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NEALIAN AND LENOXIAN (WOLFCAMPIAN, LOWER PERMIAN) DEPOSITIONAL SEQUENCES, FUSULINID FACIES AND BIOSTRATIGRAPHY, GLASS MOUNTAINS, WEST TEXAS

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INTRODUCTION

The Wolfcampian Series crops out along the base of the Glass Mountains escarpment (King, 1930, 1937) and, in the western part of the Marathon Basin, in folded and faulted beds exposed in the Dugout structural fold belt, the westernmost belt in the Marathon Orogen (Ross, 1963). The Wolfcampian is divided into two stages, a lower Nealian Stage and an upper Lenoxian Stage (Ross and Ross, 1987a, 1987b). Strata of these two stages are separated by a major tectonic event in the history of the Marathon orogeny and, as a result, by a major angular unconformity that separates the structurally deformed strata of the Nealian from the slightly deformed Lenoxian strata that crop out nearly continously as a band across the base of the Glass Mountains escarpment.

NEALIAN (LOWER WOLFCAMPIAN)

The Neal Ranch Formation (Ross, 1963) which represents the Nealian Stage is exposed in four areas. In its type section in the Wolf Camp Hills, the Neal Ranch Formation contains *Pseudoschwagerina uddeni*. Nealian exposures in deformed beds in the Dugout fold belt from about 6.5 km west of the town of Marathon northwestward to the base of the Lenox Hills escarpment also contain a few limestone beds with *P. uddeni*. Much thinner Nealian successions are exposed at Gap Tank along the Fort Stockton–Marathon road and in the Hess Ranch horst where a Tertiary igneous intrusion brings Nealian strata to the surface. Each of these four localities was deposited in a different lithologic facies and is not physically continuous with the others along the outcrops, although they share in large part the same faunas.

Wolf Camp Hills

The type section of the Neal Ranch Formation in the Wolf Camp Hills (Fig. 1) is the most complete and best documented of the four areas of outcrop and the relations of the Nealian sedimentation to the underlying Gaptank Formation and overlying Lenox Hills Formation are clearly exposed. Deposits at this locality represent a shallow embayment which developed above an unconformity on folded massive limestones of the Gaptank Formation of Virgilian age.

It is likely that the Wolf Camp Hill embayment 'syncline' was formed contemporaneously with Nealian deposition. In early to middle Virgilian time, the broad Old Meeks Place Anticline formed a peninsula which projected northward from the Marathon Orogenic belt. By late Virgilian time, the west flank of this anticline was the site of a massive carbonate build-up, the Gray Limestone Member of the Gaptank Formation. After deposition of the Gray Limestone Member, and prior to the deposition of the Neal Ranch Formation, the Old Meeks Place Anticline was further folded. At this time, the Neal Ranch Formation was deposited as an eastward thinning sedimentary wedge against the eroding west flank of the Old Meeks Place Anticline. The base of the formation becomes younger as it transgresses onto the flank of the Old Meeks Place anticline (Figs. 1, 2). Thus, within a lateral distance of about 1.5 km, beds near the middle of the western outcrops pass laterally into beds that are the base of the formation in the eastern outcrops. The upper boundary of the Neal Ranch Formation is the regional angular unconformity which postdates the Dugout Creek thrust phase of the Marathon Orogeny. It is on this unconformity that Lenoxian sediments were deposited.

The Neal Ranch Formation is composed of three depositional sequences, and part of a fourth one (Fig. 1) that resulted from significant flooding by relatively major sea-level transgressions and regressions which lapped onto the west flank of the Old Meeks Place Anticline (Fig. 2). The lower beds of the Neal Ranch Formation are limestone pebble conglomerates, thin, graded beds of sandstone, dark blue-gray shale with sponges and conodonts, deeper-water arenaceous foraminifers, and considerable amounts of dark nodular chert. The wedges of limestone-pebble conglomerate mark sea-level lowstands and dark silty siliceous shale, that have much deeper water faunas, mark maximum flooding events. The middle part of the Neal Ranch Formation contains the best developed highstand systems tracts which are made up of relatively thin, shoaling-upwards bioherms. They shallow upwards into capping beds of dominantly cherty sandstone.

