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Permo-Pennsylvanian strata of the western San Juan Mountains, Colorado

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Mountains. The general thinning of the unit to the southeast (fig. 12) extends the line of pinchout across the San Juan Basin of New Mexico and hence through the southern Black Mesa Basin of Arizona. Northwest of this line the dolomite becomes progressively thicker and exceeds 800 feet at the basinward edge of the shelf facies.

This unit is considered to be Kinderhook to Osage in age, and as noted above, apparently becomes younger to the northwest. In the Four Corners area subsurface the *Beta* member is thought to be of Kinderhook age.

PERMO-PENNSYLVANIAN STRATA of the WESTERN SAN JUAN MOUNTAINS COLORADO

By

Sherman A. Wengerd

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INTRODUCTION

Location of Region

The San Juan Mountain region occupies an area of almost 10,000 square miles in southwestern Colorado (fig. 1). The region is accessible by paved highways from Albuquerque, Denver, and Salt Lake City, yet embraces some of the most primitive and inaccessible wilderness in North America. Physiographically, the San Juan Mountain region lies along and forms the northeast boundary of the Colorado Plateau province. The region is one of majestic peaks, deeply glaciated valleys, roaring rivers, and the best exposure of Paleozoic rocks in the southwestern United States.

General Geologic Setting

Although the San Juan Mountain region exists as an entity because of isolational tectonic activity which occurred during Laramide and Tertiary time, it is a part of a much broader cratonic element which projected southwestward from the Canadian shield. This has been called Taosia by Mallory (1952, p. 90), but is perhaps better known as the San Luis highland (Wengerd and Strickland, 1954, p. 2191) inasmuch as it was an ancient highland, intermittently distributing clastic sediments, centering northwest and north of the San Luis Valley of Colorado.

The major negative feature during Pennsylvanian time was the Paradox Basin, which subsided across the high easterly pre-Pennsylvanian shelf of the Cordilleran geosyncline. Into this basin were poured hundreds of cubic miles of graywackic and arkosic clastics from the tectonically rejuvenated San Luis, Uncompahgre, and Peñasco (Read and Wood, 1947, p. 220) highlands, subsequent to rigorous evaporite conditions which generated the anomalous Paradox formation.

As the basin filled more rapidly than it subsided, the seas regressed differentially and the transition from predominantly marine Pennsylvanian strata to predominantly nonmarine Permian strata took place.

The San Juan Mountains lie across this San Luis shelf in an area of maximum facies gradation in the Pennsylvanian and Permian strata of the Four Corners region.

History of Stratigraphic Terminology

An historical summary of stratigraphic terminology utilized in subdividing and correlating the Pennsylvanian system in the Four Corners region prior to 1954 was presented by Wengerd and Strickland (1954, p. 2165-2175). A summary of these historical data follows:

Molas formation: – Named by Cross, Howe, and Ransome in 1905 for exposures at Molas Lake, near the Durango-Silverton "Million Dollar" Highway, in the Needle Mountains Quadrangle, San Juan Mountains, southwestern Colorado. These Atoka-Des Moines strata were not recognized by Spencer, who named the Hermosa formation in 1899 from exposures in the Hermosa and Animas Canyons north of Durango, Colorado.

Pinkerton Trail formation: – Named by Wengerd and Strickland in 1954 for exposures near Pinkerton Creek Trail in Section 26, T. 37 N., R. 9 W., west of the Denver and Rio Grande Railway approximately 12 miles north of Durango, La Plata County, Colorado. This new formation, which will be described fully in a later publication, is widely distributed in the Four Corners region, and encompasses the "lower Hermosa" in the terminology of Bass (1944), and Herman and Barkell (1957).

Paradox formation: – First described by Peale in 1875 from a measured partial section at the head of Salt Creek in the Sinbad Valley near the La Sal Mountains, on the Utah-Colorado state line (Borden, 1952, p. 27). Coffin applied the term "gypsum series" to these beds in 1921, but the regional extent of the sequence was recognized by Baker in 1933, near Moab,

