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Guadalupian (Middle Permian) Conodonts of Sponge-Bearing Limestones from the Margins of the Delaware Basin, West Texas

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Key words: Guadalupian, Conodonts, Stratigraphy, Delaware Basin, Texas.

Abstract

The Guadalupian Series (with Roadian, Wordian and Capitanian stages in ascending order) is very suitable for world-wide application as the Middle Permian standard. The conodont faunas of the Delaware Basin and its slope are dominated by pelagic forms represented by ribbed *Mesogondolella* restricted to the Middle Permian of intraplatform basins and to near-shore slopes of tropical open seas. The first appearance of the serrated *Mesogondolella nankingensis* (CHING) is important for the definition of the base of the Middle Permian (base of the Guadalupian Series = base of the Roadian Stage). *Mesogondolella nankingensis* evolved in a phylomorphogenetic cline from the unserrated *M. idahoensis* (YOUNGQUIST, HAWLEY & MILLER) through transition forms closely related to *M. phosphoriensis* (YOUNGQUIST, HAWLEY & MILLER). The appearance of serrated *Mesogondolella* is a very characteristic event in Permian conodont evolution, which can be traced in southwestern and western North America, Arctic Canada and in China. This event is very suitable for the world-wide correlation of the base of the Middle Permian Guadalupian Series.

At the upper boundary of the Guadalupian, the serrated *Mesogondolella shannoni* WARDLAW changed in a phylomorphogenetic cline into the smooth *Clarkina altudaensis* KOZUR. This cline was also found in intraplatform basins of the eastern Tethys (China). For this reason, the top of the Guadalupian can be well correlated with the Tethyan scale, in which the Late Permian Lopingian Series is defined. The first appearance of *Clarkina crofti* KOZUR & LUCAS in the uppermost Lamar Limestone and in the uppermost Altuda Formation is very important as it is penecontemporaneously with the first appearance of *C. altudaensis*. This species is restricted to greater water depths.

Two new conodont species, *Hindeodus gulloides* n. sp., and *H. altudaensis* n.sp. are described. Additionally, *Clarkina crofti* KOZUR & LUCAS n.sp. is described to avoid the use of nomina nuda, because the paper of KOZUR & LUCAS (in press) has not yet been printed.

1. INTRODUCTION

The pelagic and shallow-water fossils of the Delaware Basin and its surroundings have been studied for about 100 years and described in numerous papers and monographs since GIRTY (1908). For reasons discussed below, marginal deposits of the Delaware Basin exposed in the Guadalupe and Glass Mts. are most suitable for establishing a world standard for the Middle Permian Guadalupian Series (Roadian, Wordian and Capitanian stages in ascending order) and for the immediately underlying part of the Early Permian (Cathedralian Stage).

The present paper deals with conodonts of those levels (Roadian, basal Wordian, Capitanian), from which very rich sponge spicule associations were found (KOZUR & MOSTLER, in press). This contributes to the knowledge of the fauna of the type Guadalupian. The stratigraphically most important conodonts of the Roadian and the Capitanian are discussed.

Further microfossil groups (holothurian sclerites, ostracods, radiolarians and sponge spicules) will be described in independent papers.

2. THE IMPORTANCE OF THE PERMIAN SEQUENCES IN THE GUADALUPE AND GLASS MTS. FOR THE PERMIAN STRATIGRAPHY

The Delaware Basin and its marginal development in the Guadalupe Mts. and Glass Mts. belong to the classical areas of the Permian stratigraphy. The marginal parts of the Delaware Basin in West Texas and southeastern New Mexico (Fig. 1) contain very impressive outcrops of Middle Permian (Guadalupian Series) rocks, and also parts of the Lower Permian (Cisuralian Series) and Upper Permian (Lopingian Series) deposits are exposed. The sequences of the Guadalupian Series are better exposed in the easily accessible outcrops than in any other part of the world (GLENISTER et al., 1992; KOZUR, 1992c). The Permian rocks of the Delaware Basin comprise basinal suites (deposited in water

