PALEOZOIC ROCKS ALONG LOWER NORTH FORK CANYON, INDEPENDENCE MOUNTAINS, ELKO COUNTY, NEVADA

by

J. Michael Widmier

Submitted in partial fulfillment of the requirements for the degree of Master of Arts, in the Faculty of Pure Science, Columbia University.

1960

interior drainage of the Basin and Range province. All streams north of North Fork drain northward into the Snake River drainage system.

Vegetation consists primarily of sagebrush and grass. South of North Fork the slopes are dominantly covered by short grass, but along evanescent stream courses thick, nearly impenetrable thickets and sapling groves abound. North Fork canyon is well wooded in several localities.

Rock exposures are discontinuous throughout the area. A few prominent exposures south of North Fork are surrounded by a soil of hill wash. North of the road many small, spot outcrops, usually concealed by sagebrush, help bridge gaps between larger exposures.

The eastern boundary of Humboldt National Forest lies at the mouth of North Fork canyon. A state campground and the North Fork Guard Station are located within the park along the stream. A park road traverses the canyon and connects with state highway 43 to the east. There are several ranches in the vicinity; the Doheny Ranch is the closest, located just outside the forest limits at the canyon mouth.

Field Methods

Mapping was done by plane table using a scale of 1"=500'. Air photos were available for study, but were not suitable for mapping as the rounded topography and sparse vegetation provided few distinctive landmarks.

Previous Work

The miogeosynclinal sequence of North Fork has not been previously described. J. J. Fagan (1959) studied the eugeosynclinal sequence of the northern Independence Range, and R. W. Decker (1958) has

described the geology of the Bull Run Quadrangle, which is adjacent to Wild Horse Quadrangle on the west.

Acknowledgements

The writer is indebted to Dr. Marshall Kay under whose supervision this thesis was prepared. The field assistance of Mr. Bernard Maccarillo was gratefully received, and discussions with Mr. John Fagan were most beneficial. For help in fossil identification the author is indebted to Mr. J. E. Klovan and Mr. Stephen Streeter. Field research was supported from research funds of Columbia University.

STRATIGRAPHY

The rocks along North Fork are subdivided into two major groups: 1) Formations A through D of Cambrian age, having a thickness of about 3,500 feet; and 2) Formations E through I of upper Paleozoic age, having a thickness of more than 4,000 feet. The latter are believed to be dominantly Carboniferous.

The eugeosynclinal chert sequence, shown as a single formation without subdivision, was not studied.

North of North Fork the hills mapped are designated, from east to west, as East Hill, Cambrian Hill, West Hill, Victory Hill, and Limestone Knob. The stream valleys separating these hills are, from east to west, First Canyon, Fry Canyon, Second Canyon, and Mikes Canyon. The long, continuous ridge rising south of the park road is here called Long Ridge.

Calcareous rocks are designated as calcilutite, calcisiltite, and calcarenite depending on particle size. Classification of bedding

follows the usage of Ingram (1954). The Wentworth scale (1922) is followed in the classification of clastic particle size.

Cambrian Formations

Formation A

Formation A consists of light olive-gray and dark olive-black to black, thinly laminated, non-fossiliferous, poorly exposed argillite. Hill wash and small scattered outcrops form a band of widely varying thickness across central and western East Hill, all of Cambrian Hill, and the east flank of West Hill. On East Hill the argillite is olive-black to black and is non-calcareous, while on Cambrian Hill and West Hill the argillite is light olive-gray and is cut by thin, dark red calcite veins parallel to, and oblique to the laminations. Although there seems to be little gradation from one to another, it was not possible to demonstrate any stratigraphic difference between the two. Therefore, they are included in the same formation without subdivision.

The argillite occurs exclusively in a thrust sheet and is the basal unit of the thrust sequence. Highly variable attitudes and lack of good exposures, combined with a greatly varying thickness along the outcrop band, make an estimate of thickness extremely tenuous. The argillite ranges from 0 feet to possibly 300 feet with neither the lower nor upper contacts exposed.

The argillite is believed to be the oldest unit in the area. The light olive-gray argillite is lithically similar to argillite interbeds in Cambrian Formation D. Also, there are almost no argillites in the upper Paleozoic sequence. Therefore, it is

assumed to be Cambrian, and since it is basal in the thrust sheet and is not observed within the Cambrian sequence elsewhere, it is assumed to be the oldest Cambrian unit.

Cambrian Undifferentiated

On the lower slope of Long Ridge, an area containing almost no rock exposure and very little hill wash is designated as Cambrian undifferentiated. A small outcrop of a black, finely laminated phyllite lying below the chert of Formation C has an attitude similar to the orientation of the chert. From this fact, and the observation that Cambrian units increase in extent eastward on the south side of North Fork, it is inferred that the undifferentiated area is underlain by Cambrian.

