GEOLOGY AND PALEONTOLOGY OF THE DOCKUM FORMATION (UPPER TRIASSIC), WEST TEXAS AND EASTERN NEW MEXICO

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Abstract-The Dockum Formation (Upper Triassic) of West Texas and eastern New Mexico consists of a series of clastic-dominated facies deposited within fluvial and lacustrine environments in a subsiding cratonic basin. Vertebrate fossils have been recovered from numerous localities in Texas and New Mexico. Texas Dockum localities described herein include those at Otis Chalk (Howard County), Kalgary/Home Creek (Crosby County), Sunday Canyon (Randall County) and Rotten Hill/Sierrita de la Cruz (Potter County). Vertebrate fossil localities in Quay County, New Mexico discussed include Apache Canyon, Red Peak and Shark-Tooth Hill. Vertebrate fossils recovered from the localities include a variety of freshwater sharks, actinopterygian and sarcopterygian fish, labyrinthodont amphibians and numerous reptilian taxa.

DOCKUM TECTONICS

During the Early Pennsylvanian, continental collision along the southern portion of the North American continental margin created the Anadarko, Delaware, Midland and Palo Duro basins, as well as the Amarillo-Wichita uplift, Matador-Red River arch, and the central basin platform (Handford et al., 1980). Although collision of the North and South American plates was not as great as that between North America and Africa, subduction of North America under the South American plate created the Ouachita foldbelt during this time (Walper, 1980). These tectonic provinces would have a profound influence on later Triassic geology and topography.

During the Upper Triassic, structural doming reactivated deposition in the relict Paleozoic Dockum basins, such as the Midland and Palo Duro, and resulted in a drainage reversal within that region (McGowen, 1979; Handford et al., 1980). According to Bureau of Economic Geology and University of Texas studies, the Dockum was completely enclosed by structurally high regions including the rejuvenated Amarillo uplift, Bravo dome and Matador arch to the north, the Central Basin Platform to the west, and the Ouachita uplift to the south and east. Dominant sediment input was from the Ouachita uplift (Walper, 1980; Granata, 1981). Along the Gulf Coast, formation of Triassic red bed deposits (such as the Eagle Mills Formation) and the often associated basalts within Gulf Coast grabens are believed to represent the initiation of Pangaean rifting (Walper, 1980).

STRATIGRAPHY AND SEDIMENTOLOGY OF THE DOCKUM FORMATION, WEST TEXAS AND EASTERN NEW MEXICO

Dockum Stratigraphy

Triassic deposits in Texas were first identified by Jules Marcou in 1853 on the basis of fossil wood found along the Canadian River. Cummins (1889) named the Dockum Formation for the town of Dockum in Dickens County. Gould (1907) later elevated the Dockum to group status, based on the stratigraphic sequence of the northwestern Panhandle of Texas. He divided the Dockum Group into a lower shale-dominated unit (the Tecovas Formation) and an upper sandstone/conglomerate-rich unit (the Trujillo Formation). Due to the relatively localized occurrence of these units, there have been suggestions to demote the Dockum to formation status (see discussion in Chatterjee, 1986). The Tecovas and Trujillo are recognizable in the Palo Duro Canyon and Canadian River area but are not easily discernable in the south-central and southern Dockum exposures. These units therefore seem to be of local significance only and therefore should probably be demoted to member status. However, proposal of numerous formal units within the Dockum (a situation that has always been popular and seems to be having a revival as of late) should be avoided. I particularly disagree with treating the Dockum as a formation and yet suggesting that it's members can be correlated over very large regions. Establishment of Dockum members, based on very few exposures in limited geographic areas, and which are not compared with other portions of the unit, will only lead to further confusion as to the stratigraphic relationships. However, I have followed Chatterjee (1986) in demotion of the Tecovas and Trujillo to member status.

In northeastern New Mexico and the extreme western Panhandle of Oklahoma, Dockum formations similar to those of the Texas Panhandle may be found but are referred to by different names. The Sloan Canyon Formation, consisting of a series of shales, calcareous sandstones and marls, is overlain by the Sheep Pen Formation, a thin to massive bedded tan to buff-colored sandstone (Parker, 1930). I have not studied these units and do not know the proper stratigraphic rank that should be applied to them.

