correlative. There is, for instance, a suggestion here that the McLish and Tulip Creek Formation and the lower part of the Bromide Formation (Cooper, 1956, p. 119, 121) should all be correlated with the same interval of the Pogonip. This in turn suggests that those Oklahoma formations may be, in some part, facies of each other, as indicated by Ham (1955, p. 29, fig. 10).

Faunal groupings like these do not belong clearly to either the Marmor or Porterfield stages. Instead they share elements from both. The sharing of Marmor and Porterfield elements at the generic level is typical of the Ashby Stage (Cooper, 1956, p. 138–146), and I conclude that it may be represented in the Basin Ranges by such transition faunas.

EVIDENCE OF THE CORALS

Information on the few collections of primitive colonial corals from the uppermost Pogonip strata was furnished by W. A. Oliver, Jr., and Helen Duncan, who reviewed not only the collections noted in the preceding text but others for comparison from Nevada and Utah. Although they came to no positive conclusions concerning dating of the highest Pogonip on the basis of corals, their study did not disagree with correlations made here on the basis of brachiopods. Furthermore, their study indicated that many more forms can be innocently assumed to be "*Eofletcheria*" than was previously realized.

Although it may repeat some of the data covered previously, a list of all the collections studied by them follows to facilitate comparison of the coral evidence.

W. A. Oliver and Helen Duncan (written commun., Jan. 31, 1963, and Oct. 8, 1963) stated:

> Our conclusions are of necessity vague. The list is carefully worked up but none of the identified forms are known from adequate samples. We have no measure of variation and the listed names may represent growth forms (ecologic variants) instead of species. Within the few small collections listed, we seem to have at least two types of phaceloid and at least two types of semiphaceloid corals representing from one to four species. Any of these when found might be

called *Eofletcheria* and be used to "identify" the "*Eofletcheria* zone." Your data seem to indicate that they are roughly of the same age but this cannot be confirmed from the coral data at hand. We know too little of the stratigraphy and evolution of this group elsewhere.

It is not possible to determine whether or not these corals are from western equivalents of the Chazy.

Fossil collections from Nevada include:

D1065 CO. Pahranagat Range, Lehman Formation of Hintze (1951) (p. C82, above).
"semiphaceloid *Lichenaria*" A

H-86. White Pine Range, "upper 40 ft of Pogonip with Cooper's *Hesperinia*." Collected by E. L. Humphrey in 1946.
"semiphaceloid *Lichenaria*" A
Eofletcheria A

Tank Hill Limestone, Pioche district.
Eofletcheria B
"*Lichenaria*" A (very large)

SW-60-11 (60W96) Lehman Formation of Hintze (1951), northwest of Granite Peak.
Eofletcheria B

D378 CO. Lehman Formation of Hintze (1951) west side of Granite Peak (p. C83, above).
Eofletcheria B
"*Lichenaria*" B

D711 CO. Antelope Valley Limestone, Nevada Test Site (p. C18, above).
Eofletcheria cf. A

D731 CO. Antelope Valley Limestone, 5 ft below Eureka Quartzite, Nevada Test Site (p. C18, above).
semiphaceloid *Lichenaria* A

D713 CO. Antelope Valley Limestone, 8 ft below Eureka Quartzite, Nevada Test Site (p. C18, above).
"*Lichenaria*" cf. B

Fossil collections from Utah include:

D341 CO. Tunnel Mountain, Crystal Peak Dolomite of Webb (1956).
"semiphaceloid *Lichenaria*" B
"*Lichenaria*" cf. B

Crystal Peak, Crystal Peak Dolomite of Webb (1956), *Eofletcheria* zone of Hintze; Helen Duncan and Jean M. Berdan, collectors.
"semiphaceloid *Lichenaria*" cf. A

It was felt that a similar review of the ostracodes made by Jean M. Berdan would serve the reader better if its results were incorporated with the fossil lists in the preceding text.