Formation B

Formation B is a pale yellow-brown, mediumly bedded, non-fossiliferous, well-indurated quartz siltite showing narrowly spaced parting planes on weathered surfaces. The quartz siltite is poorly exposed along the western base of East Hill, and south of the stream along the park road in a very small anticlinal outcrop. On East Hill the attitude varies widely, but no mappable pattern of folding or faulting was observed. The quartz siltite may be as much as several hundred feet thick, lower contact not exposed. On East Hill the quartz siltite is overlain by chert of Formation C, while on Long Ridge the small quartz siltite outcrop is questionably overlain by the chert. Further east on Long Ridge the quartz siltite is missing below the chert of Formation C; the latter rests directly on Cambrian undifferentiated phyllite. This area lies near the

crest of a prominent anticlinal fold in the Cambrian sediments, and it is possible that the quartz siltite behaved plastically during deformation, flowing completely off the fold crest (see Plate 2, section A–A'). However, a more satisfactory explanation for the absence of Formation B below the chert might become apparent on further study.

Formation C

Formation C is a dense black, thinly bedded, non-fossiliferous, ridge-forming chert, characteristically cut by minute calcite veins. A discontinuous cliff of chert extends along the lower east slope of Long Ridge, turns sharply north and continues downslope to the park road. Apparently it extends under the alluvium covering the canyon floor, reappearing on the north side of the stream. From a thickness of 30 feet on Long Ridge it thins slightly westward and northward. It may thicken eastward on East Hill; however, exposes are poor, the lower contact is tenuous, and the unit may be folded in this locality. The chert is conformably overlain by Formation D on Long Ridge, while on East Hill Formation E conglomerate lies with angular unconformity on both the chert and Formation D.

Formation D

Formation D is a cyclic sequence of trilobite bearing calcisiltites and argillites. Medium gray to dark gray, thinly bedded, trilobite bearing calcisiltites alternate with very thinly bedded, light olive-brown weathering argillites in one to two inch cycles. The weathered surfaces of the calcisiltites are characteristically rough, commonly showing what appear to be solution etched lineations.

Trilobite segments and droppings are preserved as dark black crystalline calcite in the gray calcisiltite matrix.

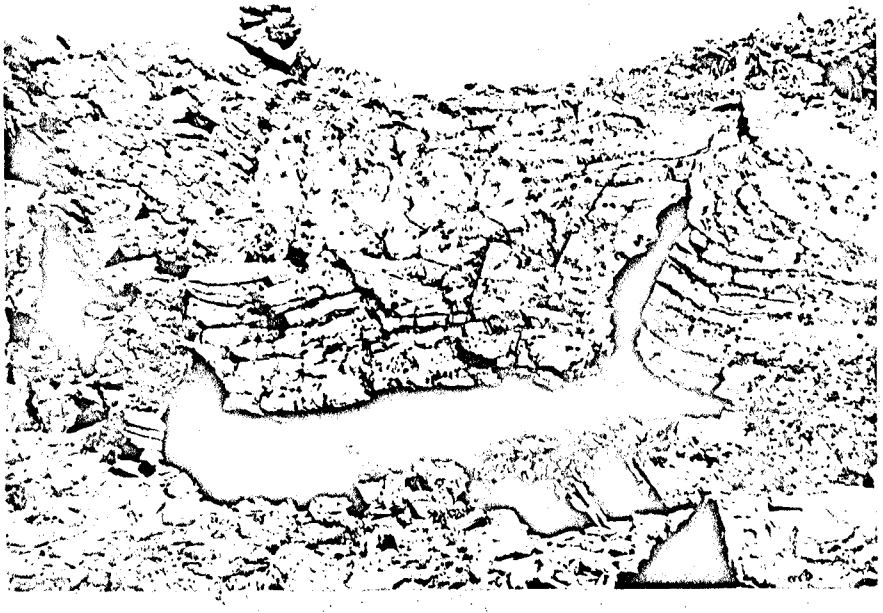
Formation D is well-exposed at the top of Cambrian Hill, on East Hill in a very small outcrop midway up the west-central slope, at the west base of East Hill, and over much of the slope of Long Ridge. The Cambrian Hill exposure lies within a thrust sheet.

On Cambrian Hill, a grayish-black, mediumly bedded, calcite and quartz veined, non-fossiliferous, dolomitic siltite five feet thick lies conformably on Formation D. Since it is observed only at this one locality and is thin, it is included in Formation D.

At the base of East Hill and also above part of the cliff formed of Formation C chert on Long Ridge, a medium gray to medium bluish-gray, mottled, mediumly bedded chert, frequently containing small, probable solution cavities outcrops between Formation C and Formation D. Graduation from the mottled chert to Formation D was observed on Long Ridge (Plate 3A); therefore, the former is believed to be highly silicified strata of Formation D.

Formation D is about 175 feet thick in the thrust sheet on Cambrian Hill; the base is a thrust plane and the upper surface is the present erosion surface. Thickness on Long Ridge is estimated at about 3,000 feet, but may be considerably exaggerated by folding.

Formation D is easily distinguished from formations above and below whether in stratigraphic or in structural contact.



