Correlation of the Fauna from the Middle Permian Section at Black Rock Northwestern, Nevada

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Geology

by

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ABSTRACT

Black Rock is located at the southwestern tip of the Black Rock Range in Humboldt County, northwestern Nevada. The Black Rock section consists of approximately 2,500 feet of Middle Permian andesitic flows, lithic volcanic wackes, and limestone. Two of the limestone horizons have yielded faunules.

The Anidanthus-Spiriferella faunule is dominated by brachiopods, bryozoa, and sponges. Accessory components include bivalves, corals, trilobites, and pelmatozoan columnals. Spiriferids are represented by the genera Spiriferella, Choristites (?), and Neospirifer. Productids include Kochiproductus, Waagenoconcha, Muirwoodia, and Anidanthus.

The Medlicottia faunule is contained in a volcaniclastic dominated limestone. The ammonite Medlicottia, the brachiopod Echinococonchus, and the Hapsiphyllid coral Allotropiophyllum are the most distinctive elements of the faunule.

Correlation of the Black Rock fauna suggests an uppermost Leonard (Road Canyon Formation) or lower Word age assignment. Black Rock does not compare easily with standard American sections, due to the influence of Tethyan and Boreal characters on many members of the fauna.
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INTRODUCTION

Gianella and Larson (1960) recognized the occurrence of a Permian marine faunule cropping out at the Black Rock, Humboldt Co. in northwestern Nevada. The Black Rock exposes several thousand feet of almost vertical dipping metavolcanic andesite tuffs and breccias. Intercalated metasedimentary limestone units contain the fossil material.

Preservation of the faunule is poor and consists predominantly of casts and molds. The fossil assemblage consists of at least two genera of trilobites, several forms of spiriferid brachiopods, productid brachiopods, bivalves, fenestrate and ramose bryozoans, sponges, and corals. Occurrence of the characteristic brachiopod genera Leptodus, Muirwoodia, Anidanthus, and other brachiopod genera and species indicates a middle Permian age for the faunules.

Willden (1964) mapped the Black Rock as belonging to the Happy Creek Volcanic Group, the type outcrop of which is exposed about 40 miles to the northwest. Willden (1964) commented that for the Happy Creek Group "perhaps the best correlation is with the marine Permian section at Black Rock, Nevada, recently discovered by Gianella and Larson (1960). The Black Rock section should also be correlated with the lower part of the next younger unit in the Jackson Mountains, the unnamed unit of Permian and Triassic ages."

Southwest of Black Rock (15-40 miles) in east-central Washoe County and northwestern Pershing County occurrences
of Permian and Triassic metamorphic rocks (undivided), have been mapped by Bonham (1969) and Tatlock (1969). Metavolcanic rocks form the bulk of most of the exposed sections. Locally, however, interbedded sedimentary rocks do occur, such as at the Mountain View mine in the Granite Range. 'Samples of fossiliferous limestone from that locality were submitted to Dr. Joseph Lintz for identification. He reported (personal communication to Bonham) that the fossils were too poorly preserved to be identified.'

**Purpose**

In contrast with the Cordilleran miogeosyncline to the east, the eugeosyncline has received relatively little detailed study. The exposures of rock sequences commonly contain a sparse fossil record, if any at all. In contrast to the miogeosyncline, the eugeosyncline has undergone regional metamorphism, which tends to make many rocks look alike. Most commonly, rock exposures of the depositional phase of the geosyncline occur as roof pendants in 'Nevadan' granitic rocks.

Dr. E. R. Larson made a collection of 'Permian' fossils from Black Rock available to me. After cursory investigation of this suite of fossils and a literature search of other published metavolcanic and metasedimentary dated sequences, the correlation, ecology, and paleogeography of this province suggested itself as a research project. In order not to overextend the project, certain concessions on
completeness were necessary. The interpretation of the paleoecology of the Black Rock fossils was to be kept to a minimum and only applied to help mediate correlation problems which were sure to arise when attempting interprovincial correlation. One of the goals of this project includes an attempt at delimiting the size and extent of the province in which similar communities of Permian macroinvertebrates lived. Since field work uncovered no fusulinid occurrences at Black Rock, the fusulinid literature of this province is cited but not included in the discussions of the faunal characteristics of the eugeosyncline. The paper is structured not only to review fossil occurrences in the province, but to introduce with a faunal list, systematics, and accompanying plates the members of the paleocommunity which were preserved in the rocks exposed at Black Rock. Reconnaissance mapping, stratigraphy, and structural interpretation were considered necessary as a basic constituent of this project.

**Method and Materials**

A total of five weeks was spent at Black Rock and other localities of Permian rocks during the summer of 1974. The Black Rock material is contained primarily in highly silicified sedimentary rocks. The most impressive specimens are obtained from talus slopes where the weathering process has etched away the fossil material contained. As a result, many key specimens are represented
as casts or molds which often obliterates internal detail, shell material, and numerous other diagnostic features. Though many specimens are suggestive of new or unknown species, I have shunned creating new species, as the Black Rock material is of such a poor quality, and the number of specimens available per species is low. This results in a proliferation of cf.'s and question marks in the faunal list.

Synonymy lists are given with each proposed or suggested species in the Black Rock fauna. The lists only include references to publications which I have examined, with the exception of the original publication where the particular species was originally named.

The systematics are based upon Treatise on Invertebrate Paleontology classification assignments. Productid brachiopod assignments are based upon Muir-Wood and Cooper (1960) in their G.S.A. Memoir 81, 'Productoidea'.

The described material has been given University of Nevada, Mackay School of Mines (UNMSM) Museum Numbers.

Geographic Setting
Black Rock is located in the Black Rock Desert in northwestern Nevada. The Black Rock Desert covers an area of about 2,600 square miles, which is predominantly a playa consisting of Pleistocene (Lahontan) lake deposits, with steep alluvial slopes flanking the north-south trending mountains. The desert is bounded on the east by the
Jackson Range and to the west by the Granite Range. Black Rock lies at the southwestern tip of the Black Rock Range which bisects the Black Rock Desert. The range stands at an altitude of over 8,000 feet which is almost 5,000 feet above the desert floor. The range consists entirely of Tertiary volcanic and sedimentary rocks. The regional Cenozoic history and volcano-tectonic events of northwestern Nevada are discussed by Korringa (1972). Korringa cites a list of previous works which will not be given in this paper, as detailed Cenozoic stratigraphy is not important in developing the topic of this paper.

The weather is typical of the Great Basin Desert environment. It is very cold with snow in the winter months, and extremely hot and dry during the summer months. Annual precipitation in the valley floor is less than 6 inches a year, and from 15 to 20 inches along the mountain crests (Sinclair, 1963). Travel is extremely hazardous during the winter months due to precipitation and bountiful ground water action, which makes the playa clays impassable. During the summer months the dryness and parched nature of the land requires that travelers carry abundant water. The Black Rock Hot Springs at the base of Black Rock provides near boiling potable water all year round. The overflow pool is cool enough to swim in, but mites make the experience usually extremely unpleasant. The xerophytic flora consists of Shadscale-big Greasewood communities.
GEOLOGY

Structure

Black Rock is an isolated structural block in the Black Rock Range. No other unit in that range exhibits similar structural or stratigraphical characters. Black Rock is bounded on all four sides by major north-south and east-west trending faults. Surrounding Black Rock are Pleistocene Lake Lahontan terraces of unconsolidated gravels and pebbles to the east and playa with bordering sand dunes to the west. The western limit of the Black Rock section is bounded by a typical Basin and Range fault (front of the range). The vegetation is thicker along this fault and the linear nature of the fault is readily visible on aerial photographs. Hot springs activity along the fault is very common. At Black Rock there are hot springs at the northwestern and southwestern corners of the section. These springs probably occur at the junction of the east-west faults and the north-south faults which form the boundaries of the Permian section. Many of the Paleozoic and Mesozoic exposures in northwestern Nevada occur as roof pendants in 'Nevadan' granites, and as a result are often significantly thermally and hydrothermally altered, obscuring any paleontological material. Black Rock is different in not occurring as a roof pendant.

The strikes and dips of beds within the Black Rock section in general are relatively uniform. The beds strike
Figure 2: Geologic Sketch Map of Black Rock, Northwestern Nevada.

- A: Andesite Flow
- B: Silicified Limestone
- C: Flow Rock/Waterlain Tuff
- D: Limestone
- E: Epiclastic/Volcanoclastic Lithic Wacke
- F: Epiclastic Lithic Wacke
- G: Andesite Flow
- H: Pebby Limestone
- B1: Fossil Localities
- Fi: Localities

Legend:
- Road
- Fault Contact
- Lithologic Contact
- Located Approx.

Scale in Feet: 0 250 500 750 1000

Map Not Corrected for Aerial Photographic Distortion.
N.60°E. with a variation of 10 degrees in either direction. The beds dip at a very high angle in all parts of the section. At the south end of the rock the beds dip from 70 to 85 degrees to the north. At the highest part of the rock, the fossiliferous limestone of Unit B, the beds are vertical. North of this point the beds dip 80 to 85 degrees to the south. The change of dip in the beds in Unit B may be a result of the biohermal nature of that unit.

The rocks exposed at Black Rock are highly fractured and faulted. There appears to be three dominant joint sets: first set N.40°W., 40°E.; second set N.15°W., 80°W.; third minor set N.45°W., 70°W..

In any structurally complex exposure of eugeosynclinal sediments in northwestern Nevada, there is a possibility of large scale thrusting. The Bilk Limestone to the northeast near the Quinn River Crossing has been shown to be an allochthonous plate by Willden (1964). The limestones at Black Rock however, appear to be contiguous with the eugeosynclinal character of the other rocks and are not believed to be thrusted. The upper and lower limits of the Black Rock section are not exposed, thus it is possible though not indicated, that the Black Rock may be an allochthonous block.

**Stratigraphy**

The Black Rock section is approximately 2,500 feet.
thick. One section was measured in a north-south direction along the crest of the Black Rock. A reconnaissance geologic map appears as Figure 2. The section is divided into units which are in general characterized by distinctive lithological types. The majority of the rocks in the section are volcanic in origin. There are three horizons of limestone and a thick section of an epiclastic volcanic wacke.

Unit A forms a bold bluff at the north end of the rock. The rock is a massive, dark green weathering, andesite or basaltic andesite. Large irregular masses of the unit are brecciated and appears to be a primary feature. The phenocrysts consist of feldspar and clinopyroxene and are no more than a few millimeters in maximum size. The rock is altered to a greenschist facies with chlorite, epidote, and calcite.

Unit B is a dark green, highly silicified peloidal biomicrite or skeletal-peloidal wackestone. In outcrop, the limestone weathers yellowish tan grading to a dark reddish brown or green. The Anidanthus-Spiriferella faunule occurs in this unit. Few fossils are found in place. Usually the large talus slopes surrounding this horizon yield the best fossil material. The majority of the specimens occur as casts or molds.

Unit C consists of irregular pods of lithic tuff with minor interbeds of highly altered limestone. The
tuff contains lithic fragments of tuffaceous rocks and flow rocks in a matrix of feldspar crystals and ash. The rocks are dark green and are very fine-grained to finely conglomeratic in texture.

Unit D is a weathered gray to yellow biomicrite. The rocks are commonly devoid of skeletal material. Pelmatozoan columnal hash and brachiopods are locally dominate.

Unit E is sandy to pebble conglomeratic in texture. The lithic fragments are of volcanic origin and are dark green and reddish brown at the exposure. Thin lenses of limestone are common and brachiopod shell fragments are are found sandwiched between clastic fragments. Bedding is irregular and tends to be massive. Thin lenses (roughly six inches) of keratophyre are conspicuous by their light gray to light green appearance in an otherwise very dark section. The stringers are conformable and most commonly seen on the north slope of the large canyon which dissects Unit E from the west.

Unit F is very much like Unit E in composition but differs in having a larger proportion of limestone. The more calcareous, finer conglomeratic to sandy portions of the unit contain the Medlicottia faunule described in the Paleontology section. The rocks are reworked and may represent a beach type deposit or reworked forereef on the flanks of a volcano. The rock appears like unit E to have both an epiclastic and volcano-clastic components. Large amounts of devitrified glass suggests the volcano-
clastic component was deposited in a submarine environment. The rocks are altered to a greenschist facies.

Unit G is a flow. The texture is very fine grained with a highly interwoven fabric of small feldspar phenocrysts. Accessory components are pyroxene and chlorite. In outcrop the rock weathers lime to dark green and brown in color.

Unit H is massive, highly fractured, and very similar in appearance to the dark green portions of Unit F. The unit is composed of a calcareous ash with pods of green limestone. Locally the unit is fossiliferous; unfortunately, the fossil detail is obliterated. The southernmost exposures of the unit are a tan, calcareous pebble limestone.
CORRELATION

The Black Rock Faunules

The Black Rock fauna has been divided for convenience into two faunules; the Anidanthus-Spiriferella faunule, and the Medlicottia faunule. Stratigraphically, these communities are separated by Units C, D, and E. The components of each faunule are listed in Tables 1 and 2, and the definition of the stratigraphic units are given in the previous section on Geology. The paleoecologic implications of the faunules are given in the section on Paleoecology.

At this time the two faunules are considered to be a single paleontologic unit for correlation purposes. This is done with the assumption that the entire Black Rock section was deposited in a relatively short period of time.

The Permian System

Murchison named the Permian System in 1840. The Permian is based on sections described by him in the province of Perm in the Ural Mountains of Russia. The System as was formally described (Murchison, Verneuil, and Keyserling, 1845) included three series: the Kungurian, Kazanian, and Tatarian. All three series at Perm consist of red beds and evaporites. About 300 miles to the west the nonmarine sediments grade into marine facies (Dunbar, 1940).

To date the original series have been supplemented with numerous other marine stages including Asselian,
ANIDANTHUS-SPIRIFERELLA FAUNULE

Table 1

Porifera
- Asteractinellid

Coelenterata
- Rugosa, gen. and sp. indeterminate.

Bryozoa
- Fenestella sp.
- Polypora sp.
- Fenestellid
- Ramose form var. 1
- Ramose form var. 2
- Massive form
- Acanthocladia sp.

Brachiopoda
- Enteletes cf. E. dumblei
- Meekella sp.
- Derbyia sp.
- D. sp. cf. D. grandis
- (?) Dyoros sp. D. subliratus
- (?) Rhamnaria sp.
- (?) Calliprotonia sp.
- Waagenoconcha sp.
- W. sp. cf. W. montpelierensis
- Kochiproductus sp.
- Anidanthus sp. A. waagenianus
- Muirwoodia multistriata
- Leptodus sp.
- Keyserlingina sp. (?)
- Poikilosakos sp. (?)
- Stenoscisma sp.
- S. sp. cf. S. plicatum
- Rynchopora taylori (?)
- Cleiothyridina sp. C. subexpansa
- Crurthyris sp.
- Neospirifer sp. cf. N. costella
- Choristites sp. (?)
- Spiriferella sp.
- S. sp. cf. S. draschei
- Phricodothyris guadalupensis
- Dielasma sp.

Bivalvia
- Acanthopecten sp. aff. A. coloradoensis
- Annuliconcha sp.
- Aviculopectenid

Annelida?
- worm tracks

Arthropoda
- Pseudophillipsia nosonensis
- Neogriffithides sp.

