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PERMIAN STRATA OF CENTRAL NEW MEXICO

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The Permian system of central New Mexico is a colorful sequence of red beds, massive light-colored sandstones, carbonate rocks, and evaporites that resulted from deposition in complexly interrelated marine and continental environments. The Permian rocks outcrop along the Lucero uplift southwest of Albuquerque, in the Zuni Mountains southeast of Gallup, along the east flank of the Manzano and Sandia Mountains, and are rather extensive along the Nacimiento Mountains as far north as San Pedro Mountain near Cuba, New Mexico. The section has been penetrated by several deep wells in the southern part of the San Juan Basin and along the flanks of the Zuni uplift. The nature and spacing of both the outcrop and subsurface control is adequate to readily correlate the Permian strata from one outcrop area to the next within the general area of the 1961 Field Conference (see Fig. 1), for the stratigraphic changes are relatively simple and natural. Regional correlations are not so well established, however, and are the subject of some controversy. While it is not within the scope of this paper to discuss the regional relationships, the terminology and correlations will here be modeled after a rather extensive study of the Permian stratigraphy of the Colorado Plateau by Baars (1961, in press) which deals with these problems at some length.

The Permian rocks of central New Mexico generally overlie the Pennsylvanian system conformably. Transitional beds are present in the southern part of the area that are termed the Bursum formation and Red Tanks member of the Madera formation. However, the Permian rests on older rocks in local areas of uplift. The basal Permian strata that overlie the Madera or Bursum formations are the red beds of the Abo formation. The Abo grades northward into the lower part of the Cutler formation of the Four Corners area, and interfingers toward the south with most of the Wolfcampian Hueco limestone (see Fig. 2). The Abo formation is overlain conformably by the orange-colored sandstones and siltstones of the De Chelly sandstone, until recently referred to the Meseta Blanca member of the Yeso formation (Baars, 1961). The De Chelly is in turn overlain by the red beds and evaporites of the Yeso formation, which formerly was termed the San Ysidro or Los Vallos member of the Yeso formation. As restricted by Baars (1961), the Meseta Blanca member was made a separate formation and correlated with the De Chelly sandstone, leaving only the upper evaporite red beds and thin dolomites in the Yeso formation. Light-colored Glorieta sandstones overlie the Yeso conformably, and interfinger or grade upward into the marine carbonates, clastics, and evaporites of the San Andres formation of probably uppermost Leonardian and/or lowermost Guadalupian age. This tightly interrelated sequence represents only about the early half of the Permian period, with late Permian time being represented by the erosional surface present everywhere on the Colorado Plateau between the Permian and Triassic rocks.