A. Silicified Cambrian cyclic beds on Long Ridge. View looking east.

B. Cliff exposure of Formation E conglomerate. View looking north.

Plate 3

Upper Paleozoic Formations

Formation E

Formation E consists of a lensing, ridge-forming, quartz and chert pebble conglomerate passing into quartz siltite and cross-bedded calcarenite. Formation E is the basal upper Paleozoic unit and is most likely Carboniferous. Thickness varies from 120 to 160 feet. At the western base of East Hill and on the slope of Long Ridge, Formation E lies with angular unconformity on the Cambrian cyclic units. On East Hill, near the mouth of the canyon, Formation E is in fault contact with eugeosynclinal cherts. On Cambrian and West Hills this unit lies within a thrust sheet. Formation E is subdivided into three members.

Member 1

Member 1 is a lensing, ridge-forming, quartz and chert pebble conglomerate of thickness varying from 0 to 25 feet. Quartz pebbles, dominating, are very light gray to bluish-gray and grayish-black while chert particles range from a dark yellowish-brown to black. Fragments range from fine pebbles to small cobbles with the mean size varying along strike. Clasts are subangular to subrounded. Voids between pebbles are filled by coarse sand to very fine pebbles or granules. The unit is poorly cemented on East Hill and Cambrian Hill; in other localities the conglomerate is well-cemented with silica and fractures through the pebbles.

The conglomerate lenses throughout the area. Prominent ridges occur along the lower western part of East Hill (Plate 3B) and near the top of Cambrian Hill. Hill wash and a few blocks of conglomerate

occur on the east flank of West Hill, at the mouth of the canyon on East Hill, and at several localities on the slope of Long Ridge.

The ridge of conglomerate on East Hill thins westward, from 15 to 20 feet on the east to 0 feet on the west. Near the base of the hill a few inches of conglomerate lie with angular unconformity on Formation D cyclic beds. The conglomerate locally grades into Member 2 quartz siltite, the transition occuring within a few feet.

Member 2

Member 2 includes a non-fossiliferous succession of light gray, mediumly bedded, resistant, salt and pepper quartz siltites and arenites; and pale to dark yellowish-brown quartz siltites with interbeds of chert and quartz pebble conglomerate near the base. The conglomerate is well-sorted, and the mean fragment size is that of a small pebble.

Member 2 is well-exposed on Cambrian Hill and near the west base of East Hill. It is also found sporadically as blocks and hill wash on the east flank of West Hill, and the east end of East Hill. Thickness varies from 80 to 120 feet.

The contact of Member 2 quartz siltite with Member 3 calcarenite can be placed within 10 feet in most localities. On the south face of Cambrian Hill Member 3 seems to lie below Member 2 and above Member 1 conglomerate. This anomaly may be the result of structural complications associated with the low-angle thrust at this locality.

Member 3

Member 3 is a dark gray to black, cross-laminated, thinly to mediumly bedded, ridge forming calcarenite, frequently with white

and orange sand grains floating in the calcarenite matrix. Locally, beds are dominantly composed of recognizable crinoid columnals. This unit is well-exposed in the thrust sheet on the east flank of West Hill, and near the top of Cambrian Hill, where it is partly silicified. It also outcrops prominently near the canyon mouth on East Hill (Plate 4A), and along the upper slope of Long Ridge. Small elongate, highly silicified outcrops, interpreted as thrust slivers and horses occur on East Hill. The calcarenite is 35 to 45 feet thick and is conformable with Formation F.

Formation F

Formation F comprises 2,000 to 2,500 feet of calcisiltite and quartz siltite with minor calcarenite and chert pebble conglomerate. Generally occuring only as hill wash, this formation underlies the west lower slope of East Hill, the south face of Cambrian Hill, and the east lower slope of West Hill. Good outcrops are found higher on West Hill in a thrust sheet. Much of East Hill is covered by wash similar to Formation F, but equivalency of all or part of the units underlying this area to Formation F is uncertain. Consequently, this area is represented as upper Paleozoic undifferentiated on the map.

Formation F is subdivided into four members; however, member boundaries are gradational throughout.

Member 1

Member 1 is defined as the beds between the top of the cross-laminated calcarenite member of Formation E and the quartz siltites of Member 2. Member 1 is very poorly exposed and, consequently, lithologic composition is poorly understood. On the southeast

shoulder of West Hill a few low ledges of black, thinly to mediumly bedded quartzitic calcisiltite seem to lie conformably on the calcarenite. Member 1 is fossiliferous at this locality, showing crinoid columnals, and unidentified brachiopods and cephalopods. On the west slope of East Hill, rust weathering quartz siltite and black quartzitic calcisiltite wash with a few ledges of black calcisiltite were observed. Member 1 is estimated to be 325 to 375 feet thick.