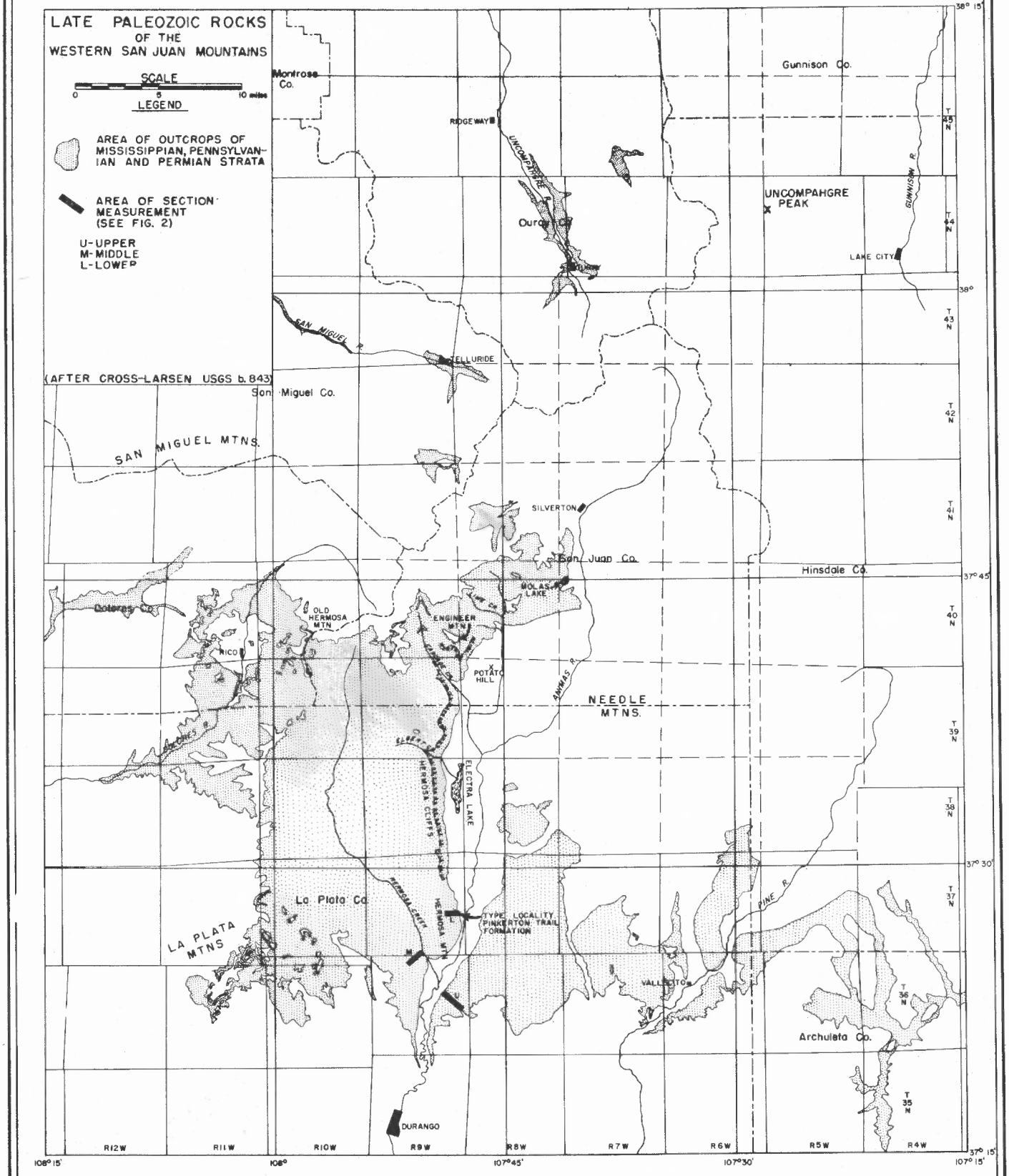
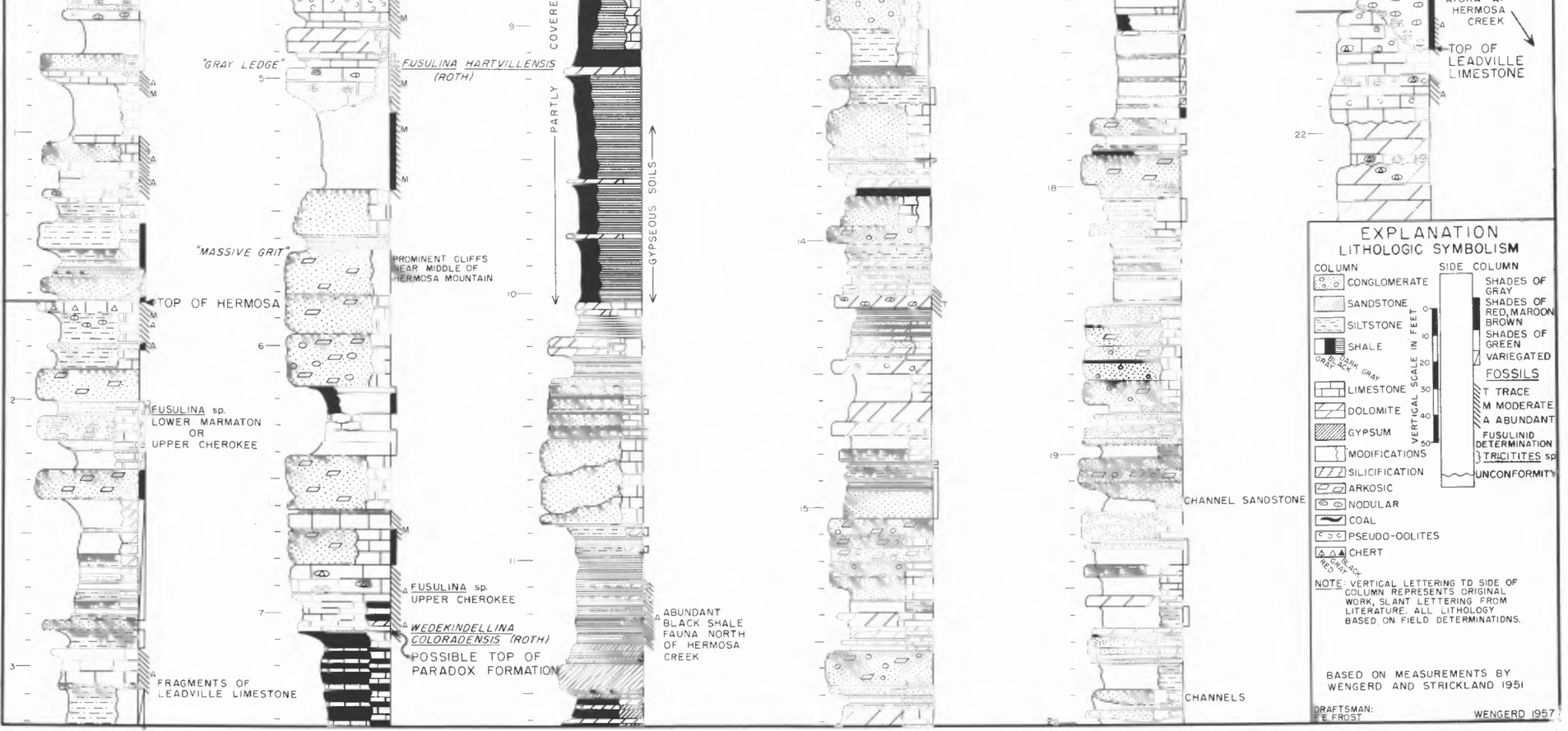