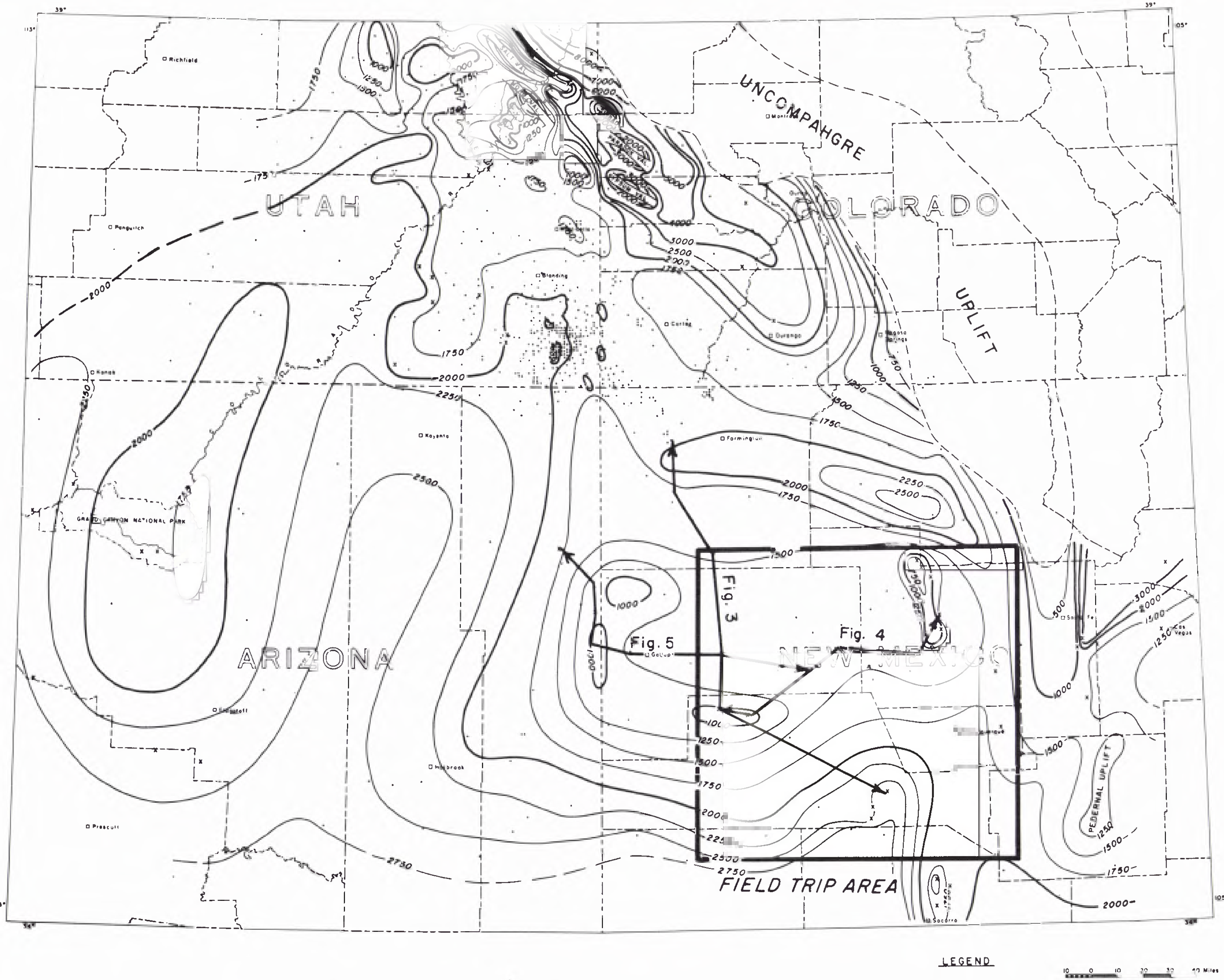
NATURE OF THE PERMO-PENNSYLVANIAN BOUNDARY

The Permo-Pennsylvanian boundary is probably represented by continuous sedimentation over most of central New Mexico. In the area south of Albuquerque, beds are present that are believed to be gradational between Pennsylvanian and Permian; these are known as the Bursum formation east of the Rio Grande and as the Red Tanks member of the Madera formation in the Lucero Mesa area (Kelley and Wood, 1946; and others). These units are largely red beds with thin interbedded limestones that overlie marine rocks of late Virgilian (uppermost Pennsylvanian) age, and at least locally contain early Wolfcampian fusulinids. Thus, if the section is not entirely conformable, very little time is available for a major hiatus. Although no known Bursum or Red Tanks beds are present north of Albuquerque, sedimentation was probably continuous across the temporal boundary throughout the southern San Juan Basin region. It is probable that basal red beds of the Abo formation are of Bursum age in the Zuni and Nacimiento Mountains and in the subsurface of the San Juan Basin, and these strata usually rest on Virgilian marine rocks of the Madera formation. The gradational Permo-Pennsylvanian boundary may continue as far north in the San Juan Basin as the Colorado border.

The major positive areas of Pennsylvanian age were not buried completely until Permian time, permitting the sedimentation of Lower Permian rocks on pre-Virgil units. Thus, the Abo red beds overlie Precambrian rocks on the Defiance, Zuni, and Penasco (Nacimiento Mountains) uplifts, and beds of early Missourian age in the Joyita Hills west of Socorro. There is little doubt that the red beds are post-Pennsylvanian on the Defiance, Penasco, and Joyita uplifts, but beds are present on the Zuni uplift that may be Upper Pennsylvanian in age. These marine beds contain a nondiagnostic megafauna that could be either uppermost Pennsylvanian or basal Permian in age, so that the exact date of complete burial of the Zuni positive element is in doubt.

ABO FORMATION

The Abo formation was named by Lee in 1909 (Jicha and Lochman-Balk, 1958) for exposures of red beds overlying the Madera and Bursum formations in Abo Canyon near Mountainair in the southern Manzano Mountains. The Abo consists of reddish brown shales, siltstones, and usually arkosic sandstones that become somewhat coarser in grain-size toward the Uncompahgre-San Luis uplift source area to the northeast. The formation is very similar lithologically to the lower Supai of eastern Arizona and the lower Cutler of the Four Corners region which are lateral equivalents of the Abo (Fig. 2). The very irregular and often lenticular bedding of the sandstones suggests a fluvial mode of deposition for much of the unit, and the occasional occurrences of vertebrate and plant fossils tend to verify a continental origin. However, the Abo interfingers toward the south with the marine Hueco limestone (Kottlowski and others, 1956; and others), which implies that sedimentation was probably on a broad coastal plain that may have been periodically flooded by marine waters in the southern part of the province. The Abo formation overlies Wolfcampian beds of the Bursum formation at the type section, dating the Abo as post-Pennsylvanian in that area. The southward interfingering of the Abo with the Hueco limestone dates the unit as mostly Wolfcampian, but there is a possibility that the uppermost part of the red beds may be Leonard in age.