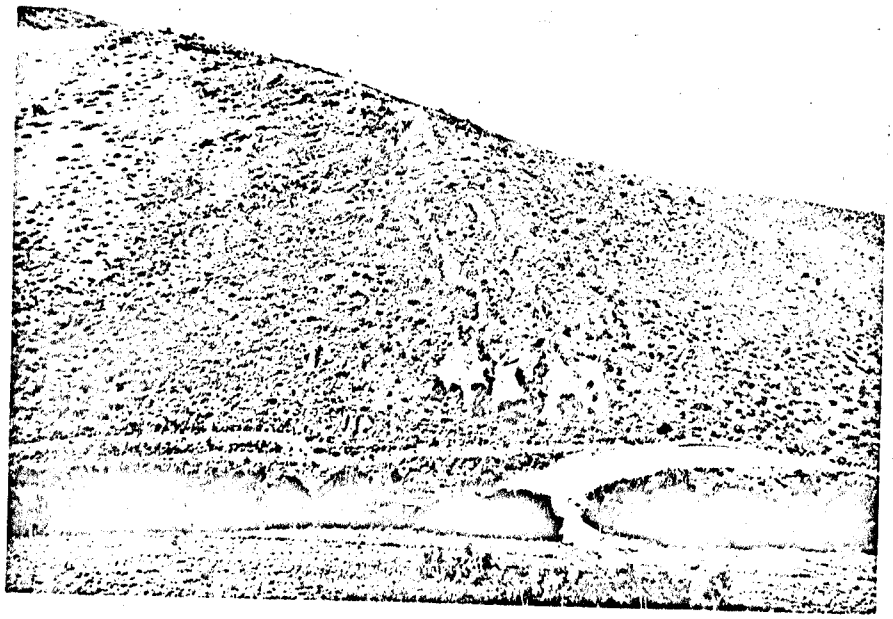
Member 2

The lower part of Member 2 is composed of poorly exposed brown and rust quartz siltites. They pass into interbedded medium to dark gray, moderate reddish-brown to pale yellowish-brown weathering, mediumly bedded, resistant dolomitic quartz siltites; dusky yellowish-brown to brownish-black, very thinly bedded, non-resistant argillaceous siltites; and dark yellowish-brown to moderate brown, thinly bedded, quartz siltites having irregular black markings resembling flattened worm burrows. Gradational lower and upper contacts of the member are poorly defined. Member 2 is 340 to 400 feet thick.

A ledge of the resistant dolomitic quartz siltite extends entirely across the lower front of Cambrian Hill, accompanied by worm-burrow siltite wash. Near the top front of West Hill, the upper part of this member is well-exposed and grades into silts of Member 3. A small exposure of worm-burrow siltite high on the west flank of Cambrian Hill is interpreted as a thrust sliver.

Member 3

Member 3 comprises sparingly-fossiliferous, red, rust, and brown weathering quartz siltites with gray to black thinly and mediumly bedded calcisiltite and calcarenite interbeds. Fossils are found



A. Ridges of Formation E calcarenite, repeated by high-angle faulting at the mouth of North Fork canyon. View looking north.

B. "Black and White" calcisiltite and lensing chert of Formation G on West Hill. View looking east.

Plate 4

only in the upper beds of this unit and consist primarily of unidentified brachiopods and a few bryozoan fragments. Siltite wash extends across most of the south face of Cambrian Hill, the extreme eastern part of the face of West Hill, and is also found near the top of West Hill in a thrust sequence. The upper contact of Member 3 in the thrust sheet is a fault contact. Thickness is on the order of 400 to 550 feet with both contacts gradational.

Member 4

Member 4 consists of poorly fossiliferous, black, thinly to mediumly bedded calcisiltites, passing into brown and rust quartz siltites with interbeds of black calcisiltite and occasional thin layers of chert pebble conglomerate. Near the top calcareous and dolomitic interbeds become increasingly prominent. Unidentified brachiopods, bryozoans and a few gastropods were found in the quartz siltites. This member, very poorly exposed, extends across the lower east half of the face of West Hill. At North Fork several good exposures of the lower black calcisiltites outcrop, but in general, the member is represented by wash. Thickness is estimated at 950 to 1,100 feet. The distinctive lithology at the base of Formation G closely defines the upper contact of Member 4.

Formation G

Formation G is composed of light gray, tan and gray weathering, mediumly bedded calcisiltite with lensing, two inch to one foot interbeds of black chert; passing into medium gray, brown weathering, mediumly to thickly bedded quartzitic calcisiltite and quartz siltite, with 10 feet of dull black, thinly bedded chert at the top. The

basal calcisiltite is labeled the "Black and White" (Plate 4B) and is characterized by a box-like network of thin quartz veins, and small irregular crystalline masses of black calcite in a matrix of gray calcisiltite. The Black and White is 50 to 60 feet thick.

Outcrops of Formation G extend downslope from the center of the south face of West Hill to the western corner of that same hill at North Fork Creek. The chert is found across a small gully on Victory Hill; however, it changes radically in orientation in passing from West to Victory Hill. Nearly vertical outcrops of the Black and White were also recognized trending northeast along Victory Hill, and scattered outcrops were recorded along the west flank of West Hill. No reasonable structural explanation can be presented for this nearly ubiquitous occurrence in the latter two areas. Obviously, several faults merge in this area, and it is likely that this is a shear zone having several distinct subareas completely blocked off by faulting.

