

THE PENNSYLVANIAN SYSTEM OF SOUTHEASTERN ARIZONA

K. C. Havenor
Pure Oil Company

INTRODUCTION

Rocks of Pennsylvanian age are found in most of the mountain ranges of southeastern Arizona and constitute part of the predominantly carbonate sequence which is characteristic of the Upper Paleozoic rocks of that area. The Pennsylvanian beds everywhere rest conformably on Mississippian beds and are transitional into the overlying Permian rocks. Exposures of Pennsylvanian rocks are discontinuous and are frequently broken by faults, eroded or covered by younger rocks.

NOMENCLATURE

The thick marine sections of Permian and Pennsylvanian rocks exposed throughout a large portion of southeastern Arizona were called originally the "Naco limestone" (Ransome, 1904) for exposures in the Naco Hills south of Bisbee, Arizona. Fossil identifications by Girty (in Ransome, 1904) showed two groups of fossils. The older group was of Early Pennsylvanian age and the younger group had a fauna similar to that of the Hueco limestone of West Texas which was considered to be of Late Carboniferous age. Redefinition of the Hueco limestone as Wolfcampian and probably Leonardian has led to the correlation of the "Naco limestone" with the Pennsylvanian Magdalena limestone in New Mexico and the Permian Hueco limestone in Texas.

In an attempt to restrict the term "Naco" to the portion of the formation which is Pennsylvanian in age, Stoyanow (1936) employed the term "Naco formation sensu stricto" and proposed a five-fold division of the Permian and Pennsylvanian rocks on the basis of their contained fossils. The application of the name "Naco formation," from 1936 until its redefinition by Gilluly, Cooper, and Williams in 1954, generally followed Stoyanow's proposal (1936) to restrict the term "Naco formation" to beds of Pennsylvanian age. This usage of the term "Naco," however, was impractical in the field because there is no lithologic break between the "Naco formation sensu stricto" and the overlying Permian "formations."

Gilluly, Cooper, and Williams (1954) proposed that the Naco group include all Permian and Pennsylvanian units in southeastern Arizona. Under this definition, the Naco group contains two units of Pennsylvanian age -- the Horquilla limestone, ranging in age from Morrowan to Missourian, and the Earp formation, which spans the Permo-Pennsylvanian boundary, ranging from Virgillian in its lower part to Wolfcampian in its upper part. Locally, in the central-southern portion of Arizona, the Earp formation cannot be distinguished from overlying Permian beds and the Pennsylvanian-Permian time surface lies within the Permian and Pennsylvanian Andrada formation (Galbraith, 1949; Wilson, 1951) which overlies the Horquilla limestone.

In the Clifton-Morenci area, Lindgren (1905b) defined the Tule Spring limestone which included lithologically similar strata of Pennsylvanian and Lower Mississippian age. No Upper Mississippian fossils were found and the formation includes a considerable hiatus within its boundaries. At its type locality, the formation consists of at least 500 feet of heavy-bedded, bluish-gray limestone which rests conformably on the Devonian Morenci shale, where present, or upon the Ordovician Longfellow

limestone where the Morenci shale is absent.

PENNSYLVANIAN FORMATIONS

Horquilla Limestone

The Horquilla limestone is generally a uniform pinkish-gray to dark gray, aphanitic to medium-crystalline, cherty, occasionally sandy, fossiliferous limestone containing gray to black, red, or greenish shale beds. The shale becomes more abundant in the upper part of the formation.

The contact between the Horquilla limestone and the underlying Mississippian beds is disconformable. At many localities, particularly where the Horquilla limestone overlies the Late Mississippian Black Prince limestone or Paradise formation, the contact is indistinct. Where the Horquilla rests on the Mississippian Escabrosa limestone, the contact is locally identified by scour-and-fill sedimentary structure, karst topography, limestone conglomerate and a distinctive red chert pebble conglomerate. In many areas, the contact between the Horquilla and Escabrosa limestones is clearly marked by the change between the cliff-forming Escabrosa and the more gentle, closely ribbed slopes of the Horquilla (fig. 8A).

Earp Formation

The Horquilla limestone grades upward into the Earp formation and the separation of the two formations is drawn arbitrarily at a horizon where the clastic rocks become predominant over the carbonate rocks. The Earp generally consists of interbedded limestone, dolomitic limestone, shale and sandstone beds that give rise to alternating ledge and slope topography that is more subdued than the ridges formed on the Horquilla limestone. The lower part of the Earp formation frequently contains beds of limestone up to 3 feet thick which may be composed entirely of fusulinid tests.

The boundary between the Permian and Pennsylvanian systems occurs within the Earp formation. There is no lithologic or erosional break and the boundary is delineated by fossil evidence alone. In some areas the boundary can be tied down to within a few feet; in other areas, the boundary can be located only within a few hundred feet (Bryant, 10). The Earp formation is conformably overlain by the Colina limestone.