ISOPACHOUS MAP OF PERMIAN SYSTEM

Figure 1

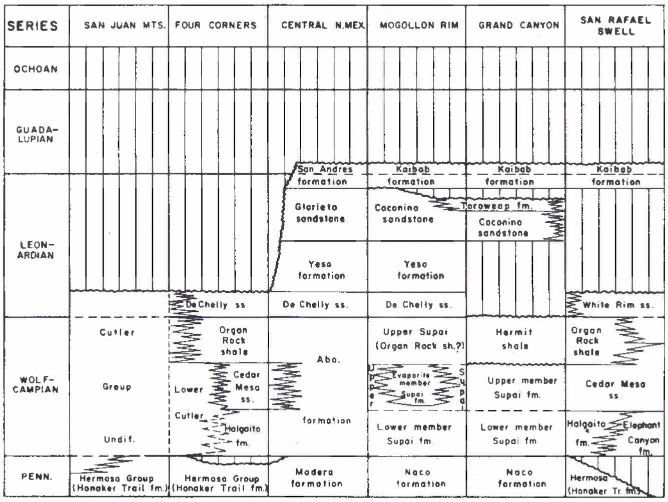


FIGURE 2

The Abo formation ranges from about 800 to 900 feet thick in the Lucero Mesa and Abo Canyon areas, but thins to less than 200 feet in the central Zuni Mountains (see Fig. 3). It averages 400-600 feet thick in the southern San Juan Basin and thins to less than 400 feet in the Nacimiento Mountains exposures. The Abo grades northward into the undifferentiated Cutler formation in the vicinity of San Pedro Mountain near Cuba, New Mexico (Wood and Northrop, 1946), and can be correlated through subsurface control into the Four Corners, Defiance uplift, and eastern Arizona areas (Figs. 4 and 5) (Baars, 1961). The red beds thicken eastward into the upper portion of the very thick Sangre de Cristo formation of the Rowe-Mora basin east of Santa Fe.

DE CHELLY SANDSTONE

The Abo red beds are overlain by orange-red sandstones and siltstones that were previously assigned to the basal Yeso formation, and were termed the Meseta Blanca member by Wood and Northrop (1946). The possibly eolian to shallow marine sandstone is very similar in lithology to the De Chelly sandstone of the Defiance uplift and Four Corners area, and was correlated with the De Chelly through subsurface and Defiance uplift studies by Baars (1961). As the result of that correlation, the Meseta Blanca member is referred to the De Chelly sandstone, and separated from the Yeso formation for ease and clarity of usage. The unit will therefore be termed the De Chelly sandstone in this paper.

The De Chelly sandstone was named for magnificent exposures of the unit in Canyon de Chelly on the Defiance uplift by Gregory (1917), and was subsequently correlated into central New Mexico into the "basal Yeso sandstone" by Baars (1961). It is an orange-red highly cross-stratified sandstone in its northern occurrences, but becomes finer grained and massive to thinly and horizontally bedded toward the south. In the Zuni Mountains and Lucero Mesa area, it is largely a flat-bedded siltstone that is undoubtedly subaqueous in origin, and possibly marine. In the southern Nacimiento Mountains, it is a highly cross-stratified fine-grained sandstone much like the Defiance uplift exposures that are generally believed to be eolian deposits. The De Chelly sandstones are usually fairly well sorted and well rounded, and are poorly cemented by ferruginous material toward the north, becoming harder and more calcareous southward. [Not all workers would agree.—Ed.] The formation cannot be accurately dated, but is probably early Leonardian because it overlies possible Leonardian Abo beds and is closely related to the definitely Leonardian Yeso formation which immediately overlies the De Chelly.