The top and bottom contacts of Formation G are sharply marked lithically by the Black and White at the base and by the thin-bedded chert at the top. However, while the lower unit is certainly conformable with Formation F, the top chert unit is separated from Formation H by a high-angle fault. It is possible that a few tens of feet of poorly exposed rock west of the bedded chert are conformable with it and should be included within Formation G. However, because of uncertainty of fault location and because of the distinctiveness of the bedded chert, its upper surface is taken as the top of Formation G. The total thickness of Formation G is 450 feet.

Formation H

Formation H consists of a sequence of black calcisiltites, calcarenites, chertified limestone, and brown weathering, finely banded, reddish-brown calcareous quartz siltite. The latter breaks along smooth bedding surfaces.

Formation H is found only in a triangular area at the southwest corner of West Hill. This area, believed to be a fault block, is bounded on the north and northeast by a thrust fault, on the east by a high-angle fault, on the south by alluvium, and, most probably, on the west by a high-angle fault. The extent of Formation H to the northwest is unknown. Generally, the stratigraphy and structure of this unit is poorly understood and no thickness can be estimated. It is possible that this unit should not be given the rank of formation.

Formation I

Formation I includes light gray to black, brown weathering, thinly to mediumly bedded, fossiliferous calcisiltites with chert replacement lenses, calcarenites, and calcareous and dolomitic quartz siltites, passing into reddish-brown weathering, thinly bedded quartz siltites interbedded with thinly bedded black chert. Brachiopods, particularly Productids and Rhynchonellids, are the dominant fossils. A few gastropods, cephalopods, pelecypods and bryozoan fragments were also collected. Several of the calcarenite beds are dominantly composed of crinoid columnals.

Formation I is well exposed on Limestone Knob, and strikes northeast across Victory Hill where it is poorly exposed. It is bounded

on the east and on the west by high-angle faults, and thins from 950 feet on Limestone Knob to 300 feet on Victory Mill.

AGE OF THE UPPER PALEOZOIC FORMATIONS

Formations H and I are tentatively assigned a possible range from upper Mississippian through Wolfcampian. Formations E, F, and G are older than Formations H and I. Their age cannot be narrowly delimited from present evidence at North Fork; however, it is strongly believed they are post-late Devonian.

Although agreement was not reached in the identification of the fauna collected from Formations H and I, estimates of age based on differing generic conclusions, particularly brachiopod genera, range from upper Mississippian to lowermost Permian. The exact stratigraphic and structural relations of these formations to the remaining Paleozoic formations is uncertain (see Plate 5). However, since Formation E conglomerate and quartz siltite lie with angular unconformity on Cambrian cyclic beds, and since Formations F and G are conformable with the conglomerate and quartz siltite, all three are assumed older than Formations H and I.

The lower units might therefore range from Ordovician through Carboniferous. The author believes them Carboniferous. Cambrian formations were folded before deposition of the basal conglomerate of Formation E. The earliest deformation in the Millard belt seems to have been in late Devonian (Nolan 1928, Kay 1951, Dott 1955); therefore, it is assumed the conglomerate is late Devonian at the earliest and rests on Cambrian rocks which were folded in the late Devonian at the earliest. Orogeny in northern Nevada culminated