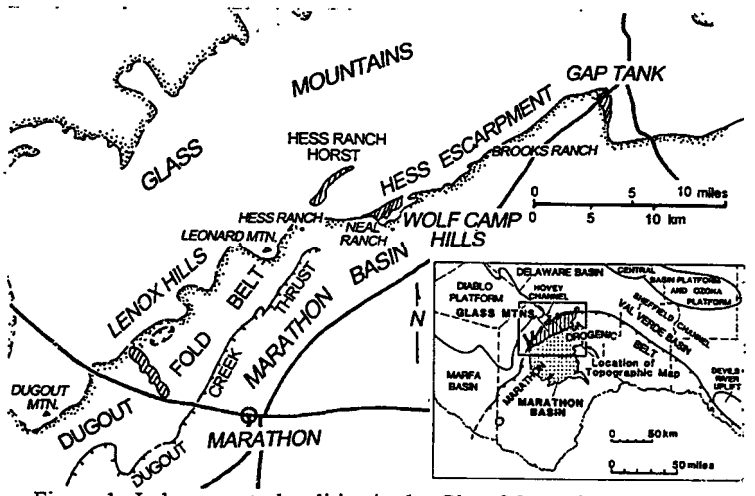

Figure 1.–Index map to localities in the Glass Mountains and northern part of the Marathon Basin, West Texas.

1997. *in* C. A. Ross, J. R. P. Ross, and P. L. Brenckle, editors, Late Paleozoic Foraminifera; their biostratigraphy, evolution, and paleoecology; and the Mid-Carboniferous boundary, Cushman Foundation for Foraminiferal Research, Special Publication 36.