FIG. 1

Drafted by: F.E. FROST

WENGERD 1957

Late Paleozoic Rocks of the Western San Juan Mountains


"GRAY LEDGE"
FUSULINA HARTVILLENSIS (ROTH)
"MASSIVE GRIT"
PROMINENT CLIFFS NEAR MIDDLE OF HERMOSA MOUNTAIN
TOP OF HERMOSA
FUSULINA sp. LOWER MARMATON OR UPPER CHEROKEE
FUSULINA sp. UPPER CHEROKEE
WEDEKINDELLINA COLORADENSIS (ROTH)
POSSIBLE TOP OF PARADOX FORMATION
FRAGMENTS OF LEADVILLE LIMESTONE
PARTLY COVERED
GYPSEOUS SOILS
ABUNDANT BLACK SHALE FAUNA NORTH OF HERMOSA CREEK
CHANNEL SANDSTONE
CHANNELS
TOP OF LEADVILLE LIMESTONE
EXPLANATION
LITHOLOGIC SYMBOLISM
COLUMN
CONGLOMERATE
SANDSTONE
SILTSTONE
SHALE
BL DARK GRAY BLACK GRAY
LIMESTONE
DOLOMITE
GYPSUM
MODIFICATIONS
SILICIFICATION
ARKOSIC
NODULAR
COAL
PSEUDO-OOLITES
CHERT
GRAY BLACK RED
SIDE COLUMN
VERTICAL SCALE IN FEET
0
10
20
30
40
50
SHADES OF GRAY
SHADES OF RED, MAROON BROWN
SHADES OF GREEN
VARIEGATED
FOSSILS
T TRACE
M MODERATE
A ABUNDANT
FUSULINID DETERMINATION
TRICITITES sp
UNCONFORMITY
NOTE: VERTICAL LETTERING TO SIDE OF COLUMN REPRESENTS ORIGINAL WORK, SLANT LETTERING FROM LITERATURE. ALL LITHOLOGY BASED ON FIELD DETERMINATIONS.
BASED ON MEASUREMENTS BY WENGERD AND STRICKLAND 1951
DRAFTSMAN: E.E. FROST
WENGERD 1957

