UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Stratigraphic Sequence of Paleozoic and Mesozoic Rocks Exposed in Central Elko County, Nevada

By

Keith B. Ketner

Open-file report No. 75-213

1975

CONTENTS

ILLUSTRATIONS

INTRODUCTION

The area described in this report (fig. 1) includes the southern Independence Range, a small part of the northern Independence Range, the Adobe Range, the Elko Hills, the Peko Hills, Double Mountain area, and adjacent small exposures.

The first mapping in the area was done by S. F. Emmons during the geological exploration of the fortieth parallel (King, 1876). This work of a broad reconnaissance nature served to discriminate general categories of rocks and, although grievous errors as to geologic ages were made in some cases, lithologic observations were accurate and are still useful. The Merrimac mining district at Lone Mountain was discussed briefly by W. H. Emmons (1910), F. C. Lincoln (1923), and Smith and Trengove (1949). Granger and others (1957) slightly revised the regional mapping done by S. F. Emmons. Lovejoy's work at Lone Mountain (1959) was the first careful detailed study in the area and has been very useful in the present study. Mapping in areas adjacent to the one studied by Lovejoy and additional collections of fossils have necessitated slight revisions in Lovejoy's interpretations. Mapping in the Mason Mountain area by J. R. Coash (1967) has been reinterpreted in the light of new data from adjacent areas. The Swales Mountain area was mapped by Evans and Ketner (1970). Evans assisted in mapping the Elko Hills and Peko Hills. The reports of a large number of paleontologists have been indispensible to the correct interpretation of the stratigraphy and structure of central Elko County. These specialists are acknowledged individually in the following pages. The terms North Fork sequence, Coal Creek sequence, Camp Creek sequence, Adobe Range sequence, and Long Canyon sequence are used informally in this report and do not represent officially approved nomenclature.

Minor geographic features not shown on fig. 1 can be located on the appropriate 7½-minute quadrangle maps as shown below. These maps are available from the U. S. Geological Survey.

Singletree Creek quadrangle:

- Lone Mountain
- Blue Basin Creek
- Cold Creek

Swales Mountain quadrangle:

- Swales Mountain
- Fish Creek
- Mouse Creek
- Swales Creek

Tuscarora quadrangle (15 minute):

- Jerrit Canyon

Stag Mountain:

- Stag Mountain

The Narrows quadrangle:

- Long Canyon

Coal Mine Canyon quadrangle:

- Coal Mine Canyon
- Coal Canyon mine

Mt. Velma quadrangle (15 minute);

- Mason Mountain
- Mt. Ic[illegible]ood

Schroeder Mountain quadrangle;

- Maggie Creek

Rodeo Creek NE quadrangle:

- Lynn Creek

Osino quadrangle:

- Jackson (Jackstone) Creek

Double Mountain quadrangle:

- Double Mountain

Twin Buttes quadrangle:

- Marys River Hills (Twin Buttes)

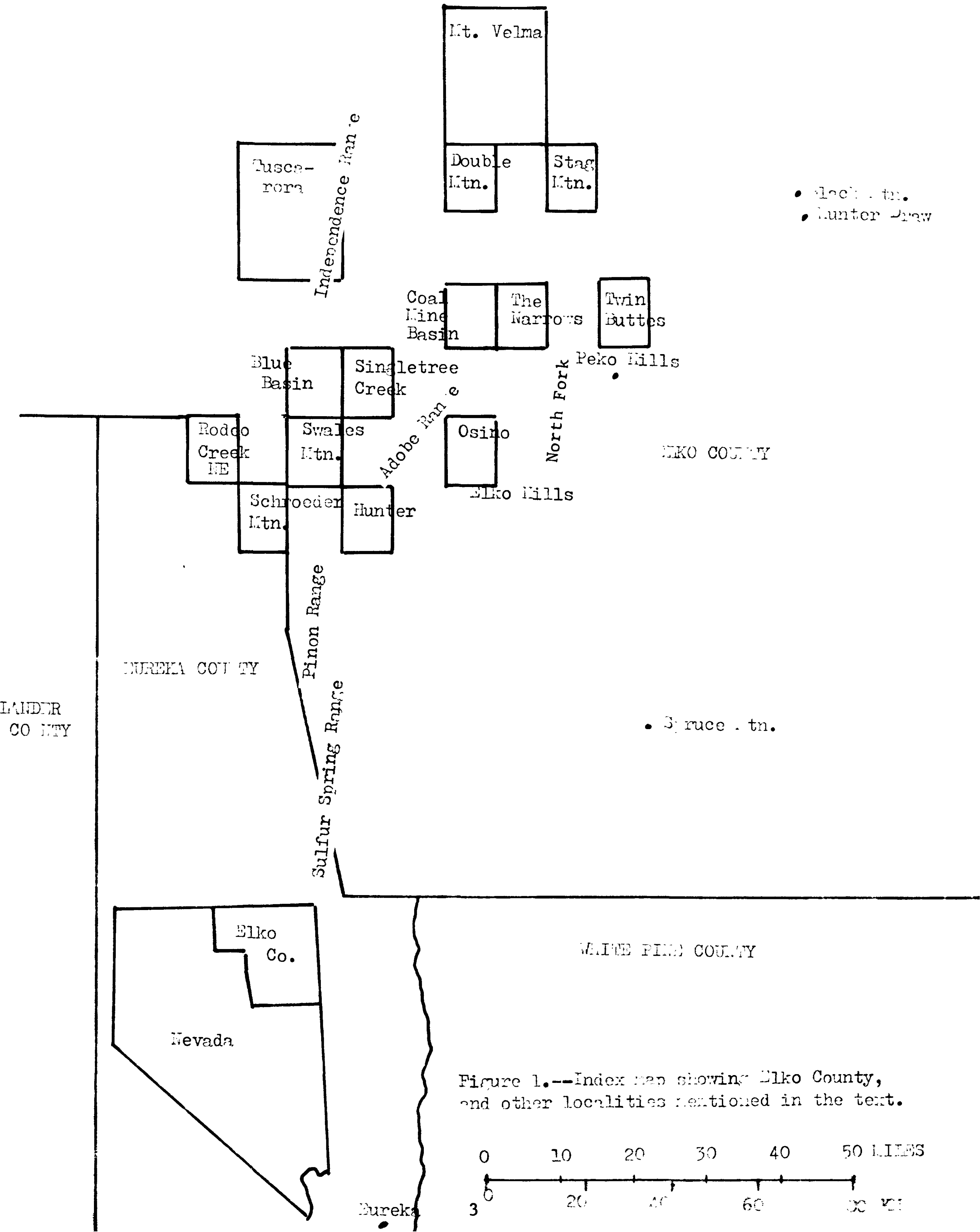

Figure 1.--Index map showing Elko County, and other localities mentioned in the text.

GENERAL FEATURES

The stratigraphic and structural aspects of central Elko County in general support the regional scheme built up by previous work. The early Paleozoic stratigraphy of the area supports the idea of a simple three-fold division of the Cordilleran geosyncline into a miogeosyncline, a eugeosyncline, and an intermediate zone.

The miogeosynclinal sediments of Ordovician to Devonian age are evidently of relatively shallow water origin as indicated by their advanced state of oxidation, abundant fauna of bottom dwelling organisms, coarse bedding, and carbonate composition. The eugeosynclinal sediments evidently were deposited in deep water because they are unoxidized, contain only a sparse fauna of free floating organisms, are thinly laminated, and are composed principally of silica rather than carbonate. Rocks deposited along the border between the miogeosyncline and eugeosyncline could be expected to be of mixed miogeosynclinal and eugeosynclinal lithology.

Most of the early Paleozoic formations exposed in central Elko County are, in fact, of mixed lithology and furthermore many mixed units here and elsewhere display evidence of having been deposited on or at the foot of a steep slope. This evidence includes turbidity current deposits and soft sediment slump structures. It is concluded therefore that the miogeosyncline-eugeosyncline border was a topographic and structural discontinuity rather than a perfectly gradational transition from shallow to deeper water.

Listed below are stratigraphic units in the area of this report that have features indicative of deposition in or near the geosynclinal transition zone.

North Fork sequence (Ordovician, Silurian, Devonian)

1. Limestone turbidites and massive lenses of slumped miogeosynclinal carbonate.
2. Scarcity of greenstone from sediments of predominantly eugeosynclinal aspect in many areas.

Roberts Mountains Formation (Silurian and Devonian)

1. Bedding features suggestive of turbidity current origin.

Nevada Formation (Devonian)

1. Carbonaceous shale and black chert interbedded with miogeosynclinal carbonate.

Coal Creek sequence (Devonian)

1. Graded beds that resemble turbidite.
2. Interbedded limestone, carbonaceous shale, and black chert.

Camp Creek sequence (Mississippian)

1. Turbidite features throughout.

Long Canyon sequence (Permian and Triassic)

1. Interbedded greenstone, shale, and brachiopod-bearing limestone.

Some of the formations exposed in central Elko County were not deposited there but were transported into the area on thrust faults. These formations include the North Fork sequence, Nevada Formation (Swales Mountain area only), and Coal Creek sequence. All major thrusts are inferred from field relations and facies relations to have had an easterly component of movement, causing rocks of eugeosynclinal facies to override those of transitional and miogeosynclinal facies and rocks of transitional facies to override those of miogeosynclinal facies.

ORDOVICIAN, SILURIAN, AND DEVONIAN

NORTH FORK SEQUENCE

The Ordovician, Silurian, and Devonian rocks of the eugeosynclinal and transitional assemblages comprise an internally thrustfaulted sheet of siliceous rocks that crops out widely in central Elko County. Although each of these systems can be identified in some places owing to the presence of graptolites, conodonts, or (rarely) trilobites, the rocks are, in large part, unfossiliferous and the discrimination of systems is a matter of guesswork. Until very detailed work is done, all three systems in central Elko County are provisionally assigned to the North Fork sequence. The name is derived from the North Fork of the Humboldt River which drains much of the area in which these rocks crop out. It is an informal designation used for convenience in this report only.

Distribution

Rocks of the North Fork sequence can be divided roughly into two major facies, partly equivalent in age. The chert-shale-siltstone facies including rocks of Ordovician to Devonian age crops out mainly in the southern Independence Range and the northern Adobe Range. The quartzite facies crops out in the northern Independence Range, on Double Mountain, and on hills north of Double Mountain. Unfossiliferous exposures of quartzite and associated chert, argillite, and siltstone in the Mt. Ichabod-Mason Mountain area previously assigned to the Triassic and Cambrian Systems (Coash, 1967) are here assigned, on the basis of lithic resemblance, to the quartzite facies of the North Fork sequence. Thus, chert, shale, argillite, and siltstone predominate south of an east-west line drawn at the latitude of Double Mountain and quartzite is a prominent if not dominant constituent north of this line.

Lithology

The North Fork sequence is composed principally of bedded chert, argillite, shale, siltstone, quartzite, and greenstone, and lesser amounts of sandstone and limestone. Rocks of the North Fork sequence exposed in the southern Independence Range have been described by Lovejoy (1959) and briefly by Evans and Ketner (1970) and Ketner (1970a). Those of the northern Independence range were described by Kerr (1962) and by Churkin and Kay (1967). These rocks are unmetamorphosed except locally as in the Marys River Hills where intrusive quartz monzonite somewhat recrystallized the shale and chert but not so much as to completely mask the identity of the rocks or destroy the contained graptolites.

Bedded chert, argillite, and shale.--These rocks which, together, probably constitute the bulk of the North Fork sequence form a continuous lithologic series. Rocks of this series from Nevada and Idaho known to be of Ordovician age were previously defined and described (Ketner, 1969). Members of the series in central Elko County, whether of Ordovician, Silurian, or Devonian age, are indistinguishable from the described Ordovician rocks and the reader is referred to that earlier publication for a descriptive and genetic account. Chert of the North Fork sequence is somewhat unusual in that it contains graptolites, in some places rather abundantly.