Pelmatozoa
- Dissociated columnals
**MEDLICOTTIA FAUNULE**

**TABLE 2**

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**General Scale**

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<th>Glenister &amp; Furnish, 1961</th>
<th>Ustritsky, 1971</th>
<th>Proposed Scale Stepanov (this volume)</th>
<th>Generally Recognized North American Divisions</th>
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<td>Stage Series</td>
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<td>Copitan Fm.</td>
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<td>Neal Ranch Fm.</td>
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**Correlation of the Main Permian Stratigraphical Scales (Stepanov, 1973)**
Sakmarian, Artinskian, Kungurian, Ufmian, Kazanian, and Tatarian. The stages in Russia are now based on fusulinids, ammonoids, and brachiopods.

No paleontological literature from standard Permian localities in Russia were available to me for comparison with the Black Rock material.

**Correlation with the Permian of West Texas**

The Glass Mountains of Texas, due to the impressive state of preservation, are generally accepted as the standard faunal reference section for North America (P. B. King, 1931, 1932, 1934, 1938, 1942; R. E. King, 1930; Adams, 1939; Dunbar, et al., 1960; Cooper, 1946; Cohee, 1960; Cooper and Grant, 1972).

Biostratigraphically, fusulinids are the major basis for subdivision of the Permian (Dunbar and Skinner, 1937; Skinner and Wilde, 1955; Ross, 1959, 1960, 1962, 1963a, 1963b). However, fusulinids have not been found at Black Rock and this valuable aid in correlation is not available.

Corals and sponges are common in the West Texas sections and have been described extensively (Finks, 1955, 1960; Girty, 1908; Ross and Ross, 1963a, 1963b). The Black Rock sponges are similar to the Lower Permian sponges *Wewokella* Girty (1911) and *Talaspongia* King (1943). The poor quality of the Black Rock material, in addition to the uncertain generic assignments of the specimens, negates their use as biostratigraphic tools.
Stratigraphical Units of the Permian of West Texas

(Cooper and Grant, 1972)
Bryozoans are very common in West Texas as they are at Black Rock. They have been incompletely studied to date (Girty, 1908) with the exception of a paper on species of Fenestrella by Elias and Condra (1957). Bryozoan zones are presented by those authors (p. 5), but have little utility at Black Rock. The poor state of preservation makes specific identifications impossible.

Biostratigraphically, ammonoids are of great utility, and have been the subject of several significant papers (Miller, 1930, 1945a, 1945b; Miller and Furnish, 1940, 1957; Miller and Garner, 1953; Plummer and Scott, 1937) on West Texas forms. Black Rock has yielded only one ammonoid, Medlicottia, a relatively long ranging form (Lower Wolfcampian to Lower Ochoan). Miller and Clark (1957) have recorded the occurrence of that ammonite from the basal Word, Road Canyon Formation. However, Medlicottia is not diagnostic of the 'Roadian' in Texas.

Trilobites have been reported from West Texas by Girty (1908), Weller (1944), and Chamberlain (1970). The three trilobites present in West Texas are Anisopyge, Ditomopyge, and Delaria. The genera Pseudophillipsia and Neogriffithides occurring at Black Rock are not represented in the Texas section.

The optimal basis of correlation falls upon brachiopods, the most abundant and diverse phylum of animals represented at Black Rock. Several significant papers have enhanced
the use of brachiopods in correlating with the West Texas sections (Girty, 1908; King, 1930; Muir-Wood and Cooper, 1960; Cooper and Grant, 1972).

Cooper (1957) points out the danger of using a single group of animals except the accepted standards of comparison for correlation. Many of the genera represented at Black Rock do not compare specifically with American forms and show a distinct affinity to Asian and Boreal forms. Non-American forms include Echinoconchus, Calliprotonia(?), Kochiproductus, Cleiothyridina, Derbyia, Spiriferella, and Choristes.

Many of the brachiopods represent long ranging forms and have virtually no biostratigraphic value. These species include the genera Orbiculoidea, Meekella, Dycros, Stenoscsisma, Rynchopora, Crurythyris, Neospirifer, Phricodothyris, Dielasma, and Waagenoconcha.

Enteletes is a long ranging, Pennsylvanian to Permian, Orthid genus. The Texas species E. dumblei, which is probably closely related to the Black Rock specimen, is characterized by its large size and coarse plications. According to Stehli (1954), E. dumblei occurs in the Hess and Word of West Texas. The genus Enteletes terminates at the end of the Willis Ranch member of the Word (Cooper and Grant, 1972, p. 118).

The peculiarly large species of Derbyia of D. grandis (Black Rock) is very closely related to the Texas form
D. nasuta. According to King (1930, p. 60), D. nasuta has been found in the Leonard, Hess, and Word.

Echinoconchid forms do not occur in West Texas. Bathymyonia occurs in the Phosphoria and the Western United States, but does not compare well in internal details with the Black Rock specimen.

The specimens described in the systematics as Waagenoconcha sp., is characterized by its greater length to width ratio and is very similar to specimens from El Antimonio, Mexico (Cooper et al, 1953). Cooper suggests that these large sized individuals are within the range of variation for the species W. montpelieriensis (1953, pl. 13, figs. 12-14). These specimens came from the Spiriferellina zone within the (Word) Monos formation in Sonora, Mexico. A similar looking form, W. leonardensis King (1930, p. 80-81, pl. 19, figs. 2-4) from West Texas, is rare and known only from the Leonard.

Kochiproductus is known from the lower Permian and terminates at the end of the Road Canyon formation (Cooper and Grant, 1972). The genera probably has a longer range outside of the American province.

Anidanthus waagenianus is known from the Leonard and Word formations of West Texas. The specific identification of Black Rock specimens is questioned due to possible alliances with species from nearby California (Coogan, 1960) and Oregon (Cooper, 1957).
Muirwoodia multistriata is known from the Word of West Texas. The genus has a cosmopolitan distribution (Russia, Arctic, Asia, Mongolia, China, Siberia, United States), and the species represented at Black Rock may not be an American one. According to Cooper and Grant (1972), the genus is restricted to the Road Canyon formation and the Word.

Three genera of Lytonnids are represented at Black Rock. The peculiar brachiopods are not diagnostic of time horizons; however, "the Lytonnid superfamily consists of 15 genera (in 1964) with the highest proportion (87%) occurring in the Leonard-Guadalupian" (Williams and Wright, 1967).

The large alate Neospirifer from Black Rock is very much like the West Texas species N. costella. The species is not common and is restricted to the Leonard. N. costella is very similar to the Asian form N. fasciger.

According to Cooper and Grant (1972), Spiriferella ranges from the Road Canyon formation well into the middle of the Capitan Series. The specimens before me are similar in size to S. sulcifer from Texas, which is found in the Middle and Upper Word Series. Spiriferella in general is not common in the United States and is not considered to be an American form.

The Black Rock fauna is closely allied with the Upper Leonard or Lower Word of West Texas. Kochiproductus terminates at the end of the Road Canyon. Muirwoodia and Spiriferella begin in the Road Canyon. Enteletes terminates by the end of the Willis Ranch time.
Controversy of the Road Canyon Formation

P. B. King (1931) erected four limestones within the Word. The lowermost formation is known as the Road Canyon formation and was placed in the Word by Cooper and Grant (1964). Miller (1945) suggested the Leonardian faunal affinities of the Road Canyon formation. Cooper and Grant (1972) have placed the formation as the uppermost Leonard.

The formation contains the Leonard ammonite Perrinites, and the Leonard brachiopods Pendiculauris, Rugatia, Chonostege, Aacosarina, Hercosestria, and Goniarina (Cooper and Grant, 1972). On the other hand, the fusulinids of the Road Canyon usually are dated as early Word (Wilde, 1968, p. 12).

As a result, many faunas dated as Lower Word before 1972 are now considered to be Uppermost Leonard ('Roadian').

The fauna at Black Rock is most likely 'Roadian' (Road Canyon equivalent) and/or possibly Lower Word in age.

Correlation of Black Rock with the Park City Group

The fossils of the Phosphoria, and Park City formations are highly limited in faunal diversity when compared to the standard West Texas sections. Only two general paleontology studies of the Phosphoria have been produced to date (Girty, 1910; Branson, 1930). An excellent summarization of the faunas of the Phosphoria was produced by Yochelson (1968). No fusulinids or echinoids are known from the formations. Fusulines reported by Frenzel and Mundorff (1942) are now
considered to be below the base of the Phosphoria. Trilobites are verified from only one locality within the formation by Chamberlain (1970). The species represented is *Anisopyge sevilloidia* and bears many differences from the Black Rock specimens. Only one sponge is known from the Phosphoria, *Actinocoelia maeandrina*, which is considered to form a time horizon in the Upper Leonard of the Western United States (Finks, Yochelson, and Sheldon, 1961). Corals are extremely rare in the formations (Duncan, 1961). Fossils most commonly represented are in order of abundance: mollusks, brachiopods, and bryozoans (Yochelson, 1968). Pelmecypods are the most abundant and have been reported on by Ciriacks (1963). *Acanthopecten* and *Annuliconcha* occur at both Black Rock and the Phosphoria.

Gastropods and cephalopods are subdominant as molluscan constituents. The cephalopods of the Phosphoria have been reported on by Miller and Cline (1934). *Medlicottia* is not known to occur in the formation.

Brachiopods again provide the best specimens for comparing Phosphoria elements with those of Black Rock. The genus *Leptodus* is known from the Phosphoria (Dutro and Yochelson, 1961). The genus usually appears to be highly altered by its environment, which greatly reduces its utility as a biostratigraphic tool.

The Phosphoria and Black Rock share the following genera: *Orbicucoidea*, *Neospirifer*, *Phricodothyris*, *Crury-
thyris, Kochiproductus, Waagenoconcha, Dielasma, Anidanthus, Muirwoodia, Derbyia, Rhynchopora. The range of most of these genera, with the exception of Anidanthus and Muirwoodia, is sufficiently long to make them of very little value biostratigraphically. According to the Table published by Yochelson (1968, p. 618-621), the Rex Chert Member of the Phosphoria is the only unit to contain Muirwoodia, Anidanthus, and Kochiproductus combined. The Rex Chert has been compared to the Coyote Butte formation in Oregon based on the occurrence of the brachiopod Antiquatonia sulcatus (Yochelson, 1968). According to Cooper (1957), the Oregon fauna is correlated with the Road Canyon formation of West Texas (formerly known as the lowest Word limestone). The Spiriferina pulchra fauna is contained in the Upper part of the Park City (the Franson member) and is known also as the "Rex Chert" fauna.

Edna Mountain Formation

The Edna Mountain Formation is significant because it is the youngest known formation overthrust by the allochthonous block of the Sonoma Event (Silberling, 1973; Macmillan, 1972). The formation is usually considered to contain a typical 'Punctospirifer pulchra' fauna. Brachiopods identified by J. S. Williams (in Roberts, 1964) include Neospirifer pseudocameratus, Chonetes sp. cf. C. ostiolatus, Linoprodactus (Anidanthus) cf. L. eucharis, Hustedia cf. H. phosphoriensis, Wellerella (?), Cleiothyridina (?),
Composita, Juresania (?), Rhynchopora (?), Conocardium (?), and Punctospirifer cf. immature P. pulcher. The corals identified by Helen Duncan are possibly the lophophyllilid Stereostylus (?). As stated earlier, the 'Punctospirifer pulchra' fauna is considered to be lower Word.

Metavolcanic and Metasedimentary Rock Sequences

Collections made by J. S. Williams (1959, p. 40) from the Clover Creek Greenstones at Baker, Oregon, suggests a Phosphoria or Word equivalence. An exposure of metavolcanic rocks west of Baker, Oregon (Bostwick and Nestell, 1967) contains a faunule including the linoproducitid Megousia. Megousia is very closely related to Anidanthus which occurs at Black Rock. Megousia differs (Muir-Wood and Cooper, 1960) in its more alate form with the highly developed ears. Megousia ranges from Leonard to Word in age (Muir-Wood and Cooper, 1960) and is very common in the Road Canyon formation of Texas.

A collection from the Seven Devils volcanics in Idaho are suggestive of the Word according to J. S. Williams (1959). The Casto volcanics near Challis, Idaho, are nonfossiliferous but are believed by Williams to be Phosphoria in age.

Rocks mapped as Permian-Triassic volcanic and sedimentary rocks (undivided) from the Jackson Mountains, Nevada (Willden, 1964), have yielded a small collection of corals and fusulinids. The corals were identified by Helen Duncan
as clisiophyllid forms. The fusulinids, though intensely metamorphosed, suggest to L. G. Henbest a late early to middle Permian age. This exposure is probably the closest datable sequence of rocks semi-equivalent to the Black Rock section. The exposure in the Jackson Mountains lies about 35 miles to the northeast of Black Rock.

The Bilk limestone is exposed just northeast of the Quinn River Crossing, northwestern Nevada. A collection was made by Willden (1964) and the brachiopods were identified by J. S. Williams as follows: Stenoscisma, Spiriferella, Grurythyris, Chonetes cf. C. monosensis, Anidanthus, Waagenoconcha cf. W. montpelierensis, Rynchopora. All genera listed from the Bilk Limestone are similar to forms described (this report) from Black Rock.

The fusulinids have been identified by L. G. Henbest (in Willden, 1964), Skinner and Wilde (1966), and Thomas (1972). No fusulinids were found in the upper part of the section and, as a result, ages suggested for the formation range from lower Wolfcampian to middle Leonardian. The zone yielding the megainvertebrate fauna collected by Willden occurs higher in the section, about 50 feet below the top of the unit. The formation is considered to be an allochthonous block.

The Diablo formation is exposed in the Coaldale Quadrangle (Ferguson and Muller, 1949, p. 52). The fauna consists of the characteristic 'Punctospirifer pulchra'
fauna with the corals *Triplophyllum* and *Campophyllum*.