AGE OF THE EUREKA QUARTZITE

The source of the great quantities of quartz sand of which the Eureka beds are composed is believed (Webb, 1958, p. 2368–2377) to have been to the east, particularly in central Utah and central Nevada. Webb believed that the lower sands, which he separated partly as the Swan Peak Formation, are regressive toward the west and the main body of the Eureka is transgressive toward the east.

The ages of the upper and lower limits of the Eureka Quartzite in southern Nevada may shed additional light on this subject.

AGE OF THE POGONIP-EUREKA BOUNDARY

Plate 1; figure 10

In the Arrow Canyon Range the highest Antelope Valley (Pogonip) beds beneath the Eureka Quartzite belong to the *Anomalorthis* Zone (USGS collns. D962 CO, D963 CO, D970 CO).

To the west at the Nevada Test Site the highest Pogonip includes fossils of the *Eofletcheria* fauna which I believe are of Marmor or younger age (USGS collns. D713 CO, D731 CO, D711 CO), and a limestone 70 feet above the base of the Eureka Quartzite includes fossils of probable Porterfield age (USGS colln. D680 CO).

Still farther west at Meiklejohn Peak the basal limy transition beds of the Eureka Quartzite contain a fauna of Porterfield age (USGS collns. D820 CO, D824 CO).

In the Inyo Mountains the fauna of the Barrel Spring Formation (USGS collns. D924 CO, D1005 CO, D1017 CO) correlates with that in the lower part of the Eureka at the test site and is probably of Porterfield age. It also includes *Dicellograptus sextans*, which indicates correlation with either zone 9 or 10 of Elles and Wood (Early Caradoc). The Johnson Spring Formation, the lithic equivalent of the Eureka Quartzite, contains a fauna of probable Wilderness age (USGS colln. D1008 CO).

It is therefore evident that the age of beds beneath the lowest quartzite of the Eureka becomes progressively younger westward to Meiklejohn Peak but is not appreciably younger in the Inyo Mountains. Furthermore if the detrital western-facies rocks of the Barrel Spring are grouped with the Johnson Spring Formation, the highest fauna with time significance in typical Pogonip carbonate rocks is that of the Zone of *Rhysostrophia* (USGS collns. D1003 CO, D1004 CO). This zone is here considered to be of Marmor age.

Above it, still within Pogonip lithology, is the *Palliseria* Zone now known to have little specific time significance. The rock interval which lies between the Marmor *Rhysostrophia* beds below and the Porterfield Barrel Spring beds above may well be of transitional Ashby age.

AGE OF THE EUREKA-ELY SPRINGS BOUNDARY

In the Arrow Canyon Range the uppermost transitional beds of the Eureka Quartzite include a fauna (USGS collns. D977 CO, D787 CO) of Wilderness (or possibly early Trenton) age (p. C12, above). At the Nevada Test Site no fossils were found in the upper quartzite, but a collection from the overlying Ely Springs Dolomite (USGS colln. D715 CO) is also of Wilderness or early Trenton age. In the Quartz Spring area *Maclurites* cf. *M. magna*, suggesting a Trenton age, occurs in transitional beds that can be assigned to the base of the Ely Springs or the top of the Eureka.

Pestana (1960, p. 864) concluded that the age of the quartzose Johnson Spring Formation of the northern Inyo Mountains is Trenton although one more recent collection (USGS D1008 CO) suggests a possible Wilderness age.

It therefore seems probable that the age of the upper limit of the Eureka Quartzite is nearly the same from east to west.

This conclusion concerning the age of the highest Eureka beds agrees closely with that of Webb (1958, fig. 6) based entirely on physical stratigraphy.

CONCLUSIONS

So long as the foregoing data are placed on a strict stratigraphic framework, their interpretation is seriously hampered. If, however, they are viewed against a temporal backdrop as in figure 10, a pattern of migrating facies seems obvious. Most striking is the westward shift of the *Palliseria* Zone, which I consider more a lithic unit than a faunal zone. Similarly the base of the Eureka Quartzite shifts westward with time.

The slabby thin-bedded limestones designated unit I by Johnson and Hibbard (1957, p. 345–347) at the Nevada Test Site also migrate westward; this explains the presence in them of an *Anomalorthis* Zone fauna in the Arrow Canyon Range, faunas of both the *Anomalorthis* Zone and Marmor Stage at the test site, and Marmor and Marmor to Porterfield transition (Ashby) faunas at Meiklejohn Peak.