Siltstone.--Although some siltstone beds are of Devonian and Ordovician age they are more characteristic of eugeosynclinal rocks known to be of Silurian age. Commonly the siltstone is composed mainly of quartz and lesser amounts of carbonate, microcline, and plagioclase. Grains are typically angular. Bedding is distinct and small scale crossbeds are common.

Sandstone.--Sandstone of medium to coarse grain size is a minor constituent of the North Fork sequence. One bed a few feet thick in the Lone Mountain area was described by Lovejoy (1959) and one, perhaps the same unit, was observed in the Swales Mountain area. It is composed almost entirely of well rounded, frosted quartz grains cemented by carbonate, silica, and iron oxide. In one outcrop the basal part contained chips of the underlying shale. Along Blue Basin Creek and in the northern Adobe Range sandstone beds a few inches thick are associated with clastic limestone and siltstone in graded sequences.

Quartzite.--Massive, medium- to coarse-grained, pure quartz arenite which fits the general description of Ordovician eugeosynclinal quartzites (Ketner, 1966) is abundant in northern exposures of the North Fork sequence.

Limestone.--Limestone interbedded with chert, argillite, and shale constitutes less than 1 percent of the North Fork sequence. Most commonly, beds are Middle Ordovician and Late Devonian in age. Many limestone units are dark-gray, thin-bedded, slightly cherty calcilutites. Some of these contain layers of cone-in-cone structures parallel to the bedding. Many consist of abundant calcite spheres about 0.1 millimeter in diameter in a matrix of finer grained calcite and organic debris. In some of the spheres poorly preserved nuclei similar to those observed in some Radiolaria of associated chert beds are preserved. These limestones contain some intergranular chert that may have been derived from Radiolaria that were replaced by calcite.

Other limestone units display features commonly attributed to turbidites. Some Middle Ordovician detrital limestone beds in the northern Adobe Range and along Blue Basin Creek in the Independence Range are in graded sequences. Basal beds of these sequences are bioclastic calcarenite containing well rounded quartz grains and poorly rounded sand-sized chert, shale, siltstone, and, rarely, volcanic rocks. Some basal beds are intraformational conglomerates made up of flat pebbles derived from the underlying bed. Finer grained beds in graded sequences include calcisiltite, quartz siltstone, impure calcilutite, and silty chert.

Chemical analyses of five samples of limestone (Table 1) indicate remarkably low percentages of MgO and Al_2O_3. Most of the impurities are composed of silica in the form of chert and detrital quartz.

Table 1.--Analyses of Middle Ordovician[1] limestone of the North Fork sequence. (Analysed by methods similar to those described in U.S. Geol. Survey Bull. 1144-A by H. Smith, L. Artis, J. Kelsey, S. Botts, G. Chloe, and J. Glenn, 1967; organic carbon by I. C. Frost, 1967.)

	Chemical analyses (weight percent)				
Sample No.	2309	2311	2315	2653	2657
SiO_2	12.6	30.9	9.2	28.3	6.4
Al_2O_3	1.0	1.7	.83	2.8	1.1
Fe_2O_3	.30	.66	.57	.72	.07
FeO	.24	.26	.22	.80	.50
MgO	.67	2.0	.34	.31	.38
CaO	46.5	34.0	48.6	36.0	49.8
Na_2O	.20	.05	.00	.06	.00
K_2O	.35	.50	.18	1.3	.39
H_2O-	.13	.21	.06	.31	.07
H_2O+	.26	.57	.18	.60	.21
TiO_2	.04	.11	.02	.13	.04
P_2O_5	.07	.08	.00	.08	.00
MnO	.05	.04	.02	.12	.20
CO_2	37.5	28.5	39.8	28.3	40.0
Organic C	.26	.43	.10	1.21	.25
Sum	100	100	100	101	99

1/ 2309, 2311 graptolite-bearing dark gray calcilutite with cherty interbeds 2653 dark gray bioclastic calcarenite with disseminated intergranular chert. 2657 black limestone with cone-in-cone structure interbedded with shale.

Barite.--Certain beds of the North Fork sequence on the west slope of Swales Mountain that are extraordinarily rich in barite are discussed here because they are possibly syngenetic deposits. Pebbles of nearly pure barite are associated with chert pebbles in thin conglomerate beds. In adjacent beds of argillite and mudstone barite rosettes seem to have grown before consolidation of the sediment because the blades of the rosettes clearly have distorted the bedding. Spectrographic analyses of the barite indicate values of lead, zinc, and molybdenum that are abnormally high for sediments and petrographic examination reveals partial replacement of sediments by opal close to the barite deposits.

Some aspects of the deposits such as the pebble conglomerate and the sediment distortion indicate a time of deposition contemporaneous with the enclosing sediments. Features such as the associated base metals and opal point to a hydrothermal origin. The problem of genesis requires much more study.

Greenstone.--Greenstone forms a minor proportion of the North Fork sequence, probably no more than 5 percent (Table 2). None of it is closely associated with Silurian fossil localities and several exposures are close to dated Ordovician and Devonian beds. The logical, but not inevitable, conclusion is that most of the greenstone is Ordovician and Devonian in age. Outcrops were examined for pillow structures and other evidence of origin but alteration and poor exposures prevent fruitful observations.

Table 2.--Analyses of greenstone from the North Fork sequence. (Analysed by methods similar to those described in U.S. Geol. Survey Bull. 1144-A by P. Elmore, L. Artis, G. Chloe, J. Kelsey, S. Botts, J. Glenn, and H. Smith, 1968-69.)

	Chemical analyses (weight percent)				
Sample No.	2266	3025	5550	5562	5584
SiO_2	54.3	42.4	44.1	45.2	49.0
Al_2O_3	18.8	16.0	15.1	14.7	14.7
Fe_2O_3	3.9	3.6	2.5	1.9	2.3
FeO	.40	4.6	4.5	6.5	6.0
MgO	.55	3.2	7.3	7.3	7.4
CaO	1.0	9.1	9.0	8.0	12.2
Na_2O	.22	.38	3.4	3.7	3.3
K_2O	10.5	6.6	2.4	.51	.11
H_2O-	1.1	1.1	1.3	1.2	.48
H_2O+	3.1	3.8	3.6	4.2	2.4
TiO_2	1.6	2.3	1.4	1.0	.89
P_2O_5	1.2	1.0	.39	.11	.07
MnO	.08	.08	.10	.15	.16
CO_2	<.05	5.7	5.0	4.8	.68
Volatiles other than H_2O and CO_2	2.4				
Sum	99	100	100	99	100

Some rocks assigned to the North Fork sequence in the northern Adobe Range are distinguishable from the Chainman Shale only with great difficulty owing to poor exposures, lack of fossils, and convergent lithology. Devonian rocks on the west slope of the range on both sides of the Coal Canyon road are especially troublesome. These rocks consist of black-bedded chert, gray thick-bedded limestone with much quartz sand, limestone flat-pebble breccia or conglomerate, platy light-colored siltstone, and sheared, black argillite. Siltstone and argillite closely resemble parts of the Chainman Formation but can be discriminated on the basis of their more complex structure. It seems quite clear that the upper plate rocks have "suffered" more than has the Chainman. Chips are sheared and outcrops are sheared and contorted. In contrast, the Chainman has been affected only by open folding, not by tight folding and shearing. There are no beds of chert-grain sandstone among the upper plate rocks like those interbedded with shale and siltstone in the Chainman.

Stratigraphy and thickness

The North Fork sequence cannot yet be subdivided lithologically into mappable units. Discrimination of geologic systems by setting arbitrary stratigraphic boundaries between fossil collections of different geologic ages is liable to be misleading and is not attempted here because of stratigraphic and structural repetition of beds and the scarcity of diagnostic fossils.

Where dating is possible Ordovician beds of the North Fork sequence consist mainly of bedded chert, argillite, shale, quartzite, greenstone, and limestone. The Silurian beds are dominantly siltstone and the Devonian beds are dominantly chert, argillite, shale, and limestone.

Two partly contemporaneous facies of the North Fork sequence are discernable: one in which the Ordovician part is relatively rich in quartzite (and greenstone to a lesser extent) and one in which it is almost lacking these and is rich in chert. The quartzite-rich facies, described by Churkin and Kay (1967), lies generally north of a line connecting Jerritt Canyon in the Independence Range with Stag Mountain (fig. 1). The cherty facies lies principally south of this line.
In areas where both the quartzitic and cherty facies are present the quartzite commonly seems to overlie the cherty facies suggesting that it lies on a thrust plate structurally higher than the cherty facies.

The limestone lenses comprising a small part of the North Fork sequence are mainly of Middle Ordovician age. One is Late Devonian. Trilobites in the limestone of the northern Adobe Range (collection 65-RJ-26) indicate its age is lower Middle Ordovician. Graptolites from a limestone unit in the Swales Mountain area (collection 2310) indicate a Middle Ordovician age. Conodonts from sandy limestone along Blue Basin Creek are of uncertain age, but most likely Lower Ordovician age according to John Huddle. Graptolites (collections 2242 and 2667) stratigraphically a little higher than the sandy limestone in this area and just below another limestone unit are Middle Ordovician in age. Limestone beds in the Lone Mountain area are associated with graptolite-bearing shales of Middle Ordovician age (collection 3020).

In the southern part of the Mt. Velma quadrangle cherty rocks assigned to the Triassic System and quartzite assigned to the Cambrian System (Coash, 1967) are here included in the North Fork sequence on the basis of strong lithic resemblance to dated sequences of Ordovician rocks.

Age and Correlation

The North Fork sequence includes dated beds of Early, Middle, and (probably) Late Ordovician; Silurian (Wenlock); Late Devonian, and possibly Early Mississippian ages. It is thus correlative with the Vinini and Valmy formations of widespread occurrence in Nevada; approximately with the Trail Creek Formation of Churkin (1963); at least partly with the Woodruff Formation of Smith and Ketner (1968), and possibly with the Webb Formation of Smith and Ketner (1968).

In the following paragraphs all fossils were collected by the author and all identifications and age assignments are by R. J. Ross, Jr. unless otherwise noted. The numbered graptolite zones are those of Elles and Wood (1914).

Swales Mountain.--In the Swales Mountain area Lower, Middle, and Upper(?) Ordovician beds have been identified by means of the following graptolite collections. No Silurian or Devonian beds were identified in the Swales Mountain area.

Field no. 3355 (U.S.G.S. D1897-CO) Swales Mountain quadrangle, T. 36 N., R. 53 E., NW$\frac{1}{4}$, SW$\frac{1}{4}$ sec. 32, on the 6600 contour line.

> _Tetragraptus fruticosus_ (3 branched)
> _Dichograptus_ sp.
> numerous fragments of dichograptids that are indeterminate
>
> Age: Zone of _T. fruticosus_ (upper zone 4)

Field no. 3077 (USGS CO-6212) Singletree Creek quadrangle, T. 36 N., R. 53 E., boundary between SW$\frac{1}{4}$ and SE$\frac{1}{4}$ of NE$\frac{1}{4}$ sec. 15, calcareous sandstone on ridge. Conodont identification by John W. Huddle.

	No. of specimens
Cordylodus sp.	3
Cyrtioniodus sp.	4
Drepanodus sp.	3
Oneotodus sp.	1
Plectodina sp.	1
Plectodina sp.	2

Sponge spicules are abundant in the light fraction

Huddle states "This collection could be as old as Upper Cambrian or as young as Silurian. It is probably Early Ordovician because it lacks the species you would expect to find in younger formations and contains some forms not yet known from the Cambrian. This conclusion is far from certain because of our limited information on conodonts of this age range".