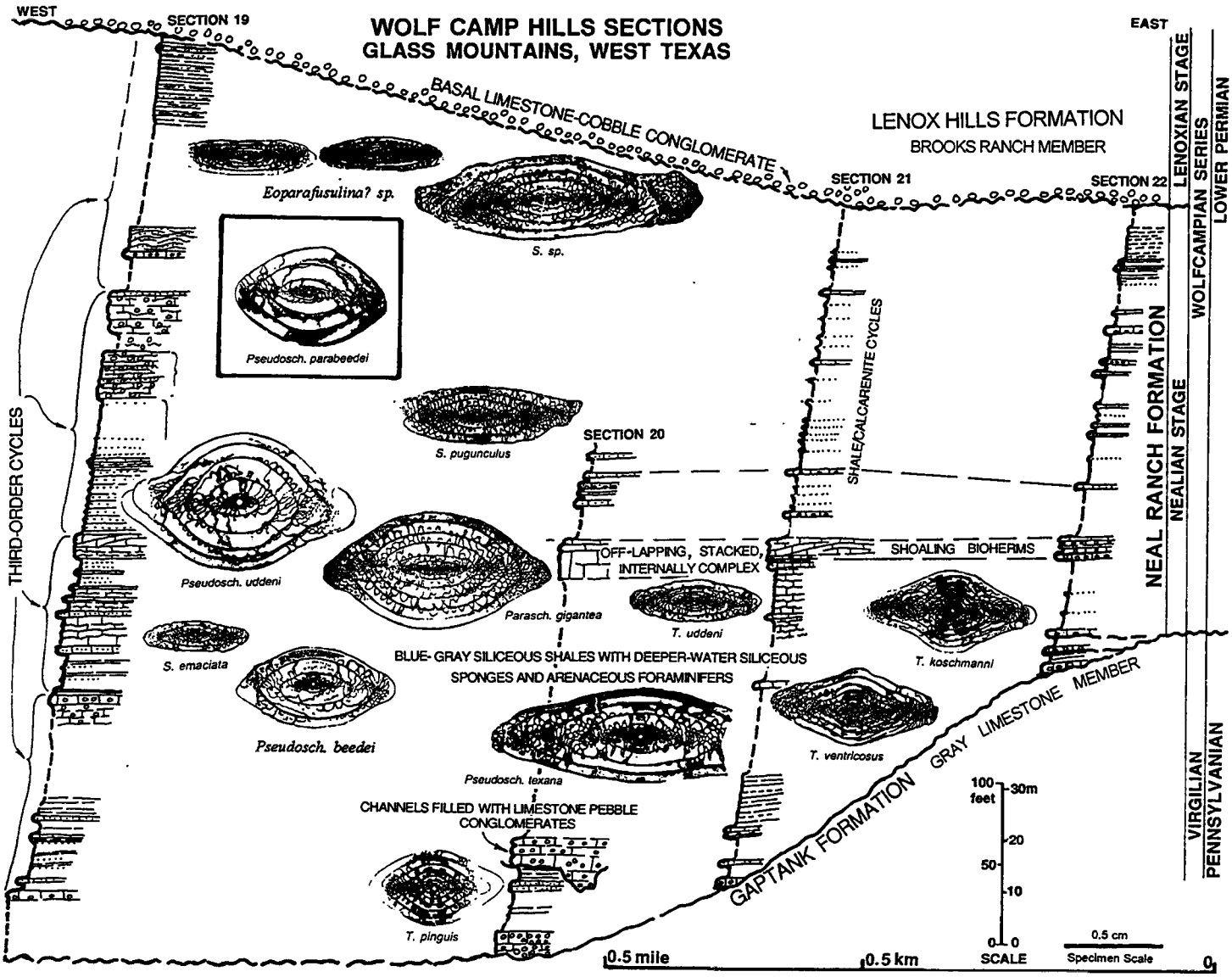

Figure 2.--Stratigraphy of the Neal Ranch Formation, Wolf Camp Hills, Glass Mountains, West Texas. Box shows *Pseudosch. parabeedei* from the Hess Ranch Horst locality. (*E.?=Eoparafusulina?, Pseudosch.=Pseudoschwagherina, Parasch.=Paraschwagerina, S. = Schwagerina, T. = Triticites*)

The small, low, biohermal build-ups have nearly flat, fringing aprons of clastic debris and prolific faunas. In the upper part of the outcrops, shallow water lithologies of yellow-weathering, thin-bedded sandstones and thicker beds of siltstones and silty shales are repeated in meter-scale cycles.

When placed within a depositional framework, a few anomalous species' occurrences suggest instances of reworked older faunas. The fusulinid faunas include *Triticites pinguis* and *T. ventricosus* which are common in the limestone pebble conglomerates, both in the limestone pebble and cobble clasts and in the matrix between the pebbles. Both of these species probably were redeposited by erosion from older beds because they are found only in the conglomerates and coarse redeposited calcarenites. In outcrops in the western part of the Wolf Camp Hills, *Pseudoschwagerina uddeni, P. texana, P. beedei* and *Paraschwagerina gigantea* and rare *T. koschmanni* appear near the middle of the formation and characterize the second Neal Ranch depositional sequence. Two different levels of biohermal growth, each 2 to 3 meters thick, are well-developed near the middle of the Neal Ranch succession and contain the most diverse fusulinid assemblages of the Neal Ranch Formation (Dunbar and Skinner, 1937; Ross, 1963). The fauna includes a few species that are assigned to late lineages of *Triticites,* such as *T. uddeni,* and *Paraschwagerina gigantea,* several species of different sizes and construction of fusiform *Schwagerina,* and *Schubertella.*