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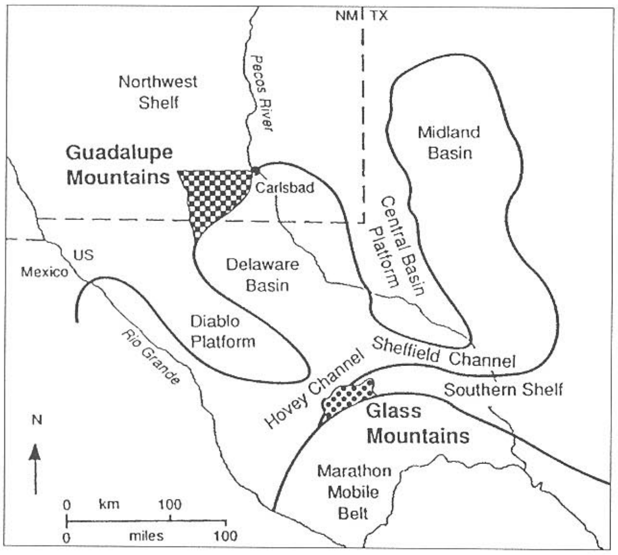

Fig. 1 Palaeogeographic location of the Delaware Basin, West Texas and SE New Mexico. Modified after ORIEL et al. (1967).

depths in excess of 500 m), slope deposits, fore-reef deposits, reefs and back-reef deposits. They cover the entire Guadalupian Series and the Cathedralian Stage (ROSS & ROSS, 1987) of the Early Permian, situated immediately below it. These different facies interfinger in basinal-marginal transition series in the above indicated lateral succession. The back-reef lagoonal deposits interfinger, in turn, with continental deposits. The well-investigated lateral facies alternations from deep-basin to fore-reef, reef and back-reef deposits allow a precise correlation of rich and well preserved shallow-water and pelagic fossil associations. All beds are unmetamorphosed and the very low thermal alteration (CAI = 1-1.5) allows reliable palynological, magnetostratigraphic and isotope investigations. The sequences are tectonically undisturbed. They are extremely rich in different, excellently preserved, pelagic and shallow-water macro- and microfaunas (ammonites, brachiopods, conodonts, fusulinids, radiolarians, echinoderms, sponges etc.), including all stratigraphically important Permian fossil groups.

At the southeastern slope of the Guadalupe Mountains a reef escarpment is beautifully exposed. The palaeoslope corresponds to the present slope. From this, exact estimations of the depositional water depth in the Delaware Basin at different distances from the reef can be made. Because no cold bottom water is present, the thermal gradient is low and no thermocline is present between 200 m and 500 m water depth. Along the fault-bounded western escarpment of the Guadalupe Mountains the transition between basinal and marginal facies can be studied through the Cathedralian-Guadalupian interval over a great distance.

In the slope sediments pelagic and shallow-water fossils occur together, and the pelagic and shallow-water biozonations, well elaborated in the Delaware Basin and its surrounding, can be well correlated. Ammonoid-, conodont- and fusulinid zonations are well established and cross-correlated (for conodonts see CLARK & BEHNKEN, 1979; CLARK & WANG, 1988). Radiolarians are common, but so far only described from one locality of the Roadian Cutoff Formation (erroneously placed into the Cathedralian Bone Spring Formation, CORNELL & SIMPSON, 1985; NAZAROV & ORMISTON, 1985), from the Late Guadalupian and from the Guadalupian-Lopingian boundary (ORMISTON & BABCOCK, 1979; NAZAROV & ORMISTON, 1985; KOZUR, 1993c).

The Guadalupian Series with Roadian, Wordian and Capitanian stages (in ascending order) and the Cathedralian Stage of the late Early Permian are all defined in the marginal parts of the Delaware Basin (Table 1). The Guadalupian Series and the Capitanian stages have been originally defined in the Guadalupe Mountains at

Slope of Guadalupe Mts. and adjacent Delaware Basin			Glass Mountains		
Group	Formation	Member	Formation	Member	Stage
Delaware Mountain	Bell Canyon	Lamar Limestone McCombs Limestone Rader Limestone Hegler Limestone	Altuda		Capitanian
	Cherry Canyon	Manzanita Limestone South Wells Limestone Getaway Limestone	Vidrio		Wordian
			Word	Appel Ranch Willis Ranch China Tank	
	Brushy Canyon	undifferentiated			
	Cutoff	Willams Ranch El Centro Shumard Canyon	Road Canyon		Roadian
	Bone Spring Limestone	undifferentiated	Cathedral Mountains		Cathedralian

Table 1 Lithostratigraphic nomenclature for the Delaware Basin.

the northwestern shelf and slope of the Delaware Basin. The Cathedralian, Roadian and Wordian stages were originally defined in the Glass Mountains, in the slope to base-of-slope facies of the southern Delaware Basin adjacent to the Hovey Channel, which connected the Delaware Basin with the southwards adjacent basins (see Fig. 1). A stratotype for the Guadalupian Series at the western escarpment of the Guadalupe Mountains, which contains a continuous basinal to base-of-slope sequence from the middle part of the Cathedralian Stage up to the Capitanian Stage, was proposed by GLENISTER et al. (1992). It is very rich in fossils, among them ammonoids, conodonts, fusulinids, radiolarians, sponge spicules.