Field no. 3330 (USGS 6263-CO) Swales Mountain quadrangle, T. 35 N., R. 53 E., NW$\frac{1}{4}$NW$\frac{1}{4}$ sec. 21. Identifications and age by John W. Huddle.

	No. of specimens
Acontiodus robustus (Hadding)	1
Acodus? sp.	1
Amorophognathus ordovicia? (Branson and Mehl)	6 fragments
Drepanodus sp.	7
Histiodella serrata Harris	4
Microcoleodus? sp.	1
Multioistodus sp.	3
Oistodus lanceolatus Pander (triangularis form)	1
Periodon sp. (*Ligonodina* tortilis form)	7
Scolopodus aff. *filosus* (Ethington and Clark)	1
S. varicostatus Sweet and Bergstrom	6

Age: This fauna occurs in the Antelope Valley Formation of the Pogonip Group in central and southern Nevada. It is probably early Middle Ordovician in age. Some of the species occur in the Joins Formation of Oklahoma and the Pratts Ferry Limestone of Alabama.

Field no. 2307 (USGS D1775 CO) Swales Mountain quadrangle, T. 35 N., R. 52 E., exact center of sec. 34.

Didymograptus compressus Harris & Thomas

Glossograptus hincksii Hopkinson (beautiful specimen)

Amplexograptus cf. *A. confertus* (Lapworth)

Diplograptus decoratus cf. var. *multus* Ross & Berry

Orthograptus sp. (this suggests zone 8 rather than 7)

Caryocaris sp.

Age: Zone of *Paraglossograptus etheridgei* or *G. teretiusculus*, zones 7-8.

Field no. 2258 (USGS D1780 CO) Just west of Swales Mountain quadrangle, T. 35 N., R. 52 E., NE¼ sec. 4, in saddle.

Didymograptus sp.

Diplograptus decoratus, possibly var. *multus*

Amplexograptus cf. *A. differtus* Harris and Thomas

Amplexograptus? sp.

Age: Zones of *P. etheridgei* to *G. teretiusculus*, zones 7-8.

Field no. 2242 (USGS D1779 CO) Singletree Creek quadrangle, T. 36 N., R. 53 E., NW¼SW¼ sec. 11, in saddle 50 feet west of jeep trail.

Glyptograptus cf. *G. teretiusculus* (Hisinger)

Diplograptus decoratus var. *multus* Ross & Berry

Deplograptus multidens aff. var. *compactus* Lapworth

Climacograptus cf. *C. riddellensis* Harris

Amplexograptus cf. *A. modicellus* Harris & Thomas

Age: Most species listed here have ranges overlapping in the zone of *G. teretiusculus*, zone 8. One species seems to be a little younger than that but is indefinitely identified.

Field no. 2667 (USGS D1786 CO), Blue Basin quadrangle, T. 36 N., R. 53 E., NW$\frac{1}{4}$NE$\frac{1}{4}$SW$\frac{1}{4}$ sec. 10, at 6280 feet altitude.

Cryptograptus tricornis

Dicranograptus nicholsoni

Dicranograptus nicholsoni var. *whitianus*

Climacograptus spiniferus

Climacograptus sp.

Orthograptus calcaratus var. *acutus*

Orthograptus cf. *O. calcaratus*

Orthograptus truncatus

Also a great variety of small biserial forms probably belonging to *Orthograptus* and/or *Glyptograptus*.

Age: Caradoc, zones of *Climacograptus bicornis* and possibly *Orthograptus truncatus* var. *intermedius* (zones 10-11).

Field no. 2310 (USGS D1774 CO) Swales Mountain quadrangle, T. 35 N., R. 52 E., on line between sec. 27 and 34, west slope of hill 5806.

Orthograptus cf. *O. truncatus* var. *intermedius* Elles and Wood

Glyptograptus altus Ross and Berry (new variety)

Age: Probably zone of *O. truncatus intermedius*. This would be zone 11 of Elles and Wood. However, the original *G. altus* came from a somewhat higher zone in Idaho.

Field no. 2252 (USGS D1777 CO), Swales Mountain quadrangle, T. 35 N., where the boundary between R. 52 N. and R. 53 N. crosses Fish Creek.

Dicellograptus, possibly a new species. Not enough specimens to be sure of all characteristics.

Climacograptus cf. *C. tubuliferus*

Climacograptus n. sp. or n. var. cf. *C. tubuliferus* but growing to greater width.

Orthograptus quadrimucronatus

Orthograptus sp. (close set, 16/10 mm, thecae)

Retiograptus sp.

Age: Zone of *Orthograptus quadrimucronatus*. Upper Caradoc (zones 12-13).

Lone Mountain.--In the Lone Mountain area Lovejoy (1959) identified Lower and Middle Ordovician beds and Silurian beds in the North Fork sequence. Additional collections cited below are Middle Ordovician and possibly Upper Ordovician, Silurian, and Devonian.

Field no. 3016 (USGS D1888 CO) Singletree Creek quadrangle, T. 37 N., R. 53 E., SW$\frac{1}{4}$NE$\frac{1}{4}$SW$\frac{1}{4}$ sec. 15, just west of road at altitude of 6800 feet.

Amplexograptus cf. *A. confertus* (Lapworth)

Amplexograptus sp. (possibly new sp.)

Glossograptus? sp.

Caryocaris sp. (very abundant)

Age: Probably zone of *Paraglossograptus etheridgei* (zone 7).

Field no. 3020 (USGS D1891 CO) Blue Basin quadrangle, T. 37 N., R. 53 E., NE corner NW$\frac{1}{4}$SW$\frac{1}{4}$ sec. 15, on northwest nose of ridge at altitude of 6680 feet.

Climacograptus *bicornis* Hall

Orthograptus *truncatus* Lapworth

Age: Probably zone of *O.* *truncatus* *intermedius* but might be a shade lower (zone 11, possibly zone 10+).

Field no. 3024 (USGS D1890 CO) Blue Basin quadrangle, T. 37 N., R. 53 E., NW¼NW¼ sec. 15, altitude 6840 feet.

Climacograptus? cf. *C. scharenbergi*

Climacograptus bicornis cf. var. *longispina*

Climacograptus cf. *C. spiniferus* Ruedemann

Orthograptus quadrimucronatus

Orthograptus sp.

Orthograptus truncatus var. *intermedius*

Dicranograptus cf. *D. raniosus longicaulis* but a new variety or new species

Dicranograptus sp.

Dicellograptus sp.

Glossograptus sp. (possibly *Paraglossograptus*)

retiolitid

Age: My best guess is zone *O. truncatus* var. *intermedius* or a bit higher (zone 11, maybe 12). The big *Dicranograptus* and *Climacograptus* cf. *bicornis longispina* suggest zone 10.

Field no. 3035 (USGS D1889 CO) Blue Basin quadrangle, T. 37 N., R. 53 E., NW corner SW¼SW¼ sec. 16 ESE of hill 6733 at an altitude of 6560 feet.

Climacograptus caudatus Lapworth

Climacograptus hvalross Ross and Berry

Glyptograptus altus Ross and Berry

Orthograptus quadrimucronatus Hall

Diplograptus multidens Elles and Wood

Cryptograptus tricornis Carruthers

Dicellograptus or *Dicranograptus* (fragments of uniserial stipes only)

Age: zones 11 or 12.

Field no. 3013 (USGS D1887 CO) Singletree Creek quadrangle, T. 37 N., R. 53 E., SW¼ sec. 22, southeast side of hill 6864 at altitude of 6760 feet.

Dicellograptus divaricatus var. *bicurvatus* Ruedemann

Dicranograptus ziczac Lapworth

Climacograptus bicornis Hall

Climacograptus cf. *C. phyllophorus* Gurley

Climacograptus aff. *scharenbergi* or a species of *Amplexograptus* with zigzag median septum. Width 1.8 mm, thecae 16 in 10 mm.

Amplexograptus arctus

Amplexograptus sp.

Diplograptus sp.

Glyptograptus cf. *G. teretiusculus*

Age: zone of *Climacograptus bicornis* (zone 10) or a little older.

One chip from this collection bears

Orthograptus quadrimucronatus

Climacograptus sp.

Dicranograptus sp.

Age: Probably zone of *O. quadrimucronatus* (zones 13-14).

Field no. 3034 (USGS D221SD) Blue Basin quadrangle, T. 37 N., R. 53 E., NE¼ NE¼ sec. 17, west side of road, 500 feet northeast of pond at an altitude of 6360 feet. Identifications by William B. N. Berry.

Monograptus dubius (Suess)

Monograptus cf. *M. flemingii* (Salter)

Monograptus cf. *M. praedubius* Boucek

possible cyrtograptid fragments

Age: Silurian, Wenlock, possibly Middle Wenlock

Field no. 3036 (USGS SD-8061) Blue Basin quadrangle, T. 37 N., R. 53 E., NE¼NW¼ sec. 21 on point at 6850 feet altitude. Thin limestone in chert. Conodont identifications by John W. Huddle.

	No. of specimens
Ancyrodella curvata (Branson and Mehl)	3
Ancyrognathus triangularis Youngquist	2
Bryantodus sp.	5
Hindeodella	6
Icriodus sp.	1
Ligondoina sp.	3
Lonchodina sp.	1
Nothognathella sp.	8
Palmatodella? sp.	4
Palmatolepis crepida Linguiformis Branson and Mehl	8
Palmatolepis gigas Miller and Youngquist	46
Palmatolepis subrecta Miller and Youngquist	11
Polygnathus sp.	17
Synprioniodina sp. bar fragments	1

Age: This collection contains much the same fauna as the Lime Creek Formation in the Upper Devonian of Iowa. It is Upper Devonian, Frasnian in age and is equivalent to the Upper *Palmatolopis gigas* zone of Ziegler 1962.

Adobe Range.--In the northern Adobe Range the following collections of trilobites, graptolites, and conodonts indicate the presence of Middle to possibly Late Ordovician, Silurian, Late Devonian, and possibly Early Mississippian beds.

Field no. 65RJ-26 (USGS D1631 CO) Wells quadrangle, T. 38 N., R. 56 E., SE 1/4 sec. 4, prominent limestone outcrop west of fenced spring. Collectors: Robert Coats and R. J. Ross, Jr.

Orthidiella sp.

Carolinites sp.

Nileus sp.

Age: Lower Middle Ordovician, *Orthidiella* zone.

Field no. 3324 (USGS D1896 CO) Wells quadrangle, boundary between T. 38 N., R. 56 and 57 N., on ridge one mile north of Long Canyon road.

Amplexograptus cf. *A. confertus*

Diplograptus amplexograptoideus Ross and Berry

Orthograptus? sp.

Glyptograptus cf. *euglyphus*

Age: Zone of *Paraglossograptus etheridgei* to zone of *G. teretiusculus* (zones 7-8).

Field no. 65-RJ-28 (USGS D1632 CO) Wells quadrangle, T. 38 N., R. 56 E., SE$\frac{1}{4}$ sec. 4, southeast of prominent limestone outcrop.

Collectors: Robert Coats and R. J. Ross, Jr.

Dicellograptus or *Dicranograptus* sp. (disjointed uniserial portions)

Climacograptus tubuliferus

Climacograptus sp.

Glyptograptus sp. (same as sp. is USGS colln. D480e CO)

Orthograptus calcaratus

Orthograptus cf. *O. truncatus* var. *intermedius*

Orthograptus quadrimucronatus

Retiograptus pulcherrimus Keble and Harris

Age: The age of this collection is Late Caradocian (zones 12-13).

Field no. 5508 (USGS 8412-SD) Wells AMS two-degree sheet, NE$\frac{1}{4}$ sec. 3, T. 37 N., R. 55 E., north bank of creek at bend. Thin limestone in chert and argillite. Conodont identifications and age determination by John W. Huddle.