An example of probably unfavorable facies for the development of a fauna is the *Palliseria* Zone; its lithofacies seems to have proved inhospitable for the *Anomalorthis* fauna at Meiklejohn Peak; it probably masks in a similar manner the Ashby faunas of the Inyo Mountains.

Fortunately correlation is aided by several forms of Porterfield age that are common to the sandy limestones of the Eureka Quartzite on the Nevada Test Site and to the siliceous argillites of the upper part of the Barrel Spring Formation in the Inyo Mountains. These argillites are clearly rocks of "western-facies" type and closely resemble components of the Vinini and Valmy Formations of west-central Nevada. The Barrel Spring seems to represent an incursion of the muddy facies from the west which may have had effect as far east as Meiklejohn Peak.

It is significant that, in the survey of all graptolite collections made by U.S. Geological Survey parties in the Basin Ranges, Ross and Berry (1963, table 1) found that most collections came from Lower Caradoc zones 9–10 of Elles and Wood (1914, p. 514–526). Since the Barrel Spring seems to correlate with one or both of these zones, it may exemplify the major Ordovician incursion of the western facies. The preponderance of Lower Caradoc rocks in the Valmy and Vinini beds of central Nevada may not be related so much to the quirks of late Paleozoic and Mesozoic tectonics as to the vagaries of original deposition.

It is worthy of note that these conclusions seem empirically correct only when one considers (1) that the *Rhysostrophia* Zone is of Marmor age, (2) that deposition was continuous from Whiterock *Anomalorthis* Zone time through Porterfield time, (3) and that the Ashby is in reality a sort of transition between the Marmor and Porterfield stages, and is not recognizable in its own right.

Regarding the Eureka Quartzite, it seems fairly evident that the belt of sand deposition moved westward as Webb (1958, p. 2368–2376) showed for areas farther north. However, as indicated in the following discussion of the area to the south of the Las Vegas shear zone (p. C90–C93), the source of this sand seems to have been to the north, a conclusion at variance with both Kirk (1933) and Webb (1958).

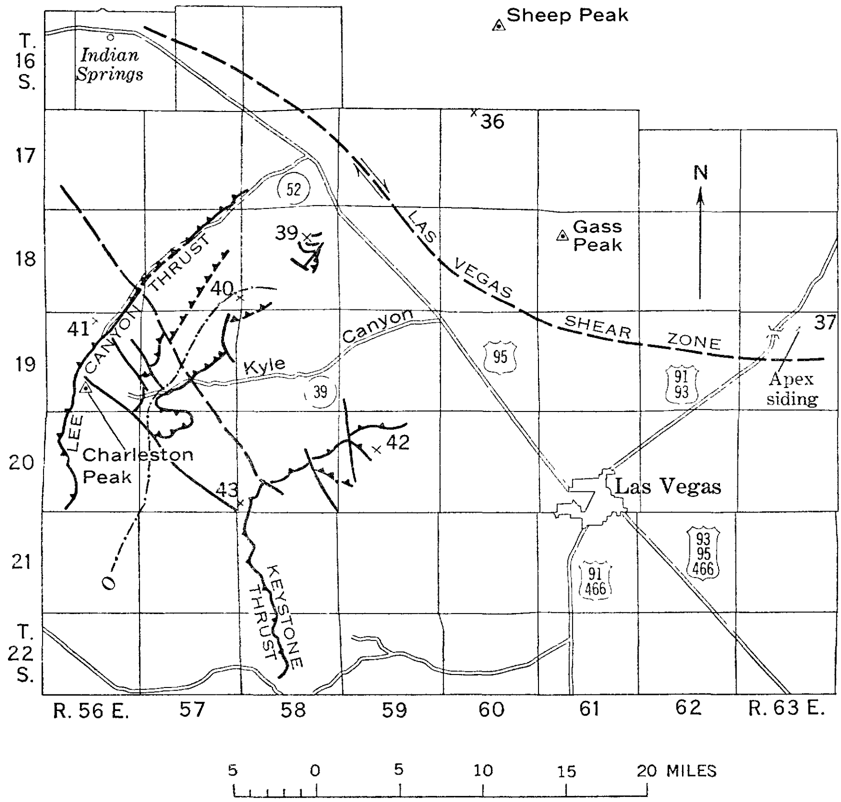
PALEOTECTONIC SIGNIFICANCE OF ORDOVICIAN SECTIONS SOUTH OF THE LAS VEGAS SHEAR ZONE