The Cathedralian, Roadian, Wordian and Capitanian stages are most suitable as world standard stages and the Guadalupian is a very suitable designation for the Middle Permian Series (GLENISTER et al., 1992; KOZUR, 1992c, 1993a). Permanent access to the proposed stratotype is guaranteed (GLENISTER, 1993). The above mentioned conditions are ideal for the definition of globally applicable Permian series and stages. For this reason, the Cathedralian, Roadian, Wordian and Capitanian stages and the Leonardian and Guadalupian series established in this area have been proposed as world standard subdivisions (GLENISTER et al., 1992; KOZUR, 1992c; JIN et al., 1994).

The entire Early Permian is exposed in the Glass Mountains. It is very rich in fossils, but the Asselian to Early Artinskian part is sedimentologically rather complicated. For this time interval, the Cis-Uralian standard from the Permian type area is better suitable as a world standard. The top of the type Artinskian can be well correlated with the base of the Cathedralian in West Texas by the first appearance of the conodont *Neostreptognathodus pnevi* KOZUR & MOVSHOVICH (MOVSHOVICH et al., 1979) (Table 2).

Such a correlation is impossible between the top of the Artinskian and any level of the Tethyan scale in Eurasia, because *N. pnevi* is absent in the Tethys, and the Late Artinskian and the few Kungurian ammonoids and fusulinids of the Cis-Uralian cannot be correlated with any level of the Tethyan Early Permian because of faunal and floral provincialism. Moreover, the type sections of the Tethyan scale are facially unsuitable or situated in tectonically complicated, poorly accessible areas of the Pamirs and in Transcaucasia. Therefore, the Early and Middle Permian Tethyan scale is unsuitable for a world standard. Moreover, in the Middle Permian it is originally based on successions of strongly facies-controlled forms of fusulinids, which are absent in the basinal facies of the Tethys and in any facies of the Boreal and Notal realms, as well as in the North American sequences, except for some displaced terranes. The Middle Permian Tethyan stages are therefore uncorrelatable with the Boreal and Notal sequences and with most of the North American sequences (with the exception of a restricted occurrence of *Yabeina* in the Lower Lamar). Moreover, they are even uncorrelatable with Middle Permian pelagic Tethyan sequences, as in Western Sicily, where fusulinids are only present in the slope facies, tectonically separated from the basinal facies (CATALANO et al., 1991, 1992; KOZUR, 1992d, 1994b, 1995b).

In the Late Permian (Lopingian Series) the facies in the Delaware Basin is mostly hypersaline. Therefore, for this time interval the Texas standard is unsuitable as a world standard. Fortunately, in the Late Permian the large shallow-water platforms within the Tethys began to brake up and pelagic sedimentation prevailed in the eastern and central Tethys, also in tectonically rather undisturbed areas, as in Transcaucasia, Central Iran and wide parts of South China. Therefore, in the Lopingian time the Tethyan standard of Transcaucasia, South China and Central Iran is very suitable as a world standard.

Through the phylomorphogenetic cline from *Mesogondolella shannoni* WARDLAW into *Clarkina altudaensis* KOZUR, the top of the Capitanian can be well correlated with the Tethyan scale (see remarks to *Mesogondolella shannoni*). *C. altudaensis* begins nearly contemporaneous with *Clarkina crofti* KOZUR & LUCAS, which preferred greater water depth than *C. altudaensis*. It is therefore common in the uppermost Lamar and in the post-Lamar/pre-Castile beds of the basinal facies of the Delaware Basin, but nearly absent in the shallow pelagic deposits of the uppermost Altuda of the Glass Mts. Here, this species occurs only in the uppermost centimetres of the Altuda, where a short deepening is indicated by mass occurrences of radiolarians, which are very rare earlier in the upper Altuda beds. On the other hand, *C. altudaensis* is missing in the deep basin facies of the Delaware Basin, in which *C. crofti* occurs immediately above *C. shannoni*. In the uppermost Altuda, *C. altudaensis*, *C. crofti* and primitive *C. postbitteri* MEI & WARDLAW occur together. The latter species is preferred now as the index species for the basal Wuchiapingian, but the exact first occurrence of this species in China is not yet known. Because of the first occurrence of *C. postbitteri* in the *C. crofti-C. postbitteri* Zone, this fauna of the uppermost Altuda is placed in the basal Wuchiapingian. The assignment of the American type *C. altudaensis* Zone into the uppermost Capitanian or lowermost Wuchiapingian is still disputed (see remarks to *M. shannoni* WARDLAW).