Utah, and it was named the Paradox formation by Baker, Dane, and Reeside (1933, p. 963). Bass (1944) reduced the Paradox sequence to member status, and it was considered by Borden to be a wedge in the lower part of the Hermosa formation (Borden, 1952, p. 27). Additional surface data since 1952, plus a careful study of outcrop sections on the Monument upwarp and in the San Juan uplift at Hermosa Mountain, Rico, and Ouray, led Wengerd and Strickland (1954, p. 2166) to suggest that the Paradox section could be easily recognized as a mappable formation. Although reversion to the member status for Paradox beds is recommended by Herman and Barkell (1957, p. 867), the presently confused terminology which now exists among stratigraphers of the Four Corners region leads the present writer to suggest that the Paradox strata be considered a valid mappable formation of regional extent.

Hermosa formation: – First named by Spencer in 1899 and used as a mappable formation by Cross and Spencer in 1900. This formation originally included all strata from the top of the Rico to the top of the Leadville limestone, which Spencer considered to be of Devonian age. Roth measured and described the Hermosa strata in Sections 26 and 35, T. 37 N., R. 9 W., La Plata County, Colorado (1934, p. 945); inasmuch as Spencer had not given an exact type locality, Roth suggested that the outcrops on Hermosa Mountain and surrounding area near the junction of Hermosa Creek and the Animas River, north of Durango, Colorado, be designated the type locality. This section was remeasured by Bass (1944) and measured in great detail by Wengerd and Strickland (1954) (see fig. 2 of this paper).

Rico formation: – First described by Cross in 1899, following work by Spencer at the type locality in the Rico Mountains near Rico, Colorado, these strata, regardless of age, are a mappable transition zone between marine and nonmarine facies in almost the entire Four Corners region. Gregory (1938, p. 38-39) considered the Rico formation of the Monument upwarp area to be of Permian age, whereas later correlations by Turnbow (1955, p. 69) resulted in lumping the Rico facies into the upper Hermosa and an assignment to the late Pennsylvanian. Henbest (1948) found Des Moines fusulinids in this transition zone near Moab, Utah.

Wengerd and Strickland (1954, p. 2175) recognized that the Rico facies were transitional, but that they could be recognized over appreciable distances. They recommended that the Rico formation be considered a basal member of the Cutler formation; this assignment met with justifiable disapproval by Herman and Sharps (1956, p. 81). Later the formation was disregarded altogether (Herman and Barkell, 1957, p. 872), following Turnbow's work (1955, p. 66).

Following is a tabulation of the older Pennsylvanian terminology as compared to the Pennsylvanian formational nomenclature resulting from recent investigations, to be published in the near future by Wengerd and Matheny in the A. A. P. G. Symposium of "Pennsylvanian System of North America."

Older Terminology	Recent Investigation
Cutler formation	Cutler group
Cedar Mesa member	Cedar Mesa formation
Halgaito member	Halgaito formation
	Hermosa group
Rico member	Rico formation
Hermosa formation	
Upper Hermosa member	Hermosa formation
Paradox member	Paradox formation
Lower Hermosa member	Pinkerton Trail formation
Molas formation	Molas formation
Leadville limestone	Leadville limestone

Stratigraphy

The total Permo-Pennsylvanian stratigraphic section ranges from 3,500 to 4,500 feet in thickness in the western San Juan Mountains. Within these strata, ranging through the upper Hermosa, Rico, and Cutler in different parts of the San Juan region, lies the Permian-Pennsylvanian temporal boundary. The base of the section is well-defined as the eroded top of the Leadville (Madison) limestone, whereas the top is rather easily chosen at the base of the Shinarump sandstone, or the base of the Dolores formation as previously used. Both these surfaces, throughout much of the region excepting where altered by hydrothermal activity or covered by volcanic rocks, are mappable (fig. 1).