COLUMNAR SECTION

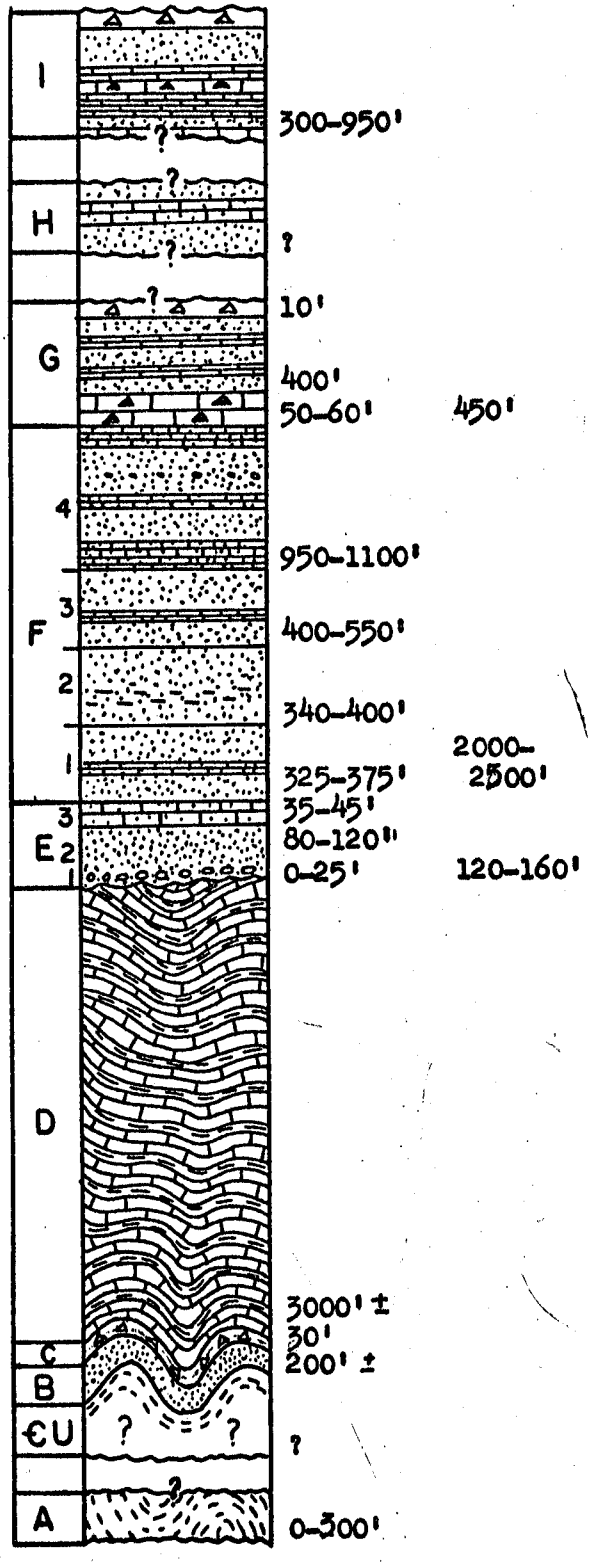


PLATE 5

during Mississippian time and unrest continued intermittently during Pennsylvanian time (Dott 1955). The conglomerate may reflect any of these periods of deformation--from late Devonian through Pennsylvanian.

The presence or absence of a depositional break between Formation G chert and Formations H and I remains a critical problem; solution should help to define the age limitations of Formations E, F, and G more closely.

STRUCTURE

General Statement

Cambrian and upper Paleozoic miogeosynclinal rocks are juxtaposed by high-angle faults with eugeosynclinal cherts, turbidites, and volcanics of unknown age. Within the area of miogeosynclinal rocks, the upper Paleozoic formations lie with angular unconformity on folded Cambrian cyclic beds and cherts. Both have been repeated by low-angle thrust faults of small displacement relative to major thrusting along the Robert's line. Structure is further complicated by high-angle faulting that is dominantly subsequent to the low angle thrusting. Stratigraphic units normally strike north-northeast and dip to the west except near the border faults with the eugeosynclinal sequence where the dip is to the east or nearly vertical.

High-Angle Border Faults

The contact of the limestones, sandstones, and conglomerates with the chert-turbidite sequence trends northeast across saddles on Limestone Knob and Victory Hill, circles around the back of West Hill, extends southeast along Fry Canyon, and turns sharply to the northeast,

crossing saddles at the back of Cambrian Hill and on the northwest flank of East Hill. A similar contact at the mouth of North Fork Canyon trends northeast on the north side of North Fork.

The fault contact is well-substantiated at several localities. At the back of Cambrian Hill fault evidence includes: highly brecciated chert, irregularly oriented Cambrian cyclic beds, calcarenite slivers of unknown age, the sharp bend in the contact, and, possibly, a spring seep on the hill slope just to the northeast.

On Limestone Knob and Victory Hill the western cherts strike northerly and dip steeply to the west, while the fossiliferous calcisiltites and calcarenites of Formation I strike slightly to the east of north and dip to the east, or are nearly vertical.

At the canyon mouth eugeosynclinal cherts and the cross-bedded calcarenite of Formation E have similar attitudes, although the former are quite variable locally. The calcarenite is right side up. Therefore, since Formations F through I are missing to the east of the calcarenite, the contact must be a fault contact.

The rectilinearity of all eugeosynclinal-miogeosynclinal contacts lends strength to the contention of high-angle faults. The western cherts are believed to lie in the downthrown block and the miogeosynclinal rocks in the upthrown block, the evidence and reasoning for this conclusion is subsequently presented.

Cambrian--Upper Paleozoic Angular Unconformity

Conglomerate and quartz siltite of Formation E lie with angular unconformity on folded Cambrian chert and cyclic beds at the southwest corner of East Hill, and on the cyclic beds over much of the slope of Long Ridge. The unconformity is well exposed on East Hill

where the angle of unconformity varies from 15° to nearly 0°. South of the park road Formation E is poorly exposed and the unconformity is not easily recognized.

Cambrian formations are folded in a prominent anticline at the base of Long Ridge, and minor folds were observed in several other localities on Long Ridge. As a whole, Cambrian units show marked irregularity in attitude. In contrast, upper Paleozoic formations are relatively unfolded and have nearly constant attitudes, except near fault zones. Therefore, the Cambrian formations were deformed prior to deposition of upper Paleozoic sediments, the deformation including folding as well as tilting. Further study of Long Ridge may reveal this more clearly.

At the southwest corner of East Hill, Cambrian chert and cyclic beds seem to continue across the canyon on the nose of the anticline without break. As a result it is believed that North Fork canyon is not the locus of a major fault. Other instances of continuity were not observed however, and further study of the base of Long Ridge is needed.