Within the central and southern Dockum basin the stratigraphic nomenclature is very confusing with various shale units generally being referred to as Tecovas or Chinle and sandstones and conglomerates given names such as Trujillo, Santa Rosa, Quito, Taylor, Dickens, Dripping Springs, Barstow or Camp Springs (Hoots, 1925; Case, 1928; Adams, 1929;Jones, 1953; Green, 1954; Reeside et al., 1957; Murry, 1986, 1987a). Although I recognize the extremely close similarities of the Dockum and Chinle formations in both geographic position and faunal composition, referral of both units to the Chinle Formation should be avoided as noted by Chatterjee (1986). The proliferation of other names as noted above illustrates the confusion that can be created when stratigraphers attempt to correlate a local unit over a large area or apply names of well-known units outside their known outcrop areas or in the

subsurface.

The Redonda Member of northeastern New Mexico, consisting of fine-grained sandstones, siltstones and conglomerates, represents the uppermost portion of the Dockum Formation exposed in outcrop (Dobrovolny and Summerson, 1946; Griggs and Read, 1959; Granata, 1981). The top of the Redonda is approximately 400 meters above the base of the Triassic (McKee et al., 1959; Granata, 1981). According to Long (pers. comm.; 1989) the large vertebrates of the Redonda Member suggest a Norian age. Both the Redonda Formation and Santa Rosa Sandstone were included in paleomagnetic studies by Reeve (1971; 1975). However, due to the lack of a substantial comparative data base no precise age could be assigned to the Redonda and Santa Rosa based on paleomagnetism. Studies by Ash (1972, 1980) and Lucas and Hunt (1987) indicate a late Carnian to Norian age for the Santa Rosa Formation. Lucas and Hunt's studies of the Santa Rosa Formation in east-central New Mexico indicate a correlation of the sequential Los Esteros, Tres Lagunas and the lower shale members with the Tecovas Formation of the Palo Duro basin. Their Cuervo Member was believed to be correlative to the Trujillo Formation of the Palo Duro Basin.

Dockum Sedimentology

According to McGowen et al. (1983), the initiation of Dockum sedimentation was due to the rifting of Pangaea in the region of the Gulf of Mexico. As compared to the earlier Permian conditions, the initial Dockum deposition was influenced by an increase in rainfall, a change from marine- to lacustrine-dominated sedimentation with concomitant establishment of the Dockum basin, and the rejuvenation of a coarse-grained sediment supply (Johns and Granata, 1987). According to Granata (1981), the earliest accumulations of Dockum sediments were in the southeastern and northwestern portions of the basin. The lowest thirty m of Dockum mudstones in the Midland basin are a time-transgressive sandy lithofacies believed to represent prodelta, delta-front and delta-plain facies of a lobate delta system.

Above the basal sandy facies, studies by McGowen et al. (1979, 1983) and Johns and Granata (1987) indicate that lacustrine sedimentation predominated, with lacustrine mudstones and siltstones as thick as 275 m present in the central Midland basin. This sequence seems to represent essentially all of the Dockum of Texas as exposed in outcrops, although debate among workers centers upon the actual extent of lacustrine sedimentation. The generally fine-grained nature of sediments within the eastern portion of the Dockum is believed to indicate a more distant source area than that seen in the south. Sediments were probably derived from reworked Permo-Pennsylvanian units (Granata, 1981; Johns and Granata, 1987). This area shows cyclic sedimentation with lacustrine and meandering fluvial facies, probably reflecting alternating humid and arid conditions during Dockum time. Four discrete sandstone packages are recognized in the lower Dockum in the Palo Duro basin, indicating fluvial and

proximal deltaic sedimentation. The separating mudstones are believed to represent distal delta-front and lacustrine environments (Johns and Granata, 1987). In the southern and northern portions of the basin, braided streams and fan deltas were the dominant depositional systems. During times of aridity, the base level in the ephemeral lakes lowered and evaporites, calcretes, silcretes and soils developed on the exposed lake floors and delta margins (McGowen, 1979). Within the eastern portion of the basin the largest sandstone concentrations are in the northernmost and southernmost areas, probably indicating the relative proximity of the sediment source.