Molas formation

The Molas formation at its type locality comprises red siltstone, waxy brown shale, thin- to massive-bedded buff arkosic granulite near the center of the section, brown limy siltstone, nodular shale, and, near its base, a transition section of limy red shale containing abundant rounded Leadville limestone pebbles, cobbles, and boulders. The Molas formation is 116 feet thick at the Molas type locality, and lies on the eroded karstic Leadville limestone. Some of these Molas detritals filtered downward as much as 100 feet into solution-enlarged joints and bedding planes of the Leadville limestone.

The Molas ranges from 40 to 120 feet in thickness in the western San Juan Mountains and is correlative with the lower part of the Pennsylvanian Sandia formation in New Mexico. At Ouray, in Box Canyon, the formation is 65 feet thick. At the type locality, the Molas is almost wholly of Des Moines age, whereas to the south between Bakers Bridge and Columbine in the Animas Valley, it is mainly of Atoka age with only the uppermost lentils being of early Cherokee (Des Moines) age (fig. 2).

The discovery of a comparatively rich marine fauna of brachiopods, pelecypods, fusulinids, and trilobites of Cherokee age in the upper 30 feet of the formation at the type locality, plus the predominantly red color of the formation similar to the infiltered "terra rossa" soils which are found below the deeply solution-pitted top of the Leadville, suggest rather strongly that the Molas is mainly an old soil profile, the upper part of which was reworked by the advancing latest Atoka to earliest Des Moines seas.

Pinkerton Trail Formation

This formation, named by Wengerd and Strickland (1954) from a type locality in Sec. 26, T. 37 N., R. 9 W., in a steep valley cut into the base of the El Rancho Encantado cliffs west of the Denver and Rio Grande railway tracks, is about 84 feet thick. It comprises gray siliceous limestone, dark-gray silty shale, very dark-gray clay shale, and clayey limestone with abundant fossils. At the type locality, the formation contains the Atoka-Des Moines time surface (fig. 2). The formation ranges from 40 to 100 feet in thickness in the western San Juan Mountains. It is correlative with the middle part of the Sandia formation in north-central New Mexico and is found in almost all deep wells drilled in the Paradox basin and on its shelves.

Although there are notable gradations in lithology over wide distances, the relative constancy of its thickness, its shelf-assemblage faunal content, and its shelf-type lithologies suggest that this critical pre-Paradox formation is the last Pennsylvanian deposit to have been made under sedimentational controls exerted by the shelf of the Cordilleran geosyncline. As such it records a very important part of pre-Paradox history during which the first sedimentational barriers for the Paradox evaporite seas were formed.

Paradox formation

The Paradox formation is wholly of Cherokee age and is divisible into three members over wide reaches of the Four Corners region, both inside and outside of the Paradox salt wedges. The three members record a basinal penesaline-saline-penesaline megacycle which was deposited rapidly, particularly the middle salt member. The formation grades southwestward into normal high-shelf dolomite through the classical facies gradations of anhydrite-gypsum, dolomite, reefing dolomitized carbonates, thence to high-shelf disconformities. These lithologies are related to the rates of subsidence, evaporation, and clastic inflow from the low positive Zuni-Defiance-Kaibabelement to the southwest and the higher Uncompahgre-San Luis-Peñasco uplifts on the northeast.

Northeastward, in the region of the San Juan Mountains, the Paradox formation grades into fine-grained dark-gray shale, coarse arkosic San Luis-type arkosics, graywackic siltstone, limy to clayey dense dolomite, black gypseous shale, and several thin lentils of gypsum (fig. 2). The base of the formation, in the Columbine area of the Animas Valley, contains thin coal, carbonaceous shales with beautifully preserved plant leaves and stems, and several sandstone channels. These sedimentary characteristics are present also in other parts of the Four Corners region, but here in the San Juan Mountains they record particularly well the withdrawal of Pinkerton Trail seas and a short time of subaerial conditions prior to the vast basination of the Paradox geosyncline.

The Paradox formation, not as easily mapped in the San Juan Mountains as in the subsurface of the Paradox basin (because of cover as well as northeastward increase of coarse clastics), ranges from 600 to 1200 feet in thickness in the western San Juan Mountains. The facies can be recognized in the Ouray and Rico exposures, but the formation is best exposed in the Animas Valley (fig. 2).

The Paradox formation correlates with the upper Belden-lower Maroon of the Eagle-Gypsum basin in northwestern Colorado, with the upper Sandia-lower Madera of north-central New Mexico and with a part of the Naco-lower Supai of Arizona.