Low-Angle Thrusts

The most prominent structural feature in the area of miogeosynclinal rocks is a low-angle thrust that repeats both Cambrian and upper Paleozoic stratigraphic units. The thrust extends from North Fork at the base of East Hill northwestward across East Hill and Cambrian Hill, and then turns north and continues up Fry Canyon on the west slope of Cambrian Hill. The thrust reappears on the east slope of West Hill, extends south along Fry Canyon, turns west cutting across the face of

West Hill, and finally is lost on the southwest shoulder of West Hill.

Topographically the thrust rises across Cambrian Hill, travels downslope on the east side of Fry Canyon, rises again on the west side, and remains nearly constant across the face of West Hill. The present dip of the thrust surface is therefore north to northeast. On the northwest slope of Cambrian Hill, a small segment of the thrust is shown to bend to the northeast and rise topographically, producing a south or southeast dip. This may be merely a warping of the thrust surface, or may be an anomaly caused by the adjacent high-angle border fault. However, it is also possible that this segment is in reality a minor high-angle fault that cuts the thrust and should therefore be shown on the map as a high-angle fault.

The thrust appears as a lineation on photographs (Plate 6) and the contact can be located precisely in several localities. On East Hill ridges of Formation E conglomerate and quartz siltite change from northeast trending to northwest trending ridges, and then are sharply cut off with Cambrian argillite lying above. The folding of the conglomerate and quartz siltite ridges appears to have resulted from drag movement along the fault.

Further west on East Hill, a sliver of silicified calcarenite of Formation E lies below wash of Cambrian argillite and above Formation F quartz siltites and black calcisiltites. On Cambrian Hill Formation E conglomerate rests on quartz siltite of Member 3, Formation F. The thrust can only be approximately placed on the west slope of Cambrian Hill.

On West Hill along Fry Canyon, first Formation A argillite, then quartz siltite of Formation E, and finally calcarenite of Formation E

A. View looking northwest at West Hill. A low angle thrust is marked by a prominent lineation on the south and east flanks. Formation G is overturned immediately below the thrust on the south face.

B. View looking north at Cambrian Hill. Cambrian cyclic beds outcrop prominently on the hill summit with Formation E ridges exposed just below. Quartz siltite ridges of Member 2, Formation F, rise topographically from the southeast flank of Cambrian Hill where they abut against a low angle thrust trending downslope across the south face. Both are marked by prominent lineations.

Plate 6

lie on siltites of Formation F. Across the face of West Hill, Formation F forms the base of the thrust. The "Black and White" calcisiltite of Formation G has been overturned (Plate 7) and sharply cut off below the thrust. What happens to the thrust on the southwest shoulder of West Hill remains undetermined.

Although the thrust on Cambrian Hill cannot be traced across Fry Canyon to West Hill, it is reasonable to assume this is one thrust sheet. In general, the units at the base of the thrust sheet strike northeast, dip west, and become progressively younger westward. The units over which the thrust has ridden also become progressively younger to the west. These units also strike north to northeast and dip west except where drag movement has occurred.

A second thrust has ridden Cambrian cyclic beds over argillite at the top of Cambrian Hill. The large mass of Formation E downslope is interpreted as a block picked up during faulting and enveloped in the argillite.

The net slip on the thrust cannot be very great since the same units are found on both sides of the fault. A half mile to a mile may well be a high estimate.

Evidence seems to support east to west or northeast to southwest thrust movement in contrast to west to east movement observed almost universally in other localities along the Robert's line. As a result, the author is suspicious of the validity of his evidence, but presents it here as was observed in the field. First, on West Hill and East Hill drag folding is in accord with west movement of the thrust sheet. Second, units in the thrust sheet are found west of their presumed counterparts in the lower block. If the units below the thrust are

not the autochthonous counterparts of those in the thrust sheet as presumed, the latter evidence should be reinterpreted. The drag folding is hard to explain; the only explanation in accord with west to east movement would seem to be underthrusting with the lower block the active component. This could also explain the second observation.

High-Angle Faults

A high-angle normal fault is inferred to extend northwestward from the base of East Hill, rising topographically, and crossing the northeast flank of Cambrian Hill where it turns to the northeast and abuts against the border fault separating the miogeosynclinal and eugeosynclinal sequences. From the southwest slope of East Hill to the back of Cambrian Hill the fault is uncertainly placed. Undifferentiated upper Paleozoic rocks lie in the north and upthrown block. Near the back of Cambrian Hill, Cambrian cyclic beds are believed to lie in the downthrown block along the fault contact. Along the remainder of the contact, Formation A argillite lies adjacent to the fault. On East Hill small blocks of Formation E silicified calcarenite and Cambrian cyclic units are interpreted as horses. The thrust sheet immediately south of the normal fault is believed to have formerly extended to the northeast, but has since been eroded from the upthrown block of the normal fault. This fault may be an offshoot of a major border fault along the east side of Independence Mountains.