The De Chelly sandstone thickens eastward from less than 200 feet on the southern Defiance uplift to more than 300 feet in the Zuni Mountains and 600 feet in the southern San Juan Basin. The siltstones thin generally southward to 400 feet in the southern Lucero Mesa area and to about 200 feet in the vicinity of Socorro, New Mexico (Figs. 3, 4, and 5). South of this latitude, it becomes increasingly thinner and less distinctive (Kottlowski and others, 1956). The De Chelly thins to the north also, and is 200 to 300 feet thick in the Nacimiento Mountains south of its facies change into Cutler red beds near Cuba, New Mexico (Wood and Northrop, 1946). This belt of facies change (from the red cross-stratified sandstone to arkosic Cutler red beds in a northeasterly direction) extends toward the northwest into the Four Corners area in the subsurface, outcropping again on the Monument upwarp in southern Utah. It is probable that the sandstone was derived from contemporaneously deposited red clastics of the undifferentiated Cutler arkosic facies, and windblown toward the southwest into the southern San Juan Basin where marine environments were encountered.

YESO FORMATION

The Yeso formation, as herein restricted, is a mixture of red beds, evaporites, and thin beds of carbonate rocks that conformably overlie the De Chelly sandstone. Only the northern margin of the Yeso depositional basin is present in central New Mexico. The formation is composed largely of Cutler-like red beds in the Nacimiento Mountains, where the unit is probably truncated by pre-Triassic erosion in the northern part of the range (Wood and Northrop, 1946). Toward the south, the Yeso contains thin beds of dolomite and becomes lighter red in color in the Zuni Mountains, and contains gypsums along with the light red beds and dolomites in the eastern Zunis and in the Lucero Mesa area (Figs. 3, 4, and 5). The Yeso simultaneously thickens in a southerly direction from 0-100 feet in the Nacimientos to about 600 feet in the Lucero Mesa area (Kelley and Wood, 1946). The formation may be divided areally into a northerly dark red-bed facies termed the San Ysidro facies by Wood and Northrop (1946) and a southerly light red-bed and evaporite facies termed the Los Vallos facies by Kelley and Wood (1946). The terms were originally member names assigned to the Yeso, but they may be usefully applied as facies terms with the present terminology. The clastic content of the Yeso becomes more arkosic and coarse grained toward the north as the rocks become darker colored and less evaporitic, suggesting a northerly source for the clastics. Since it is very unlikely that the Uncompahgre-San Luis source area was active after about De Chelly time, it is probable that the Yeso red beds are derived from the reworking of Cutler arkosic red beds to the north. The general lithology of the Yeso suggests that the depositional environment was a shallow partially restricted sea which received red clastics from a ready supply in the north.

The Yeso type section is on Mesa del Yeso near Socorro, New Mexico, where the formation was named and described by Lee in 1909 (Jicha and Lochman-Balk, 1958). In that general area, the Yeso is divisible into a lower orange sandstone member, a lower evaporite member, the Canas gypsum member, and the Joyita sand-