The Reeves and Robinson formations crop out near Taylorsville in northern California. Diller (1908) is given credit for having named both the Reeves and Robinson formations. Originally he defined the formations to separate the finer Robinson tuff from the coarser lapilli tuff and breccia of his Reeves formation. McMath (1958) realized that Diller’s Robinson represented an intercalation within the Reeves and that it occurs at numerous stratigraphic intervals. McMath divided the rock column in half, defining the lower half as the Reeves and the upper half as the Robinson. Dutro and Yochelson (1961) have published the discovery of *Leptodus* from Diller’s original collections. The specimen is credited as having come from the Robinson, but it is unclear to me which formation (following McMath’s redefinition) the specimen should be credited to. *Leptodus* is accompanied by a fauna with the following taxa: echinoderm debris, large crinoid columnals, undetermined horn corals, indeterminate fenestrate bryozoans, *Derbyia* sp., *Meekella* sp., *Waagenoconcha* (?), *Spiriferella* (?) sp. (an alate form), *Squamularia* sp., *Spiriferina* (?) sp., *Aviculopecten* sp., *Clavicosta* (?) sp., *Annulliconcha* sp., and other indeterminate pelecypods. Thompson and Wheeler (1946) state that *Fusulina elongata* Shumard listed from the ‘Robinson’ (Reeves of McMath) locality of Diller (1908) is probably referable to *Parafusulina*. 
A. Cache Creek Group
B. Ishbel Group
C. Sicker Group
D. Coyote Butte Formation
E. McCloud, Nosoni, and Dekkas Formations
F. Reeves and Robinson Formations
G. Quinn River Crossing (Bilk) Limestone
H. Black Rock section
I. Edna Mountain Formation
J. Park City and Phosphoria Formations
K. Kaibab Formation
L. West Texas Sections

LOCATION OF IMPORTANT PERMIAN SECTIONS IN WESTERN NORTH AMERICA
The Nosoni Formation

The Nosoni formation of Shasta Co., California, has yielded a relatively large fauna of 25 brachiopods, fenestellid bryozans, pelecypods, gastropods, a lophophyllid coral (*Stereostylus bollibokkensis*), a trilobite, and four species of fusulinids (*Parafusulina*). The trilobite (Wheeler, 1935a, 1935b), *Pseudophillipsia nosonensis*, represents the same species that occurs at Black Rock. These localities are the only two known occurrences of this species. The two formations share the brachiopod genera *Anidanthus*, *Muirwoodia*, *Neospirifer*, *Rhynchopora*, *Spiriferella*, *Stenoscisma*, *Waagenoconcha*. *Buxtonia* of the Nosoni (Coogan, 1960) may be the same as *Kochiproductus* of Black Rock. The Nosoni brachiopods have a mixture of both Leonard and Guadalupian species. The fusulinids indicate a lower Word age. The age of this formation suggests Road Canyon equivalence. The species in California are quite different than those represented at Black Rock, but the Nosoni species are also quite dissimilar to those of the nearby Oregon fauna described by Cooper (1957).

The Coyote Butte Formation

"Some elements of the Permian fauna of the Coyote Butte Formation in central Oregon suggest correlation with the Road Canyon Formation. In spite of the European and Asiatic types in the fauna, the small *Muirwoodia* (=*Yakolevia*) are very similar to those of the Road Canyon."
Antiquatonia, Kochiproductus, Martinia, small Waagenoconcha, small 'Leptodus', costellate chonetids, and small alate Stenoscisma all suggest Leonard. Small Spiriferella is rather suggestive of later affinities, but it also occurs in the Road Canyon. Cooper (1957) correlated the Oregon (Coyote Butte) with that of the Lower Word of the Glass Mountains, now the Road Canyon" (Cooper and Grant, 1972).

Black Rock and the Oregon section share the following genera: Derbyia, Meekella, Anidanthus, Muirwoodia, Kochiproductus, Waagenoconcha, Stenoscisma, Rynchopora, Cruryothyris, Spiriferella, Neospirifer, 'Squamularia', (Phricodothyris), Cleiothyridina, and Dielasma. On a species level, the faunas tend to be dissimilar. The faunas are similar in that they do not display typical 'American' species.

Cache Creek Group

Two general megainvertebrate studies have been published from the Cache Creek Group. Kindle (1926) reported the occurrence of Leptodus cf. L. tenuis from Permian strata in the Cassiar District of British Columbia. Leptodus is supplemented with the occurrences of Fusulina sp., Bryozoa fragments, Productus sp., Spirifer cf. S. cameratus, Eumetria(?) sp., Athyris sp., Spiriferella(?), with the added occurrences of Margaritina (?) sp., and Steinmannia from another lot of the fauna.

Crockford and Warren (1935) published a faunal list from the Cache Creek which suggests strong similarities
between that fauna and the fauna of the Coyote Butte formation of Oregon (Cooper, 1957). Both faunas have strong Tethyan or Eurasiatic affinities.

Smith (1935) identified two corals *Waagenophyllum* and *Canina* from Cache Creek rocks near Kamloops, about 150 miles east of Vancouver. Smith stresses the Tethyan influence which characterizes the species of both specimens.

**Sicker Group--Vancouver Island**

Yole (1963) reports an 'Early Permian fauna' from the Sicker Group of Vancouver Island which he has correlated with the Coyote Butte fauna of Cooper (1957), the Black Mountain formation of northwestern Washington, and a portion of the Cache Creek Group of British Columbia (McGugan, Roessingh, and Danner, 1964). The fauna contains the brachiopods *Kochiproductus*, *Echinoconchus*, *Horridonia*, *Antiquatonia*, *Neospirifer*, *Laevicamera*, and *Spiriferella*. Fritz (1932) has reported a bryozoan fauna, also from the Sicker Group on Vancouver Island. The impact of this paper is unknown to me as the publication was not available to me.

Sponges are known to occur from the Cache Creek Group (Rigby, 1973), and the species represented are *Scheiia tuberosa*, *Haplistion aff. H. aeluroglossa*, and a chiastoclonellid. The specimens represented do not compare with specimens from Black Rock.

**Ishbel Group--Eastern British Columbia and Alberta**

A fauna from the Ishbel formation about one hundred
miles southwest of Calgary has yielded a middle Permian fauna containing the following elements: large Spirifer, Spiriferella, Dictyoclostus, Muirwoodia, Buxtonia, Chonetes, Crurythyrus, and Cleiothyridina (McGugan, 1963). This collection displays the characteristic 'Russian' faunal influence, a combination of Cordilleran and Tethyan.

The 'Russian' fauna is known from the Middle Permian of Oregon, the Yukon, the Canadian Arctic, Greenland, Russia, and some Asiatic countries (McGugan, 1963).

Correlation with Arctic Canada

Many species of the Black Rock section exhibit strong 'Boreal' affinities. Arctic Permian brachiopods belong to cosmopolitan families that are known to have evolved slowly and ranged through long spans of time (Stehli and Grant, 1971). This character is not desirable for correlation. Standard Russian Permian sections have been reasonably compared with Arctic sections due to the close association of their faunal elements. The American sections are not so easily compared.

The Boreal aspect of the Black Rock fauna is discussed in more detail in the section on Paleoecology.

The Black Rock section shows many similarities to the Assistance formation (Harker and Thorsteinsson, 1960), the Central East Greenland fauna (Dunbar, 1955, 1962), and Svalbard (Gobbet, 1963). According to Ustritsky and Chernyak (1973) these formations represent Upper Permian
Arctic sections which are comparable with the Ufmian stage in Russia (Dutro, 1961). Ustritsky proposes the stage name Paykhoyan, which is initially marked by the appearance of the brachiopod genera Grumantia, Megousia, Svalbardopproductus, Pterospirifer, Pseudosyringothyris, and by the bivalve genera Procrassatella, Prooxytoma, Pseudobakewellia, and mass development of the genus Kolymia.

The Paykhoyan is further divisible into lower and upper divisions based upon the appearance of Cancrinelloides, Stepanoviella, Taeniothaerus, Licharewia and the absence of common Lower Permian genera Chonetina, Uralopproductus, Kochiproductus, Purdonella, and Attenuatella.

The presence of Kochiproductus rules out an Upper Paykhoyan age for the Black Rock fauna. This places the section roughly in synchronicity with the Assistance formation, Svalbard, and Central East Greenland.

*Medlicottia malmquisti* is reported from Central East Greenland. According to Nassichuk, Furnish, and Glenister (1965), the ammonite genus has wide geographic distribution in rocks of both Lower and Upper Permian age (Sakmarian-Dzhulfian stages). Medlicottia is a relatively common faunal element in strata of Guadalupian age, but are extremely rare in the younger Permian.

Rigby and Terrell (1973) describe the occurrences of the sponges Scheiia tuberosa, Haplistion arcticum, H. latituba, H. diactinum, and Raanespongia monilis from the
Assistance formation. The Assistance formation is Roadian at the type locality but considered to be Artinskian where the sponges were collected. Though sponges are common at Black Rock, the sponges described by Rigby and Terrell are not found in northwestern Nevada.

Summary of Correlations

In the West Texas section, Black Rock seems most similar to the Road Canyon formation (Late Leonard). The lowermost Word is not excluded from consideration at this time. According to Waterhouse and Bonham-Carter (1972), the Roadian in Texas is correlative with lowermost Kungurian in Russia.

In the Rocky Mountains, the Rex Chert (Spirifer pulcher) fauna of Phosphoria age is most similar. The fauna is also very much like the Nosoni and Dekkas formations of California, and the Coyote Butte fauna of Oregon. The Reeves and Robinson formations are also probably correlative. The nearby Bilk Limestone at Quinn River Crossing is also equivalent. In Canada and the Arctic, portions of the Cache Creek Group, Sicker Group, Ishbel Group, Takandit formation, and the Assistance formation are paleontologically very similar. See correlation chart (Figure 6) for a synopsis of important correlations with Black Rock.
## Correlation of Permian Units in Western North America

(Modified from McGugan, Ross, and Danner, 1963)

<table>
<thead>
<tr>
<th>Permian System</th>
<th>Standard American Section</th>
<th>Canadian Arctic</th>
<th>Yukon Territory</th>
<th>Canadian Pacific Coast and B.C.</th>
<th>Oregon</th>
<th>Northern California</th>
<th>Northwestern Nevada</th>
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<td>Unnamed Carbonate</td>
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<td>Upper Chilwack Group</td>
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<td>Assistance FM.</td>
<td>Takhandit FM.</td>
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<td>Dekkas and Nosoni FMS</td>
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**CORRELATION OF PERMIAN UNITS IN WESTERN NORTH AMERICA**
Faunal Communities

Two significant fossiliferous horizons ($B_1$ and $F_1$) occur at Black Rock. The faunules represent two very different types of assemblages. Locality $B_1$ is a biocoenosis (an assemblage of organisms that lived together as an interrelated community; Krumbein and Sloss, 1963, p. 277). Locality $F_1$ is a thanatocoenosis (a group of organisms brought together after death; Krumbein and Sloss, 1963, p. 277). Further clarification of these concepts as they are applied to the Black Rock faunules is discussed below.

Anidanthus-Spiriferella Faunule (Locality $B_1$)

Anidanthus is easily identifiable, and Spiriferella is very abundant. The dominant constituents of the faunule are Spiriferid and Productid brachiopods. Sponges and Bryozoans are almost as common as the Brachiopods. Trilobites, corals, and pelecypods are represented but are not as common. The faunule is predominantly epifaunal, and probably represents a subtidal community. A complete list of the faunule is included in Table 1. Coogan (1960) recognizes an Anidanthus-Spiriferella faunule from the Nosoni formation of California; however, many of the constituent members are different.

Medlicottia Faunule (Locality $F_1$)

Only one specimen of Medlicottia has been found to date, but the specimen is one of the few identifiable
members of this faunule. *Echinococonchus* and *Allotropiophyllum* also occur in this horizon. Numerous indeterminable brachiopod fragments, corals, and gastropod steinkerns were found at this locality. The sandy nature of the horizon and the numerous broken fragments suggest a reworked environment.

**Patch Reefs**

The population density of invertebrates in Unit B at Black Rock is very high. Sponges are seen to grow in close masses. Bryozoans encrust brachiopods and pelycepods. Some of the larger brachiopods appear to be deformed possibly through crowding during growth.

A patch reef as discussed by Ladd (1969) is formed where reef organisms are settled on a relatively firm foundation in shallow waters. These isolated patches usually lack typical reef features such as lagoons and forereefs.

The most strongly represented fossils in the *Anidanthus-Spiriferella* faunule are the sponges, bryozoans, and articulate brachiopods. This combination of fossils is common in the patch reefs of West Texas. The Road Canyon formation is the last of the small bioherms or patch reefs (Cooper and Grant, 1972, p.117).

Heckel (1974) restricts the use of the term 'reef' to buildups that "grow in the face of potentially destructive water turbulence. If no evidence of turbulent
water is apparent, then the positive topographic feature can be called a bank..."

The lack of winnowing of the mud suggests a bank type of environment. The composition of the fauna indicates open circulation and the rock type suggests relatively moderate energy.

Cascadian Paunule Province

It has long been recognized that some Permian Fusulinid localities in north and central British Columbia (Thompson, Wheeler, and Danner, 1950), southwestern British Columbia (Skinner and Wilde, 1966), northern Washington (Johnson and Danner, 1966; Skinner and Wilde, 1966), Oregon (Bostwick and Nestell, 1967; Bostwick and Koch, 1962), and California (Douglass, 1967) are closely related to Tethyan fusulinid faunas. These Tethyan Permian faunas have been compiled and discussed in detail by Bostwick and Nestell (1967) and indicated that Lower Permian faunas are dominated by non-Tethyan members of the subfamily Schwagerininae, whereas Middle and Upper Permian fusulinids usually belong to the subfamily Verbeekininae and Neoschwagerininae. Many of the genera of these subfamilies are considered to be 'Tethyan' in character. It has been suggested that the Middle and Upper Permian eugeosyncline was connected to the Tethyan Seaway (Dunbar, 1941). Danner (1965) suggests that the 'difference between the Tethyan faunas of North America, however, may be more that of an environmental facies than that of an isolated seaway'.

Though Tethyan affinities have long been noted, the Boreal aspect of westernmost North American faunas have not been as widely compared. Work by Stehli and Grant (1971) indicates that 16 brachiopod families are cosmopolitan in their distribution. The 'Cosmopolitan Dominant' families are: Schuchertellidae, Orthotetidae, Chonetidae, Marginiferidae, Echinoconchidae, Buxtoniidae, Dictyoclostidae, Linoproductidae, Stenoscismatidae, Rhynchoporidae, Athyrididae, Spiriferidae, Brachythyrididae, Spiriferinidae, Elythidae, and Dielasmatidae.

Faunal diversity ranges from low diversity in high latitudes and high diversity in low latitudes. Valentine (1973) cautions that though this hypothesis is well documented numerous parameters are involved and that diversity is not totally temperature dependent.

If the general hypothesis is true, Boreal faunas should yield less non-Cosmopolitan Dominant families than rapidly evolving, endemically oriented, higher diversity situations more characteristic of tropical or semi-tropical environments such as the Tethyan Realm. This relationship can be shown as a ratio:

\[
\frac{\text{Total Brachiopod Families Found}}{\text{Cosmopolitan Families Found}} - \frac{\text{non-Cosmopolitan Families Found}}{\text{Cosmopolitan Families Found}}
\]

(Stehli and Grant, 1971)

Stehli and Grant (1971) show that this ratio will yield a relatively low number for a Boreal fauna (0.33 for
central East Greenland) as compared to a higher number for a lower latitude situation (0.66 for Las Delicias, Mexico).

The main objection to the 'Permian Ratio' is that other paleoecological parameters may alter the validity of the ability for the ratio to express temperature sensitivity. For example, soft bottom faunas will yield lower ratios than faunas. The predominant Black Rock fauna (Anidanthus-Spiriferella fauna) represents a carbonate firm bottom fauna; therefore, Stehli's 'Permian Ratio' may apply. The 'Permian Ratio' for the Black Rock Anidanthus Spiriferella fauna is 0.31. This ratio indicates a low diversity for the Black Rock faunule.

