10-Bryant-Permian

MARKER ZONES IN PERMIAN FORMATIONS OF SOUTHERN ARIZONA

Donald L. Bryant
Universidade de Bahia, Brazil

INTRODUCTION

Permian and Pennsylvanian rocks crop out in mountain ranges in southern Arizona from the Waterman Mountains in central Pima County to the New Mexico border. Massive limestones in the upper part of the Permian portion of the section form many of the sheer cliffs that are so prominent in this region.

The contact between rocks of Pennsylvanian and Permian age lies within a conformable series of beds. In southeastern Arizona the contact is within the Earp or Andrada formations but farther east it is lower in the section. The location of the boundary depends upon determination of faunal zones. In some areas the change from Virgilian fusulinids below the contact to Wolfcampian above can be made within a few to a few tens of feet. Where the fusulinids are sparce or absent, the boundary between the two systems may be uncertain within several hundred feet.

The total thickness of the Permian section in southern Arizona may reach 5,000 feet but probably no area has more than 4,000 feet and most areas have less than 2,500 feet. The lower part of the system is composed generally of poorly resistant rocks -- limestone, sandstone, siltstone, shale, and marly limestone; locally gypsum is common. About 800 feet of quartzose sandstone and dolomitic limestone form the middle part and about 1,000 feet of massive limestones form the upper part.

The fauna of the Permian rocks is varied. Fusulinids are common in the lower part but other types of fossils are relatively rare; in the upper part, fusulinids are rare. The clastic rocks are generally barren of fossils, but the limestone beds may have a rich fauna. Locally, limestone units may be characterized by a predominance of brachiopods or gastropods. The brachiopod biotopes usually contain corals, bryozoa, echinoderm fragments, pelecypods, and gastropods. In the gastropod biotopes, however, other fossils tend to be few and scattered.

The fauna have many elements in common with those of the Permian of West Texas and of the Grand Canyon. The equivalence of the brachiopods to those of Leonardian and Guadalupian age in Texas has long been recognized and the fusulinids of the lower part correlate well with many well-known Wolfcampian assemblages. The Permian of southern Arizona ranges in age from lowest Wolfcampian to probably middle Guadalupian.

NOMENCLATURE

The nomenclature of the Permian rocks of southern Arizona has been a vexing problem for many years. The original Carboniferous Naco formation of the Bisbee district, defined by Ransome (1904), included beds of both Pennsylvanian and Permian ages. Gilluly, Cooper, and Williams (1954) elevated the Naco formation to group rank and defined six new formations within it. The lower four formations of the Naco group are the Horquilla formation, Earp formation, Colina limestone, and Epitaph dolomite. These four have type sections in the Tombstone district and were part of the original Naco formation. Two younger Permian formations, the Scherrer formation and the Concha limestone, have type sections in the Gunnison

Hills. They are not present in the Tombstone-Bisbee district and were not part of the original Naco formation. Within the Naco group occurs the boundary between the Pennsylvanian and Permian systems in southeastern Arizona.

The Horquilla formation, the basal member of the Naco group, is wholly Pennsylvanian in age and ranges from Morrowan to Missourian. Resting conformably upon the Horquilla formation is the Earp formation which contains within its limits the base of the Permian system (Havenor 9). The Earp formation is Virgilian in age in its lower part and Wolfcampian in age in its upper part. The Pennsylvanian-Permian contact, based on fusulinids, is a few hundred feet above the base of the formation and is entirely transitional. The four post-Earp formations, Colina, Epitaph, Scherrer, and Concha, range in age from Wolfcampian to Guadalupian, but neither fusulinids nor ammonoids are found in sufficient quantities in them to allow precise series boundaries to be established.

In some ranges west of the Whetstone Mountains it has not been possible to differentiate the Earp, Colina, and Epitaph formations. Galbraith (1949) and Wilson (1951) used the term Andrada formation for these rocks in the Empire Mountains. In the Waterman Mountains, McClymonds (1957) originally described similar beds as the Andrada formation but later (McClymonds, 15; 16) referred to them as Earp-Colina undifferentiated.

PERMIAN MARKER ZONES

Distinctive correlatable units in the Permian of southern Arizona include both faunal and lithologic marker zones. Some of these zones are local and restricted to one or a few ranges; others are regional and can be recognized throughout southern Arizona.

Earp Formation

The Earp formation consists of interbedded limestone, dolomitic limestone, varicolored shale, and sandstone that give rise to alternating ledge and slope topography above the massive ridge-forming limestone beds of the Horquilla limestone. The lower part of the Earp formation may be quite fossiliferous, but the upper part is less so. The thickness of the formation ranges from more than 2,700 feet in the Portal area to about 1,100 feet in the Gunnison Hills.