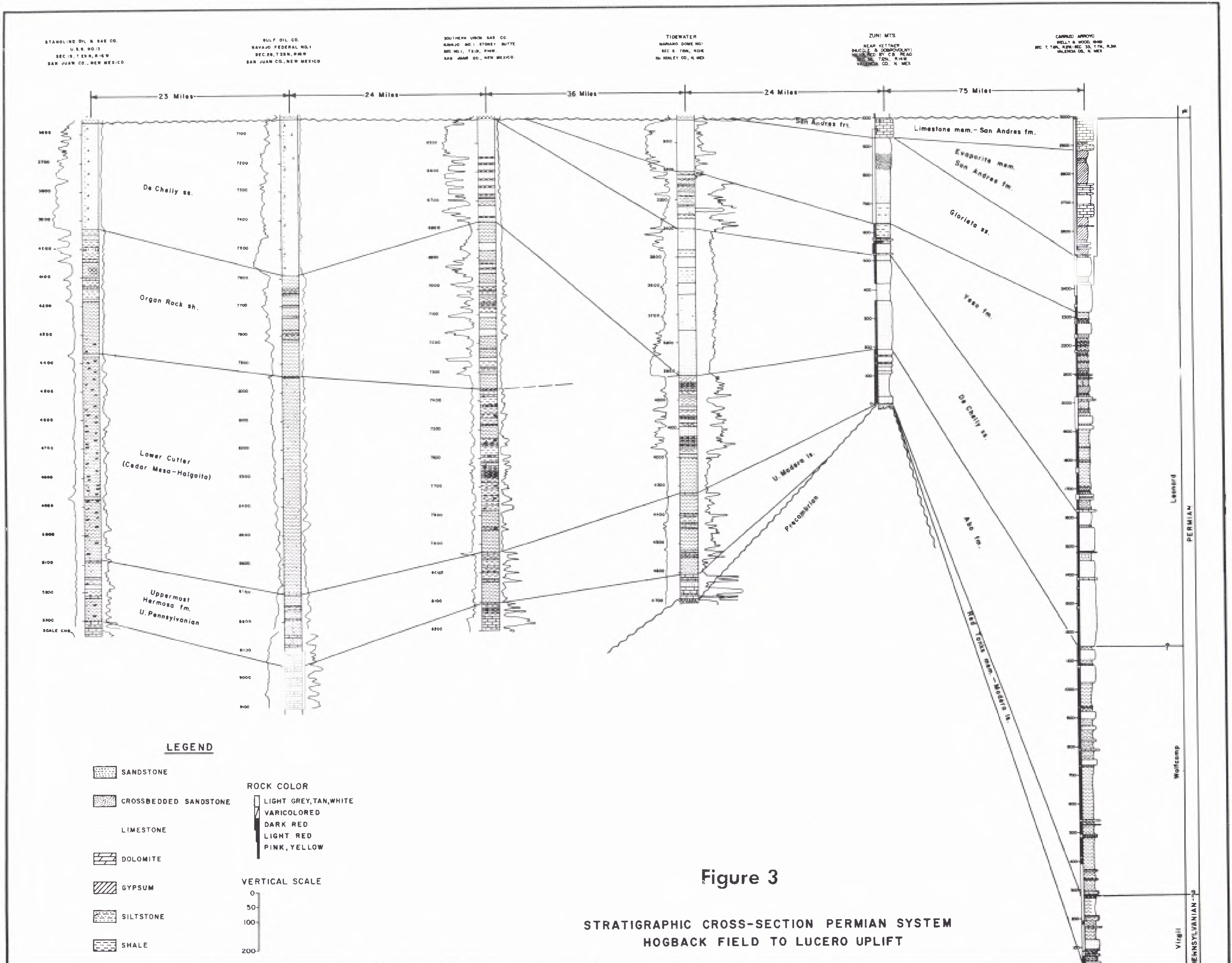


Figure 3

STRATIGRAPHIC CROSS-SECTION PERMIAN SYSTEM
HOGBACK FIELD TO LUCERO UPLIFT

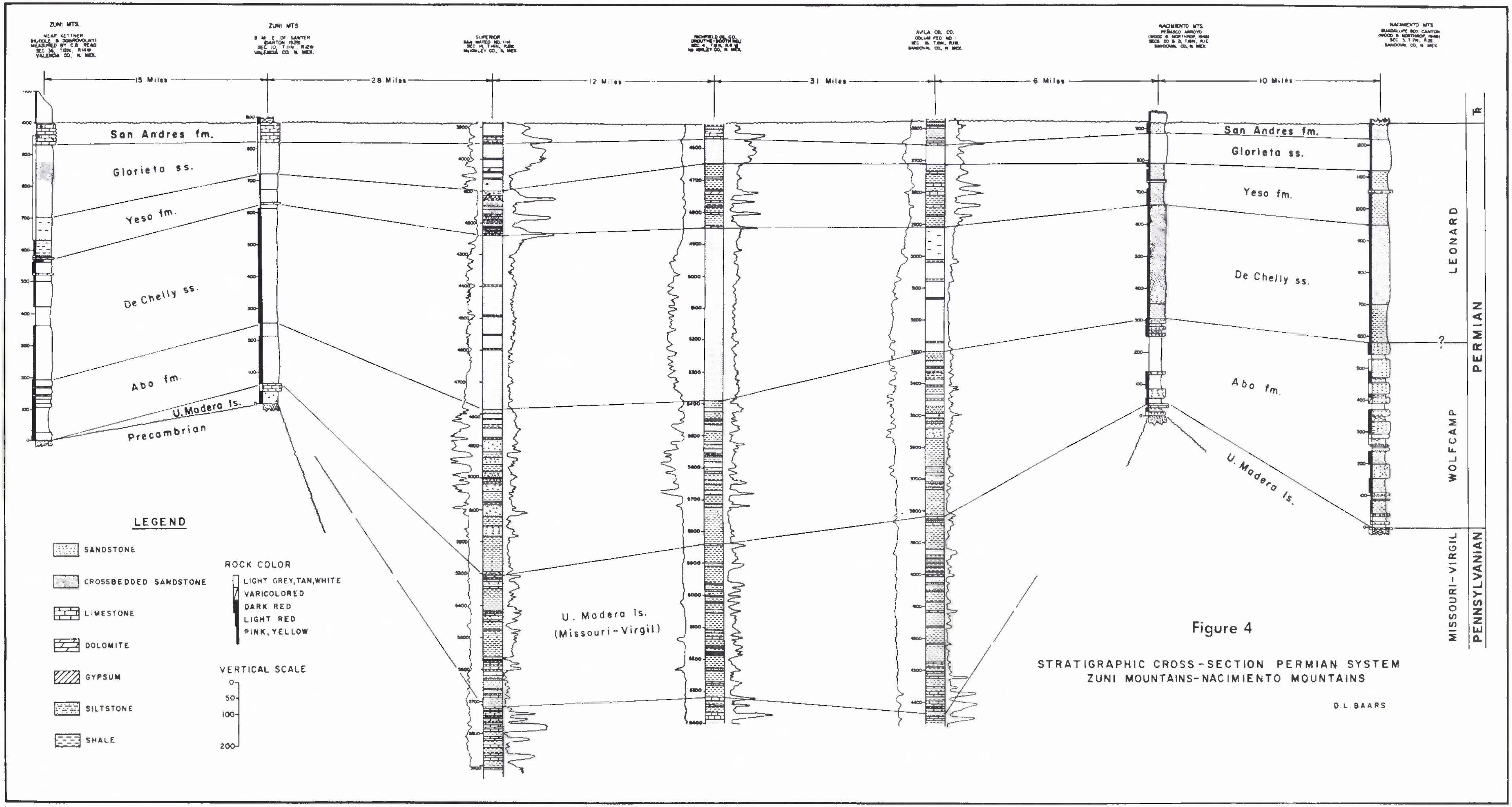


Figure 4

STRATIGRAPHIC CROSS-SECTION PERMIAN SYSTEM
ZUNI MOUNTAINS-NACIMIENTO MOUNTAINS

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stone member, in ascending order (Needham and Bates, 1943). The Yeso is dated mostly by work done in southern New Mexico, where it is considered to be Leonard in age on the basis of invertebrate megafossil and fusulinid studies. The formation is not present in the Four Corners area for it pinches out and is truncated by pre-Triassic erosion across the southern San Juan Basin, but it is present in eastern Arizona where it is the uppermost part of the Supai as previously used.

GLORIETA SANDSTONE

The term Glorieta sandstone has been used in a variety of ways since 1915, and was defined in its present usage by Needham and Bates (1943) who designated the type section at Glorieta Mesa near Rowe, New Mexico. The unit is a white fine- to medium-grained, siliceous sandstone that is typically cross-stratified. [In many places the cement is calcareous.—Ed.] The bedding is typified by cross-strata in two- to six-foot thick simple sets that are each bevelled to a plane at the upper surface. The primary dips of the cross-stratification average 10 to 20 degrees. The general impression is one of horizontal thin bedding, with massive large-scale cross-stratification confined to a few isolated occurrences in the Zuni Mountains. It is probable that the Glorieta sands were deposited in a high-energy littoral environment, with only local inclusion of offshore bar or eolian