All *C. altudaensis*, figured by MEI et al. (1994a, b), are *C. shannoni*, mostly with distinct crenulation on the anterior platform, typical for *M. shannoni*, but missing in *C. altudaensis*. However, in the intraplatform basin Zhoushan section at Shushoon, Anhui (South China), typical *C. altudaensis* (WANG, 1994, pl. 50, fig. 20) appeared at the top of the Wuxue Formation (uppermost Maokou), whereas *M. praexuanhanensis* (WANG, 1994, pl. 50, fig. 21; pl. 51, fig. 1) and even *M.* "*xuanhanensis*" MEI & WARDLAW [junior synonym of *M. nuchalina* (DAI & ZHANG), see KOZUR, 1995a] already appeared at the base of the Wuxue Fm. All these forms have been determined as *Neogondolella aserrata*, *N. serrata* and *N.* n.sp. A by WANG (1994).

	Series	Stage	Conodont Zones and Assemblage Zones			Conodont Standard Zonation	
			Shallow- water	pelagic			
TRIAS.	Early Triassic = Scythian	Brahmanian ("Induan")	Isarcicella isarcica	Clarkina carinata		Isarcicella isarcica	
			Hindeodus parvus			Hindeodus parvus	
PERMIAN	Upper Permian = Lopingian	Changxingian	Hindeodus latidentatus	C. deflecta-C. changxingensis	C. xiangxiensis	H. latidentatus-C. deflecta	C. xiangxiensis
					C. postwangi		C. postwangi
			Hindeodus julfensis	Clarkina subcarinata		C. subcarinata-H. julfensis	
		Wuchiapingian / Dzhulfian		Clarkina mediconstricta		Clarkina mediconstricta	
			Iranognathus tarazi	Clarkina orientalis		Clarkina orientalis	
				Clarkina transcaucasica		Clarkina transcaucasica	
				Clarkina leveni		Clarkina leveni	M. divergens-M. rosenkrantzi
			Merrillina divergens	Clarkina niuzhuangensis		Clarkina niuzhuangensis	
				Clarkina postbitteri-Clarkina crofti		Clarkina postbitteri-Clarkina crofti	
		disputed	Hindeodus altudaensis	Clarkina altudaensis ?		Clarkina altudaensis ?	
	Middle Permian = Guadalupian	Capitanian		Mesogondolella shannoni		Mesogondolella shannoni	
				M. postserrata		M. postserrata	
		Wordian	Gullodus catalanoi	M. aserrata	Mesogondolella siciliensis	Mesogondolella aserrata	
		Roadian	S. subsymmetricus Neostreptogn. clinei	M. nankingensis		Mesogondolella nankingensis	Sweetognathus subsymmetricus
	Lower Permian = Cisuralian	Cathedralian	Neostreptogn. sulcoplicatus	Mesogondolella idahoensis		M. idahoensis-N. sulcoplicatus	
			Sichuanognathus ? prayi	Mesogondolella zsuzsannae		M. zsuzsannae-S. ? prayi	
				Mesogondolella glenisteri Mesogondolella asiatica		M. glenisteri-S. ? prayi	
			Neostreptogn. exsculptus-Neostreptognathodus pnevi			M. glenisteri-N. exsculptus	
				M. shindyensis-M. intermedia		M. intermedia-N. exsculptus	
		Artinskian	N. pequopensis-N. ruzhencevi	Mesogondolella bisselli		M. bisselli-N. pequopensis	
			Sweetognathus whitei			M. bisselli-S. whitei	
			S. inornatus-S. whitei			M. bisselli-S. inornatus	

Table 2 Artinskian to basal Triassic conodont zonation (slightly modified after KOZUR, 1995a).