Ancyrodella nodosa Ulrich and Bassler	27
Ancyrognathus triangularis Youngquist	4
Icriodus alternatus Branson and Mehl	3
Palmatolepis gigas Miller and Youngquist	84
Palm. proversa Ziegler	7
Palm. subrecta Miller and Youngquist	61
Palm. unicornis Miller and Youngquist	4
Polygnathus decorosus Stauffer	55
Poly. granulosus Branson and Mehl	1
Poly. normalis Miller and Youngquist	6

Numerous well preserved bars not identified.

Age: This fauna is early Upper Devonian, probably Lower *Palmatolepsis gigas* zone, Frasnian.

Field no. 5581 (USGS 8419-SD) Wells AMS two-degree sheet, sec. 35, T. 38 N., R. 55 E., one mile WSW of spring at sharp bend in road, Coal Mine Canyon. Identifications and age by John W. Huddle.

Ancyrodella gigas Youngquist	3
A. nodosa Ulrich and Bassler	1
A. rotundiloba alata Glenister and Klapper	2
Bryantodus sp.	1
Diplododella sp.	1
Polygnathus asymmetricus asymmetricus Bischoff and Ziegler	2
P. cf. *foliatus* Bryant	1
P. sp.	1
Synprioniodina sp.	1

Age: This fauna is early Upper Devonian in age as is indicated by the species of *Ancyrodella* and *Polygnathus asymmetricus*.

Field no. 5582 (USGS 8420-SD) Wells AMS two-degree sheet, sec. 35, T. 38 N., R. 55 E., one mile WSW of spring at sharp bend in road, Coal Mine Canyon. Identifications and age by John W. Huddle.

Ancyrodella sp.	3
Bryantodus sp.	4
Flacodus sp.	1
Hindeodella sp.	2
Icriodus nodosus (Huddle)	2
Icriodus sp.	20
Ligonodina franconia Sannemann	1
Lonchodina sp.	1
Polygnathus asymmetricus ovalis Ziegler and Klapper	14
Poly. decorosus s. l. Stauffer	18
Poly. foliatus Bryant	7
Prioniodina sp.	2

Age: early Upper Devonian.

Two collections of conodonts from the northern Adobe Range suggest the possibility that the North Fork sequence includes some beds of Early Mississippian age. Identifications by John W. Huddle.

Field no. 5041 (USGS 23364-PC) Wells Am AMS sheet, sec. 35, T. 38 N., R. 55 E., one mile WSW from spring at bend in road.

Polygnathus _symmetricus_ Cooper	1
Polygnathus _radinus_ Cooper	1 Bushburg
Palmatolepis?	1
Synprioniodina sp.	1

Field no. 5044 (USGS 23366-PC) same locality as 5041.

Pseudopolygnathus sp.	1
Polygnathus _symmetricus_ Cooper	8
Polygnathus _triangularis_?	1
Nothognathella	1
Fragments	19
Bryantodina sp.	1
Diplododella sp.	2

Age: Concerning the question of whether these collections are Devonian or Mississippian Huddle says: "Field no. 5041, seems most likely to be Mississippian because of the presence of _Polygnathus_ _radinus_ Cooper. This was described from the Bushburg Fm. of Okla. Ages determined on single specimens are shaky."

"The presence of _Pseudopolygnathus_ and _Poly_. _symmetricus_ Cooper in collection no. 5044, indicates a probably Early Mississippian age. I would be more certain of this if _Siphonodella_ were present, as it is in many Joana Ls. faunas. Even so the age is more likely Mississippian than Devonian."

Conditions of deposition

Sediments of the North Fork sequence are properly designated as eugeosynclinal because they contain a small amount of volcanic rocks, are highly siliceous, and are somewhat carbonaceous. However, they are nearly lacking in immature, unsorted graywacke-like sediments often thought to be characteristic products of eugeosynclinal conditions and indicative of unsettled tectonic conditions. Far from being unsettled, the Cordilleran geosyncline in Ordovician, Silurian, and Devonian time was a model of steady uniform subsidence never equalled after the geosyncline was disrupted by the Antler orogeny.

The seaway in which sediments of the North Fork sequence were deposited was continuous over much of what is now Nevada, Idaho, and other areas. It should not be thought of as isolated basins or lagoons. Scarcity of carbonate and of bottom-dwelling organisms, and prevalence of unoxidized carbon, point to stagnant waters over this large area for a long period of time. The prevalence of finely laminated beds indicates a depth below wave base and a lack of burrowing organisms. These conditions are interpreted to indicate a cover of very deep water.

Graded sequences of calcarenite are interpreted as turbidity current deposits. In at least one place, Blue Basin Creek, directional sole marks indicate an easterly source. Apparently at times, especially in Middle Ordovician and Late Devonian times, banks of limy deposits at the edge of the miogeosyncline slumped and formed turbidity currents that carried carbonate downslope into the normally hostile eugeosynclinal environment.

Quartzites and sandstones probably originated west of the eugeosyncline (Ketner, 1966) or were transported from the north by longitudinal currents parallel to the path of miogeosynclinal sands (Ketner, 1968).

The site of deposition of the North Fork sequence was one of tectonic tranquillity close to the edge of the miogeosyncline.

Roberts Mountains Formation

Distribution

Upper parts of the Roberts Mountains Formation crop out on the banks of Camp Creek, Swales Mountain quadrangle, and near the crest of Lone Mountain, Singletree Creek quadrangle. The lower part of the formation is not exposed, but was explored by core drilling near Camp Creek.

Lithology

In the Swales Mountain area, the Roberts Mountains Formation consists principally of siliceous, carbonaceous calcilutite and sporadic beds of calcarenite. Much of it is thick bedded, but thinly laminated intervals are common. In the Swales Mountain area the formation commonly lacks the platy fissility that is characteristic elsewhere.

At Lone Mountain the Roberts Mountains Formation is thin- to medium-bedded, carbonaceous, blue-gray limestone that breaks down to dark-blue-gray soil and to platy and irregular fragments. Metamorphosed parts near the intrusive show thinner beds and more lithic variation than do the unmetamorphosed beds.

Acetic acid insoluble material, mainly quartz, illite, and carbon, constitutes a large percentage of the formation, averaging about 30 percent at the Camp Creek locality (Table 3).

Table 3.--Percentage of acetic acid insoluble matter in segments of core of the Roberts Mountains Formation, Swales Mountain quadrangle, Nevada

Depth below surface (feet)	Percent insoluble matter
0	22
100	14
200	34
300	26
400	31
600	32
700	25
800	40
900	31
1000	30
1100	33
1200	25
1300	31
1400	28
1500	28
1600	29
1700	26
1800	27
1900	27
2000	27
2100	26
2200	40
2300	30
2400	27
2500	26
Ave.	29

X-ray diffraction of acetic acid insoluble material indicates it is composed mainly of quartz and illite. Thin section examination shows some of the quartz is composed of detrital silt and very fine sand sized grains of monocrystalline quartz. Most of the quartz, however, is too fine grained to identify in thin section.

A fraction of a percent of the acid insoluble material is composed of very small grains of pyrite and probably pyrrhotite. Analyses of three composite samples of pyrite and pyrrhotite(?) revealed an average gold content of 0.4 parts per million.

Table 4 gives 13 chemical analyses representative of the upper 2500 feet of the formation at Swales Mtn. Calculations based on these analyses indicate illite constitutes about 20 percent of the formation by weight and quartz about 10 percent with calcite making up almost all the remainder.

Table 4.--Chemical analyses of Roberts Mountains Formation,

Swales Mountain quadrangle, Elko County, Nevada

Chemical analyses (weight percent)

	4800	4803	4806	4808	4810	4812	4814	4816	4818	4839	4844	4846	4848
SiO_2	20.4	21.6	30.3	35.0	26.8	20.0	21.0	23.0	22.4	21.0	21.0	24.0	20.2
Al_2O_3	3.9	3.6	3.7	6.4	6.0	3.8	4.8	5.5	5.4	5.0	4.2	5.2	4.5
Fe_2O_3	.39	.40	.75	.46	.00	.00	.00	.38	.29	.09	.09	.29	.19
FeO	.92	1.0	1.5	1.4	1.8	1.4	1.3	1.2	1.2	1.2	1.2	1.4	1.1
MgO	1.5	1.5	2.1	2.2	2.1	2.0	2.2	2.2	2.2	2.0	2.9	2.3	2.2
CaO	38.7	38.0	31.8	27.1	31.7	37.9	35.9	34.4	34.7	36.8	36.2	34.2	37.0
Na_2O	.03	.02	.06	.04	.07	.16	.20	.09	.04	.20	.04	.02	.02
K_2O	.85	.80	1.0	1.7	1.4	.90	1.1	1.4	1.2	1.2	1.0	1.2	1.1
H_2O^-	.12	.09	.10	.11	.17	.12	.14	.06	.10	.16	.10	.11	.11
H_2O^+	.98	.91	1.0	1.3	1.4	1.0	1.3	1.3	1.4	1.0	1.2	1.5	1.1
TiO_2	.20	.19	.19	.30	.28	.20	.24	.27	.24	.24	.20	.24	.19
P_2O_5	.04	.07	.08	.06	.08	.04	.06	.08	.06	.05	.06	.07	.06
MnO	.04	.03	.04	.04	.04	.02	.02	.02	.02	.02	.02	.04	.02
CO_2	31.8	31.6	27.4	23.8	28.0	32.4	31.8	30.1	30.5	31.0	31.8	29.5	32.2
Organic carbon	.29	.33	.45	.31	.28	.23	.30	.35	.32	.27	.31	.37	.36
Sum	100	100	100	100	100	100	100	100	100	100	100	100	100

In the Lone Mountain area the lithology of the Roberts Mountains Formation is somewhat obscured owing to contact metamorphism. Thin chert beds in the lower part of the exposed section near the intrusive rocks may represent selective silicification as indicated by Lovejoy (1959) but they may have been somewhat cherty originally. Upper parts of the unit at Lone Mountain are black, carbonaceous, slabby limestone.

Stratigraphy and thickness

The base of the Roberts Mountains Formation is not exposed in the area of this report. In the Camp Creek area of Swales Mountain quadrangle it is overlain concordantly by the Early Mississippian Camp Creek sequence Here the contact is placed where black calicilutite gives way to interbedded quartz sandy calcarenite and gray calcilutite. At Lone Mountain the Roberts Mountain Formation is overlain concordantly by the Nevada Formation. The upper contact is placed where thinly interbedded chert and limestone merges into coarsely crystalline chert-free limestone.

In the Camp Creek area nearly flat-lying beds of the formation were penetrated by drill to a depth of more than 2500 feet (Ketner, Evans, and Hessin, 1968). Inasmuch as the collar of the hole was about 200 feet stratigraphically below the top of the unit, and the base of the formation was not reached the total thickness must exceed 2700 feet unless undiscovered structural complications have caused repetition of beds.

Age and correlation

No fossils have been found in the Roberts Mountains Formation in the area of this report and its identity and age must of necessity be based on lithologic correlation with dated exposures. The nearest of these are in the Maggie Creek and Lynn windows to the south and west of Swales Mountain (T. E. Mullens and J. G. Evans, written commun., 1969) and in the central Independence Range north of Lone Mountain (Kerr, 1962).

Based on correlation with these exposures the formation is Silurian and Devonian in age.

Conditions of deposition

The fine grain, lack of fossils, unoxidized carbon content and geographic position suggest that the part of the formation that lies in the Independence Range was deposited in deep water between the miogeosyncline where a dolomitic facies is more common and the eugeosyncline where siliceous siltstone and chert are prevalent. Some calcarenite beds suggest a possible turbidite origin.

DEVONIAN

NEVADA FORMATION

Distribution

The Nevada Formation crops out on Lone Mountain where it forms the upper part of the McClellan Creek sequence of Lovejoy (1959) and in the Swales Mountain area in a thrust plate along Swales Creek and Louse Creek.