deposits. The equivalent Coconino sandstone in northern Arizona (Fig. 2) differs mainly in type of cross-stratification. The Coconino is composed of large-scale, randomly oriented wedge-shaped cross-stratification sets that are unmistakably of eolian origin. The Glorieta sandstone interfingers with both the underlying Yeso formation and the younger San Andres formation, placing it conformably between two marine deposits of Leonardian age.

The Glorieta sandstone is a relatively uniform deposit, striking approximately east-west and thickening gradually southward. The northward termination is one of depositional thinning complicated by later truncation. In the northern Nacimiento Mountains, the Glorieta is truncated by pre-Triassic erosion (Wood and Northrop, 1946), much as is the case in the subsurface of the southern San Juan Basin and on the Defiance uplift (Baars, 1961). The formation thickens southward to about 300 feet in both the Zuni Mountains and Lucero Mesa areas (Fig. 3). The Glorieta is very widespread to the south and east in New Mexico.

SAN ANDRES FORMATION

The uppermost Permian unit of central New Mexico is the San Andres formation named by Lee in 1909 (Jicha and Lochman-Balk, 1958) for exposures in the San Andres Mountains of central southern New Mexico. A type section was designated by Needham and Bates (1943) in Rhodes Canyon in the northern San Andres Range. The formation is composed largely of carbonate rocks and fine-grained clastics in the Zuni Mountains, but changes rapidly to red beds toward the north and evaporites toward the southeast. The San Andres formation has long been considered equivalent to the Kaibab formation of northern Arizona (Fig. 2).