Stehli and Grant (1971) have made the following generalizations about Permian Boreal Faunas: (1) 'The Permian Boreal consists only of cosmopolitan families (but not only Cosmopolitan Dominant families) that tend to evolve slowly'; (2) 'The Boreal fauna is a cold water fauna with bipolar distribution'; (3) 'The Boreal fauna tends to be dominated by Spiriferoids most of them large. Productids are the second most strongly represented group; large paucispinose forms are abundant, and small or spiney forms are rare'; (4) 'Genera which may be endemic to the Boreal assemblage are: Arctitreta, Craspedalosia, Horridonia, Kuvelousia, Licharewia, Pterospirifer, Odontospirifer, Septacamera, and probably
some genera of Syringothyridae; (5) 'Genera which are common but not endemic to the Boreal realm are Waagenoconcha, Kochiproductus, Liostella, Cancrinella, Yakovlevia, Stenoscisma, Camerisma, Rynchopora, Cleiothyridina, Spiriferella, Permophricodothyris and Dielasma'.

Examination of the 'Black Rock' specimens shows that Spiriferids are large and very common members. The genus Spiriferella in the West Texas section tends to be very small and not common (Cooper and Grant, 1972); however, at Black Rock large specimens are very abundant. The large oval Spiriferid Choristites does not occur in the United States but is common in the Arctic. The Productids also tend to be very large in size. The dominant productids are Kochiproductus, Waagenoconcha, and Anidanthus (very similar to Linoproductus). Other common brachiopods at Black Rock are large species of Stenoscisma, Cleiothyridina, and Rynchopora.

The preceding discussion strongly suggests a Boreal influence in the section at Black Rock. Reexamination of the Dekkas Formation (Coogan, 1960), Coyote Butte formation in Oregon (Cooper, 1957), the Cache Creek Formation in British Columbia (Kindle, 1926), and the Bilk Limestone in Nevada (Willden, 1964) suggests that these sections were also highly influenced by cool water effects. The faunas of westernmost North America represent a characteristic taxonomic composition which is not only influenced by American forms and Tethyan forms but also
Boreal forms. This suggests a rather distinct faunal province.

The cool water effects on these eugeosynclinal assemblages delimits a distinctive ecological province. The region is titled the 'Cascadian Faunal Province' in this paper.

The Permian is not the only period to which Boreal affinities are believed to have been extant in the invertebrate communities of westernmost North America. Portlandian (Late Jurassic) faunas from the 'Knoxville' formation in California are also closely allied with Boreal forms (Weaver, 1949). This faunal province is titled the 'Pacific-Boreal' Province by Sachs (1973).

Valentine and Meade (1961) and Addicott (1966) have shown that cool water molluscan forms migrated southerly during portions of Pleistocene time. Valentine (1955) describes cold water upwelling along the coast of Baja California which produces anomalously cool water faunas in normally warm oceanic waters. Along the coast of California at some localities, Valentine (1961) and Addicott (1966) have shown that Pleistocene ocean temperatures were considerably cooler than today, and many California coastal faunas contain both southern and northern ranging species. Figure 7 depicts the differences of molluscan faunal zonation in late Pleistocene to recent times.

A more complete faunal record from the western United States in Paleozoic and Mesozoic time would probably show
Figure 7

Near-shore marine climate

Late Pleistocene
Modern

COOL TEMPERATE

TEMPERATE

CALIFORNIA

WARM TEMPERATE

(With cyclic range of temperate to subtropical)

TEMPERATE

WARM TEMPERATE

SUBTROPICAL

TO TROPICAL

(Summer 1966)

TROPICAL

PLEISTOCENE VERSUS RECENT MARINE CLIMATIC ZONES

Addicott, 1966)
recurring incursions of cool water elements into this faunal province.

According to Ustritsky and Chernyak (1973), the boundary between the lower and upper Permian (Kungurian-Ufimian; Leonard-Guadalupian) in the Arctic is characterized by a faunal development which is related to a 'general sea transgression and establishment of a brief connection between the Arctic and Tethys seas'. This transgression also may be the cause of the influx of Tethyan and Boreal affinities into western North America.

Permian glaciation and worldwide cooling in Kungurian time (Shuchert, 1929; Waterhouse and Bonham-Carter, 1972) could account for the expansion of the Boreal Realm. Melting of the glacial ice pack would result in a marine transgression. Currents having come from these melfing ice fields would be markedly cooler. The resultant replacement of stenothermal faunal elements with more cold tolerant species accounts for the Boreal appearance of the Black Rock fauna. Cold water forms evolve at a much slower rate as compared to warmer, shallower, more closed marine systems such as the West Texas embayments. These cold currents could account for the longer residual Leonard aspect to the (Roadian) Oregon fauna (Cooper, 1957), the (Roadian) Dekkas fauna (Coogan, 1960), and the correlative fauna at Black Rock.
The Problem of Leptodus

The presence of members of the families Meekellidae, Richthofinidae, Lyttonidae, Lophyllidae, and Verbeekinidae is considered indicative of a Tethyan (warm water) facies (Stehli, 1971). Comparison of the Lyttonid Leptodus with the bivalve Tridacna led Cowen (1970, 1975) to suggest habitat requirements for the genus of shallow, warm, clear water. The presence of the warm water forms Leptodus and Meekella in the Black Rock fauna presents a conflicting situation when combined with the cold water forms of the fauna which have already been discussed.

In order to extend the number of ecological habitats in which Leptodus may occupy, it can be suggested that a comparable living form to the extinct brachiopod, are members of the pelecypod family Ostridae. Listed below are several important considerations.

(1) When brachiopod genera decreased after the Paleozoic, the unoccupied niches for attached brachiopods was in part reoccupied by the oysters, beginning in later Triassic time (Tasch, 1973).

(2) In gross form Leptodus and many oyster genera are quite similar.

(3) In the larval stage oysters are dityarian, but as adults the anterior muscle quickly atrophies. Leptodid musculature is often degenerate and assymetrically developed (Williams, 1953).
(4) In the feeding mode, the gap of the valves, of both oysters and Olhaminids, is very small. Oysters are known to have only a gap of 2-3.5 mm. at the ventral margins. The small gap keeps out intruders and allows for a relatively closed circulation system. The peculiar cardinal area for Lyttonids made large scale articulation impossible.

(5) The large lobate lophophore allowed for good circulation while filter feeding (Leptodus), just as the large ciliated gills of oysters efficiently strain suspended material.

(6) Both oysters and Leptodids have large, thick, heavy shells. The shape of the oyster shell is curved to conform mainly to the shape of the large gills, just as the peculiar Leptodid shell form conforms to the shape of the lophophore.

(7) Differences of sunlight, substrate, and crowding are believed to be the cause of polymorphism in oysters. Species of Leptodus are highly variable and probably the form is highly determinate upon the same parameters as those which affect oysters.

(8) Oysters commonly occur in accumulations above the general substrate, as fringe, string, or patch reefs. Oysters need a stable and firm substratum for attachment. Leptodids commonly formed patch reefs in West Texas (Grant and Stehli, 1969).
Oysters are distributed near the shores of all continents except in the polar regions. The large oyster *Ostrea gigas* occurs in reefs off Japan and occurs along the coast of North America from Baja California to Alaska. *Leptodus* has a cosmopolitan distribution on all continents. In the Western Hemisphere the brachiopod is known to range as far north as British Columbia and as far south as Ecuador. (Most of the data used on oysters can be found in the Treatise on Invertebrate Paleontology, Part N, Stenzel, 1971).

The genus *Leptodus* certainly was most successful in lower latitude, Tethyan habitats, but by analogy with oysters it is very difficult to confine them to that realm. Valentine and Meade (1961) recognized the occurrence of several Pleistocene mollusc localities where faunas contained both warm water and cool water elements. Though the precise implication of the presence of *Leptodus* as an element in the fauna of Black Rock is not clearly understood, it has been shown that the genus is highly adaptable and is probably not a conclusive stenothermal indicator in all cases.

Permian History in Western North America

The Cordilleran eugeosyncline is characterized by a shallowing trend throughout the lower Permian. By Middle Permian most known deposits are shallow water andesitic tuffs and lithic wackes much like the Black
### The Late Paleozoic Geologic History of Northwestern Nevada

**Correlations Modified from Langenheim and Larson, 1973**

<table>
<thead>
<tr>
<th>Pennsylvanian</th>
<th>Eugeosyncline</th>
<th>Miogeosyncline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ochoan</td>
<td>Sonoma Event</td>
</tr>
<tr>
<td></td>
<td>Guadalupian</td>
<td>Cassiar Orogeny</td>
</tr>
<tr>
<td></td>
<td>Leonardian</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wolfcampian</td>
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<tr>
<td></td>
<td>Kawvian</td>
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<tr>
<td></td>
<td>Oklan</td>
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<tr>
<td></td>
<td>Ardian</td>
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</tbody>
</table>

**Increasing Shallowness of Eugeosynclinal Environment**

- Black Rock Section
- Trenton Cyn. Mar.
- Jory Member
- Pumpernickel Fm.

**Edna Mountain Fm.**

**Antler Peak Limestone**
Rock section. Volcanism (Wheeler, 1939; McGugan, Roess, and Danner, 1964) was prolific and probably in thickness and extent was more impressive than the Tertiary Columbia Plateau basalts (Ross, 1938).

The andesitic eruptions must have taken place near the sea as explosive fragmental ejectamenta and tuffs are often associated with marine sedimentation. Such is the situation at Black Rock.

Middle Permian time was a period of development of many biohermal patch reefoid bodies in the shallow trough. The faunas that developed exhibit a combination of American, Tethyan, and Arctic faunal ('Russian') elements (McGugan, Roess, and Danner, 1964).

This faunal province, 'Cascadian' (this paper), is traceable throughout much of British Columbia (Cache Creek, Ishbel, and Sicker Groups), Washington, Oregon (Coyote Creek formation), western Idaho, northern California (Nosoni and Dekkas formations, Calaveras and Reeves? formations), and northwestern Nevada (Bilk Limestone, Black Rock section). Black Rock is the southernmost known exposure of Arctically influenced faunal elements.

Ustritsky and Chernyak (1973) recognized that Upper Permian 'faunal development is connected with a general sea transgression and establishment of a brief connection between the Arctic and Tethyan seas'.
Evidently the western coast of North America was also involved in the interconnection and received an influx of Arctic and Tethyan elements. As pointed out by Danner (1965), 'the difference between Tethyan faunas and other faunas of North America may be more of an environmental facies than that of an isolated seaway.'

After Guadalupian time, there is a period of folding, shearing, and batholithic intrusion (Cassiar Orogeny) from British Columbia down through Oregon (at least) (Dott, 1971; McGugan, Roess, and Danner, 1964). Locally in northern Nevada and possibly western Idaho there occurred concurrent gravity sliding commonly known as the Sonoma event (Silberling, 1973; MacMillan, 1972). Much of the eugeosyncline is characterized by an erosional interval during Lower and Middle Triassic time.

Summary and Conclusions

The Black Rock section consists of approximately 2,500 feet of Middle Permian andesitic flows, lithic volcanic wackes, and limestone. Two of the limestone horizons have yielded faunules.

The Anidanthus-Spiriferella faunule occurs in a skeletal peloidal wackestone. The palaeoenvironment is interpreted as being a bank or patch reef. Sponges, bryozoans, and brachiopods dominate the skeletal fraction. Accessory components include bivalves, corals, trilobites, and pelmatozoan columnals. The most abundant brachiopods
qualitatively are the Spiriferids, including the genera Spiriferella, Choristites (?), and Neospirifer. Productids are numerous also, the most common genera being Kochiproductus, Waagenoconcha, Muirwoodia, and Anidanthus. Three genera of the bizarre Permian Lytonnids are recognized: Leptodus, Keyserlingina (?), and Poililosakos(?).

Permian fossil assemblages in British Columbia, Washington, Oregon, Nevada, and California have long been recognized to contain Tethyan faunal elements. In addition to this Tethyan influence, Black Rock also exhibits Boreal characters. These characters are displayed by fossils occurring as extremely large individuals and low family diversity. This unique combination of Boreal, Tethyan, and American faunal elements delimits a broadly defined biofacies in the Cordilleran eugeosyncline. The region composed of these combinations of faunal elements is informally titled the 'Cascadian' faunal province in this paper. The province is quite likely an environmental facies strongly controlled by cool water currents.

The second collection of fossils, the Medlicottia faunule, was taken from a volcano-clastic dominated limestone. The ammonite Medlicottia, the brachiopod Echinoconchus, and the Hapsiphyllid coral Allotropiophyllum are the most distinctive elements of the fauna. Other members include indeterminate corals, gastropods, and brachiopods. The lithology is interpreted as a high energy beach type of environment and the faunule most probably represents a thanatocoenose.
Correlation of the Black Rock faunules suggests an uppermost Leonard (Road Canyon Formation) or lower Word age assignment. Portions of the Phosphoria (Rex Chert fauna) are also correlative with the Black Rock. Striking similarities with the Oregon Coyote Butte and California Nosoni faunas suggests further time equivalence. Other comparable faunas include portions of the (Bilkl) limestone near Quinn River Crossing in northwestern Nevada, the Robinson Formation in California, the Cache Creek Group in British Columbia, and the Assistance Formation in Arctic Canada.
DESCRIPTION OF SPECIMENS COLLECTED AT BLACK ROCK, NEVADA

Porifera

Plate B, Figures 1-3

Sponges collected from the Anidanthus-Spiriferella locality most certainly represent only one genus. With respect to external form, all specimens collected are ellipsoidal in transverse section, measuring 2-4 cm. in the greatest dimension. The narrowest dimension is usually about half the greatest dimension. In longitudinal section, the sponges are cylindrical. Fragmentary specimens have lengths of at least 8 to 10 centimeters. The sponges are similar in external form to the calcareous sponges Talaspongia and Wewokella.

The Treatise on Invertebrate Paleontology refers these genera to the siliceous sponge family Asteractinellidae (E93-94), characterized by a profuse number of sphaeraster spicules. The genera feature a cylindrical form, with the endosomal skeleton being finer textured in Talaspongia.

King (1943) erected a family, Wewokellidae, to include Wewokella and Talaspongia. The genera were considered by him to be calcisponges, the spicules being very large for silicisponges. He did note, however, that such complex spicules were unknown among the calcareous sponges. The Black Rock specimens are badly altered and the composition of sponge parts is unknown.
Coelenterata
Plate B, Figures 3-4

Corallite fragments are common from both the Anidan-thus-Spiriferella and Medlicottia collections. Unfortunately, the material is quite fragmentary. Famil determinations without the shape of the corallites, appearance in several growth stages, and longitudinal sections is extremely difficult.

A particularly complete section was identified questionably as Allotropiophyllum. The specimen displays the typical Hapsiphyllid characters of a fossula bounded laterally by cardinal lateral septum and axially by a wall consisting of fused axial ends of major septa of the counter quadrants (Plate B, Figure 3).

Bryozoa
Plate B, Figures 6-8

Bryozoa are very common as an element in the Anidanthus-Spiriferella faunule. Fenestrates are the most common form (Plate B, Figure 6). Most of the specimens collected can easily be assigned to the genera Fenestella and Polypora. Two varieties of Fenestella are recognized. The first variety occurs as medium sized fronds composed of very fine branches and dissepiments. The zooecia are in two rows. The second variety occurs as medium to large fronds, the branches being coarser than the first variety. The fenestrules are also more rounded rather than oval as in
the first variety.

*Polypora* forms coarse fans, with oval fenestrules. Disposition of the zooecia are irregular, but form roughly 3 to 5 rows, on branches and dissepiments (Plate B, Figure 7).