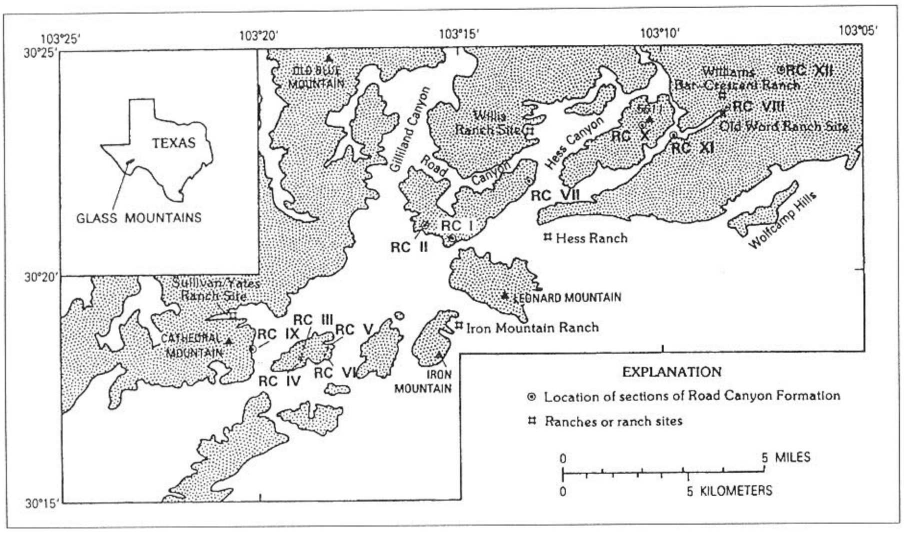

Fig. 2 Southwestern portion of Glass Mountains showing section locations of the Road Canyon Formation (after WARDLAW & GRANT, 1990). For the present paper, the Roadian type locality (RC I) was investigated.

3. LOCALITY DATA AND GEOLOGICAL SETTING

The material, described in the present paper, was derived from the Road Canyon and basal Word Formation of the Roadian type section in the Glass Mountains (Figs. 1, 2), from the upper Altuda Formation of the Glass Mountains (detailed locality data see ROHR et al., 1991, fig. 25, locality 2.3) and from the famous road cut outcrop of the Rader Member of the Bell Canyon Formation along US Highway 62-180 SE of the Guadalupe Mountains (Fig. 3).

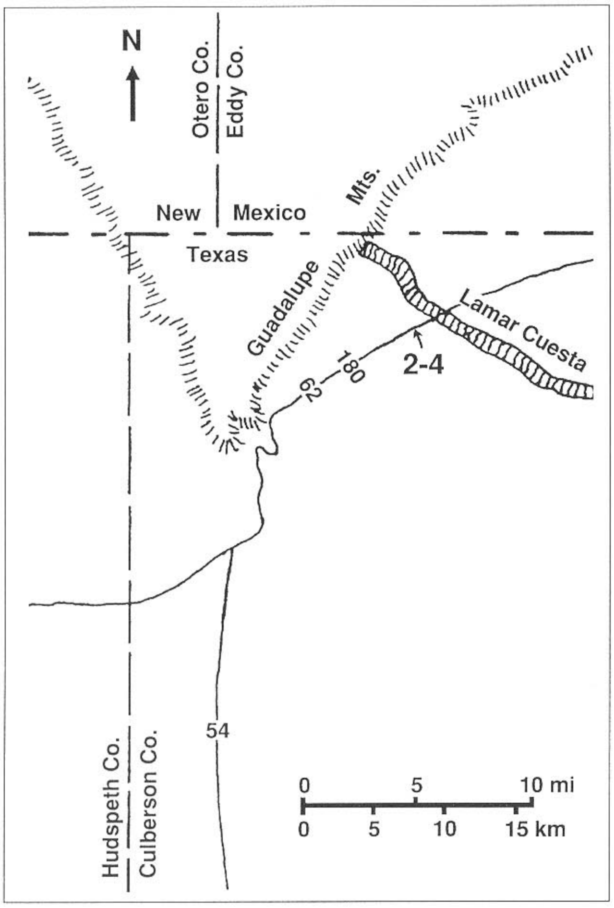

Fig. 3 Sampling locality (2-4) of the Rader Member at US Highway 62/180, east of the Guadalupe Mts., West-Texas.