Lithology

Where it is best exposed on the south flank of Lone Mountain, the Nevada Formation consists almost entirely of limestone. Partial recrystallization has altered much of the formation but enough of the original texture is preserved to indicate a general resemblance to the Nevada Formation as it is known in the Pinon Range (Ketner, K. B., and Smith, J. Fred, Jr., 1963). The prevailing aspect is one of fine to coarse grained thick bedded calcarenite. Quartz sandy zones occur near the middle of the unit.

At Swales Mountain the Nevada Formation is a parautochthonous unit that lies on a thrust which presumably carried it from the west. Its more westerly origin is reflected in its lithology which here has lost some of the typical features of the Nevada Formation. The upper part of this unit and some beds lower down are thick bedded dark gray calcarenite. In one area, north of Swales Creek, the calcarenite is varied by thin interbeds of black chert. Lower parts are predominately thin bedded or massive fine grained dark silty and argillaceous limestone that weathers yellow. The fine grained limestone carries Tentaculites in abundance.

Stratigraphy and thickness

At Lone Mountain the base of the Nevada Formation is gradational with the underlying Roberts Mountains Formation and is placed where thin-bedded quartz-silty fine-grained carbonaceous rocks of the Roberts Mountains Formation give way to thick-bedded calcarenites. At Swales Mountain the base of the unit is bounded by a thrust fault and it lies on autochthonous Silurian to Mississippian limestone.

The upper contact of the Nevada Formation at both Lone Mountain and Swales Mountain is thrust faulted.

Where it is exposed best, on the south side of Lone Mountain, the Nevada Formation consists of limestone throughout. Quartz-sandy zones that are overlain by beds containing Styliolina near the middle of the unit may represent the Oxyoke Canyon member of the Nevada Formation which in the Pinon Range (Ketner and Smith, 1963) is a thick quartzite unit. If so, all three major parts of the unit corresponding to those of Carlisle and others (1956) are present although their Union Mountain member is only feebly represented.

Age and Correlation

The Nevada Formation in the Swales Mountain and Lone Mountain areas is probably of Middle Devonian age as indicated by the following collections of fossils identified by J. T. Dutro, Jr. and W. A. Oliver, Jr.

Field no. 2241 (USGS D215-SD) Swales Mountain quadrangle, T. 36 N., R. 33 E., SW$\frac{1}{4}$, SE$\frac{1}{4}$, sec. 32, right bank of Louse Creek.

Dutro states "This collection consists entirely of tentaculitids, referable to the genus Styliolina, which are quite common in parts of the Nevada Formation elsewhere in Nevada. Although the genus ranges from Middle Silurian through Upper Devonian (lower Famennian), I would suggest that a reasonable correlation can be made with the Middle Devonian part of the Nevada Formation."

Field no. 2331 (USGS 7709-SD) Swales Mountain quadrangle, T. 36 N., R. 53 E., SE$\frac{1}{4}$, SE$\frac{1}{4}$ sec. 32, at 6640 feet altitude.

Styliolina sp.

Crassilina? sp.

Dutro states: "If the forms tentatively identified as *Crassilina* actually belong in that genus, a Middle or early Late Devonian age is indicated."

Field no. 2333 (USGS 7710-SD) Swales Mountain quadrangle, T. 36 N., R., 53 E., SW$\frac{1}{4}$ sec. 27, west-facing hillside on 116° 008 00' west longitude.

corals

Spinatrypa sp.

Styliolina sp.

Dutro says "The presence of Spinatrypa definitely indicates a Devonian age because the genus ranges from latest Early Devonian through early Late Devonian (Frasnian). The collections containing Styliolina are likely to be of Middle Devonian age. I suggest they represent a part of the Nevada Formation, perhaps the Woodpecker Limestone member."

Field no. 2696 (USGS 7732-SD) Singletree Creek quadrangle, T. 37 N., R. 53 E., $N\frac{1}{2}NW\frac{1}{4}$ $SW\frac{1}{4}$ sec. 24, at an altitude of 6960 feet. Oliver identified the corals and Dutro the other forms.

Spiriferoid brachiopods (indeterminate; probably Devonian types)

Gastropods (indeterminate)

Styliolina sp. (probably Middle or early Late Devonian)

Thamnoporoid corals

Alveolites? sp.

"Grypophyllum?" sp.

Chonophyloid coral

Of this collection from Lone Mountain Oliver states "The corals could be Silurian or Devonian, but are more suggestive of Early or Middle Devonian, probably not Late Devonian. Coupled with Dutro's information a Middle Devonian age seems very likely."

Conditions of deposition

Near Eureka, Nevada, easterly exposures of the Nevada Formation are dolomitic and contain a prominent quartzite unit. In more westerly exposures, closer to the eugeosyncline, correlative beds are less dolomitic and sandstone thins drastically (Nolan and others, 1956). By analogy the Nevada Formation at Lone Mountain, Elko County, is a westerly facies of the Nevada Formation although still similar enough to the type section to be considered part of the miogeosynclinal assemblage. At Swales Mountain, however, rocks assigned to the Nevada Formation are an even more westerly facies that has been brought eastward on a thrust fault. Carbonaceous shale and bedded chert in the unit at Swales Mountain indicate it was deposited in an environment verging on that of the eugeosyncline. The mixture of miogeosynclinal and eugeosynclinal rock types indicates an environment on the slope that separates the miogeosyncline from the eugeosyncline. The Nevada Formation at Swales Mountain therefore can be considered to be of a transitional facies.

DEVONIAN

COAL CREEK SEQUENCE

Name and distribution

The formation informally designated as the Coal Creek sequence by Lovejoy (1959) crops out along Cold Creek (formerly Coal Creek) at the southern end of Lone Mountain in the Singletree Creek quadrangle.[1] The exposures are on the north side of the creek in sections 23 and 26, T. 37 N., R. 53 E. This is the only place in the area of this report in which the Coal Creek sequence crops out.

1/ The Coal (or Cold) Creek of the Independence Range is not to be confused with Coal Canyon of the Adobe Range.

Lithology

The Coal Creek sequence is composed of two plates separated by a thrust fault. The lower plate is composed mainly of limestone, argillaceous limestone, both characteristically very thin bedded, and greenstone. The upper plate is composed of similar limestone and graded sequences of quartz-sandy limestone, siltstone, shale, and bedded black chert. In some areas much of the upper plate is soft, brown to black calcareous flaky shale. It is poorly bedded and breaks down to form soft soil. There are no natural outcrops of shale.

Stratigraphy and thickness

Upper and lower contacts of the sequence are not exposed because of thrust faults and the stratigraphic relation between the upper and lower plate sequences is obscured by a thrust fault. If the two sequences are contemporaneous they represent different facies telescoped by a thrust fault but the paleontological data are too scanty to permit an exact comparison of ages. The upper plate can be regarded as a more westerly facies than the lower plate.

The exposed thickness of each unit is a few hundred feet.

Age and correlation

Rocks in both plates of the Coal Creek sequence are probably of lower Upper Devonian and possibly Early Mississippian ages. Identification and age assignments are by W. A. Oliver, Jr., J. T. Dutro, Jr., and J. W. Huddle.

Field no. 2335 (USGS 7712-SD) Singletree Creek quadrangle, T. 37 N., R. 53 E., center of E$\frac{1}{2}$NW$\frac{1}{4}$ sec. 25, at roadside. Lower plate.

Nervostrophia? sp

Douvillina? sp.

Devonoproductus cf. D. vulgaris Stainbrook

Dutro states "The collection consists of echinodermal debris and brachiopods, predominantly disassociated valves of Devonoproductus. This genus is known from latest Middle Devonian and early Late Devonian (Frasnian), but it is more common in the Frasnian.

"The association with the two strophomenoid forms suggests a Frasnian age, perhaps correlated with the Sly Gap fauna of New Mexico and beds of similar age in eastern Nevada mapped by Harald Drewes in the Schell Creek Range."

Field no. 2836 (USGS 7869-SD) Singletree Creek quadrangle, T. 37 N., R. 53 E., NW$\frac{1}{4}$SW$\frac{1}{4}$NW$\frac{1}{4}$ sec. 25, at 6450 feet altitude. Lower plate.

	No. of specimens
Spathognathodus crassidentatus? (Branson and Mehl)	3
S. stabilis? (Branson and Mehl)	1
Polygnathus normalis? Miller and Youngquist	2

Huddle states "*Spathognathodus stabilis* occurs in Late Devonian and Mississippian. *S. crassidentatus* has been reported only from Early Mississippian rocks and *Polygnathus normalis* has been reported only from Late Devonian rocks."

Macro fossils in this same collection were examined by Dutro who states:

"This collection contains many small silicified specimens of *Cyrtina* that appear to be like species found commonly in rocks of Kinderhook age in the mid-continent. There are a few fragments of other kinds of brachiopods, including an indeterminant orthoid, a possible dielasmid and a compositoid. A Late Devonian or Early Mississippian age is probable."

Field no. 2334 (USGS 7711-SD) Singletree Creek quadrangle, T. 37 N., R. 53 E., center of sec. 25, on hilltop. Upper plate.

Hexagonaria sp. (several spec.)

Phillipsastraea (= _Pachyphyllum_) sp. cf. _P._ _Woodmani_ (1 spec.)

horn coral (2 indeterminate fragments)

ramose favositid corals (common in one block)

massive stromatoporoid (1 small fragment)

Atrypoid brachiopod

Oliver states "This is early Late Devonian (Frasnian) in age as indicated by _Phillipsastraea_; _P._ _Woodmani_ is a Devils Gate species."

Conditions of deposition

The Coal Creek sequence is a transitional facies apparently deposited on the slope between the miogeosyncline and eugeosyncline. Part of the formation, especially in the lower of the two parautochthonous plates, somewhat resembles the correlative Devils Gate Formation of the miogeosyncline except that it contains greenstone lenses suggestive of eugeosynclinal conditions. Interbedding of graded carbonate sequences and bedded black chert units in the upper plate suggest deposition between miogeosyncline and eugeosyncline.

MISSISSIPPIAN

CAMP CREEK SEQUENCE

Distribution

The Camp Creek sequence, an informal unit, is a distinctive limestone that crops out along Camp Creek in the Swales Mountain quadrangle (Ketner, 1970). It is well exposed in sec. 4, T. 35 N., R. 53 E. and is also exposed at Hunter Draw in the Black Mountain area, sec. 15, T. 39 N., R. 64 E. (Oversby, 1969). These are the only known exposures.

Lithology

The Camp Creek consists almost entirely of repeated graded cycles of quartz-sandy bioclastic calcarenite and argillaceous calcisiltite and calcilutite. The graded cycles are between 1 and 5 feet in thickness. Commonly the basal beds of each are composed of well sorted sand-sized grains. A majority of the grains are angular to rounded calcite, but well rounded quartz grains constitute a small part of the rock. Basal beds in some graded cycles include small chips eroded from the upper surfaces of earlier formed cycles. Rarely the basal beds are edgewise conglomerates composed of large plates of earlier formed consolitated material. Convolute lamination and crossbedding are common in the coarser grained parts of graded cycles. Upper beds of graded cycles are composed of silt- to clay-size carbonate, less commonly of clay-shale. The fine-grained uppermost beds of graded cycles are marked by differential pressure pits, flute marks, tool marks, and worm trails. Although some of these markings are preserved as positive molds of calcilutite, most are preserved as negative casts composed on the overlying calcarenite. Load casts and fluting are the most common types of sole marks. Many forms of fluting are directional in plan and the few directional measurements which could be made on outcrops indicate a direction of currents from the northeast quadrant.

Stratigraphy and thickness

The Camp Creek sequence seems to lie conformably on the Roberts Mountains Formation. Alternatively the contact is inconspicuously disconformable. Thickness of the unit from the base, arbitrarily fixed among the transitional beds between the typical Roberts Mountains lithology and the first distinctly graded cycle, to the overthrust parautochthonous Devonian carbonate is about 650 feet.