Fragments of ramose and massive forms are common also. The style of preservation at Black Rock inhibits the generic identification of these specimens. The ramose forms can be roughly broken into two groups. The first group occurs as coarse stalks (Plate B, Figure 7). The second group is finer stalked, with the zooecia being spaced much further apart.

*Acanthocladia* occurs as pinnately paired branches diverging perpendicularly from a main stalk, about every three millimeters. Zooecia are in three rows on branches. The details of the central stalk are unknown (Plate B, Figure 8).
Brachiopoda Dumeril, 1806

Class Articulata Huxley, 1869

Order Orthida Shuchert and Cooper, 1932
Suborder Orthidina Shuchert and Cooper, 1932
Superfamily Enteletacea Waagen, 1884
Family Enteletidae Waagen, 1884
Subfamily Enteletinae Waagen, 1884
Genus Enteletes Fischer De Waldheim, 1825

Enteletes cf. E. dumblei Girty

Plate C, Figures 1-2


Brachial valve large, very convex, hinge line short, valve with prominent, rounded plication on fold, with three lesser plications on each lateral flank; interior of valve with thin median septum.
Measurement in Millimeters

<table>
<thead>
<tr>
<th></th>
<th>Length</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Rock spec.</td>
<td>28 mm. est.</td>
<td>34 mm. est.</td>
</tr>
<tr>
<td>West Texas spec. Girty 1908</td>
<td>22 mm.</td>
<td>26 mm.</td>
</tr>
<tr>
<td>West Texas spec. King 1930</td>
<td>30 mm.</td>
<td>33 mm.</td>
</tr>
<tr>
<td>Sierra Diablo spec. Stehli 1954</td>
<td>26 mm.</td>
<td>27 mm.</td>
</tr>
</tbody>
</table>

**Discussion** - The genus *Enteletes* is rather distinctive, and the species is indicated by the specimen's large size, and the strength of the plications. According to Stehli (1954), the species is so highly variable that it is difficult to characterize, and understanding its range of variability can be gained only on an examination of a large series of specimens. In the comparison of measurements above, I have taken only the larger specimens from each locality. It can be seen that the Black Rock specimen appears to be larger than the other specimens. The 'Black Rock' section has yielded only one inner mold of a brachial valve, therefore, this highly variable species *E. dumblei* is only suggested.

**Locality** - $B_1$, talus slopes, *Anidanthus-Spiriferella* faunule.

**Specimen No.** - 7276

Order *Strophemenida* Opik, 1934
Suborder *Strophomenidina* Opik, 1934
Superfamily *Davidsoniacea* King, 1850
Family *Meekellidae* Stehli, 1954
Subfamily Meekellidae Stehli, 1954

Genus *Meekella* White and St. John, 1867

*Meekella* sp.

Plate C, Figures 3-5

Shell medium sized, subconical; pedicle valve low, gently convex, greatest width about mid valve, ornamentation consists of approximately 16-20 low plications which are themselves marked by 2 to 4 sharp but fine costa.

Measurements in Millimeters

<table>
<thead>
<tr>
<th></th>
<th>Length</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Rock spec. no. 7274</td>
<td>27 mm. est.</td>
<td>23 mm. est.</td>
</tr>
<tr>
<td>Black Rock spec. no. 7275</td>
<td>35 mm. est.</td>
<td>37 mm. est.</td>
</tr>
</tbody>
</table>

**Discussion** - *Meekella* is represented in the 'Black Rock' section by three fragmentary inner molds. Due to the great number of species that have been described, specific determination or even comparison is exceedingly difficult. The occurrence of *Meekella* in the westernmost United States has not been previously noted to this author's knowledge.

**Locality** - B1, talus slopes, Anidanthus-Spiriferella faunule.

**Specimen No.** - 7273, 7274, 7275

Family *Orthotetidae* Waagen, 1884

Subfamily *Derbyiinae* Stehli, 1954

Genus *Derbyia* Waagen, 1884

*Derbyia* sp.

Plate C, Figures 8-10
Shell small to medium, somewhat wider than long, valves biconvex, irregular. Pedicle valve strongly convex, widest just anterior of the hingeline, valve ornamentation of thin, sharp costa, separated by 2 to 6 very thin delicate costella; interarea large, triangular about 32 mm. wide at base by 30 mm. long in middle, interarea gently convex, deltidium strongly convex, with a shallow medial groove. Brachial valve more gently convex.

<table>
<thead>
<tr>
<th>Pedicle Valve</th>
<th>Brachial valve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>Width</td>
</tr>
<tr>
<td>Black Rock spec. a.</td>
<td>30 mm. est.</td>
</tr>
<tr>
<td>Black Rock spec. b</td>
<td>20 mm. est.</td>
</tr>
</tbody>
</table>

Discussion - This species is only from four fragmentary molds. No internal detail is available which leaves even the generic status of these specimens somewhat in doubt. Ornamentation is highly variable among the Streptorynchids, Orthotetids, and Derbyids.

Locality - B_1, talus slopes, Anidanthus-Spiriferella faunule.

Specimen No. - 7285A-D.

Derbyia cf. D. grandis Waagen

Plate C, Figure 7

This species is represented at Black Rock by one broken pedicle fragment only. Unfortunately, only the anterior portion of the shell is preserved so that the cardinal area is missing. A reconstruction of the shell would indicate that the animal was quite large, about
100 mm. wide with a proportionately large length. The ornamentation is quite strong, consisting of fine costae, numbering about 12-13 per centimeter at the ventral margin. Strong concentric undulations on the shell make the valve slightly irregular.

The species *Derbyia grandis* is strongly suggested because of the shell's exceedingly imposing size and the fine but strong costellae. A similar species *D. nasuta* is described from Texas by Girty (1908, p. 182-183, pl. 26, figs. 6-6c) and King (1930, p. 59-60, pl. 8, figs. 1-2). According to King (1930), *D. grandis* resembles *D. nasuta* closely in size, ornamentation, irregularity of growth, and shape and size of the cardinal process. *D. grandis* differs in having a hinge about as long as the greatest width of the shell and a narrower deltidium. The Black Rock specimen compares quite favorably with Harker and Thorsteinsson's (1960) figured specimen of *Derbyia cf. D. grandis* from the Canadian Arctic.

**Locality** - B1, talus slopes, Anidanthus-Spiriferella faunule.

**Specimen No.** - 7284

Suborder Chonetidina Muir-Wood, 1955

Superfamily Chonetacea Bronn, 1862

Family Chonetidae Bronn, 1862

Subfamily Rugosochonetinae Muir-Wood, 1962

Genus *Dyvoros* Stehli, 1954
(? Dyoros cf. Lissochonetes subliratus
Plate C, Figure 6

Lissochonetes cf. L. subliratus Girty, 1908

Chonetes subliratus King, The Geology of the Glass Mountains, Univ. of Texas Bull. 3042, pt. 2, p. 63-64, pl. 9, fig. 25; pl. 10, figs. 1-7.


This species is represented in the Black Rock collection by only one badly exfoliated pedicle valve. The pedicle valve is medium sized, wider than long, smooth, with deep angular sulcus surrounded laterally by large humps.

Stehli (1954) differentiates Dyoros from Lissochonetes on the basis of its larger size, pronounced fold and sulcus, spinose median septum, and a raised rim of papillae on the brachial valve.

Numerous species of Dyoros and Lissochonetes are similar to the Black Rock specimen. A comparison of these species is given by McKee, 1938, on p. 233. McKee's figure illustrates adequately that the Black Rock specimen is not
of adequate quality to definitively give the species title. The large size of the specimen is most like *L. subliratus* and *L. ostiolatus*. Of these two species the divergence of the humps is slightly more like *L. ostiolatus*. However, the depth of the sulcus is more like *L. subliratus*. Ears are present as in *L. subliratus*. Based on these features, *L. subliratus* is indicated as the species designation.

**Measurement in Millimeters**

<table>
<thead>
<tr>
<th></th>
<th>Length curved</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Rock spec.</td>
<td>18 mm.</td>
<td>30 mm. est.</td>
</tr>
</tbody>
</table>

**Locality** - B1, talus slopes, *Anidanthus-Spiriferella* faunule.

**Specimen No.** - 7282

**Suborder Productidina Waagen, 1883**

**Superfamily Strophalosiacea Shuchert, 1913**

**Aulostegid or Strophalosid**

**Plate C, Figure F**

A fragmentary specimen from Black Rock consists of a partial pedicle valve. The specimen is highly deformed; however, the specimen does appear to possess irregular rugae. The most striking feature of the shell is the numerous, small, irregularly spaced spine bases. The feature of rhizoid spines on an otherwise unornamented shell is characteristic of several families of the superfamily Strophalosiacea. These traits belong to members of both the families *Strophalosiidae* and *Aulostegidae*. 
Locality - B₁, talus slopes, Anidanthus-Spiriferella faunule.

Specimen No. - 7281

Family Aulostegidae Muir-Wood and Cooper, 1960

Rhamnaria sp.(?) Muir-Wood and Cooper, 1960

Plate C, Figure 12

Shell medium to large, pedicle valve ornamented with coarse, quincuncially arranged spines. The collection consists of numerous fragmentary casts and molds.

Discussion - The large size and peculiarly arranged spines strongly suggest this genus. Muir-Wood and Cooper assigned two species to this genus R. guadalupensis and R. kingorum.

Locality - B₁, talus slopes, Anidanthus-Spiriferella faunule.

Specimen No. - 7279A-D

Superfamily Productacea Stehli, 1954

Family Echinoconchidae Stehli, 1954

Genus Echinoconchus Weller, 1914

Echinoconchus' sp.

Plate D, Figures 1-2

This genus is represented by one almost complete interior of a brachial valve. Shell medium sized, suboval, wider than long, slightly concave. Cardinal process trilobed, with medial shaft deeply sulcated; thin median
septum over about three-quarters of visceral disc, small fold beginning about where medial septum ends, lateral septum thin, rounded; ornamentation consists of low rugae bearing a concentric row of medium sized spines; adductors scars faint lying just laterally to the median septum; brachial ridges non-existent.

**Measurement in Millimeters**

<table>
<thead>
<tr>
<th></th>
<th>Length</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Rock (brachial valve)</td>
<td>40 mm. est.</td>
<td>60 mm. est.</td>
</tr>
</tbody>
</table>

**Discussion** - The genus 'Echinoconchus' is referred to in quotes because according to Muir-Wood and Cooper (1960, p. 243-244) the genus is restricted to the Mississippian. Cooper (1957) used the genus in his description of the Oregon fauna, but his specimen is smaller and narrower. As far as I know, Cooper's specimen has not yet been assigned to another genus. The Black Rock specimen also cannot be assigned another generic title. Meek's *Productus nevadensis* (1877) has been assigned the genus *Bathymyonia* and is very common in Nevada, Utah, Idaho, and other exposures of the Phosphoria formation. *Bathymyonia* differs from the Black Rock specimen in being much narrower and carrying a massive cardinal process, adductors being strongly dendritic, and long median septum.

**Locality** - F₁, Medlicottia faunule.

**Specimen No.** - 7280

Genus *Calliprotonia* Muir-Wood and Cooper, 1960
(?!) Calliprotonia sp.

Plate D, Figure 3

This genus is probably represented only by one partial fragment of the interior of a brachial valve. The valve is medium sized, subquadrate in outline, with massive posterior platform for the cardinal process. The most striking feature is the rather wide and deep 'prominent flange projecting ventrally' (Muir-Wood and Cooper, 1960), which acts as an extension of the heavy lateral ridge ('ear baffle', Muir-Wood and Cooper, 1960, p. 24, fig. 3B), becoming anteriorly an 'anterior marginal rim'. Lateral ridge and anterior rim covered heavily with recumbent spine bases. Prominent thin, median septum projects about three-quarters the length of the shell. Adductor scars deep, elongate oval. Brachial ridge lacking.

Discussion - The fragmental specimen available for study lacks many important features characteristic of Calliprotonia. The marginal rim is much more massive than the species C. renfrarum upon which the genus is based. The median septum is longer and the distinct brachial ridges are lacking. Brachial ridges are rare in the closely related genera Echinoconchus and Echinaria. In Echinoconchus and Echinaria the lateral ridges do not extend down to the lateral margins. Though the two species referred to this genus by Muir-Wood and Cooper (1960) do not agree on several major aspects, the Black Rock specimen is
referable to this genus at this time.

**Locality** - B1, talus slopes, Anidanthus-Spiriferella faunule.

**Specimen No.** - 7287

Subfamily Waagenoconchinae Muir-Wood and Cooper, 1960

Genus *Waagenoconcha* Chao, 1927

*Waagenoconcha* cf. *W. montpelierensis* Girty, 1910

Plate C, Figures 4-5


*Waagenoconcha montpelierensis* King, 1930, *Geology of the Glass Mountains*, Univ. of Texas Bull. 3042, p. 81, pl. 14, figs. 5-6.


**Waagenoconcha montpelierensis** Muir-Wood and Cooper, 1960, Productoidea, Geol. Soc. of Amer., Memoir 81, pl. 90, figs. 1-9.

Shells are medium sized, subcircular, greatest width is across the middle of the shell; pedicle valve is moderately convex in lateral profile, greatest convexity is in the umbonal region, umbo is strongly inflated, triangular, separated from the ears by steep lateral slopes; sulcus begins within the umbonal region shallow and narrow, becoming slightly wider anteriorly; ornamentation consists of fine quincuncially arranged spine bases, strong, concentric growth lines irregularly deposed.

Brachial valve subquadrate almost subrounded, flat in visceral area becoming shallowly concave to the anterior with very low, broad fold; interior of the brachial valve lateral ridges narrow but strongly developed about one-half the width of the hinge line, median septum narrow extending length of the visceral area; cardinal process with long shaft, trilobate.

**Discussion** - This species is common at Black Rock as is evident from the numerous broken fragments. The species at Black Rock compares easily with specimens of W.
monpelierensis from West Texas, the Phosphoria formation, and the Kaibab formation.

According to Cooper (1957), W. parvispinosa from Oregon differs from W. monpelierensis in that the Oregon species is more deeply sulcate on the pedicle valve and has a more prominently folded brachial valve and finer spines. W. parvispinosa also tends to be smaller in general than the type specimen of W. monpelierensis. The Black Rock specimens tend to be larger than the type specimen.

Locality - B1, talus slopes, Anidanthus-Spiriferella faunule.

Specimen No. - 7269A-F

Waagenoconcha sp.

Plate D, Figures 6-7

Shell medium sized, elongate oval in outline, greatest width about three-quarters of the way anteriorly; pedicle valve is moderately convex, umbo region is highly inflated, finely and unevenly rugated on umbonal region; sulcus on midshell is low, very broad, almost indistinct; anterior of the shell sharply geniculated, finely rugated with small growth lines; shell ornamented with fine quincuncially arranged spines, coarsest at midvalve becoming finer, almost indistinct, towards the anterior.

Discussion - The shell referred to the genus Waagenoconcha consists of a partial fragment of a pedicle valve. Most species of the genus are characterized by an inflated,
triangular shaped umbo. King (1930) described a species, \textit{W. leonardensis} which is characterized by an almost sub-quadrate outline, with a much wider umbo. King's specimen is not geniculated as strongly anteriorly as the Black Rock specimen. One of Cooper's (et al., 1953) figured specimens (pl. 13, figs. 12-14) exhibit the Black Rock characters. Cooper includes this specimen in the highly variable species \textit{W. montpelierensis}.