The type section of the Road Canyon Formation (type of the Roadian) is a base-of-slope succession, located on the hill north of Leonard Mountain on the east side of Gilliland Canyon, north of the Iron Mountain Ranch, near the 103°15' meridian (WARDLAW & GRANT, 1990). The sequence (Fig. 4) consists of fossil-rich limestones, cherty limestones, silt- and mudstones, and subordinately cherts. In the lower part, an approximately 12 m thick debris flow is present. Other, thinner conglomeratic limestones occur within the sequence. The limestones are peloid or skeletal packstones and wackestones. They are very rich in often silicified, well preserved macrofaunas, especially brachiopods (e.g. *Collemataria*, *Composita*, *Coscinophora*, *Derbia*, *Meekella*, *Megousia*, *Neophricadothyris*, *Neospirifer*, *Peniculauris*), corals, crinoid columnals, echinoid debris, sponges, snails. The likewise very rich microfauna consists of conodonts, fusulinids (*Parafusulina*), sponge spicules and radiolarians. Only the conodonts are described in the present paper. The sponge spicules will be described by the present authors in a special Porifera volume of Geol. Paläont. Mitt. Innsbruck. The very rich radiolarian fauna, identical with that of the Roadian Cutoff Formation of the Guadalupe Mountains, will be described in a separate radiolarian volume (Geol. Paläont. Mitt. Innsbruck, Sonderbd.).

The exposed lowermost part of the overlying Word Formation (Wordian) consists of siltstones with limestone intercalations.

The investigated part of the Altuda Formation (Capitanian to basal Lopingian) is exposed at locality 2.3 after ROHR et al. (1991) in the Glass Mountains, NW of the Old Blue Mountain south of the Esterwood Ranch. The sample KoUS-141, rich in sponge spicules, was taken 10 m below the base of the Tessey Formation (Fig. 5). This sample yielded *Mesogondolella shannoni* WARDLAW, a guideform of the latest Capitanian.

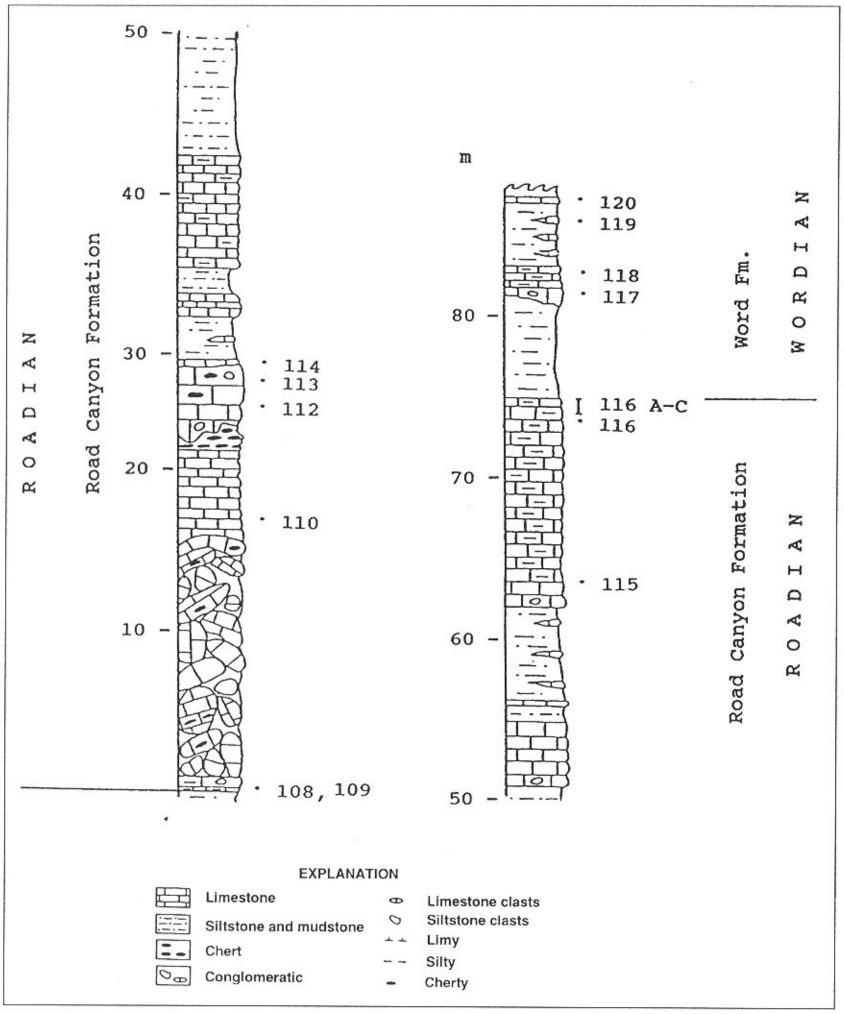

Fig. 4 Lithologic succession in the Roadian type section in the Glass Mountains (modified after ROHR et al., 1991).