By Reuben James Ross, Jr., and C. R. Longwell

Ordovician stratigraphy supports other evidence for right-lateral movement of 25–40 miles along the Las Vegas shear zone and hints that the Middle Ordovician sands of the Eureka Quartzite were derived from other than a southerly or southeasterly land source.

In discussing the significance of the Las Vegas shear zone, Longwell (1960) presented the evidence for right-lateral movement along it and indicated that the areas to the north and south are broken into numerous thrust plates. Within several of these plates south of the shear zone, we measured Ordovician stratigraphic sections, which include (maps, fig. 11, 12) lower Lucky Strike Canyon (loc. 39), upper Lucky Strike Canyon (loc. 40), Lee Guard Station (loc. 41), eastern La Madre Mountain (loc. 42), and west side of Red Rock Canyon (loc. 43). The section at Frenchman Mountain (loc. 38) lacks Ordovician and Silurian rocks, the Devonian resting directly on Cambrian.

Between the sections listed above, there are large differences in thicknesses and aspects of Ordovician units. Contrasts may be entirely stratigraphic, but it is evident that tectonic displacement has resulted in some of the marked contrasts.



EXPLANATION

Southeast edge of Eureka Quartzite
Hypothetical zero isopach

Thrust fault
Dashed where approximately located

Normal fault
Dashed where approximately located

Transverse fault
Showing relative horizontal movement

FIGURE 11.—Map showing positions of measured sections relative to structural elements near the Las Vegas shear zone. Based on geology by C. R. Longwell. For identity of localities see table 1.

The absence of the Eureka Quartzite, probably the most useful single stratigraphic marker in the Basin Ranges, in much of the area south of the Las Vegas shear zone has frustrated division of the lower Paleozoic so that rocks of probable Cambrian to Devonian age are grouped as the Goodsprings Dolomite (Hewett, 1956, p. 38–40). Why the Eureka disappears and why the Pogonip and Ely Springs carbonate rocks lose their identities are of considerable paleotectonic importance.

The Eureka Quartzite is much reduced in thickness in lower Lucky Strike Canyon south of the shear zone and at Apex siding (fig. 12, loc. 37) to the north of it and northeast of Las Vegas. That these two sections have much in common and are approximately 35 miles apart supports other evidence for that amount of lateral displacement on the Las Vegas shear zone.

Isopach maps of the Antelope Valley Limestone and the Eureka Quartzite seem to substantiate this displacement for the sections on Lucky Strike Canyon (fig. 12, locs. 39, 40). However, the section near the Lee Guard Station (fig. 12, loc. 41) obviously has not been displaced as far; Longwell showed (fig. 11) that the vicinity of the Lee Guard Station is separated from lower Lucky Strike Canyon (figs. 11, 12, loc. 39) by a thrust fault. The terrain south of the shear zone must have been telescopically compressed by imbrication of thrust plates. This is further suggested by the proximity of sections in the La Madre Mountain and Red Rock Canyon (figs. 11, 12, locs. 42, 43), where the Ordovician, if present at all, is much abbreviated.

It is very difficult to construct meaningful isopachs on any of the Ordovician units east of the Keystone thrust on the south of the shear zone. A sub-Devonian unconformity causes thinning of Ordovician units which cannot everywhere be differentiated from thinning toward the southeast within the Ordovician itself. To this uncertain situation tectonic events have lent a Gordian complexity.