Andrada Formation

The term Andrada formation is used locally in the western part of southeastern Arizona where the formations of the Naco group which overlie the Horquilla limestone cannot be separated from each other (Bryant, 1955). The Andrada formation is generally thin bedded and composed of varicolored sandstone, siltstone and shale containing gypsum and marl. Although it is lithologically distinct from the underlying Horquilla limestone, the contact between them is gradational and the boundary is drawn where the clastic rocks become predominant over the carbonate rocks. The boundary between the Permian and Pennsylvanian systems occurs within the lower portion of the Andrada formation and there is no evidence of a sedimentational break or an unconformity between the systems.

Fusulinid beds are no so abundant in the Andrada as in the Earp, but the same faunal zones distinguish both formations from the Horquilla.

THICKNESSES OF PENNSYLVANIAN SECTIONS

The thicknesses of the Pennsylvanian sections throughout southern Arizona, in most cases, are difficult to establish accurately because the upper boundary of the Pennsylvanian is hidden within a conformable series of lithologically similar beds. In addition, the Pennsylvanian rocks have been intensely deformed, broken, intruded and eroded since post-Permian time and, as with all other rocks in southern Arizona, there is little continuity of exposures.

In the Chiricahua Mountains, the Pennsylvanian system is approximately 2,100 feet thick. Westward, near the Naco Hills south of Bisbee, the Pennsylvanian rocks are about 1,400 feet thick. In the Whetstone Mountains, about 50 miles northwest of Bisbee the Pennsylvanian system ranges from approximately 1,000 to 1,100 feet thick. Twenty miles farther north, in the Gunnison Hills, it is about 1,900 feet thick. In the Vekol Mountains, about 75 miles west-northwest of Tucson, the exposed Pennsylvanian rocks are approximately 700 feet thick (McClymonds, 16).

A northwest-trending area of thicker deposition apparently extended across southeastern Arizona and the wedge of sediments in this trough thickens southeastward. The trough of deposition may have had within it several semiseperate basins of accumulation and their relationship to basins of Pennsylvanian deposition in other areas in Arizona has been discussed by Havenor and Pye (1958).

AGE OF PENNSYLVANIAN BEDS

Paleontological data from the Pennsylvanian beds from the Chiricahua Mountains section and the Naco Hills section show the presence of Fusulinella, Fusulina, and Triticites zones. These horizons indicate deposition from Atokan through Virgilian time. Similar fusulinid zones have been reported from the Whetstone Mountains sections. In the Vekol Mountains, megafossils from the exposed Pennsylvanian rocks, such as Spirifer rockymontanus, Neospirifer cameratus Morton, Composita subtilita, and Dictyoclostus americanus Dunbar and Condra, probably indicate a range from Desmoinesian through Missourian time.

Within Arizona the presence of undisputed Morrowan fossils is not known. By mid-Atokan time the fossil record indicates that several hundred feet of Horquilla limestone had already been deposited in the vicinity of the Chiricahua Mountains and in the Naco Hills. By mid-Desmoinesian time all of southeastern Arizona was inundated and had probably received considerable thicknesses of carbonate and fine clastic deposits. The outcrops to the north and west of the southeastern quarter of the State strongly suggest that by the end of Desmoinesian time the Pennsylvanian seas had reached their maximum areal extent in Arizona.

The transition to Permian time in southeastern Arizona was one of little environmental change from the preceding Pennsylvanian period. The lithology of the upper part of the Horquilla limestone and the lower part of the Earp formation records a gradual influx of fine-grained clastic material which increases upward into the Permian Wolfcamp series. In central-southern Arizona the Andrada formation, with its high sand, marl, and gypsum content in the basal portion of the formation, indicates a more shallow and restricted environment of deposition than does the underlying Horquilla limestone. The final retreat of the Pennsylvanian and Permian seas that occupied southeastern Arizona probably did not occur until late in Permian time.

PENNSYLVANIAN ROCKS IN ADJACENT AREAS

Areas adjacent to southeastern Arizona contain strata which are lithologically similar to and correlate with the Horquilla limestone and the Earp formation. Northward, the Pennsylvanian is represented by the Pennsylvanian part of the Supai formation and the Paradox basin sequence of evaporite, limestone, and clastic rocks and red beds. In southwestern Arizona clastic rocks of probable Pennsylvanian age have been reported by Wanless (1949) and Wilson (in McKee, 1951) and boulders carrying Pennsylvanian fauna have been reported from Cretaceous (?) - Tertiary (?) conglomerate (Gilluly, 1946; McKee, 1947).

Southward, in Sonora, Mexico, the limestone strata at Sierra de Teras are considered correlative with the Escabrosa limestone and the Naco group and are more than 5,000 feet thick (Ordonez, 1956). In New Mexico, the Pennsylvanian system is generally represented by the Magdalena group and its various subdivisions. In southwestern New Mexico, however, Zeller (1958) designated and differentiated the Pennsylvanian and Permian rocks in the Big Hatchet Mountains into members of the Naco group. At this locality the boundary between Pennsylvanian and Permian strata lies completely within the Horquilla limestone, considerably below the base of the Earp formation, and shows a transition in lithology across time lines between southeastern Arizona and southwestern New Mexico.