**Locality** - B\textsubscript{1}, talus slopes, Anidanthus-Spiriferella faunule.

**Specimen No.** - 7286A-B

**Family Buxtonidae Muir-Wood and Cooper, 1960**

**Genus Kochiproductus Dunbar, 1955**

\textit{Kochiproductus} sp.

**Plate E, Figures 7-9**

Shell, large; pedicle valve mildly convex, with long trail, valve medially sulcate, sulcus originating in umbonal region.

Brachial valve ornamented by strong costae, about 8 costae per five millimeters at midshell, finely to coarsely rugated, producing a reticulate pattern on the visceral area, trail and flanks more strongly rugated producing large swollen nodes, visceral area broad, flat, geniculating strongly on anterior flanks, trail long.

Interior of brachial valve with long trilobed cardinal process, lateral ridges strong, median septum thin,
extending about 30 millimeters anteriorly, adductor scars dendritic.

**Discussion** - *Kochiproductus* is identified from Black Rock based on the unusually large size and the long trilobate cardinal process. Though *Kochiproductus* is a very common element, only fragmentary material is available for identification. Cooper (1957) recognizes two species from the Oregon fauna, *K. transversus* and *K. cf. K. porrectus*, an Asian species upon which the genus is based. The two American forms, *K. peruvianus* and *K. victorioensis*, are much smaller (King, 1930). According to Muir-Wood and Cooper (1960), *Productus longus* Meek 1877 is a *Kochiproductus* from the Permian of Nevada; however, I have not been successful in locating a description of this species.

The Black Rock material shows a great deal of variation and generally they can be divided into two general ornamental types. One type is coarsely rugated which produces numerous nodes and ridges. The second type is characterized by coarser costae and highly reduced rugae. The finely rugated form is more like *K. cf. K. porrectus* Cooper (1957).

**Locality** - B₁, talus slopes, *Anidanthus-Spiriferella* faunule.

**Specimen No.** - 7299, 7300, 7301, 7302

**Family Linoproductidae** Stehli, 1954

**Subfamily Linoproductinae** Stehli, 1954

**Genus Anidanthus** Hill, 1950
Anidanthus cf. A. waagenianus Girty, 1908

Plate E, Figures 5-6

Productus waagenianus Girty, 1908, The Guadalupian Fauna, U.S.G.S. Prof. Paper 58, p. 253-254, pl. 12, figs. 6-7a.

Productus eucharis Girty, 1910, Fauna of the Park City Formation, U.S.G.S. Bull. 436, p. 28-29, pl. 2, figs. 3-4.

Marginifera eucharis Girty, 1927, in Geology of Part of Southeastern Idaho, U.S.G.S. Prof. Paper 152, p. 80, pl. 28, figs. 23-25.

Linoproductus waagenianus King, 1930, The Geology of the Glass Mountains, Texas, Univ. of Texas Bull. 3042, p. 77, pl. 17, figs. 10-15 (non figs. 11-15).

Shell medium sized, wide (about 38 mm.), anterior of shell missing. Pedicle valve consists of a cast, beak broken; ornamentation consists of costae, on umbo only, evenly spaced, numbering about 15 per centimeter; spine bases sparse, scattered.

Brachial valve consists of an interior mold, ears broken, median broadly sulcate, costellae slightly coarser than pedicle valve, numbering about 10 per centimeter, posterior portion of the valve wrinkled with rugae, sharp, irregular, about 5 per 5 millimeters; rugae separated by coarse lamellations. Lamellae is approximately the same thickness as costae, resulting in a reticulate pattern;
cardinal process small, buttressed by cardinal ridges forming thickened hinge line; adductor scars ovoid, about 4 millimeters long by 2 millimeters wide, diverging away from each other anteriorly at about a 60 degree angle.

**Discussion** - According to Muir-Wood and Cooper (1960), 'Productus waagenianus Girty 1908 from the Permian of the Guadalupe Mountains, Texas, is probably an Anidanthus or Linoproductus but is certainly not a Megousia' (p. 310).

The genus Anidanthus as originally described by Hill (1950, p. 9) features the reticulate pattern on the brachial valve. Linoproductus may have a few broad rugae on the flanks and ears; however, they are not traceable across the venter. Based on these observations, the Black Rock specimen is assigned to the genus Anidanthus.

This specimen appears to be conspecific with specimens of *P. waagenianus* and *P. eucharis* described by Girty from the Phosphoria of Idaho and the Permian of West Texas. As King (1930) points out, 'Girty failed to compare *L. eucharis* and *L. waagenianus*... There is not a single important detail in which the descriptions and figures of the two differ'. Two specimens were collected from Black Rock and though they are only partial fragments, they represent rather large specimens when compared to Girty's figures (1908, 1910, 1927). King (1930) compares *L. waagenianus* with *L. aagardi* from the Urals and Spitzenbergen. He suggests that though the two species appear to be closely similar the American form has a
greater hinge line. Since the entire hinge line does not occur on the Black Rock specimens, distinction between these two species is not possible.

Anidanthus is a common element in the faunas of the westernmost United States. Cooper (1957) designated a new species A. minor from the fauna of Oregon. In his discussion, L. waagenianus was considered to be generically distinct from Anidanthus and excluded. However, the Tethyan form A. aagardi, which was considered to be almost synonymous with A. waagenianus, was discussed. 'The Russian form, however, is larger and less strongly convex than the American species. The costellae of the American species are stronger than the Russian form.' The Black Rock specimen is larger.

Coogan (1960) described a new species A. shastensis from the Nosoni formation of California. The characteristic feature on this species is the sinuate pedicle valve, which does not occur on the Black Rock specimens. The Black Rock specimen is also larger and much more alate.

J. S. Williams (Willden, 1964) also reported the occurrence of Anidanthus from the Bilk Limestone at Quinn River Crossing, Nevada. No description is available; therefore, a comparison is not possible.

The large size for the genus and the alate form suggest the species A. waagenianus (which is highly variable in size) or the similar Russian form A. aagardi.
Locality - E₁, talus slopes, Anidanthus-Spiriferella faunule.

Specimen No. - 7295A-C

Subfamily Paucispiniferinae Muir-Wood and Cooper, 1960

Genus Muirwoodia Likharev, 1947

Muirwoodia cf. M. multistriatus Meek

Plate E, Figures 1-4


Productus multistriatus Meek, 1877, Geol. Expl. of the 40th Parallel, v. 4, p. 76-78, pl. 8, figs. 3, 3a-3e.

Muirwoodia multistriata Muir-Wood and Cooper, 1960, Geol. Soc. Amer. Memoir 81, p. 322-323, pl. 120, figs. 1-8.

Shell medium sized, transverse, subtrapezohedral, widest along the hinge line; pedicle valve beak small, flattened, ears well developed, trail broken; sulcus starts on umbo, develops as a narrow, deep, rounded depression, flanks bounding costellate with about 3 costellae per millimeter.

Interior of brachial valve, cardinal process short and wide, lateral ridges well developed, median septum lacking, adductor scars two small prominent non-ornamented lobes, brachial ridges well developed; strainer spines numerous on anterior of shell, sharp fold with large globose sulci on lateral flanks.
Measurement in Millimeters

<table>
<thead>
<tr>
<th>Pedicle valve</th>
<th>Length</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Rock spec.</td>
<td>25 mm. est.</td>
<td>40 mm.</td>
</tr>
<tr>
<td>M. multistriata (Meek's type, King, 1930)</td>
<td>25 mm.</td>
<td>44 mm.</td>
</tr>
<tr>
<td>M. transversa (Cooper, 1957)</td>
<td>21.1 mm.</td>
<td>35.8+ mm.</td>
</tr>
</tbody>
</table>

Interior of Brachial valve

| Black Rock spec. | 20 mm. est. | 38 mm. est. |
| M. multistriata (Muir-Wood and Cooper, 1960) | 24 mm. | 41 mm. |

Discussion - The genus Muirwoodia is very similar externally to the genus Yakolevia Fredericks, 1925 (Muir-Wood and Cooper, 1960, p. 323). The Black Rock specimens compare favorably with Meek's (1877) described and figured specimens of P. multistriatus. The Black Rock specimens do not exhibit the large halteroid spines laterally off of the cardinal extremities, or anteriorly on either side of the median sulcus, but these portions of the shell are broken away.

The interior of the brachial valves in the Black Rock specimens differ from M. multistriata in lacking the dendritic adductor scars and the lack of development of the median septum. Muir-Wood and Cooper (1960) point out that the muscle scars are sometimes obscure, sometimes dendritic.

Cooper's (1957, p. 39-40, pl. 5A, figs. 1-13) specimens of the species M. transversa from Oregon are similar, but
according to Cooper are smaller and more strongly geniculated.

M. multistriata differs from Coogan's (1960) M. californica in that the former species is wider, has more pronounced ears, and lacks rugae on the lateral slopes.

Locality - B1, talus slopes, Anidanthus-Spiriferella faunule.

Specimen No. - 7296, 7297A-D

Suborder Oldhaminidina Williams, 1953

Superfamily Lyttoniacea Waagen, 1883

Family Lyttoniidae Waagen, 1883

Genus Leptodus Kayser, 1882

Leptodus sp.

Plate F, Figures 1-8

Shell large, deformed; pedicle valve mildly convex, wider anteriorly than posteriorly, rounded in outline, median septum runs the length of interior of valve, median septa not straight but bent and arched, septa bordered by longitudinal furrows about 2 mm. wide, pinnately paired septa directed laterally away from the medial furrows, arching towards the anterior, pinnately paired septa are spaced about 3 per centimeter, septa are separated by rounded, interspaces about 2 millimeters in width, interspaces bear a broad median longitudinal ridge, conspicuously lower than the adjacent septa but strongly enough developed so that a prominent groove lies on each side of it... in the bottom of each of the grooves lying beside
the septa, there is a row of regularly arranged pits about .75 mm. apart, which give rise to shallow longitudinal depressions (stripes) extending across the interseptal space and terminating at the crests of the septa, to which they give a strongly crenulate appearance (King, 1930, p. 103).

**Discussion** - It is suggested by King (1930) that several species of this genus are probably only just one highly variable species. The only real known difference between *L. nobilus* and *L. americanus* is the presence of a long, well developed median septum in the American species, whereas in the Asian form the posterior portion has been resorbed. In this respect, the Black Rock specimens are more highly aligned with the American form.

**Locality** - B1, talus slopes, Anidanthus-Spiriferella faunule.

**Specimen No.** - 7303A-W

**Family Poikilosakidae Williams, 1953**

**Genus Poikilosakos Watson, 1917**

**Poikilosakos sp. (?)**

Plate G, Figure 1

This genus, if present at Black Rock, is represented by only one partial internal pedicle valve. The shell is characterized by assymetrical lobation, with a slightly concave shape. The lobes are broad and, including the medial loop, number at least six pairs. The Treatise (1965)
classification indicates that with the median lobe there are three pairs; however, Williams' (1953, pl. 3, p. 285) diagrammatic representation of Oldhaminid morphogeny suggests that advanced Poikilosakos could easily have developed six pairs of lobes. Keyserlingina is also suggested but differs in the symmetrical development of the lobes and by not showing the large, shallow, frond-like development of the lobes.

**Locality** - B71, talus slopes, Anidanthus-Spiriferella faunule.

**Specimen No.** - 7304

Order Rhynchonellida Kuhn, 1949
Superfamily Stenoscismatacea Oehlert, 1887 (1883)
Family Stenoscismatidae Oehlert, 1887 (1883)
Subfamily Stenoscismatiniae Oehlert, 1887 (1883)
Genus Stenoscisma Conrad, 1839

*Stenoscisma cf. S. plicatum* (Kurorga)

Plate G, Figure 5

Shell large, widest at anterior; ornamentation consists of plicae, six in the deep, well defined sulcus, and an unknown number on the gently sloping lateral flanks.

**Discussion** - Though the generic characters such as internal features (the prominent spondylium and camophorium) upon which an unquestionable assignment can be made are lacking, the rynchonellid form and the unusually large size suggests *Stenoscisma*. The specimen even represents a large
species for this genus.

Girty (1908) and King (1930) describe a large species *Stenoscisma venustum*. Unfortunately, the anterior external form of this species is very much like that of *S. plicatum*. *S. venustum*, according to King (1930), has three to seven, but generally five, plica in the sulcus, with four to six more rounded ones on the flanks. Harker and Thorsteinsson's (1960) specimens are characterized by six plica in the sulcus, six or seven on the fold, and five or six on the flanks. Cooper's (1957) specimen of *S. cf. S. plicatum* has five plica in the sulcus and six on the flanks.

Coogan (1960) has a specimen from the Nosoni formation to which he has titled *Stenoscisma venusta* characterized by five to six large, sharp, rounded sinal plications and six rounded lateral plications. Unfortunately, Coogan did not compare his material to Cooper's (1957) from Oregon.

Due to the close proximity of the Oregon section (Cooper, 1957), *S. plicatum* is preferred as the species designation. It is truly unfortunate that Cooper (1957) did not compare his specimen against American form *S. venustum*, for both species exhibit so much variation that much is left uncertain.

**Locality** - B1, talus slopes, Anidanthus-Spiriferella faunule.

**Specimen No.** - 7291
Stenoscima sp.

Plate G, Figure 6

Shell large, ornamentation on the pedicle valve nine fine plicae in the sulcus, with seven wider spaced plicae on the convex, rounded flanks.

Discussion - This species differs from the specimen referred to S. plicatum in its smaller size and increased number of plicae.

Locality - B^1, talus slopes, Anidanthus-Spiriferella faunule.

Specimen No. - 7293

Superfamily Rynchoporacea Muir-Wood, 1955
Family Rynchoporidae Muir-Wood, 1955
Genus Rynchopora King, 1865
Rynchopora taylori (?) Girty, 1908
Plate G, Figures 3-4


Shell small, broken posteriorly, pentagonal in plan view of pedicle valve, greatest width about 4 mm. from geniculation at anterior surface, greatest thickness at anterior; pedicle valve ornamented with 23 costae, sulcus deep, broad, taking up about one-half the width of the shell,
seven costae in sulcus, tongue geniculated at right angles to sulcus; lateral flanks arched at very anterior, as a large plication, with eight costae on each flank; interior structure on pedicle valve, lateral septum two-thirds length of valve.

Measurements in Millimeters

<table>
<thead>
<tr>
<th>Species</th>
<th>Length</th>
<th>Width</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Rock spec.</td>
<td>10+ mm.</td>
<td>10 mm.</td>
<td>unknown</td>
</tr>
<tr>
<td><em>R. taylori</em> Girty, 1908</td>
<td>12 mm.</td>
<td>14.5 mm.</td>
<td>8.5 mm.</td>
</tr>
<tr>
<td><em>R. taylori</em> King, 1930</td>
<td>11 mm.</td>
<td>14 mm.</td>
<td>9 mm.</td>
</tr>
<tr>
<td><em>R. taylori</em> Coogan, 1960</td>
<td>12 mm.</td>
<td>14 mm.</td>
<td>7 mm.</td>
</tr>
<tr>
<td><em>R. magna</em> Cooper, 1957</td>
<td>18.6 mm.</td>
<td>20.9 mm.</td>
<td>17.5 mm.</td>
</tr>
</tbody>
</table>

Discussion - According to King (1930), the only difference between *R. taylori* and *R. illinoisensis* (described in Girty, 1915) is that the former species has a proportionately narrower fold, which has 1 or 2 less plications, while the lateral slopes are proportionately broader and have 1 to 3 more plications, the total number being the same in both species.