The many fusulinid zones in the Earp (and Andrada) formation are critical to the location of the Pennsylvanian-Permian boundary. In addition, these fusulinid zones are locally characterized by distinctive coloration of the fusulinids and of the rock matrices. Careful records of the different color combinations and their positions in the section might disclose a useful tool for correlation purposes in the field.

Another potential marker in the Earp is a conglomerate with a high incidence of orange to red chert pebbles. Beds of such conglomerate are recorded about 350 feet below the top of the Earp in the type section at Tombstone and also occur about 300 feet below the top in the Gunnison Hills, about 150 feet below the top in the Naco Hills, and about 350 feet below the top in the Swisshelm Mountains. In the Portal section in the Chiricahua Mountains, a similar conglomerate crops out about 1,400 feet above the base of the Earp formation. In this area there is no agreement about the placement of the top of the Earp. In the southern Whetstones, there is a coarse conglomerate about 450 feet above the base of the Earp, and at American Peak, in the Patagonia Mountains near Mowry, there is a thick conglomerate, strikingly similar to

that in the Gunnison Hills, that lies about 300 feet above the top of the Horquilla formation within the probable Earp equivalent.

Colina and Epitaph Formations

At the type locality near Tombstone the Colina limestone is about 600 feet thick. It consists dominantly of dark gray to black limestone in thick beds which commonly are more than 25 feet thick.

One of the distinguishing characters of the Colina limestone in central Cochise County is the occurence of large Omphalotrochus, found in abundance only in the Colina limestone. Accompanying the Omphalotrochus are great quantities of echinoid spines. In the Whetstone Mountains the large Omphalotrochus are not uncommon in the Colina limestone, but west of the Whetstones they have not been found. In the Portal-Hilltop area in the Chiricahua Mountains, the writer has noted this large distinctive gastropod in beds less than 2,000 feet above the top of the Horquilla formation. The writer assigned these beds to the Colina limestone although they were assigned by Sabins (1957a) to the Earp.

The Epitaph dolomite in the type section at Tombstone is nearly 800 feet thick and is gradational from the Colina below. It is composed dominantly of dolomite but there are many limestone and clastic rocks in the upper part. The top of the section is eroded and overlain unconformably by the Cretaceous Glance conglomerate.

Strata similar to the Epitaph dolomite do not crop out in southern Arizona except in the Bisbee-Tombstone district. Sabins (1957a), from his studies in the Chiricahua Mountains, believed that the "Epitaph is a dolomitized facies of the upper Colina and lower Scherrer that is confined to the Dragoon Mountains." From the excellent section in the Sands Ranch area of the southern Whetstone Mountains, the present writer believes that the name Epitaph formation may be used for the 1,200 feet of rocks in the middle of the section that lie between unquestionable Scherrer above and the Colina limestone below.

In the Chiricahua Mountains there are nearly 3,300 feet of rocks between the Horquilla formation below and a quartzite of the Scherrer formation above. Sabins (1957a) assigned the lower 2,700 feet to the Earp and the upper 600 feet to the Colina limestone. In a nearby section measured by the writer, 1,600 feet were assigned to the Earp, 700 feet to the Colina, 800 feet to the Epitaph, and 150 feet to the Scherrer formations.

In the Whetstone Mountains near Sands Ranch there are about 2,600 feet of strata between the Horquilla formation and the lower quartzite of the Scherrer formation. Here the writer assigned 700 feet to the Earp, 700 feet to the Colina, and 1,200 feet to the Epitaph formations. The upper half of the strata assigned to the Epitaph formation include about 200 feet of thick beds of gypsum. No gypsum has been reported in equivalent beds to the east.

The writer believes that the somewhat dolomitic limestone strata which underlie the Scherrer formation in the Gunnison Hills are assignable to the Epitaph, rather than to the Colina to which they were doubtfully assigned by Gilluly, Cooper, and Williams (1954).

In the ranges west of the Whetstone Mountains the rocks between the Horquilla and the Scherrer formations are not readily assignable to the formations of central

Cochise County (Galbraith, 21; McClymonds, 15, 16). The western sections are more heterogeneous and contain a higher percentage of clastic rocks than do the type sections. There are no thick limestone beds like those in the Colina and Epitaph, and fossils are scarce. Gypsum, however, occurs in the upper part of the undifferentiated Earp, Colina, and Epitaph formations (Andrada formation of Wilson, 1951) in several of the western ranges and it is assumed that it correlates with the gypsum of the Whetstones.