The Rader Member of the Bell Canyon Formation (Capitanian) exposes a spectacular submarine debris flow in road cuts on both sides of U.S. Highway 62/180 about 1700 m NE of the Nickle Creek Station (Fig. 3, locality 2-4). The sequence begins with thin-bedded Bell Canyon sandstones with mostly horizontal, but some ripple laminations. Silty and shaly interbeds are common. According to REID et al. (1988), this unit is probably a low-velocity, turbulent, traction-current deposit and the clean, fine-grained, well sorted sands were derived from aeolian shelf sandstones.

The boundary with the overlying debris flow is not sharp, therefore indicating a debris flow with a sand matrix. Carbonate blocks, some up to 2x3 m, were derived from shelf deposits. Overlying the debris-flow deposits, in the upper part of the Rader, there are micrograded basinal limestones, which yielded the samples described below.

The presence of reef rocks in the clasts of the debris-flow, which is under- and overlain by fine-grained basinal rocks, indicates that the debris-flow was a submarine slide which travelled a considerable distance from the reef, which was situated 6-7 km to the NW, and is well exposed in the escarpment of the Guadalupe Mts.

The general geological situation during the Middle Permian (Guadalupian Series) at the northwestern margin of the Delaware Basin, in the Guadalupe Mountains, is shown in Fig. 6. The Capitan reef separated the Delaware Basin in the SE from a back-reef lagoon and an arid subaerial shelf. Sand from the shelf was transported through gaps in the reef into the Delaware Basin. The reef slope at the margin of the Delaware Basin was steep and rather deep. The progradation of the reef was therefore slow.

Figure 7 shows the situation at the southern margin of the Delaware Basin in the Glass Mountains. A reef chain separated the semirestricted Delaware Basin from the open sea to the south. A narrow deep-water connection between the Delaware Basin and the open sea was present, and is called the Hovey Channel. The forereef area in the Hovey Channel and at the southern margin of the Delaware Basin had a shallow pelagic environment during the Capitanian Altuda Formation. The progradation of the reef was rather fast.

With the closing of the pelagic connection in the Hovey Channel, the Delaware Basin became a hypersaline sea at the base of the Ochoan. This disruption of the connection of the Delaware Basin with the open sea may be contemporaneous with a widely recognizable

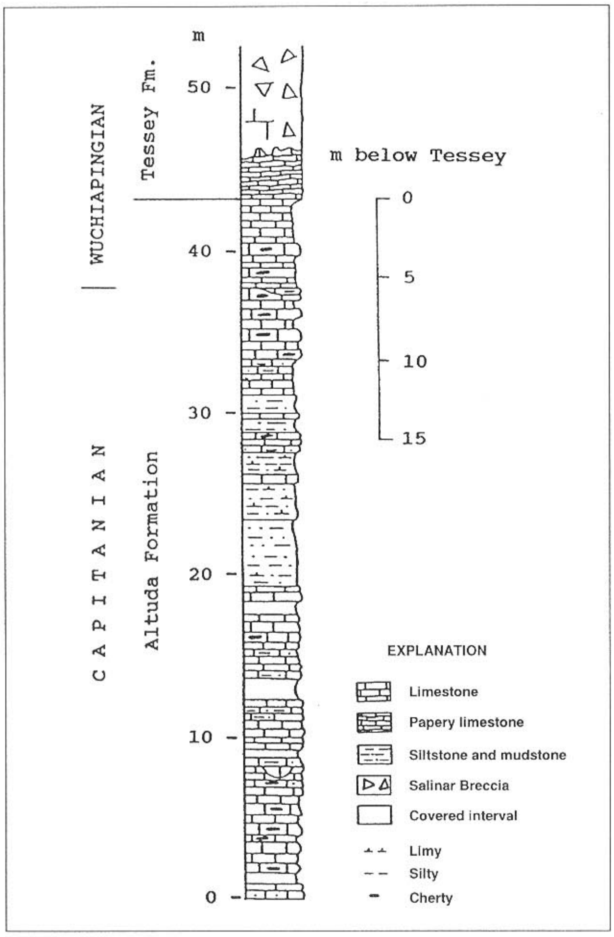

Fig. 5 Upper Altuda Formation and lowermost Tessey Formation at Stop 2.3 in the Glass Mountains (ROHR et al., 1991).

sea-level drop near the Guadalupian-Lopingian boundary. It caused in most sections in South China a gap or (and) deposition of paralic, coal-bearing beds.