In the area of Death Valley, thicknesses of the Eureka Quartzite can be interpreted to produce isopachs curving strongly toward the northwest. If this is a reasonable interpretation it may suggest that the southwest end of geosynclinal accumulation has been displaced on a series of shears, each with right lateral movement. At the present time (1963), too little concrete information is at hand to allow more than speculation on this possibility.

Much of the Ordovician thickness is lost southward and southeastward to pre-Devonian erosion, but some thinning is also the result of intra-Ordovician stratigraphy. Between lower and upper Lucky Strike Canyon, the thickness of the Eureka Quartzite decreases from 17 feet to nothing; as far as we have been able to tell, it may be represented by limestone or dolomite at the upper Lucky Strike Canyon

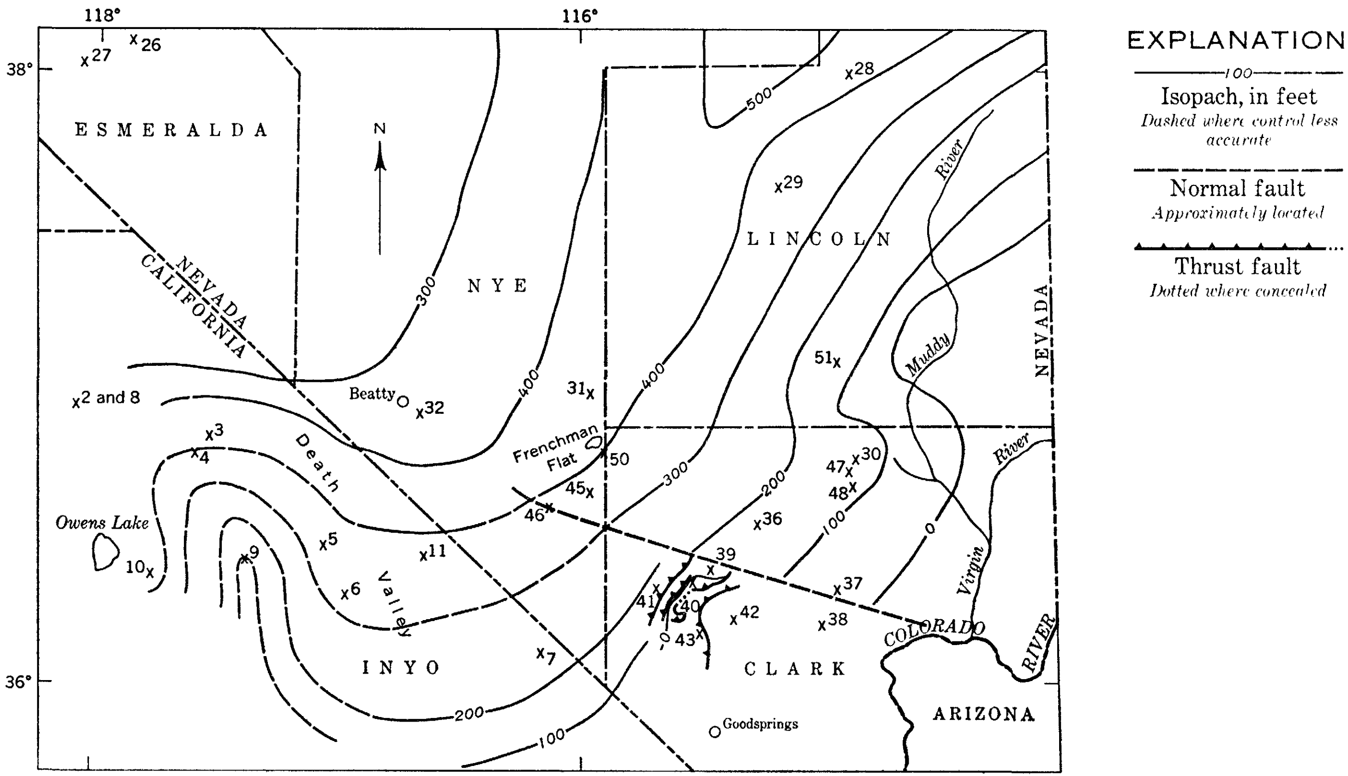


FIGURE 12.—Isopach map of the Eureka Quartzite. For identity of localities see table 1. ×, Ordovician localities.

locality, and there is some faunal evidence for such a correlation (USGS colln. D982 CO). However, at that locality the Ely Springs Dolomite may be in atypical guise and may not be distinguishable.