*R. magna* Cooper (1957) is much larger with wider fold and sulcus. Cooper's *Rynchopora* sp. A is approximately the same size as the Black Rock specimen but is too coarsely ribbed. Cooper considers his species A to be an accident; adulthood was achieved but the proper full size was not attained.

Locality - B₁, talus slopes, *Anidanthus-Spiriferella* faunule.
Specimen No. - 7298A, 7298B

Order Spiriferida Waagen, 1883
Suborder Athyrididina Boucot, Johnson and Staton, 1964
Superfamily Athyridacea M'Coy, 1844
Family Athyrididae M'Coy, 1844
Subfamily Athyridinae M'Coy, 1844
Genus Cleiothyridina Buckman, 1906

Cleiothyridina cf. C. subexpansa (Waagen)

Plate G, Figure 2

Shell large, transversely suboval, median of brachial valve with low broad fold; ornamentation broad, flat-lying, lamellar expansions terminated on the well-preserved portions of the shell with fine spinous fringes.

Measurements in Millimeters

<table>
<thead>
<tr>
<th></th>
<th>Length</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Rock spec.</td>
<td>28 mm.</td>
<td>50 mm. est.</td>
</tr>
</tbody>
</table>

Discussion - This specimen unfortunately consists of a partially fragmented, deformed brachial valve mold. This species of Cleiothyridina may be significant because no specimen from the Permian from the United States that I am aware of attains such large proportions. Harker and Thorsteinsson (1960, p. 73-74) figure a specimen from the Canadian Arctic which they have compared to C. subexpansa. Harker's specimen lacks the distinct fold; however, he does point out that Wiman (1914, Uber die Karbonbrachiopoden Spitzenbergens und Beeren Islands; Nova Acta Regiae Soc.
Sci. Upsaliensis, ser. 4, v. 3, no. 8, pl. 1) figures this species and the fold is clearly illustrated. Harker also compares other Arctic and Tethyan species to C. subexpansa. These references are not at my disposal and I must rely on the comparisons and descriptions of Harker and Thorsteinsson as being correct.

Locality - B_1, talus slopes, Anidanthus-Spiriferella faunule.

Specimen No. - 7290

Suborder Spiriferidina Waagen, 1883

Superfamily Cyrtiacea Frederiks, 1919 (1924)

Family Ambocceliidae George, 1931

Genus Crurithyris George, 1931

Crurithyris sp. (?)

This genus is probably represented in the Black Rock section. Several shell fragments show the small-sized, pear-shaped outline which is rather characteristic of the genus. Ornamentation is lacking.

Locality - Unit D

Specimen No. - 7294

Superfamily Spiriferacea King, 1846

Family Spiriferidae King, 1846

Genus Neospirifer Frederiks, 1919

Neospirifer cf. N. costella

Plate H, Figure 1
Specific identification or description is not possible due to the fragmentary and crushed nature of the material available. The genus is easily distinguished from Spiriferella due to its transverse form, lesser convexity of the pedicle valve, and the lower but broader interarea. The fasciculations contain numerous fine costae. The well-defined, angular, but shallow sulcus contains numerous costae with one well-defined costae at the very bottom of the sulcus.

Measurements in Millimeters

<table>
<thead>
<tr>
<th></th>
<th>Length</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Rock spec.</td>
<td>at least 33 mm.</td>
<td>48 mm. est.</td>
</tr>
<tr>
<td>N. costella King</td>
<td>35 mm.</td>
<td>50 mm.</td>
</tr>
</tbody>
</table>

Cooper (1957) described specimens of Neospirifer from the Oregon, but specific identification was not possible due to the fragmentary nature of that material. The specimens did differ, however, in their very finely ribbed nature. Coogan (1960, p. 256) describes specimens of Neospirifer to which he compared the species N. texanus Meek as a faunal component of the Nosoni formation. N. texanus is characterized by its greater length in proportion to its width, its short hinge line, and its high incurved beak (King, 1930, p. 117). These features do not typify the Black Rock specimens. The specimens are very much like N. costella King (1930). King suggests a strong similarity between his Texas specimens and the Tethyan form N. fasciger Keyserling.
Locality - B₁, talus slopes, Anidanthus-Spiriferella faunule.

Specimen No. - 7292A-E

Family Brachythrytididae Frederiks, 1919 (1924)

Genus Choristites Fischer de Waldheim, 1825

Choristites sp. (?)

Plate H, Figures 2-4

Shell large, wider than long, greatest width at about midvalve, transversely oval in outline; pedicle valve evenly convex, strongly incurved beak, large V-shaped sulcus, ornamentation fine even costae.

Brachial valve, low, evenly convex, with low rounded fold, ornamentation fine, evenly spaced, numerous growth lamellae.

Interior of pedicle valve with slightly divergent dental plates, small, slight medial septum. Brachial valve without crural plates but with slight medial septum.

Measurements in Millimeters

<table>
<thead>
<tr>
<th></th>
<th>Length</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Rock spec. A</td>
<td>45 mm.</td>
<td>62 mm.</td>
</tr>
<tr>
<td>B</td>
<td>35 mm.</td>
<td>48 mm.</td>
</tr>
<tr>
<td>C</td>
<td>47 mm.</td>
<td>68 mm.</td>
</tr>
<tr>
<td>D</td>
<td>56 mm.</td>
<td>76 mm.</td>
</tr>
<tr>
<td>E</td>
<td>40 mm.</td>
<td>54 mm.</td>
</tr>
</tbody>
</table>

Discussion - The generic assignment of these specimens is in much doubt. It is typical, though not a requirement,
of the family Spiriferidae, that the hinge line is the greatest width of the shell and a median septum is lacking. These anomalous features exclude the probability that the collection of molds taken from Black Rock are not members of that family. In the family Brachythryrididae the features of the genera Choristites and Purdonella are differentiated on the basis of cardinal area features, an area of the shells which is not preserved. Few species of American spiriferids reach the unusually large size these specimens suggest. Choristites is known to have a cosmopolitan range but is very rare in the United States. In Russia and the Canadian Arctic many species compare with a certain amount of success.

**Locality** - E₁, talus slopes, Anidanthus-Spiriferella faunule.

**Specimen No.** - 7315A-G

**Genus** Spiriferella Chernyshev, 1902

**Spiriferella** cf. *S. draschei* Toula

**Plate H, Figures 5-7**

Shell large, length and width roughly equal, shell thick, greatest width at midvalve, pedicle valve highly convex, beak incurved, small but tall interarea, sulcus narrow originating near posterior of umbo, deep, flat-bottomed; costae fasiculated into large plicae, five plicae per lateral flank, the plica nearest the sulcus strongest in intensity, size, and number of costae; strongest plica originates as one costa on beak, bifurcating with new costa at anterior of umbo,
within 5 millimeters a third costa bifurcates on lateral flank of plica, fourth costa originating from medial costa on interior flank.

Measurements in Millimeters

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Length</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Rock spec.</td>
<td>50 mm. est.</td>
<td>50 mm. est.</td>
</tr>
<tr>
<td>S. draschei (Cooper, 1957)</td>
<td>26.9 mm.</td>
<td>22.3 mm.</td>
</tr>
<tr>
<td>S. cf. S. polaris (Coogan, 1960)</td>
<td>38 mm.</td>
<td>20 mm.</td>
</tr>
<tr>
<td>S. scobinus (Meek, 1877)</td>
<td>48 mm.</td>
<td>50 mm.</td>
</tr>
<tr>
<td>S. sulcifer (King, 1930)</td>
<td>50 mm.</td>
<td>47 mm.</td>
</tr>
</tbody>
</table>

Discussion - Fragments of this species are very common at Black Rock; however, a complete specimen is unknown. This species compares well in shape and ornamentation with S. draschei described (Cooper, 1957) from the Permian of Oregon. The Oregon specimens, however, are only about half the size of the Black Rock specimens. Cooper states, however, that his specimens are much smaller than the types. According to Cooper, the species is known from the Cache Creek Group in British Columbia.

The Nosoni formation's S. cf. S. polaris does not have the distinct fasiculations, the size of the specimens are too small, and the general outline is trigonal rather than subquadrate.

Meek (1877) also describes a species S. scobinus from the Permian of Nevada. The specimens of S. scobinus were collected from a 'light colored Carboniferous limestone' at
latitude 40 degrees North, longitude 115 degrees West. I believe this locality comes from the Maverick Springs Range in northern White Pine County and is probably referable to the Park City Group there.

Meek's specimens, much like Coogan's, from California do not display the prominent fasiculation.

*S. sulcifer* from the Permian of West Texas (King, 1930) is large enough to qualify as the Black Rock species, but the costa are only grouped in three to four fasicles.

**Locality** - B, talus slope, Anidanthus-Spiriferella faunule.

**Specimen No.** - 7314A-G

*Spiriferella* sp.

Plate H, Figures 8-10

Shell large, much longer than wide, with steep sub-parallel flanks; pedicle valve with extremely incurved beak, costae fasiculated into low plicae, sulcus distinct, rounded, originating near the beak; costa bifurcate into three costae in umbonal region.

**Measurements in Millimeters**

<table>
<thead>
<tr>
<th>Description</th>
<th>Length</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Rock spec.</td>
<td>at least 60 mm.</td>
<td>35 mm.</td>
</tr>
<tr>
<td><em>S. parva</em> Cooper (1957)</td>
<td>22.7 mm.</td>
<td>14.9 mm. est.</td>
</tr>
</tbody>
</table>

**Discussion** - This species is distinct from the other species from Blok Rock *S. cf. S. draschei* in being laterally compressed, less curvature of the shell, more
rounded plicae, and more costae per fasiculation. *S. parva* from Oregon (Cooper, 1957) is similar in appearance but is much smaller and the plicae appear to be much more angular and distinct.

**Locality** - B1, talus slope, Anidanthus-Spiriferella faunule.

**Specimen No.** - 7309A-J

Superfamily Reticulariacea Waagen, 1883  
Family Elythidae Frederiks, 1919 (1924)  
Genus *Phricodothyris* George, 1932  
*Phricodothyris guadalupensis (?)* Shumard, 1859  
Plate G, Figures 7-8


*Squamularia guadalupensis* King, 1930, The Geology of the Glass Mountains, Texas, Univ. of Texas Bull. 3042, pt. 2, p. 118-119, pl. 40, figs. 4-lla.


Shell large, suboval, wider than long, greatest width at about seven millimeters from the hingeline; brachial
valve low, evenly convex, beak rounded, valve ornamented with strong rounded, evenly spaced rugae, about eight rugae per five millimeters.

Measurements of brachial valve

<table>
<thead>
<tr>
<th></th>
<th>Length</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Rock spec.</td>
<td>16 mm.</td>
<td>24 mm.</td>
</tr>
</tbody>
</table>

Discussion - This species is highly variable and very abundant in many Permian sections. *Phricodothyris* can only be distinguished from *Neophricadothyris* in that the latter has the spiralia posterolaterally directed. Species of *Phricodothyris* such as the Asian form *P. asiaticus* tend to be larger but the range of variation could very well overlap.

Locality - B\(^1\), talus slope, Anidanthus-Spiriferella faunule.

Specimen No. - 7307A-F

Suborder Terebratulidina Waagen, 1883
Superfamily Dielasmatacea Shuchert, 1913
Family Dielasmatidae Shuchert, 1913
Subfamily Dielasmatinae Shuchert, 1913

Genus *Dielasma* King, 1859

*Dielasma* sp. (?)

Plate G, Figure 9

This family is represented by a single mold of a brachial valve. The specimen illustrates the general Dielasmid form with a small medial fold anteriorly. Specimens described from Oregon (Cooper, 1957) tend to be much smaller.
Externally similar specimens from the Nosoni formation are Composita's and tend to be as wide as they are long.

Locality - B1, talus slope, Anidanthus-Spiriferella faunule.

Specimen No. - 7316A-B

BIVALVIA

Bivalves are common at Black Rock as they are at many Permian fossil localities. Presently the taxa is virtually useless in the Permian as a biostratigraphic tool. The material collected is of extremely poor quality and consists of a widely assorted collection of fragmental molds.

Acanthopecten sp. is the most common of the Bivalves (Plate I, Figure 1). The genus is characterized by the coarse costa which are regularly dissected by well developed growth lamellae, which are pointed ventrally as spines on the radial ornamentation. Two distinct forms are recognized. One form is medium-sized with small but sharply distinct interspaces between them. The spines are not well developed as they are in many species.

The second form has wide, low costa, which are medianly subdivided by thin sharply defined keels. Growth spines are very well developed. The Black Rock material appears to be closely related to A. delawarensis and A. coloradensis. The specific characters of these species is defined by Newell (1937, p. 75-76); however, specific details are not preserved on the Black Rock material.
One mold of *Annuliconcha* sp. has been collected (Plate I, Figure 2). Most other Bivalve fragments, though unidentifiable, can be roughly assigned to the Aviculopectinid group.

**Cephalopoda**

*Medlicottia* sp.?

Plate I, Figure D

The specimen collected represents an inner mold of a discoidal ammonite with flat flanks. The shell is probably not ornamented. The suture pattern is vividly visible everywhere but along the venter. This is unfortunate, for the two key characters of the genus are the furrow along the venter and the complex suture pattern on the first lateral lobe. The specimen was originally probably about 10 centimeters in diameter. The Medlicottids are so distinct in their characters that little doubt exists of the taxonomic placement of this specimen. Most of the genera of that family have characters which tend to exclude them from consideration.

**Locality** - F₁, Medlicottia faunule.

**Specimen No.** - 7320

**Phylum Arthropoda**

**Class Trilobita** Walch, 1771

**Order Ptychopariida** Swinnerton, 1915

**Suborder Illaenina** Jaanusson, 1959
Superfamily Proetacea Salter, 1864
Family Phillipsiidae Oehlert, 1886
Genus Pseudophillipsia Gemmellaro, 1892
Pseudophillipsia cf. Griffithides nosonensis Wheeler
Plate I, Figures 6-7


Specimen ellipsoidal, about 35 mm. long, 22 mm. wide across tips of genal spines, specimen with peripheral border, genal spines directed posteriorly about 5 segments, specimen with prominent undissected occipital lobe, distinct occipital lobes, cephalon of medium convexity; thorax nine segments, lateral lobes separated from axial lobe by sharp furrow, pleural lobes relatively flat, sloping steeply away laterally about mid-lobe, on lateral slopes segments directed slightly posteriorly. Pygidium highly arched, axial lobe with ten segments, pleural lobes with six segments, axial lobe evenly wide to the posterior, where it is highly rounded, pleural lobes highly arched, prominent.

Discussion - The Black Rock specimen compares almost identically with Wheeler's Nosoni specimen G. nosonensis.

Locality - B₁, Anidarthus-Spiriferella faunule.