Hermosa Formation

This formation, formerly believed to represent the entire Pennsylvanian system excepting the Molas shale, was split off the top of the Pennsylvanian sequence by Wengerd and Strickland (1954, p. 2165-2166) following the earlier recognition of formational status for the Paradox strata (Baker, Dane, and Reeside, 1933, p. 963). This writer believes that the Hermosa should be raised

to group status, and that the section between the Paradox and the Rico should be given a new name.

The Hermosa formation comprises light- to dark-gray dense limestone, highly micaceous siltstone, silty graywacke, nodular clayey limestone, sandy limy dolomite, and thick wedge-like lentils of arkosic gritstone which grade southwestward into limy sandstone.

The Hermosa formation is about 660 feet thick in the Animas Canyon but ranges from 550 to 850 feet in thickness in the western San Juan Mountains. It is widely distributed in the Four Corners region and ranges from a high-shelf dolomite through normal stable shelf to unstable lithologies in the central part of the Paradox basin, to a highly graywackic-arkosic section near the Uncompahgre uplift, northwest of the San Juan Mountains.

The lower part of the Hermosa formation records the complete ventilation of the Paradox geosyncline after rigorous evaporitic conditions, whereas its upper more clastic part records the clastic filling of the basin which was to initiate forced regression of Pennsylvanian marine waters from the Four Corners region.

The Hermosa formation correlates with the Madera and Pennsylvanian part of the lower Abo in north-central New Mexico, with part of the Maroon, Gothic, and McCoy formations of the Eagle-Gypsum basin, and with part of the Supai formation in Arizona.

Rico Formation

The Rico formation is a transitional facies from Hermosa marine carbonates and clastics below to Cutler non-marine clastics above in the San Juan Mountain area. A rather complete summary of its lithology and age was given by Eckel and Williams (Eckel, 1949, p. 13, 21-24). Because the Rico comprises dense knarly greenish-gray limestone, red feldspathic sandstone, and red siltstone interbedded with thin fossiliferous limestone, it is a physical transition related to influx of nonmarine clastics coupled with regression of marine waters. The formation ranges from uppermost Des Moines, Missouri, Virgil, to Wolfcamp Hueco in age from areas immediately adjacent to the Uncompahgre-San Luis uplift, southwestward and northwestward into the Paradox Basin. In the Animas Canyon, the Rico transition is probably of Missouri age (fig. 2).

The Rico formation is between 100 and 200 feet thick in the western San Juan Mountains; however, Eckel (1949, p. 15) stated that he has measured 259 to 297 feet of these transitional beds. This is clearly a function of the height in the superjacent Cutler at which fossiliferous marine limestone lentils can be found, or the choice of a marine limestone for the top of the mappable Hermosa. Roth (1934), Bass (1944), and many others have attempted to delineate the Hermosa and Rico strictly on the basis of time surfaces. It is obvious that these lithologically mappable formations transgress time surfaces in complex responses to rates of basinal subsidence and tectonic uplift which control the relative ratio of basinally-produced sediment versus uplift-produced sediment. Because this is a function not only of time, but more importantly of distance and bottom conditions, these mappable units cannot be expected to be of the same age even within such a small area as the western San Juan Mountains.

Cutler Formation

The Cutler formation ranges from 1,500 to 2,200 feet in thickness in the western San Juan Mountains. It comprises red to brown limy sandstone, micaceous siltstone, feldspathic sandstone, arkose, nodular shale, and thin knarly fresh-water limestone of continental fluviatile origin.

The formation is described in detail by Eckel (1949, p. 16-19) from a measured section at Babcock Peak. It is overlain by Dolores strata (Shinarump to Chinle) by angular unconformity in the Ouray area at the type locality adjacent to Cutler Creek.

Near the coarse-sediment-supplying uplifts, the lower Cutler contains the Permian-Pennsylvanian time surface, indicating that a strong positive pulsation took place in the Uncompahgre-San Luis uplift as early as Missouri and Virgil time; this effect may not have been felt far basinward until the uplift accelerated into Wolfcamp time and caused regression of marine waters.

The Cutler formation contains fine to very coarse detritus from both the San Luis and Uncompahgre uplifts. The formation is probably wholly of Wolfcamp age where its lower lentils are not of Missouri or Virgil age. The Cutler is correlative with the upper Maroon of the central Colorado trough, the upper Weber sandstone of the Rangely area, with the lower Chupadera and Abo formations of north-central New Mexico, and with the Toroweap, Coconino, Hermit, and upper Supai of the Grand Canyon region.