West of Red Rock Canyon (fig. 12, loc. 43) Ordovician dolomites bear *Receptaculites oweni*, underlie Devonian units and overlie thin-bedded dolomites from which we obtained no fossils but which may be the dolomite equivalent of the Eureka Quartzite, dolomitized Pogonip, or Upper Cambrian strata. Obviously if any Middle or Lower Ordovician was lost in this area because of erosion, it was removed before deposition of the Ely Springs Dolomite. However, as indicated below, the section in upper Lucky Strike Canyon suggests that the sands of the Eureka were not deposited this far to the southeast and that carbonate sediment accumulated there instead.

On the basis of less extensive information than is now available (1963), Kirk (1933, p. 39–43) was convinced that the sands of the Eureka Quartzite in southern Nevada were derived from the south and southwest. Webb (1958, p. 2368–2377) seemed to favor an easterly source but did not discuss southern Nevada in this regard.

The Eureka beds thin rapidly to the south and southeast and, where absent, are overlapped by equivalents of the Ely Springs Dolomite (Red Rock Canyon, fig. 12, loc. 43).

Between Lee Canyon (fig. 12, loc. 41) and lower Lucky Strike Canyon (fig. 12, loc. 39), the Eureka Quartzite thins from 133 to 17 feet. If the latter locality is replaced palinspastically east of Apex Siding (fig. 12, loc. 37), where the thickness is 39 feet, this decrease in thickness is not of unusual dimension. What is of special interest is the presence of a thin interval of collophane nodules at each of these localities. There is no compelling reason for these to be the same age. But the formation of collophane may be presumed to require unusual chemical conditions along a coast (Phleger and Ewing, 1962, p. 161–162, 176–177), and such conditions along this coast seem to have been reached for a limited time.

The formation of collophane may not have precisely contemporaneous in these localities. Nevertheless, its presence at the top of each of the sections allies the thin easterly deposits with the upper rather than with the lower part of the Eureka Quartzite in the westerly areas.

If deposition of collophane was approximately contemporaneous, then very little if any of the Eureka Quartzite was lost to erosion in this area. Quite the contrary. At lower Lucky Strike Canyon the nodules are found 16 feet below the top of the formation. At both other localities to the west where we have noted them, they are in the top 2–3 feet. The nodules are present in the Arrow Canyon Range 88–93 feet above the base of the quartzite. It therefore seems possible that the sands were being spread toward the southeast or south into a calcareous facies in this area with the youngest sands being carried the farthest. If the locality in upper Luck Strike Canyon (fig. 12, loc. 40) held its present southerly position relative to lower Lucky Strike Canyon (fig. 12, loc. 39) prior to thrusting, the absence of the Eureka Quartzite can be easily explained by failure of the sands to reach that far to the south. Instead of sand, carbonate deposition may have taken place. A similar explanation may account for the absence of the Eureka beds at Red Rock Canyon (fig. 12, loc. 43) and in much of the area of the Goodsprings Dolomite.

In line with Webb's (1958) conclusions it may be that the lower quartzites were deposited in a regressive facies, eroded or reworked, and then overlapped by the upper collophane-bearing quartzites. We have no evidence at present either for or against this theory, but we emphasize that within the upper quartzites there still seems to be a southward thinning.

As a result we do not favor a southerly or southeasterly source for the sands of the Eureka Quartzite. Other paleogeographic and paleotectonic considerations, not covered in this paper, suggest a northerly source. Coastal currents along the east side of an ocean in the northern hemisphere may move southward because of the incidence of prevailing winds or the coriolis effect or both. Such southward currents might have moved enormous amounts of sand from central Idaho or from the mouths of rivers denuding the ancestral Uinta uplift, much as sand is moved today along the California coast.

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STEWART L. UDALL, *Secretary*

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Thomas B. Nolan, *Director*

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