Specimen No. - 7312
The only visible difference is the lack of glabellar furrows seen on the Nosoni formation specimen. The Nosoni specimen is lacking most of the pygidium, but the material available is compared favorably with the genus *Pseudo-phillipsia* showing the characteristic features of genal spines, expanded glabella, and depressed area between lateral preoccipital glabellar lobes. The pygidium of the Black Rock specimen, however, is more like that of *Delaria* short, with a reduced number of segments. Based on pygidial fragments alone, *Pseudophillipsia* cf. *G. nosonensis* would be assigned to *Delaria*.

The species is very common at Black Rock; however, most specimens are largely exfoliated, or consist of outer molds.

**Genus Neogriffithides Toumansky, 1935**

**Neogriffithides sp.**

*Plate I, Figure 8*

This genus is represented by two partial pygidial molds. The pygidium is small, highly tapered. The axial ridge is high, sharply sloping laterally. On the pleural lobes, the segments are directed sharply posteriorly.

**Locality - B₁, Anidanthus-Spiriferella faunule.**

**Specimen No. - 7310A-C**
REFERENCES


Chamberlain, C. K., 1970, Permian Trilobite Species from Central Wyoming and West Texas, Jour. of Paleo., v. 44, no. 6, p. 1049-1054.


Easton, W. H., 1960, Permian Corals from Nevada and California: Jour. of Paleo., v. 34, p. 570-583.


Finks, R. M., 1955, Conularia in a Sponge from the West Texas Permian: Jour. of Paleo., v. 29, no. 5, p. 831-836, pl. 82.


_________, 1910, The Fauna of the Phosphate Beds of the
King, P. B., 1931, The Geology of the Glass Mountains, Texas
Part 1: Descriptive Geology: Univ. of Texas Bull. 3038, 167 pp., 15 pl., map.


Miller, A. K., 1930, A New Ammonoid Fauna of Late Paleozoic Age from Western Texas: Jour. of Paleontology, v. 4, no. 4, p. 383-412, 2 pl.

________, 1945a, Some Exceptional Permian Ammonoids from West Texas: Jour. of Paleontology, v. 19, no. 1, p. 14-21, pl. 7-8.
_________, 1945b, Permian Nautiloids from the Glass Mountains and the Sierra Diablo of West Texas: Jour. of Paleontology, v. 19, no. 3, p. 282-294, pl. 44-45.

_________, and D. L. Clark, 1957, Permian Ammonoids from the Western United States: Jour. of Paleontology, v. 31, p. 1057-1068, pl. 133-134.


_________, and __________, 1957, Ammonoids of the Basal Word Formation, Glass Mountains, West Texas: Jour. of Paleontology, v. 31, no. 6, p. 1052-1056, pl. 133.

_________, and H. F. Garner, 1953, Permian Ammonoid Zones of the West Texas Region in Spring Field Trip to Chinati Mountains, Presidio County, Texas, May 28-30, 1953, West Texas Geol. Soc. (Guidebook)


Ross, C. A., 1959, The Wolfcamp Series (Permian) and New Species of Fusulinids, Glass Mountains, Texas: Jour. of the Washington Acad. of Sciences, v. 49, no. 9, p. 299-316, 4 pl.

____________, 1960, Fusulinids from the Hess Member of the Leonard Formation, Leonard Series (Permian), Glass Mountains, Texas: Contributions from the Cushman Foundation for Foraminiferal Research, v. 11, no. 4, p. 117-133, pl. 17-21.

____________, 1962, Fusulinids from the Leonard Formation (Permian), Western Glass Mountains, Texas: Contributions from the Cushman Foundation for Foraminiferal Research, v. 13, no. 1, 21 pp, 6 pl.


____________, 1963b, Fusulinids from the Word Formation (Permian), Glass Mountains, Texas: Contributions from Cushman Foundation for Foraminiferal Research, v. 14, no. 1, p. 17-31, pl. 3-5.

____________ and J. P. Ross, 1963a, Pennsylvanian, Permian Rugose Corals, Glass Mountains, Texas: Jour. of Paleontology, v. 36, no. 6, p. 1163-1188, pl. 160-163.

____________ and __________, 1963b, Late Paleozoic Rugose Corals, Glass Mountains, Texas: Jour. of Paleontology, v. 37, no. 2, p. 409, pl. 48-50.


Smith, S., 1935, Two Anthracolithic Corals from British Columbia and Related Species from the Tethys: Jour. of Paleo., v. 9, no. 1, p. 30-42.


Wilde, G. L., 1968, in Wilde, G. L. and R. G. Todd, Guada-


PLATE A

(A) View of the western exposure of Black Rock. Black Rock rises from the playa surface at the southwestern tip of the Black Rock Range. John C. Fremont named the prominent feature on January 2, 1844, describing the locality as a 'rocky cape, jagged-broken point, bare and torn. The rocks are volcanic, and the hills here have a burnt appearance-cinders and coals as at a Blacksmith's forge' (Jackson and Spence, 1970, The Expeditions of John Charles Fremont).

(B) Camera lucida sketch of the view in Figure A, showing stratigraphic units. The contact between Units A and B dips to the south, whereas all the other contacts dip steeply to the north. This relationship is not clearly seen in this perspective, but is measurable on a Brunton compass.
PLATE B
A. Asteractinellid (?) Sponge
(1) Transverse section through a typical sponge from the Anidanthus-Spiriferella faunule locality (X1). UNMSM 7319A.
(2) Oblique view of the exterior of a sponge (X1). UNMSM 7319B.
B. Allotropiophyllum sp. (?)
(3) Transverse section of a Zaphrentid type coral with shortened cardinal septum (personal communication, R. M. Jeffords, 7-10-75), X1.4. UNMSM 7272. Medlicottia locality.
(4) Longitudinal view of a large corallite taken from within ten feet of the contact of Units A and B, (X1.1). UNMSM 7308.
D. Fenestrate Bryozoan
(5) Typical fenestrate bryozoan. They are one of most common fossils occurring at Black Rock, reverse view (X1). UNMSM 7267. Anidanthus-Spiriferella locality.
E. Polypora and Ramose Form
(6) Coarsely fenestrate Polypora, obverse view, and finely stalked ramose form (X2). UNMSM 7263. Anidanthus-Spiriferella locality.
F. Acanthocladia sp.

(7) Bryozoa characterized by pinnately paired branches, reverse view (X1.8). UNMSM 7264. Anidanthus-Spiriferella locality.
PLATE C

A. **Enteletes cf. E. dumblei** Girty
   (1-2) Respectively, dorsal (X1) and posterior (X1.6) views. Plications are large and rounded. UNMSM 7276. **Anidanthus-Spiriferella** locality.

B. **Meekella** sp.
   (3) Cast of a pedicle valve (X1.2). UNMSM 7273. **Anidanthus-Spiriferella** locality.
   (4) Ventral view of a species very different from specimen No. 3 on this plate (X1.4). UNMSM 7275. **Anidanthus-Spiriferella** locality.
   (5) Third species of **Meekella** present at Black Rock (X1.4). UNMSM 7274. **Anidanthus-Spiriferella** locality.

C. (?) **Dyoros cf. Lissochonetes subliaratus** Girty
   (6) The taxon is represented by one exfoliated ventral valve (X1). UNMSM 7282. **Anidanthus-Spiriferella** locality.

D. **Derbyia** cf. D. *grandis* Waagen
   (7) Fragmentary pedicle valve clearly illustrating the unusually large size of this species (X1). UNMSM 7284. **Anidanthus-Spiriferella** locality.

E. **Derbyia** sp.
   (8) Clay squeeze of brachial valve and large triangular interarea of ventral valve (X1). UNMSM 7285A. **Anidanthus-Spiriferella** locality.
PLATE C

(9) Clay squeeze of pedicle valve of a larger specimen (X1.4). UNMSM 7285B. Anidanthus-Spiriferella locality.

(10) Latex cast of a dorsal valve (X1.4). UNMSM 7285C. Anidanthus-Spiriferella locality.

F. Aulostegid? or Stropholosid?

(11) Fragmentary pedicle valve (X1). The shell is unornamented with the exception of numerous rhizoid spine bases. UNMSM 7281. Anidanthus-Spiriferella locality.

G. Rhamnaria sp. (?)

(12) Pedicle valve with large quincuncially arranged spines (X1.2). UNMSM 7279A. Anidanthus-Spiriferella faunule.
A. 'Echinoconchus' sp.
   (1-2) Respectively, interior of a brachial valve (clay press), X1, and posterior view of the same brachial valve (touched up to highlight cardinal process), X2. UNMSM 7280. Medlicottia locality.

B. (?) Calliprotonia sp.
   (3) Interior of a brachial valve (X0.95). The single specimen is very questionably referred to this genus. UNMSM 7287. Anidanthus-Spiriferella locality.

C. Waagenoconcha montpelierensis
   (4) Adult pedicle valve (X1). UNMSM 7269A. Anidanthus-Spiriferella locality.
   (5) Fragmentary portion of brachial valve interior (X1.2). UNMSM 7269B. Anidanthus-Spiriferella locality.

D. Waagenoconcha sp.
   (6) Ventral valve (X1). UNMSM 7286A. Anidanthus-Spiriferella locality.
   (7) A mold of the exterior of a brachial valve (X1). UNMSM 7286B. Anidanthus-Spiriferella locality.
A. **Muirwoodia cf. M. multistriata**
   (1-3) Respectively, ventral view (X1), posterior (X1), and side view (X1). UNMSM 7297A. *Anidanthus-Spiriferella* faunule.
   (4) Interior of a brachial valve (latex cast), X0.9. UNMSM 7296. *Anidanthus-Spiriferella* locality.

B. **Anidanthus cf. A. waagenianus**
   (5) Ventral view (X0.9). UNMSM 7295A. *Anidanthus-Spiriferella* locality.
   (6) Internal cast of brachial valve (X1). UNMSM 7295B. *Anidanthus-Spiriferella* locality.

C. **Kochipruductus sp.**
   (7) Ventral view (X1). UNMSM 7299. *Anidanthus-Spiriferella* locality.
   (8) Inner mold of a brachial valve (X1). UNMSM 7302. *Anidanthus-Spiriferella* faunule.
   (9) Outer mold of a brachial valve (X1). Note the long shafted, trilobed cardinal process. UNMSM 7301. *Anidanthus-Spiriferella* locality.
A. Leptodus sp.

(1-2) Respectively, interior of a pedicle valve, including the small triangular area of articulation (XI.1), and a magnified view of the triangular area (clay press of former specimen), XI.8. UNMSM 7303E. Anidanthus-Spiriferella locality.

(3) Interior of a pedicle valve, the median septum appears to have been resorbed posteriorly, often considered to be a specific character of the Asian form, L. nobilis (Xl). UNMSM 7303R. Anidanthus-Spiriferella locality.

(4) A mold of the pedicle valve showing some finer details, striations and lateral grooves on the lateral septa (XI.1). UNMSM 7303A. Anidanthus-Spiriferella locality.

(5) Interior of a pedicle valve (Xl). UNMSM 7303C. Anidanthus-Spiriferella locality.

(6) Internal view of the septal plate. This specimen is a juvenile individual (X2.7). UNMSM 7303C. Anidanthus-Spiriferella locality.

(7) Internal mold of a ventral valve (Xl). UNMSM 7303N. Anidanthus-Spiriferella locality.

(8) Internal mold of a ventral valve (XI.2). UNMSM 7303V. Anidanthus-Spiriferella locality.

B. Lytonnid, genus and species indet.
(9) Interior of a ventral valve (Xl). The specimen possesses a peculiar median septum which terminates anteriorly as a large, round, prominent knob. UNMSM 7303L. *Anidanthus-Spiriferella* faunule.

C. *Keyserlingina* sp. (?)

(10) Internal mold of a ventral valve (Xl.1). UNMSM 7305. *Anidanthus-Spiriferella* locality.
A. Poikilosakos sp. (?)  
(1) View of the interior mold of a ventral valve (X1.1). UNMSM 7304. Anidanthus-Spiriferella locality.

B. Cleiothyridina cf. C. subexpansa  
(2) Dorsal view of a fragmentary cast (X1.2). UNMSM 7290. Anidanthus-Spiriferella locality.

C. Rynchopora taylori (?)  
(3) Anterior view (X2), showing lateral flanks arched at the anterior as large plications. UNMSM 7298A. Anidanthus-Spiriferella locality.  
(4) Interior mold of a pedicle valve (X1.8). UNMSM 7298B. Anidanthus-Spiriferella locality.

D. Stenoscisma cf. S. plicatum  
(5) Anterior view showing coarse, sharp plica (X1). UNMSM 7291. Anidanthus-Spiriferella locality.

E. Stenoscisma sp.  
(6) Pedicle valve (X1.2). UNMSM 7293B. Anidanthus-Spiriferella locality.

F. Phricodothyris guadalupensis (?)  
(7) Fragmentary inner mold of a ventral valve (X1.2). UNMSM 7307A. Anidanthus-Spiriferella locality.  
(8) Inner mold of a dorsal valve (X1.2). UNMSM 7307B. Anidanthus-Spiriferella locality.

G. Dielasma sp.?  
(9) Clay press of a ventral valve mold (X1.2).
PLATE G

UNMSM 7316A.
PLATE H

A. **Neospirifer** cf. **N. costellae**
   (1) Fragmental pedicle valve displaying alate form and fasiculated ornamentation (XI). UNMSM 7292A.

B. **Choristites** sp. (?)
   (2) An inner mold of a slightly deformed brachial valve (X0.95). The costae are faintly visible. UNMSM 7315A. *Anidanthus-Spiriferella* locality.

C. **Spiriferella** cf. **S. draschei**
   (5-6) Respectively, pedicle view (XI), and side view of same valve (XI.2). UNMSM 7314A. *Anidanthus-Spiriferella* locality.
   (7) Inner mold of a dorsal valve (XI). UNMSM 7314B. *Anidanthus-Spiriferella* locality.

D. **Spiriferella** sp.
   (8-10) Respectively, posterior view of pedicle valve (XI), ventral view (XI), and side view of same (XI). UNMSM 7309A. *Anidanthus-Spiriferella* locality.
PLATE I

A. Acanthopecten sp.
   (1) Latex cast of left valve (XI.1). UNMSM 7317A. Anidanthus-Spiriferella locality.

B. Annuliconcha sp.
   (2) Latex cast of left valve (XI). UNMSM 7318A. Anidanthus-Spiriferella locality.

C. Pelmatozoan Columnals
   (3) Pentagonocyclic columnals, with accessories joined (XI). UNMSM 7313A. Anidanthus-Spiriferella locality.
   (4) Pentagonocyclic column (X2). The lumen is very large. Photograph is retouched to highlight the visible features. UNMSM 7313E. Anidanthus-Spiriferella locality.

D. Medlicottia sp.
   (5) The specimen is preserved as a mold, the simple ammonitic sutures highlighted as deep grooves in the specimen (XI.2). UNMSM 7320. Medlicottia locality.

E. Pseudophillipsia nosonensis
   (7) View of pygidium and posterior segments (XI). View illustrates the change from a low arch in the
PLATE I

thoracic segments to a high arch in the pygidium (XI). UNMSM 7312B. Anidanthus-Spiriferella locality.

F. Neogriffithides sp.

(8) Fragment of a pygidium (XI). UNMSM 7311B. Anidanthus-Spiriferella faunule.