The northeastern portion of the lower Dockum is characterized by lacustrine, deltaic and fluvial systems, representing several periods of lacustrine delta progradation. Within Palo Duro Canyon, the lower 90 ft (27.4 m) of conglomerates, sandstones, siltstones and mudstone foresets indicate fan-delta facies, upon which lie approximately 60 ft (18.3 m) of lacustrine mudstones. This progradational sequence consists of massive to horizontally bedded yellow, gray, reddish-brown and purple mudstone with lenses of satin spar and burrowed, impure dolomite and limestone. This sequence is believed to represent deposition in a shallow, ephemeral lake (McGowen et al., 1979). Upper sandstone units in Palo Duro Canyon are believed to represent deposition in high-constructive lobate delta, meanderbelt and valley-fill systems. Two lobate delta sequences are represented which are capped by delta plain and a second lacustrine sequence (McGowen et al., 1979). The lacustrine muds are overlain by 8 to 15 m-thick delta foresets which indicate waters some 10-25 m deep. Capping the sequence is a fan delta-delta platform sheet sandstone and conglomerate. Another set of beds, identical to those directly underlying, are found within the last sequence, indicating identical depositional conditions. Both sequences indicate an eastern sediment source (Seni, 1978).

Within Tule Canyon, approximately 50 km south of Palo Duro, the stratigraphic and sedimentologic features suggest a fluvial rather than a lacustrine-dominated environment (Boone, 1979). Lower units within the canyon consist of sandstones with local conglomeratic units, indicative of aggrading braided stream deposits or alluvial fans and fan-delta deposits in humid regions. Indications of shallow ephemeral lakes are only locally present, indicating that major episodes of lacustrine deposition may not have occurred everywhere during lower Dockum time. Within the upper sequence at Tule Canyon, Boone's studies indicate the presence of braided streams as deep as 7 m and as wide as 230 m with paleocurrents to the north or east. This change in facies is believed to indicate an increase in base level concomitant with increasing lake depth and increased Dockum rainfall.

Studies by Johns and Granata (1987) indicate that there was a progressive shift toward a deeper and more extensive lacustrine basin through time throughout the Palo Duro basin area. However, weathered lacustrine mudstones, intraclast-filled fractures and pedogenic carbonates within the upper portion of the lower Dockum indicate a temporary decrease in lake size, followed by another

transgressive sequence during upper Dockum time.

Within the northern portion of the Dockum, locally derived fan and alluvial plain deposits are found south of the Bravo dome and along the western edge of the Amarillo uplift. It was estimated that the Dockum above these older tectonic highs was as much as 120 m thick, which is much more sediment than could have been derived from these sources. It is believed that the source of sediments was farther east along the Amarillo uplift or possibly from the northwest. The probable occurrence of lacustrine mudstones in this area above the fan and alluvial plain deposits indicates a lacustrine transgression within the northern basin (McGowen et al., 1979).

Within the northwestern part of the Dockum basin, north and northwest of the Matador arch, coarse-grained sandstone meanderbelt facies are present in DeBaca, Guadalupe, San Miguel and Quay counties, New Mexico. This unit has been designated the middle sandstone member of the Santa Rosa Sandstone (McGowen and Garner, 1970). The middle sandstone member is overlain by a deltaic deposit, which in turn is capped by some 60 m of lacustrine muds. This sequence has been used to hypothesize a basinwide expansion of the lacustrine environment during the uppermost part of the lower Dockum (Granata, 1981).

The upper Dockum is preserved only in eastern New Mexico. An easterly prograding fluvial deltaic system was developed within the northeastern and north-central Dockum basin at this time, characterized by a high sand to mud ratio with rather confined parameters updip and expanded lobes toward the central basin. The easternward shift of Dockum deposition may be indicated by the character exhibited by the Redonda Formation in the Tucumcari basin of New Mexico, with cyclic sedimentation of lacustrine mudstones and lake margin fine-grained, well sorted sandstones. Increased aridity may be indicated by the presence of evaporites in the Redonda and by the Jurassic dune-formed Exeter Sandstone (Granata, 1981).

OTIS CHALK LOCALITIES

Location

Trilophosaurus quarry #1 (SMU #122) is situated at 32° 10'20'' N 101° 14'50'' W, Hyman 7.5' Quadrangle, Howard County, Texas. Schaeffer's (1967) fish quarry is situated 250 m N30° W of Huensinger Well 3, northeast of the Otis Chalk Community at approximately 32° 09' 47''N 100° 14' 58''W (Murry, 1987a).

A number of Works Progress Administration and University of Texas localities are situated approximately 5 km north of Otis Chalk which have been excavated by University of Michigan, University of Oklahoma and University of Texas (Fig. 1). The Works Progress Administration quarry 2 was situated approximately 90 m east of quarry 1 at 6 m lower elevation. Quarries 3 and 3a were approximately 1.6 km south of quarry 1 and quarry 4 was in a