Summary of Paleozoic Geologic History

The Pardox basin and the San Luis uplift are the ma-

jor ancient geologic features of the Four Corners region. The region contains sedimentary rocks ranging from Precambrian to Recent in age, with only the Ordovician and Silurian rocks notably absent. The Paradox basin and San Luis uplift have a complex marine sedimentational-tectonic history beginning in Pennsylvanian time, prior to which they were a part of the cratonic high shelf lying east of the Cordilleran miogeosyncline. During late Pennsylvanian time, pulsatory tectonism began to drive away the seas by vast alluviation from the disintegrating tectonic positives.

This complex structural history has led to several conflicting sets of names for the ancient positive and negative features as compared to the Laramide-Tertiary positive and negative features. The ancient uplifts and the Paradox basin are genetically related in time and space, and the disintegrational history of the region appears to be as follows: (1) simple marine shelf (pre-Pennsylvanian); (2) more localized Paradox geosyncline subsided obliquely across one sector of the San Luis shelf (Pennsylvanian); (3) great continental alluviation (late Pennsylvanian-early Permian); (4) peneplanation (late Permian). The San Juan Mountain region is thus a Laramide-Tertiary tectonic feature which lies athwart the steep San Luis shelf on the northeast flank of the Paradox basin.

Pre-Pennsylvanian Time

The area – the old San Luis uplift and the Paradox geosyncline of Pennsylvanian age–was a broad low-lying shelf to the pre-Pennsylvanian Cordilleran miogeosyncline whose deepest waters lay to the west and northwest. Alternately covered by thin, warm carbonate-depositing seas, which also deposited fine to medium quartzose clastics from the east, the deposited strata were episodically exposed to erosion to create widespread disconformities. This eastern cratonic shelf was the southwest part of, and epeirogenically controlled by, the San Luis positive area, itself a southwestern projection of the Siouxian sector of the interior craton of North America.

The basal Cambrian sediments contain rounded boulders in sectors where slight tectonic activity occurred along the edge of the San Luis uplift. However, most pre-Pennsylvanian sediments were deposited on a stable shelf with few coarse clastics moving from the low-lying San Luis uplift on the east into the Cordilleran miogeosyncline on the west.

Pre-Pennsylvanian formations include the Tintic-Ignacio sequence of doubtful Cambrian age; Devonian strata are represented by the Elbert and Ouray formations; and the Mississippian is represented by the Leadville limestone.

Pennsylvanian Time

During an initial time of positive shelf stability, from Springer to mid-Atoka time, weathering and erosion took place over the locale of the San Juan Mountains. During late Atoka to earliest Des Moines time, Molas and Pinkerton Trail marine strata were deposited. After slight uplift to subaerial conditions, the Paradox geosyncline began its ponderous subsidence, extending southeastward as one of the easternmost of the Cordilleran miogeosynclinal basins of deposition. Subsidence of the Paradox geosyncline appears to have been autogeosynclinal throughout most of Cherokee (early Des Moines) time, with medium-grained slightly arkosic to graywackic San Luis clastics interfingering with evaporite strata of the Paradox formation southwestward to northwestward from the San Luis highland. In late Des Moines (Marmaton) time, the Uncompahgre uplift on the northeast became tectonically active as renewed subsidence took place to form a post-Paradox clastic basin. A thick wedge of arkose was deposited along this tectonic mobile belt southwest of the Uncompahgre highland.

Toward the close of Pennsylvanian time, the marine seas began to withdraw southeastward into the Sonoran geosyncline, northwestward into the Oquirrh basin, and westward to the Cordilleran miogeosyncline. After considerable erosion of high-shelf sediments, shallow marine waters again transgressed briefly across the northwest and southeast areas of the Four Corners region during Wolfcamp time. Rather broad reaches of the Four Corners region are known to have Wolfcamp marine sediments correlative with coarse, arkosic, continental clastics that moved rapidly southwestward off the Uncompahgre uplift, and finally pushed the seas out as the region began a vast epeirogenic rise to be peneplaned.

Virtually the entire range of maximum sedimentational lithofacies gradations listed above took place during Cherokee time, both outside and for some distance inside the wedge-edges of Paradox salt. Marmaton, Missouri, and Virgil strata on the southwest shelf of the Paradox geosyncline are almost wholly thin-bedded clastics and carbonates of high-shelf origin. Correlative strata within the geosyncline, adjacent to the southwest flank of the San Luis and Uncompahgre uplifts,

are coarse-grained, "dumped" continental arkosic clastics.