The San Andres formation of the Zuni Mountains contains two distinctive units that weather to a lower ledgy slope and an upper massive cliff. The lower unit consists of a thin- to medium-bedded alternation of sucrosic dolomites, shales, siltstones, and sandstones that make up half or more of the formation. The upper cliff-forming unit of the San Andres is typically a massive limestone that is quite variable laterally. Most commonly it is a very dense carbonate mud deposit that contains large productid brachiopods and large cephalopods, but varies to local deposits of skeletal calcarenites that appear to be beach deposits that alternate with quartzose Glorieta-like sandstones. The upper San Andres also contains rare biohermal accumulations that are partially dolomitized. This upper unit was apparently deposited on a shallow marine shelf in tropical waters.

The shallow carbonate shelf assemblage grades rapidly to a shoreward red-bed facies in the subsurface north of the Zuni Mountains (Fig. 4). Thin carbonates are occasionally present, but they are only a minor constituent in the southern San Juan Basin. The sequence is similar in the southern Nacimiento Mountains where a single dolomite bed is present in a thin red-bed unit. The San Andres is truncated northward by pre-Triassic erosion in the northern Nacimientos (Wood and Northrop, 1946), as well as in the subsurface of the southern San Juan Basin and on the Defiance uplift. The present northern limits of the formation are probably not very different from the position of the shoreline, however, for the northern red-bed facies is interpreted as shoreward lagoonal and intertidal deposits.

The San Andres thickens rapidly toward the southeast into an evaporite basin that centers approximately in the Lucero Mesa area (Fig. 3). Kelley and Wood (1946) described the thick evaporites in outcrops along the Lucero uplift, which appear to be equivalent to the lower part of the Zuni Mountain sequence. The San Andres evaporites differ from the underlying Yeso evaporitic deposits in that red beds are not associated with the San Andres formation in the restricted basin. The association of evaporites with drab-colored related sediments may indicate deeper water and reducing bottom conditions in the San Andres basin.

The San Andres formation thickens gradually southward from a feather-edge in the central Nacimiento Mountains and southern San Juan Basin to about 100 feet in the Zuni Mountains. Its thickness increases to 400 feet in the evaporitic section along the Lucero uplift. The San Andres can be readily traced southward through good outcrops to the type section and the Guadalupe Reef country, where the formation is probably partly Leonardian and partly Guadalupian in age (Boyd, 1958). It is probable that only the lower Leonardian portion of the San Andres is present in the area of the Field Conference.

PERMIAN-TRIASSIC UNCONFORMITY

The contact between the Permian rocks and the overlying Triassic beds is everywhere unconformable in central New Mexico. The hiatus involved the last half of Permian and earliest Triassic time. Physical evidence of the unconformity is usually a low-relief erosional surface, but local areas display more profound erosional features. The surface in the Zuni Mountains is generally a rolling hill-and-valley topography with about 40 feet of relief, but in the vicinity of Ft. Wingate in the western part of the range steep valleys were cut 100 feet into the Permian rocks, removing all of the San Andres formation in local channels. The unconformity is slightly angular in the Nacimiento Mountains, for the Permian strata were truncated northward until the Triassic rests directly on the De Chelly sandstone near Cuba (Wood and Northrop, 1946). A similar northward truncation exists in the subsurface north of the Zuni Mountains, but since the upper formations are all