Above the bioherms, the succession is mostly siltstone, very fine sandy siltstone, and has local channels filled with sandy, limestone pebble conglomerates and sandstones. A few thin (5–10 cm) sandy calcarenitic limestones mark a series of meter-scale cycles. In contrast to the lower part of the formation, the upper part was deposited in relatively

shallow water with only minor changes in sea level evident. Fusulinids are present and include inflated forms, such as *Pseudoschwagerina* and *Paraschwagerina* and several additional forms that include a large species of *Schwagerina* and small, elongate, subcylindrical forms similar to the primitive *Eoparafusulina, E. allisonsis.*

Dugout Fold Belt Locality

The Nealian discontinuously crops out between Highway 90, 7 km west of the town of Marathon, northwest to the base of the Lenox Hills (Ross, 1963). Near the base of the Lenox Hills, a dark gray limestone contains *Pseudoschwagerina uddeni, Paraschwagerina gigantea, Schwagerina emaciata,* and *S. pugunculus* and adjacent calcarenites have *Triticites uddeni.* Although structurally part of the Dugout fold belt, these beds with Nealian faunas are the same age as the Neal Ranch Formation in the Wolf Camp Hills. Near Highway 90, *Triticites ventricosus* and several primitive species of *Schwagerina* suggest that Bursumian age rocks are present so that strata representing part of the hiatus between the Virgilian Gaptank Formation and the Neal Ranch Formation in the Wolf Camp Hills are present. For the most part, the strata in the Dugout Fold Belt are coarse to fine proximal turbidites, calcarenites, and clastics that contain fusulinid faunas of Middle and Late Pennsylvanian (including Bursumian). The presence of *Pseudoschwagerina uddeni* in these strata demonstrates that the last major episode of folding in the Marathon Orogenic system postdated deposition of the Nealian. Previously, when only Pennsylvanian faunas had been reported in the Dugout fold belt, many geologists working in the area (for example, King, 1930, 1937) assumed that the last major deformation of the Marathon Orogenic deformation had coincided with the Pennsylvanian–Permian boundary. It also demonstrates that earlier thrust and fold belts within the Marathon Orogenic system were sufficiently consolidated to act as structural bulwarks as the Marathon Orogeny progressed.

Hess Ranch Horst Locality

The Hess Ranch horst locality is important because it exposes the deeperwater, black siltstone and shale facies of the Val Verde Basin which forms a distinctive foredeep depositional basin immediately north of the Marathon Orogen. The Nealian fusulinids at this locality are dominated by *Pseudoschwagerina parabeedei* and lend credence to the hypothesis that *Pseudoschwagerina* was either planktonic or easily transported by waves and currents. Also present in 4 to 10 cm calcarenitic layers are typical Nealian species including *Schwagerina pugunculus* and *Paraschwagerina gigantea?*

The Nealian strata in the Hess Ranch Horst are located northwest and, hence, basinward of the Wolf Camp Hills exposures of the Neal Ranch Formation. It is likely that these are a younger part of the Neal Ranch succession and may even represent beds that are higher than those exposed in the Wolf Camp Hills. They are older than the Lenox Hills Formation which also overlies these beds in the Hess Ranch Horst. *Pseudoschwagerina parabeedei* may identify a higher depositional sequence.

Gap Tank Locality

At Gap Tank, about 30 m of the Neal Ranch Formation lies in a small structural syncline developed on the eroded surface of the middle part of the Gaptank Formation and beneath conglomerates of the Lenox Hills Formation. Post-Cretaceous faults cut across the exposures in a WNW direction. Like the type sections, these Neal Ranch beds include small biohermal build-ups, calcarenites, silty shales, and a few conglomerates. *Pseudoschwagerina uddeni, Triticites koschmanni, Schwagerina gracilitatis, S. compacta, Paraschwagerina acuminata* and, from near the top, a primitive species of *Eoparafusulina, E. allisonensis.*

LENOXIAN (UPPER WOLFCAMPIAN)