The transition to Permian nonmarine strata is almost everywhere one of a complex and horizontally shifting vertical gradation from thin marine beds to predominantly red-bed facies. This transition facies, called the Rico formation, ranges from latest Des Moines to Hueco (Wolfcamp) age depending upon its geographic relation to the withdrawing seas and the clastic-shedding uplifts.

Permian Time

This last period of the Paleozoic era was one of continental deposition in the Four Corners region, mainly because of tectonism in the Ancestral (Colorado) Rockies which supplied abundant fine to coarse arkosic clastics. These tectonic elements were the rejuvenated San Luis uplift, the Peñasco (Nacimiento) uplift, the Uncompahgre uplift, and the lower-lying Zuni-Defiance uplift which was virtually completely covered by clastic continental Permian rocks.

Marine waters encroached the southeastern part of the Four Corners region during San Andres (post-Yeso) time, and the contemporaneous Kaibab seas encroached from the southwest and west over the westernmost part of the Four Corners region. However, the rapidity of clastic deposition from the Uncompahgre-San Luis-Peñasco uplifts kept the Permian depositional surface well above sea level over most of the site of previous marine deposition in the earlier Paradox geosyncline.

MESOZOIC STRATA FLANKING THE SOUTHWESTERN SAN JUAN MOUNTAINS COLORADO AND NEW MEXICO

By
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Mesozoic sedimentary rocks underlie most of the mesa and canyon country south, west, and northwest of the main mass of the San Juan Mountains. They extend into the mountains along the canyons of the Uncompahgre and San Miguel Rivers. Two well exposed sections of these Mesozoic rocks will be seen along the field trip route near Durango and north of Ouray, in the canyons of the Animas River and Uncompahgre River respectively. About 3½ miles north of the Durango Fiesta Grounds, a gray coarse-grained crossbedded sandstone (Shinarump or basal Chinle-Dolores) relatively conformably overlies the Permian Cutler redbeds, a typical lower contact relationship for the southwestern part of the area. The upper contact, between the Cretaceous and Tertiary rocks, is within the Animas formation in the Durango region. Near Silverton, and in much of the main mass of the San Juan Mountains, the Mesozoic beds are absent, and the early Tertiary Telluride conglomerate or younger volcanic units rest erosionally unconformably on various of the Paleozoic formations or the Precambrian rocks. North of Ouray the Triassic Dolores formation unconformably overlies the Cutler redbeds or the Hermosa formation, and the Telluride conglomerate or San Juan tuff rests unconformably on the Mancos shale and older beds. The upper and lower contacts of the Mesozoic strata on the west side of the San Juan Mountains and in the outlying Rico and San Miguel Mountains are similar to those near Ouray.

Although the Mesozoic rocks occur only on the flanks of the southwestern San Juan Mountains, having been removed by early Tertiary erosion, not deposited, or concealed beneath thousands of feet of volcanic rocks within the higher parts of the mountains, these strata are important in the adjacent areas to the south and west where they contain large amounts of gas, oil, uranium, and coal. The entrance route from Albuquerque to Durango crosses many outcrops of the Mesozoic beds as do the exit routes to Cortez and Pagosa Springs. To quote Larsen and Cross (1956, p. 48), "An excellent place to study the complete Mesozoic section is near Durango . . . and also farther east in the Ignacio quadrangle." To paraphrase our Morman friend Brigham Young – This is the place. This article, as planned, was to be written by an eminent authority on the Mesozoic strata of the area, one who has walked out the beds in the field. Unfortunate last-minute circumstances prevented this promised contribution from crystallizing; therefore the present material is a hectic compilation of previously published papers plus very little field checking.

HISTORICAL REVIEW

Some of the earliest descriptions of the Mesozoic rocks in this region were those by Cross and Purington (1899) in the Telluride folio, Cross and Spencer (1900) of the Rico Mountains, Cross et al. (1907) in the Ouray folio, and Cross and Hole (1910) in the Engineer Mountain folio. Near Ouray the Triassic beds were referred to the Dolores formation, and a sharp angular unconformity was noted at the base whereby fossiliferous Dolores conglomerates rest on inclined and beveled Cutler redbeds and marine Hermosa rocks. The Dolores consists of marl,