Scherrer Formation

The type Scherrer formation in the Gunnison Hills rests on dark limestone that Gilluly, Cooper, and Williams (1954) tentatively assigned to the Colina limestone, but which, as has been stated, this writer believes belongs about 1,000 feet above the type Colina limestone and in the upper part of the Epitaph formation. In the type section the Scherrer formation consists of about 65 feet of red siltstone at the base, 300 feet of white sandstone, 165 feet of limestone, and 150 feet of white sandstone at the top. Above this is the basal calcareous sandstone of the Concha limestone.

The Scherrer formation is readily recognizable throughout southern Arizona. Both sandstone members are commonly quartzitic and are characterized nearly everywhere by abundant reddish brown spots of oxidized iron minerals. The middle limestone member is generally somewhat dolomitic and contains quartzite knots and blebs. It is similar in this respect to both the upper and lower dolomitic limestones of the Epitaph formation, but in most localities a distinctive fossil zone occurs near the middle of the member of the Scherrer. In this zone, and apparently confined to this zone, there are echinoid spines shaped like short, thick baseball bats, which are referred to the genus Permocidaris. Commonly, the upper sandstone member is less thoroughly indurated than the lower. In areas where only one sandstone member is exposed, it is difficult to determine whether it is the upper or lower member.

Concha Limestone

The type section of the Concha limestone in the Gunnison Hills consists of about 30 feet of limestone and sandy limestone at the base followed by 100 feet of massive cherty limestone, which is unconformably overlain by the Cretaceous Glance conglomerate.

The upper 90 feet of the type Concha limestone is a disttinctive dark cherty limestone that is equivalent to the basal part of a limestone sequence nearly 800 feet thick in the Chiricahua Mountains and more than 1,000 feet thick in several of the ranges west of central Cochise County. These rocks are included in the Concha formation of this report, although the name Rainvalley formation has been used in theses (Bryant, 1955; McClymonds, 1957) to distinguish these beds from the lower 500 feet which are typical Concha.

In the Mustang Mountains the higher Permian strata are well exposed and this area would serve as an excellent supplementary type locality for these rocks. In this area (Bryant, 1955) there are 560 feet of massive dark cherty limestone above the Scherrer formation which were assigned to the Concha limestone and more than 400 feet of more varicolored, thinner bedded limestone above the typical Concha which are suggested as a type section for the new Rainvalley formation.

The Concha limestone is richly fossiliferous and has several distinctive marker zones that can be recognized throughout southern Arizona. The dark, very cherty

limestones in the lower part are commonly about 150 feet thick with abundant large Dictyoclostus and bryozoa. This unit maintains its distinctive lithology from the Portal-Hilltop area in the Chiricahuas to the Waterman Mountains (McClymonds, 18).

Near the middle of the formation is a unit about 30 feet thick to which the field term "tan chert zone" was given. Very light gray chert comprises 30 to 50 percent of the rock which weathers to a distinctive light brown or tan color. This is notably lighter in color than most of the chert in the Concha limestone, and, in addition, two fossil zones bracket the chert and usually leave no doubt as to the identity of the unit. Immediately below the "tan chert zone" there is a zone of abundant horn corals, which are rare in the lower part of the formation. About 20 feet above the top of the "tan chert zone" there is a zone of abundant Neospirifer, usually accompanied by many Derbyia, Meekella, and Dictyoclostus. Neospirifer is rare throughout the Permian sequence except in this single zone. In the Chiricahua Mountains the "tan chert zone" is not distinctive, nor is it in the Waterman Mountains, but the Neospirifer zone is present in both localities.

The only fusulinids above the Earp formation known to this writer occur in two narrow zones about 15 feet apart approximately 350 feet above the base of the Concha and 75 to 100 feet above the "tan chert zone". These fusulinid zones were not noted in the Mustang Mountains, but they occur in several of the Empire Mountain sections and at Helmet Peak, and at least one of them occurs in the Tucson and Waterman Mountains. From these zones a Parafusulina of lower Guadalupian (Word) age has been identified.

Near the top of the Concha limestone, a dominantly molluscan fauna replaces the brachiopod assemblage which is characteristic of the lower part of the formation. Gastropods are abundant and pelecypods are common. Two of the rare ammonoids of the Permian of southern Arizona came from this zone in the Mustang Mountains.

Above the typical Concha limestone, thinner bedded, more varicolored limestones more than 500 feet thick form the distinctive Rainvalley formation (Bryant, 1955). The basal part of this formation contains large euomphalids and about 200 feet above the base, there is a five-foot thick chert bed with a great abundance of Composita. These beds form correlatable markers in some of the ranges of central and eastern Pima and northern Santa Cruz Counties. Throughout the rest of southern Arizona, except in the northern Chiricahua Mountains, erosion has removed most or all of the Concha. In the Portal-Hilltop area more than 700 feet of beds occur above the Scherrer formation, but these have not been adequately studied and only the basal cherty limestone of the Concha and the Neospirifer zone have been certainly located.