The Lenox Hills Formation, the upper part of the Wolfcampian Series (the Lenoxian Stage), is traceable across the base of the entire southern escarpment of the Glass Mountains and postdates the last major orogenic movements (the Dugout Fold Belt phase) of the Marathon Orogeny (Ross, 1963). In the western part of the Glass Mountains, the Lenox Hills Formation was deposited by several thick gravel-rich stream deltas that have conglomeratic material derived from the highlands of the Marathon Orogenic belt. These conglomeratic deltas prograded westward and northwestward into the deep-water Hovey Channel. Between these deltas are a series of inter-delta basins with shales, siltstones, sandstones, and calcarenites that contain fusulinid faunas characterized by *Schwagerina nelsoni, S. crebrisepta, S. diversiformis,* and *Eoparafusulina linearis,* and nearby bioherms with *Pseudoschwagerina robusta* and *P. convexa.* To the east (Fig. 2), these facies pass into calcarenitic and calcisiltic beds and locally into a carbonate shelf-margin bioherm at Leonard Mountain and at the Hess Ranch house.

Farther east, in the eastern part of the Glass Mountains, the basal beds of the Brooks Ranch Member of the Lenox Hills Formation are limestone pebble conglomerates that fill erosional valleys and uneven topography cut into the underlying Neal Ranch and Gaptank Formations. These beds are overlain by shallow-water, nearshore clastics, red beds, and thin dolostone facies which include four well-defined cycles consisting of fluvial-shoreline-shallow subtidal depositional facies.

The biofacies change eastward from a fusulinid-rich biohermal shelf margin at Leonard Mountain into less favorable environments. Fusulinid genera and species rapidly become less abundant and less diverse eastward into shallow subtidal and intertidal, predominately siltstone and sandstone, lithofacies (Fig. 2). The last species of schwagerinid fusulinids occur near the middle of the Hess escarpment (section 29, Fig. 2). In these facies, the few occurrences of fusulinids, such as *Schwagerina extumida, S. dispansa,* and *S. tersa,* are characterized by numerous specimens of a single species in only one or two thin beds. Dolostones just to the east (King's section 27, Fig. 2) have small spheroids that might be recrystallized staffellids.

Five depositional sequences are present in the Brooks Ranch Member. The lowest is a valley fill and flooding succession in the Brooks Ranch syncline and includes limestone-cobble conglomerates, siltstone, and recrystallized limestone. The second depositional sequence is more