Age and Correlation

The Camp Creek sequence is of Kinderhook (early Early Mississippian) age as indicated by the following collection of conodonts from the middle part of the formation. They were identified by J. W. Huddle.

Field no. 2593 (USGS 22702-PC), Swales Mountain quadrangle, T. 35 N., R. 53 E., east edge of SE 1/4 NW 1/4 sec. 4, on south-facing slope.

	No. of specimens
Bryantodus sp.	1
Gnathodus sp.	1
Polygnathus inornatus Branson	1
P. cummunis Branson and Mehl	3
Pseudopolgnathus sp.	1
Siphonodella obsoleta Hass	10
Spathognathodus	1

According to Huddle, a comparison of this fauna with that of the Webb Formation (Smith and Ketner, 1968) fails to indicate a significant age difference. Referring to collections from both units he states (written commun., 1968) "Both collections could be as old as the upper Hannibal Shale or as young as uppermost Chouteau Limestone in the upper Mississippi Valley. The presence of an advanced species of *Gnathodus* in both collections suggests that they are both equivalent to some part of the Chouteau Limestone."

The Kinderhook age of the Camp Creek sequence was confirmed by C. G. Tillman, who identified the genus *Siphonodella* in eight samples ranging from the base to the top of the formation. Tillman identified the following species from the Camp Creek.

Siphonodella obsoleta -- common

Siphonodella isosticha -- common

Siphonodella cooperi

Siphonodella duplicata(?)

Gnathodus delicatus

Polygnathus communis

Conditions of deposition

Striking lithologic features of the Camp Creek sequence such as graded bedding, sole marks, and convolute lamination suggest the formation was deposited by turbidity currents. The northeasterly provenance of the Camp Creek indicated by directional sole marks and its location near the transition zone between the miogeosyncline and the eugeosyncline suggests that it was deposited by currents flowing from the edge of the miogeosyncline toward the eugeosyncline.

Because the Camp Creek sequence is an easterly derived deposit free from detritus of eugeosynclinal rocks, its deposition must have preceded the first local emergence of those rocks. However, the evident instability of sediments near the edge of the miogeosyncline suggested by turbidity currents may have resulted from early pulses of the Antler orogenic episode. The Mississippian Chainman Shale in the northern Independence Range (Waterpipe Canyon Formation of Kerr, 1962) and in the neighboring Adobe Range (Ketner, 1970) contains abundant debris of eugeosynclinal rocks. Therefore, the initial local emergence of eugeosynclinal rocks must have followed soon after deposition of the Camp Creek sequence.

CHAINMAN FORMATION

Distribution

The Chainman Shale is exposed in the northern Adobe Range, in the Elko Hills, and in the Peko Hills. In the Adobe Range it crops out beneath the ridge-forming Diamond Peak Formation along the eastern margin of the range north of Jackson Creek and beneath a major thrust near the Coal Canyon Mine at the northern end of the range. In the Elko Hills it crops out on the upthrown side of reverse faults along the Humboldt River. It is exposed over a wide area in the Peko Hills where it forms the upper plate of a thrust fault.

Lithology

The Chainman is divisible into two distinct stratigraphic units. The lower unit consists almost entirely of chert-and quartz-grain sandstone. Some beds are more accurately classified as quartzite. There are interbeds of grit and small-pebble conglomerate. No shale or siltstone beds were observed, but topographic conditions indicate the presence of shale beds that do not crop out. Commonly thick beds of coarser material are separated by thin beds of finer material. Sorting is poor and cross beds are absent. Weathered rock is brown or purple.

The upper unit of the Chainman is mainly of siliceous shale and shaly siltstone but it includes a few beds of sandstone and an occasional lens of puddingstone. The shale is not notably fissile. It is black when fresh, gray or brown when weathered. The contact with the underlying sandstone unit is gradational, that is, there is an intermediate zone of interbedded shale and sandstone. Puddingstone at the contact contains Chainman material of pebble to boulder size and in addition contains cobbles of eugeosynclinal quartzite of the Valmy type.

Stratigraphy and thickness

The base of the Chainman is not exposed. Presumably it lies on Early Mississippian carbonate such as the Camp Creek sequence or fine-grained siliceous sediments similar to those of the Webb Formation (Smith and Ketner, 1968).

The absence of the Chainman in the southern Independence Range may indicate complete erosion of the unit or, more likely, it may indicate that the area of the Independence Range was a source of Mississippian detritus.

In the northern Adobe Range, where exposures are best, chert-grain sandstone at least 5,000 feet thick forms the lower part of the exposed Chainman and siliceous shale about 1,000 feet thick forms the upper part.

Age and correlation

No diagnostic fossils were found in the Chainman so its age can be inferred only from its stratigraphic position below the well dated Diamond Peak Formation and from its lithic resemblance to similar rocks of the Pinon Range (Smith and Ketner, 1968). Since the Diamond Peak in the Adobe Range is at least in part Late Mississippian in age the Chainman probably includes beds of Early Mississippian and may include beds of Late Mississippian age.

Conditions of deposition

The Chainman is a largely marine deposit in the Pinon Range and although marine fossils (conodonts of indeterminate age) were found in only one place in the area of this report the formation in this area is regarded as largely marine also.

Here as elsewhere the Chainman consists of detritus derived from eugeosynclinal rocks and records an early phase of the Antler Orogeny. The generally fine grain of the formation indicates that uplift in the early stages of orogeny was rather subdued in comparison with later uplift which resulted in the great outpouring of Diamond Peak conglomerate.

DIAMOND PEAK FORMATION

Distribution

The Diamond Peak Formation makes up most of the Adobe Range and it also crops out in the Elko Hills. It is conspicuously absent from the Independence Range. Thin conglomerate units similar to the Diamond Peak Formation near Lone Mountain are probably much younger in age and in any case are volumetrically unimportant.

Lithology

The Diamond Peak Formation is composed almost entirely of chert-pebble and quartzite-pebble conglomerate. A small proportion of the formation is composed of sandstone, sandy red beds, and fossiliferous limy shale and cherty limestone. The conglomerate is generally very massive with beds 1 to 50 feet thick. No cross beds were seen and sorting of grains is poor. The clasts range to 1 foot in diameter with an average maximum in most beds of pebble or cobble size. Clasts are composed of quartzite and chert with lesser amounts of siltstone and argillite. Most clasts are of poorly rounded chert. Quartzite, the second most common of the larger clasts, tends to be well rounded. However the sphericity of the quartz pebbles is not high. Sandstone and siltstone clasts tend to be flat. Greenstone and shale pebbles are not seen. These constituents may have decomposed and now constitute the upper Paleozoic shales. Consolidation varies but is generally poor. Outcrops are rounded and rubbly. Pebbles break free from matrix. Most beds are predominately grit. Sandstone seems rather scarce but shale and limestone are present locally.

Clasts of conglomerate and sandstone are composed of detritus from eugeosynclinal rocks. The coarse grain of many conglomerate beds indicates a nearby source.

Stratigraphy and thickness

The base of the Diamond Peak Formation as poorly exposed on the east side of the Adobe Range is abrupt. No consistent stratigraphic variations within the deposit are apparent.

The thickness is impossible to measure accurately and the upper contact is erosional but the formation is conservatively estimated from its distribution and attitude to be at least 5,000 feet thick.

Age and correlation

The following collection of fossils from a limestone lens among conglomerates well above the base of the formation indicate a very Late Mississippian age according to Mackenzie Gordon, Jr. Field no. 2632 (USGS coll. 22679-PC). Hunter quadrangle, saddle along trail in the NE$\frac{1}{4}$SE$\frac{1}{4}$SE$\frac{1}{4}$ sec. 4, T. 34 N., R. 54 E.

Fistuliporoid bryozoan, encrusting form
Stenoporoid bryozoan, encrusting form
Crinoid columnal
Rhipidomella? aff. *R. nevadensis* (Meek)
Schizophoria cf. *S. texana* Girty
Schuchertella? sp. indet.
Kozlowskia n. sp.
Inflatia sp.
Diaphragmus sp.
Ovatia? sp. indet.
Anthracospirifer aff. *A. curvilinearis* (Easton)
Cleiothyridina cf. *C. sublamellosa* (Hall)
Composita aff. *C. subquadrata* (Hall)
Punctospirifer transversus (McChesney)

Gordon says of this collection "The presence of a characteristic though as yet undescribed species of the productoid brachiopod *Kozlowskia* indicates that this collection is of very Late Mississippian age. *Kozlowskia* n. sp. is commonly associated with *Rhipidomella nevadensis* (Meek) in the uppermost beds of the Chainman Shale in the Confusion Range, Utah, just above the goniatite zone of *Cravenoceras merriami*."

The following collection from limy argillaceous beds well above the base of the Diamond Peak Formation is assigned by MacKenzie Gordon, Jr. to the middle part of the Mississippian. Field no. 5129 (U.S.G.S. coll. 23786-PC). Osino quadrangle, NE 1/4 NE 1/4 sec. 2, T. 35 N., R. 55 E., 500 feet northeast of fork in Sherman Creek.

Horn corals, gen. & sp. indet.

Stenoporoid, ramose form

Trepostomatous bryozoan, ramose form

Fenestella sp.

Hemitrypa sp.

Worthenopera sp.

Krotovia sp.

Setigerites? sp. indet.

Echinoconchus sp.

Buxtonlid, gen. & sp. indet.

Spirifer sp.

Cleiothyridina sp. indet.

Gordon states concerning this collection, "This faunule is dominated by a species of *Echinoconchus* with an unusually large number of spine rows on each concentric band in the pedicle valve. Also common are the bryozoans, among which appears to be the Mississippian genus *Worthenopora*. *Worthenopora* was also identified in the yellow siltstone beds on ← Ferdelford Creek in the Carlin quadrangle. The range of this genus is late Early Mississippian (Keokuk) to early Late Mississippian (Warsaw). This collection, therefore, is assigned to the middle part of the Mississippian. Other characteristic species of the Ferdelford beds are lacking."

Another collection from the same spot was identified and commented on by Gordon as follows:

Hemitrypa sp.

Schuchertella sp.

Echinoconchus sp.

Setigerites? sp.

Buxtonlid, gen. & sp. indet.

Spirifer sp.

"This bed was dated by an earlier collection as Middle Mississippian (late Osage or early Meramec). The present collection does not provide any evidence to change the earlier determination."

The Diamond Peak Formation in the area of the Adobe Range is at least partly contemporaneous with the Tonka Formation of Dott (1955) and the Diamond Peak Formation of Smith and Ketner (1968).

Conditions of deposition

The coarse chert and quartzite clasts that comprise the Diamond Peak Formation indicate a nearby mountainous provenance terrain composed of eugeosynclinal sedimentary rocks such as those of the Ordovician, Silurian, and Devonian systems in the Independence Range. The remarkably poor sorting of these clasts, the presence of red beds and the scarcity of marine fossils indicate a largely subaerial origin.

The Diamond Peak Formation probably consisted of coalescing alluvial fans that extended from a mountainous terrane eastward to the sea. During much of Chainman time the shoreline lay to the west of the Adobe Range, but later in most of Diamond Peak time it lay to the east.

PENNSYLVANIAN, PERMIAN

STRATHERN FORMATION

Distribution

The Strathearn Formation is exposed in the southern Adobe Range near its type section (Dott, 1955) and in the Elko Hills.

Lithology

The Strathearn Formation is a unit of predominantly bioclastic quartz-silty fusulinid-bearing limestone, chert-grain grit and conglomerate, red calcareous quartz siltstone, and black chert. Its lithology in the area of this report is similar to that of the type area near Carlin Canyon. The carbonate component resembles the Riepe Spring Formation of the Spruce Mountain area and the red siltstone resembles the Rib Hill Formation of that area.