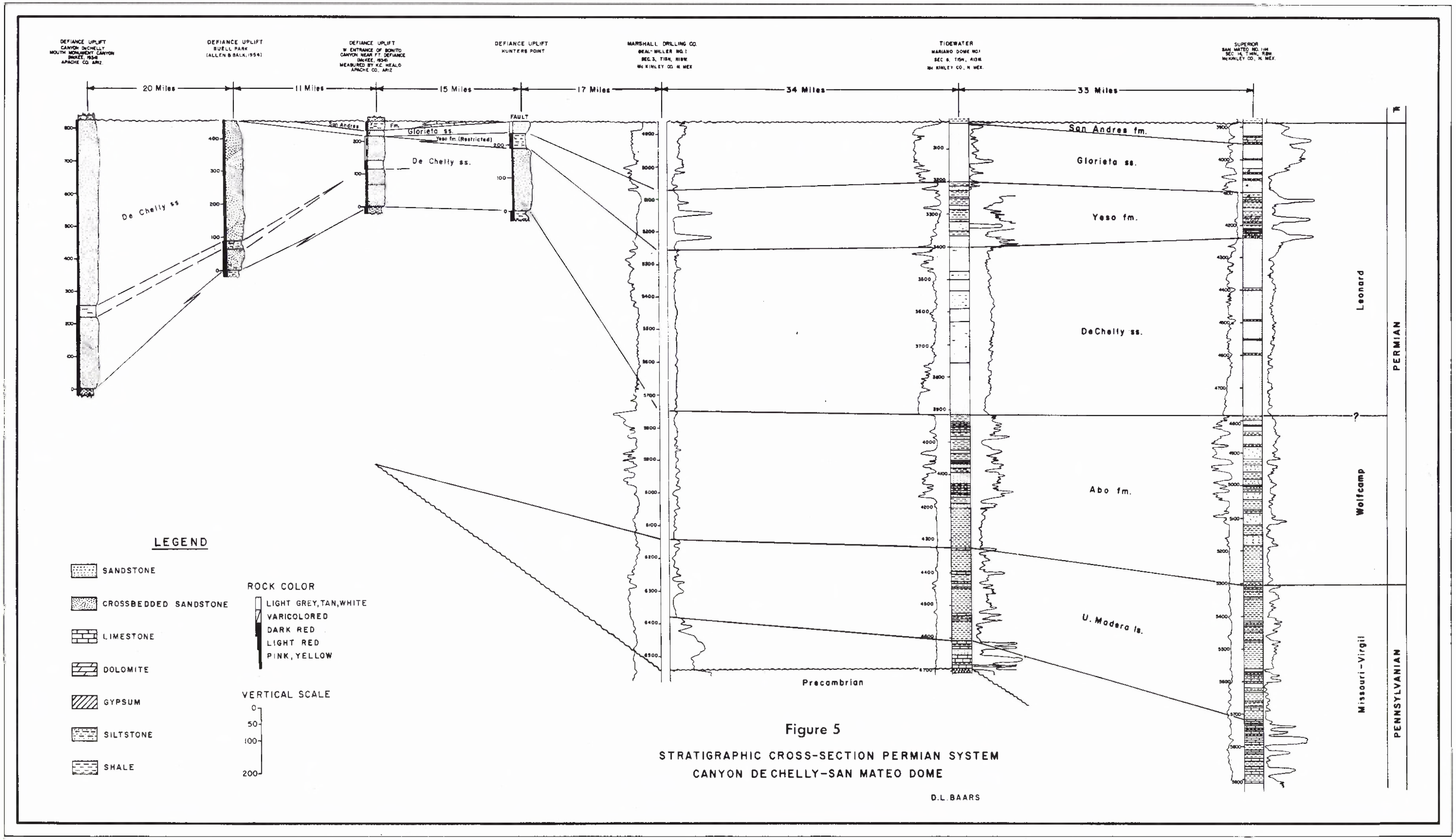

Figure 5

STRATIGRAPHIC CROSS-SECTION PERMIAN SYSTEM
CANYON DE CHELLY–SAN MATEO DOME

near their depositional limits it is difficult to evaluate the effectiveness of the erosion. A similar northward removal of Permian rocks is evident along the Defiance uplift.

REFERENCES CITED

Baars, D. L., 1961, Permian system of the Colorado Plateau: Am. Assoc. Petroleum Geologists Bull. (in press).

Boyd, D. W., 1958, Permian sedimentary facies, central Guadalupe Mountains, New Mexico: New Mexico Bur. Mines and Mineral Res. Bull. 49.

Gregory, H. E., 1917, Geology of the Navajo country: U. S. Geol. Survey Prof. Paper 93.

Jicha, H. L., Jr., and Lochman-Balk, Christina, 1958, Lexicon of New Mexico geologic names: Precambrian through Paleozoic: New Mexico Bur. Mines and Mineral Res. Bull. 61.

Kelley, V. C., and Wood, G. H., Jr., 1946, Lucero uplift, Valencia, Socorro, and Bernalillo Counties, New Mexico: U. S. Geol. Survey Oil and Gas Inv. Prelim. Map 47.

Kottlowski, F. E., Flower, R. H., Thompson, M. L., and Foster, R. W., 1956, Stratigraphic studies of the San Andres Mountains, New Mexico: New Mexico Bur. Mines and Mineral Res. Mem. 1.

Needham, C. E., and Bates, R. L., 1943, Permian type sections in central New Mexico: Geol. Soc. America Bull., v. 54, p. 1653-1658.

Wood, G. H., Jr., and Northrop, S. A., 1946, Geology of Nacimiento Mountains, San Pedro Mountain, and adjacent plateaus in parts of Sandoval and Rio Arriba Counties, New Mexico: U. S. Geol. Survey Oil and Gas Inv. Prelim. Map 57.

[Note.—It is anticipated that this stimulating paper will evoke lively discussion.—Ed.]