Alternately, this fault might be interpreted as a second northeast dipping thrust fault. If this were the correct explanation, the lower thrust sheet would never have extended northeastward over the upper Paleozoic undifferentiated.

High-angle faulting is undoubtedly present along Second Canyon west of West Hill, but displacements and exact locations are uncertain. A high-angle fault between Formations G.and H is interpreted as being prior to thrusting. Numerous high-angle faults of small displacement are scattered throughout the area and are subsequent to the thrusting, although good stratigraphic evidence for the timing is lacking in many instances.

Relative Displacement on the Border Faults

Although evidence for high-angle faults at all contacts of the western cherts and associated rocks with the miogeosynclinal deposits is well-substantiated, the relative displacement on these faults is uncertain. The hypothesis favored is that the cherts have moved down relative to the limestones and quartzitic rocks.

On East Hill and on Long Ridge, upper Paleozoic conglomerate and quartz siltite lie with angular unconformity on Cambrian cyclic beds and cherts. The absence of any preserved western cherts between the Cambrian and the conglomerate-quartz siltite is noteworthy.

If the thick cherts are all, or in part, pre-upper Paleozoic, it is unlikely that they would be found in close proximity, without structural movements, to an area of non-deposition or an area where subsequent erosion has removed all traces of deposited eugeosynclinal sediments. It is more likely that the cherts were thrust into an area that received dissimilar sediments, if any, during the Ordovician to upper Paleozoic interval.

If the cherts are equivalent in age to the limestones and quartzitic rocks, I believe thrusting must be postulated to account for the close proximity of, and lack of gradation between the two rock types.

Finally, if the cherts are entirely younger than the miogeosynclinal rocks, they could merely represent an environmental change with time and would rest on top of the miogeosynclinal rocks.

At the end of thrusting in the first two cases, and at the end of deposition in the third, the cherts would lie on limestones and quartzitic rocks. To expose the latter by high-angle faults, cherts must be eroded from an upthrown block.

If it were possible that two contrasting lithic sequences were deposited in the close proximity observed, the relative displacement might be either up or down in the block containing miogeosynclinal formations. This, I feel, is the poorest explanation.

SUMMARY OF TECTONIC HISTORY

During the Cambrian, deposition of a thick sequence of calcisiltite and argillite cyclic beds succeeded argillite, minor chert, and quartz siltite sedimentation in a tectonically stable miogeosyncline. Stability is particularly reflected in the uniformity of the cyclic beds. From the end of the Cambrian through the middle Paleozoic, lower North Fork was probably an area of relatively thin deposition and the sediments deposited, if any, were removed by erosion along with some Cambrian prior to initiation of upper Paleozoic sedimentation. Cambrian formations were also folded prior to deposition of the basal conglomerate and quartz siltite of Formation E. Evidence of time of deformation is lacking; late Devonian would seem the earliest possible time if North Fork conforms with the tectonic history of the region as a whole.

Deposition of a thick sequence (more than 2,000 feet) of calcisiltites and quartz siltites, with minor calcarenites and chert

GEOLOGIC MAP
OF THE
LOWER NORTH FORK AREA

GEOLOGIC FORMATIONS

- Qal — Alluvium
- J — Jurassic
- UPPER PALEOZOIC: I, H, G, F4, F3, F2, F1, E3, E2, E1
- CAMBRIAN: D, C, B, A
- THRUST

SCALE 1"= 500'

500 0 500 1000 1500

CONTOUR INTERVAL = 200'

N MN 17°

SYMBOLS

- FORMATION CONTACT (BROKEN WHERE INFERRED)
- MEMBER CONTACT
- STRIKE AND DIP OF BEDDING
- SYNCLINAL FOLD AXIS
- ANTICLINAL FOLD AXIS
- THRUST FAULT (BROKEN WHERE INFERRED)
- NORMAL FAULT (BROKEN WHERE INFERRED)
- HIGH ANGLE FAULT (QUESTIONABLE)
- STREAM
- ROAD

Victory Hill
Mikes Canyon
Limestone Knob
Fly Canyon
Combash Hill
East Hill
Long Ridge
BM 6625
7600
7400
7200
7000
6800

2420 0068

Widmier 1960

24200068

GEOLOGIC MAP OF LOWER NORTH FORK INDEPENDENCE MOUNTAINS, NEVADA

SYMBOLS

- Strike and dip of bedding
- Horizontal beds
- Strike of vertical beds
- Strike and dip of minutely folded beds
- Strike and dip of overturned beds
- Strike and dip of foliation
- Direction of plunge of minor anticline
- Axis of overturned syncline
- Fold axis
- Springs
- Streams
- High angle fault (downdropped block indicated) broken when inferred
- Thrust fault (broken when inferred)
- Concealed fault
- Formation contact (broken when inferred)
- Member contact

FORMATIONS

- J — Carb.
- CARBONIFEROUS: I, H, G, F, E
- K — Alluvium
- CAMBRIAN: D, C, B, A

CONTOUR INTERVAL=200'

SCALE 1:1000

0 1000 2000