Stratigraphy and thickness

In the Elko Hills where the base of the Strathearn is well exposed it lies nearly concordantly on the Diamond Peak Formation. In the Adobe Range the contact is somewhat discordant. The lower part consists of interbedded chert-pebble conglomerate and bioclastic limestone. The middle part is dominantly thick bedded bioclastic limestone and the upper part is interbedded limestone and calcareous quartz siltstone.

The formation is about 400(?) feet thick in the Elko Hills and 1500 to 2000 feet thick in the southern Adobe Range.

Age and correlation

Abundant fusulinids in the Strathearn Formation indicate its age ranges from Late Pennsylvanian possibly to Early Permian. No exclusively Permian fusulinids were found.

Correlative formations are the lithologically similar Antler Peak Limestone (Roberts, 1964) and the Etchart Limestone (Hotz and Willden, 1964).

Conditions of deposition

Coarsely clastic and cross-bedded deposits in the Strathearn Formation indicate it was deposited in shallow water close to shore. Much of the clastic material is reworked cherty detritus derived from underlying Mississippian conglomerates.

Cross-bedding studied by Dott (1955, p. 2251) indicates westward moving currents. The absence of Strathearn equivalents between Mississippian and overlying younger Permian beds in the northern Adobe Range to the north and in the Pinon Range to the south (Smith and Ketner, unpublished data) indicate the Strathearn was deposited in a narrow east-west passageway that may have opened to the area in which the Antler Peak and Etchart Limestone were deposited.

PERMIAN

ADOBE RANGE SEQUENCE

Name and distribution

Adobe Range sequence is used as an informal term for all post-Strathearn Permian rocks in the area of this report except the distinctive Permian-Triassic Long Canyon sequence.

Included in the Adobe Range sequence are the Buckskin Mountain, Beacon Flat, and Carlin Canyon Formations of Fails (1960). Correlative rocks of similar lithology that have not yet received formal designation also crop out in the Pinon Range (J. Fred Smith, Jr., and Keith Ketner, unpub. data) and in the northern Independence Range (Churkin and Kay, 1967) and these are also included.

In the area of this report the Adobe Range sequence crops out in the extreme southern and northern ends of the Adobe Range and in the Elko Hills.

Lithology

The Adobe Range sequence is composed of siltstone, mudstone, sandstone, limestone and chert (tables 5 and 6).

The siltstone is commonly composed mainly of angular quartz grains; small amounts of angular plagioclase, microcline, and chert; carbonate grains of irregular and rhombic shapes; and phosphatic (collophane) grains of irregular, cylindrical, or pelletal shapes. Detrital grains rarely exceed 0.1 mm in diameter. Phosphatic pellets are generally of similar size. Bedding is thin and irregular. Fossils are scarce. Weathered surfaces are yellow.

Siliceous detrital rocks that have compositions similar to that of siltstone but are of finer grain are called mudstone. Those of coarser grain are sandstone. Neither of these are as abundant as siltstone.

Limestone units are commonly gray, thick-bedded, partly silicified, calcarenites of bioclastic origin. Most of them contain abundant silt size and sand size detrital quartz and chert.

Most of the bedded chert contains siliceous sponge spicules, cylindrical and pelletal phosphate, and rhombic carbonate. It is commonly interbedded with silty limestone and limy siltstone and seems to have been formed by secondary replacement of those rocks. The more thorough the silicification process the darker and more translucent is the chert. Chert increases in abundance upward in the column.

Table 5 .--Chemical analyses of chert of the Adobe Range sequence of Permian age, Elko County, Nevada

[Samples analysed in 1969 by methods described in U.S. Geol. Survey Bull. 1144-A, supplemented by atomic absorption, by P. Elmore, S. Botts, G. Chloe, H. Smith, J. Kelsey, L. Artis, and J. Glenn.]

	5080	5242	5249	5265
SiO_2	86.3	77.4	89.2	91.5
Al_2O_3	1.0	1.2	.80	2.1
Fe_2O_3	1.2	.27	.45	.43
FeO	.08	.14	.06	.08
MgO	1.0	4.0	.18	.00
CaO	5.0	6.7	4.3	2.2
Na_2O	.78	.47	.41	.38
K_2O	.20	.28	.14	.31
H_2O^-	.20	.25	.21	.14
H_2O^+	.70	.85	.75	1.1
TiO_2	.08	.05	.08	.08
P_2O_5	.09	.33	2.0	.74
MnO	.00	.03	.00	.00
CO_2	3.4	8.0	.66	.38
Sum	100	100	99	99

Table 6.--Chemical analyses of siltstone and very fine grained sandstone of the Adobe Range Group of Permian age Elko County, Nevada

[Samples analysed in 1969 by methods described in U.S. Geol. Survey Bull. 1144-A, supplemented by atomic absorption, by P. Elmore, S. Botts, G. Chloe, H. Smith J. Kelsey, L. Artis, and J. Glenn.]

	Elko Hills			Southern Adobe Range				Northern Adobe Range			
	5114	5120	5124	5242	5247	5250	5252	5183	5185	5188	5192
SiO_2	88.7	86.9	86.6	77.4	70.9	70.9	74.6	82.7	64.8	84.7	84.4
Al_2O_3	5.6	6.0	6.2	1.2	1.5	1.4	1.3	1.9	2.1	1.5	1.0
Fe_2O_3	1.2	1.3	1.4	.27	.80	.87	.78	.56	1.0	.58	1.6
FeO	.12	.12	.14	.14	.08	.10	.10	.12	.06	.04	.02
MgO	.10	.23	.40	4.0	.40	.42	.58	.65	.86	1.3	.20
CaO	.22	.77	.86	6.7	14.1	13.9	11.3	6.6	16.2	5.5	6.9
Na_2O	.15	.15	.46	.47	.67	.62	.64	.28	.65	.30	.26
K_2O	.68	.65	.83	.28	.43	.41	.51	.24	.57	.10	.26
H_2O^-	.22	.28	.28	.25	.21	.24	.26	.18	.18	.18	.06
H_2O^+	1.9	2.2	2.1	.85	1.1	1.2	1.3	.92	1.1	.71	.76
TiO_2	.32	.37	.43	.05	.11	.14	.07	.13	.20	.05	.07
P_2O_5	.06	.08	.09	.33	7.9	7.4	6.4	2.5	5.0	1.7	4.0
MnO	.00	.00	.02	.03	.00	.00	.04	.00	.00	.00	.00
CO_2	<.05	.06	<.05	8.0	.94	1.9	1.0	2.4	7.2	2.6	.50
Aqua Regia soluble S as SO_3							.44		.39		
S[illegible]	[illegible]	[illegible]	100	100	[illegible]	100	[illegible]	[illegible]	100	[illegible]	100

Stratigraphy and thickness

The Adobe Range sequence lies conformably on the Strathearn Formation in the southern Adobe Range and Elko Hills but upper beds extend beyond the borders of the Strathearn both northward and southward. These onlapping beds unconformably lie on Mississippian rocks in the northern Adobe Range and in the Pinon Range (J. Fred Smith, Jr. and Ketner, unpub. data). They lie on Cambrian rocks in the northern Independence Range where the unit mapped by Churkin and Kay (1967) as "autochthonous Carboniferous and/or Permian limestone" is now regarded as wholly of Permian age and correlative with the upper part of the Adobe Range sequence.

The stratigraphic units proposed by Fails (1960) are useful only in the Carlin Canyon area. They can be recognized in a general way in the nearby southern Adobe Range, but even there, formation boundaries are too indefinite to be useful in reconnaissance mapping.

In general, however, the tendency noted by Fails for cherty beds to be concentrated in the upper part of the section is widespread in the region. Moreover, in this investigation the concentration of phosphate was found to increase upward in the section and reach a maximum among the cherty beds near the top.

Age and correlation

Although the lower part of the Adobe Range sequence is only sparingly fossiliferous, its age, based on stratigraphic position and paleontologic data cited by Fails, is Leonard and probably Wolfcamp. The upper part is Guadalupian and Late Permian.

According to MacKenzie Gordon, Jr. the following collections from the Elko Hills indicate the lower part of the Adobe Range sequence is correlative with the upper part of the Antler Peak Limestone and is probably of Early Permian age.

Field no. 5006 (U.S.G.S. coll. 23784-PC). Osino 7 1/2-min. quadrangle, Elko County, Nev. East brow of sandstone ridge, opposite low summit, about midway between 6851 ft. and 6721 ft. summits in Elko hills about 6,000 ft. southwest of summit of Elko Mountain. SE 1/4 SW 1/4 NW 1/4 SE 1/4 sec. 27, T. 35 N., R. 56 E.

Purdonella sp.

Martinia sp.

Crurithyris sp. A

Field no. 5008 (U.S.G.S. coll. 23361-PC). Osino 7 1/2-min. quadrangle, Elko County, Nev. On north side of canyon directed northwestward from summit of Elko Mountain, about 250 feet upslope from canyon bottom, approximately at middle of E. Line of NW 1/4 NW 1/4 sec. 23, T., 35 N., R. 56 E.

"*Chonotes*" n. gen. n. sp. aff. *C. rostrata* Dunbar and Condra

Kochiproductus? sp. indet. (juvenile)

Crurithyris sp. A

Peruvispira sp.

Gordon says of this collection, "*Peruvispira* is a typically Permian snail but has been found in Upper Pennsylvanian (Virgil) rocks. I am not yet sure whether the sulcate chonetid and *Crurithyris* together indicate Permian age, but I rather suspect so. At any rate this faunule indicates a correlation with the upper-most Antler Peak."

This collection from the outhern Adobe Range indicates a Late Permian age for the middle part of the Adobe Range sequence according to MacKenzie Gordon, Jr.

Field no. 5246 (U.S.G.S. coll. 23789-PC). Hunter 15-min. quadrangle, Elko Co., Nev. Center of SE 1/4 sec. 30, T. 34 N., R. 54 E., at 6,240-ft. contour on north slope of peak 6352. Collector, K. Ketner, June 28, 1968.

Punctospirifer sp. A

Orthomyalina sp.

Gordon says, "This faunule is the same as that of the highest fossiliferous bed of the Permian sequence in the Carlin region. Age is Late Permian."

John Pojeta and E. L. Yochelson (written commun., 1968) report the age of the following collection of gastropods and pelecypods as follows:

"The fauna is similar to that of the Arcturus Formation as exposed in the Ely district. The Arcturus is dated as Lower Permian in age, but its exact equivalents to the West Texas standard are uncertain."

Bellerophon (*Bellerophon*) sp. indet.

?*Euphemites* (fragment)

?pleurotomariacean (fragment)

Naticopsis (*Marmolatella*) n. sp.

Murchisonia (?*Taosia*) sp. indet.

?*Aclisina* sp. indet.

Phestia cf. *P.* *obesa* (White)

Schizodus aff. *S.* *bifidus* Ciriacks

Astartella sp.

Nuculopsis sp.

Beds above this fauna contain *Atomodesma*.

The age of the upper part of the Adobe Range sequence as based on several collections of conodonts, brachiopods and pelecypods is probably Guadalupian and Late Permian.

John W. Huddle (written commun., 1968) reports the following collections from the middle part of the sequence in the southern Adobe Range to be probably Guadalupian in age:

Field No. 5243 (U.S.G.S. 23367-PC) Hunter quadrangle, NE 1/4 sec. 30 on top of hill 6324.

Gondolella idahoensis Y. H. & M.

Field No. 5245 (USGS 23368-PC) Hunter quadrangle, SE 1/4 sec. 30, in saddle between hills 6324 and 6352.

Gondolella idahoensis Y. H. & M.

Streptognathodus sulcoplicatus Y. H. & M.