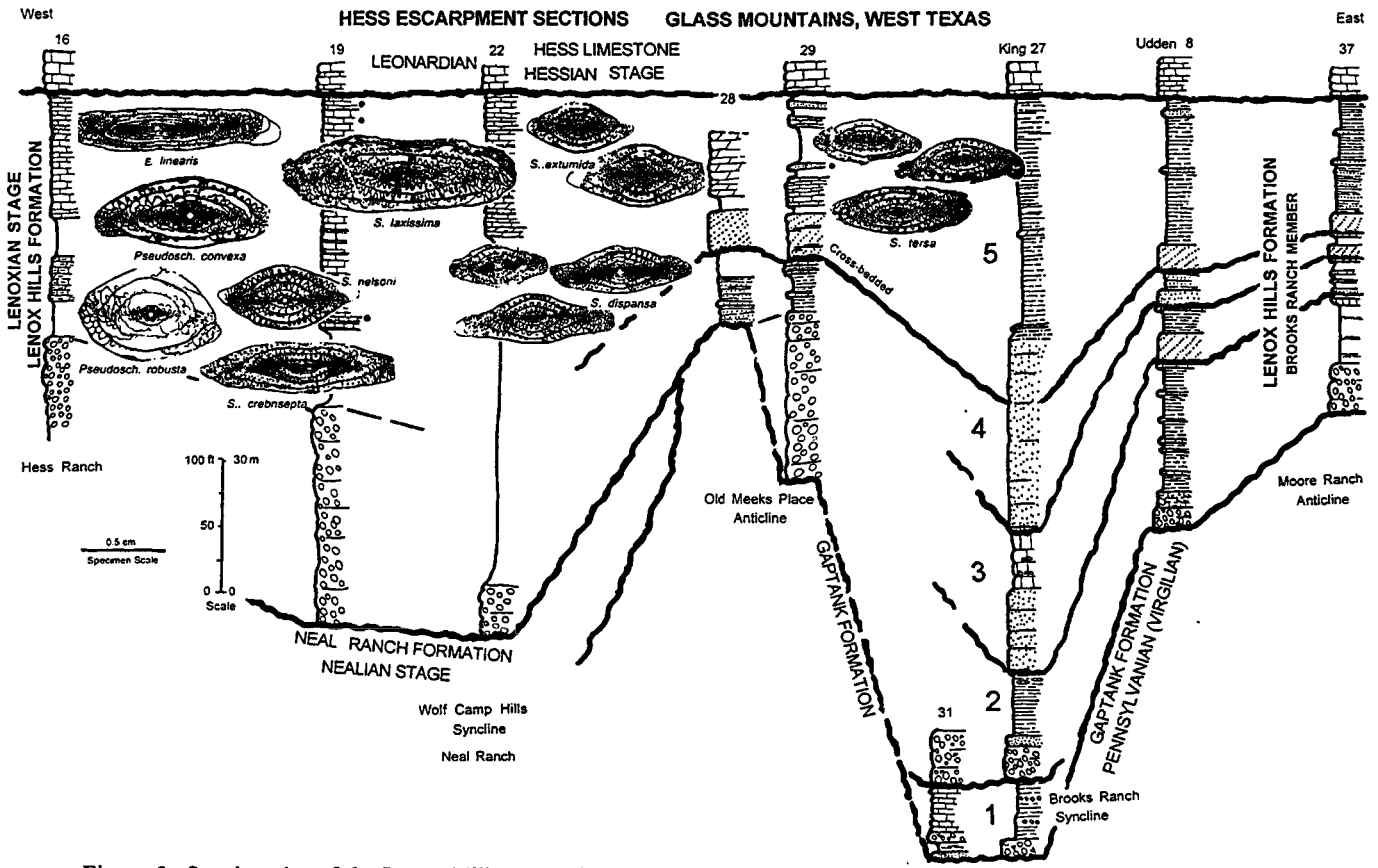

Figure 3.–Stratigraphy of the Lenox Hills Formation along the base of the Hess escarpment from the central part to the eastern part of the Glass Mountains, West Texas. Black dots are location of the few scattered fusulinid-bearing beds in the middle part of the band of outcrops. Depositional sequences in the Brooks Ranch Member are numbered.

extensive and covers much of the adjacent local topography. Cross-bedded sandstone and reddish to brown siltstone are common and thin limestone is present in this and in the succeeding two depositional sequences. These lower four depositional sequences of the Brooks Ranch Member (Fig. 2) appear to pass laterally into thick conglomerates and intervening sandstones and siltstones that form the lower part of the Lenox Hills Formation along the western part of the Hess escarpment. The few fusulinids known from these lower depositional sequences are likely redeposited from older beds.

The highest depositional sequence in the Brooks Ranch Member has a distinctive cross-bedded sandstone at its base and passes upward into brown silty shales and thin cyclically repeated dolostones. This depositional sequence passes westward into increasing amounts of dolostones and limestones and toward the western end of the Hess escarpment it progressively includes *Schwagerina tersa, S. dispansa, S. nelsoni, S.* extumida, *S. crebrisepta, Psuedoschwagerina robusta, Eoparafusulina linearis* and others.

CONCLUSIONS

The Wolfcampian Series is represented in the Glass Mountains by the Neal Ranch Formation and the Lenox Hills Formation. Each has distinctive fusulinid faunas which characterize the Nealian and Lenoxian Stages. The Neal Ranch Formation in its type area includes three depositional sequences and part of a fourth one. The Lenox Hills Formation includes five depositional sequences. Ecological gradients in species and species diversity are related to lateral depositional facies changes.

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