MacKenzie Gordon, Jr. (written comm., 1967) says that the following collection from the upper part of the sequence in the northern Adobe Range is probably Late Permian in age. Field no. 3322 (U.S.G.S. coll. 23211-PC) center of boundary between T. 38 N., R. 56 E. and T. 38 N., R. 57 E;

Stenoporoid bryozoan

Polypora sp.

Derbyia? sp.

Punctospirifer n. sp.

Composita sp. indet.

Orthomyalina sp.

Aviculopinna sp. indet.

Aviculopecten aff. *A. vanvleeti* Beede

Float blocks about 300 feet topographically and stratigraphically lower than collection 3322 contain the following:

Stenoporoid bryocoan, gen. & sp. indet.

Polypora sp.

Xestotrema pulchrum (Meek), variant

Gordon says of this collection, "The large spiriferinid in this collection agrees moderately well with '*Spiriferina*' *pulchrum*(Meek) except that some of the pedicle valves are somewhat more convex than the typical form and the median sulcus is slightly deeper and more V-shaped than is typical. The generic name given above is that of Grant which will be published in a week or two. Many authors have referred Meek's species to *Punctospirifer* but it lacks the imbricate lamellose surface sculpture of that genus. So far as is now known *Xestotrema* is restricted to certain Late Permian rocks in the western United States."

This collection in chert grain sandstone/is a near-shore fauna of probable Permian age according to MacKenzie Gordon, Jr. Field no. 5436 (U.S.G.S. coll. 23782-PC). In tracks of jeep road running south from Coal Mine Canyon road, SW 1/4 Sec. 36, T. 38 N., R. 55 E.

Stenoporoid bryozoan, ramose form

Lingula sp. (large fragment)

Davidsoniacean, gen. & sp. indet.

Chonetacean, gen. & sp. indet.

"*Spiriferina*" sp.

Aviculopinna sp.

Pectinoid, gen. & sp. Indet.

Sanguinolitid, gen. & sp. indet.

Edmondia? sp.

Schizodus sp.

Naticopsis sp.

Peripetoceras sp.

The following collection was identified by MacKenzie Gordon, Jr. Field no. 5501 (USGS loc. 23798-PC) Wells AMS two degree sheet, west 1/2 sec. 32, T. 38 N., R. 56 N.

Stenoporoid bryozoan, gen & sp. indet.

Trigonoglossa sp. indet.

Orbiculoidea sp.

Sphenosteges cf. S. hispidus (Girty)

Rhynchopora sp.

Xestotrema sp.

Composita sp.

Paleoneilo ? sp. indet.

Gordon reports "This collection is Permian in age and as it contains the genera Sphenosteges Muir-Wood & Cooper and Xestrotrema Cooper & Grant it is probably Late Permian in age".

PERMIAN, TRIASSIC

LONG CANYON SEQUENCE

Distribution

The Long Canyon sequence crops out only in the northern Adobe Range where it extends in a narrow belt from Coal Canyon northeastward to Long Canyon. The term "Long Canyon sequence" is used informally in this report.

Lithology

At base the Long Canyon sequence is mainly platy, silty limestone with less shale. It is brown or dark gray but weathers greenish gray. Some beds and lenses are of dark limestone that weathers chocolate brown.

Upper parts of the formation are also dark silty limestone and shale that weathers gray green but these upper beds are less platy and have more chocolate brown beds and lenses. Greenstone is common in both Permian and Triassic parts. The greenstone is generally concordant but in one exposure it definitely cuts across bedding and has metamorphosed the sediments on both sides.

Stratigraphy and thickness

The Long Canyon lies concordantly on the Adobe Range sequence. It is overlain unconformably by Tertiary volcanic sediments and lava flows. The Permian part of the formation does not differ markedly from the Triassic part. The two systems are differentiated only on the basis of fossils contained in some limestone beds.

Greenstone forms persistent beds a few feet thick. Nearly all are concordant with the bedding of the enclosed sedimentary rocks and the concordant contacts are not metamorphosed. However, in one place near the Coal Canyon road Triassic shale has been intruded disconformably and metamorphosed along the contacts.

Because of structural complications the thickness of the formation cannot be accurately determined. However, it is estimated to be more than 2000 feet.

Age and correlation

The Long Canyon sequence ranges in age from Late Permian to Early Triassic. The following fossils collected from limestone beds in the lower part of the formation were identified by MacKenzie Gordon, Jr.

Field No. 3348 (U.S.G.S. 23214-PC) T. 38 N., R. 56 E., 3 miles due east of Coal Canyon mine on north facing slope between horizontal control points (marked by triangles, Wells A.M.S. sheet).

Stenoporoid bryozoan, ramose form

Derbyia sp.

Aulosteges sp.

Grandaurispina? sp. indet.

Kozlowskia? sp. indet.

Bathymyonia nevadensis (Meek)

Small coarse-spined *Buxtonia*-like productoid, gen. and sp. indet.

Echinauris subhorrida (Meek)

Megousia sp.

Field No. 3349 (U.S.G.S. 23215-PC) T. 38 N., R. 56 E., three miles due east of Coal Canyon mine on peak in saddle between horizontal control points (marked by triangles on Wells A.M.S. sheet).

Derbyia sp.

Aulosteges sp.

Grandaurispina? sp. indet.

Bathymyonia nevadensis (Meek)

Echinauris subhorrida (Meek)

Megousia sp.

Rhynchopora sp. indet. (fragment)

Punctospirifer n. sp.

Of the two collections above, Gordon states "Both collections are post-Wolfcamp Permian in age and are probably Late Permian in age. The Echinauris and the Bathymyonia are known also in the Gerster Formation and in the Franson Member of the Phosphoria."

The following small collection indicates a Permian and probably Late Permian age according to MacKenzie Gordon, Jr.

Field No. 3325 (U.S.G.S. 23213-PC) extreme NE corner of sec. 12, T. 38 N., R. 56 E., 50 feet north of Long Canyon road at the point where the road turns north and enters a narrow tributary canyon.

Bathymyonia nevadensis (Meek)

An additional collection from the same unit was reported as follows: Field no. 5477 (U.S.G.S. coll. 23792-PC). on ridge one-half mile south of spring at sharp bend in road sec. 1, T. 37 N., R. 55E.

Stenoporoid bryozoan, gen. & sp. indet.

Chonetid, gen. & sp. indet.

Aulosteges sp.

Kochiproductus sp.

Yakovlevia multistriata (Meek)?

Bathymyonia? sp. indet.

Xestotrema pulchrum (Meek)

Gordon says, "This assemblage is Late Permian in age and can be correlated with that of the Gerster Formation of the Nevada-Utah border country and the Franson Member of the Park City Formation."

The following Triassic fossils identified by N. J. Silberling were collected from chocolate-brown limestone lenses in shale of the upper part of the Long Canyon sequence.

Field No. 3347 (USGS M5028) sec. 29, T. 38 N., R. 56 E., 500 feet north of Coal Canyon road where it makes a sharp bend from northwest to southwest.

Anasibirites cf. *A. emmonsi* Mathews, of Smith

Hemiprionites cf. *H. typus* (Waagen)

?*Pseudomonotis*? *occidentalis* (Whiteaves)

fish remains: scales, etc.

Silberling states that this collection represents early, but not earliest, late Early Triassic age.

References cited

Carlisle, Donald, Murphy, M. A., Nelson, C. A., and Winterer, E. L., 1957, Devonian stratigraphy of Sulphur Springs and Pinyon Ranges, Nevada: Am. Assoc. Petroleum Geologists Bull., v. 41, no. 10, p. 2175-2191.

Churkin, Michael, Jr., and Kay, Marshall, 1967, Graptolite-bearing Ordovician siliceous and volcanic rocks, northern Independence Range, Nevada: Geol. Soc. America Bull., v. 78, p. 651-668.

Coash, J. R., 1967, Geology of the Mount Velma quadrangle, Elko County, Nevada: Nevada Bur. Mines Bull. 68, 21 p.

Dott, R. H., 1955, Pennsylvanian stratigraphy of Elko and northern Diamond Ranges, northeastern Nevada: Am. Assoc. Petroleum Geologists Bull., v. 39, p. 2211-2305.

Elles, G. L., and Wood, E. M. R., 1914, A monograph of British graptolites: London Paleontological Soc., pt. 10, p. 487-526.

Emmons, W. H., 1910, A reconnaissance of some mining camps in Elko, Lander, and Eureka Counties, Nevada: U.S. Geol. Survey Bull. 408, 130 p.

Evans, J. G., and Ketner, K. B., 1971, Geologic map of the Swales Mountain quadrangle and part of the Adobe Summit quadrangle, Elko County, Nevada: U.S. Geol. Survey Misc. Geol. Inv. Map I-667.

Fails, T. G., 1960, Permian stratigraphy at Carlin Canyon, Nevada: Am. Assoc. Petroleum Geologists Bull., v. 44, p. 1692-1703.

Granger, A. E., Bell, M. M., Simmons, G. C., and Lee, Florence, 1958, Geology and ore deposits of Elko County, Nevada: Nevada Bur. Mines Bull. 54.

Hotz, P. E., and Willden, Ronald, 1964, Geology and mineral deposits of the Osgood Mountains quadrangle, Humboldt County, Nevada: U.S. Geol. Survey Prof. Paper 431, 128 p.

Kerr, J. W., 1962, Paleozoic sequences and thrust slices of the Seetoya Mountains, Independence Range, Elko County, Nevada: Geol. Soc. America Bull., v. 73, no. 4, p. 439-460.

Ketner, K. B., 1966, Comparison of Ordovician eugeosynclinal and miogeosynclinal quartzites of the Cordilleran geosyncline: U.S. Geol. Survey Prof. Paper 550-C, p. C54-C60.

_____1970a, Geology and mineral potential of the Adobe Range, Elko Hills, and adjacent areas, Elko County Nevada: U.S. Geol. Survey Prof. Paper 700-B, p. B105-B108.

_____1970b, Limestone turbidite of Kinderhook age and its tectonic significance, Elko County, Nevada: U.S. Geol. Survey Prof. Paper 700-D, p. D19-D22.

Ketner, K. B., Evans, J. G., and Hessin, T. D., 1968, Geochemical anomalies in the Swales Mountain area, Elko County, Nevada: U.S. Geol. Survey Circ. 588, 13 p.

Ketner, K. B., and Smith, J. F., Jr., 1963, Geology of the Railroad Mining district, Elko County, Nevada: U.S. Geol. Survey Bull. 1162-B, 27 p.

King, Clarence, 1878, Systematic geology: U.S. Geol. Explor. 40th Parallel (King), v. 1, 803 p.

Lincoln, F. C., 1923, Mining districts and mineral resources of Nevada: Nevada Newsletter Publishing Company, Reno, Nevada, 295 p.

Lovejoy, D. W., 1959, Overthrust Ordovician and the Nannie's Peak intrusive, Lone Mountain, Elko County, Nevada: Geol. Soc. America Bull., v. 70, no. 5, p. 539-563.

Nolan, T. B., Merriam, C. W., and Williams, J. S., 1956, The stratigraphic section in the vicinity of Eureka, Nevada: U.S. Geol. Survey Prof. Paper 276, 77 p.

Roberts, R. J., 1964, Stratigraphy and structure of the Antler Peak quadrangle, Humboldt and Lander Counties, Nevada: U.S. Geol. Survey Prof. Paper 459-A, p. A1-A93.

Smith, J. F., Jr., and Ketner, K. B., 1968, Devonian and Mississippian rocks and the date of the Roberts Mountains thrust in the Carlin-Pinon Range, Nevada: U.S. Geol. Survey Bull. 1251-I, p. 1-18.

Smith, M. C., and Trengove, R. R., 1949, Investigation of the Rip Van Winkle lead-zinc-silver mine, Elko County, Nevada: U.S. Bur. Mines Rept. Inv. 4605, 13 p.