After the Delaware Basin was filled up by Late Permian hypersaline rocks, a Late Ochoan shallow-water sea covered the former Delaware Basin, and the Rustler Formation, the last pre-Cretaceous marine unit, was deposited. The Rustler Formation is hypersaline in the NW, but fully marine (with crinoids and brachiopods) in the SE. The P/T boundary seemingly lies within the Rustler Formation.

4. SYSTEMATIC PALAEONTOLOGY

All material is deposited in the collection of the Geologic-Paleontologic Institute of Innsbruck University.

Genus *Hindeodus* REXROAD & FURNISH, 1964

Type species: *Spathognathodus cristulus*
YOUNQUIST & MILLER, 1949

Hindeodus excavatus (BEHNKEN, 1975)

(Pl. I, Fig. 1)

Remarks: *Hindeodus excavatus* is the most common *Hindeodus* species in the Cathedralian and Guadalupian. Its forerunner, *Hindeodus minutus* (ELLISON, 1941), displays an "anticusp-like", rudimentary anterior blade, mostly with 1-2 small denticles, and the posterior blade is not so high and short. Juvenile forms of the two species are nearly inseparable, but in *H. minutus* the blade is mostly not so short and high as in *H. excavatus*. In the Asselian, *H. minutus* is still present, whereas in the Cathedralian *H. excavatus* is already present. Transitional forms are known from the Artinskian. Their blade is relatively long and low as in *H. minutus*, but an "anticusp-like" rudimentary anterior blade is no longer present, as in *H. excavatus*.

H. typicalis (SWEET, 1970), which evolved from *H. excavatus* near the Guadalupian-Lopingian boundary, displays a larger l/h ratio of the blade.

Hindeodus permicus (IGO, 1981) is similar, but distinguished by the abrupt lowering of the blade in posterior part of the unit. Some of the specimens assigned to *H. excavatus* by WARDLAW & GRANT (1990) belong to *H. permicus* (WARDLAW & GRANT, 1990, pl. 2, figs. 5, 6; pl. 3, figs. 6, 7, 9).

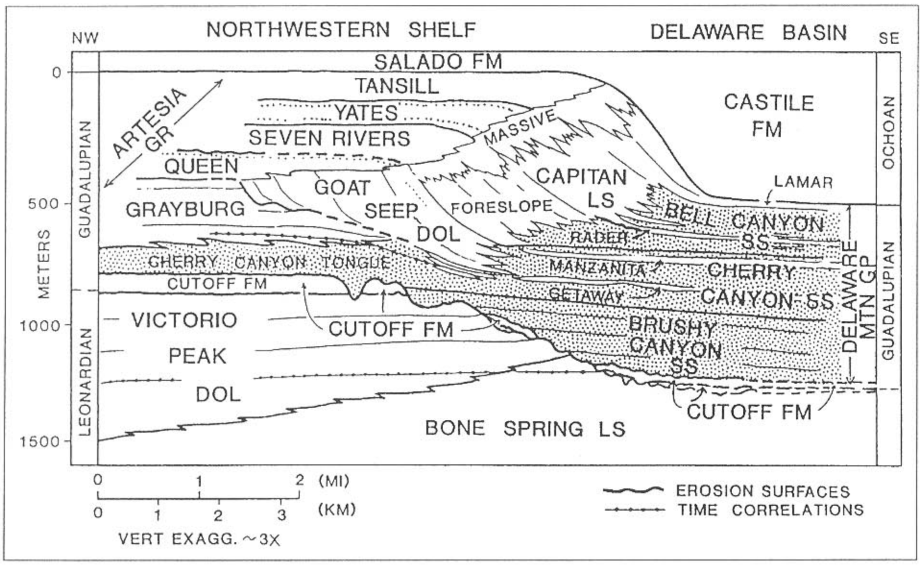

Fig. 6 Stratigraphic diagram of the Guadalupe Mountains showing the major stratigraphic units and some major erosional surfaces (after PRAY in REID et al., 1988).

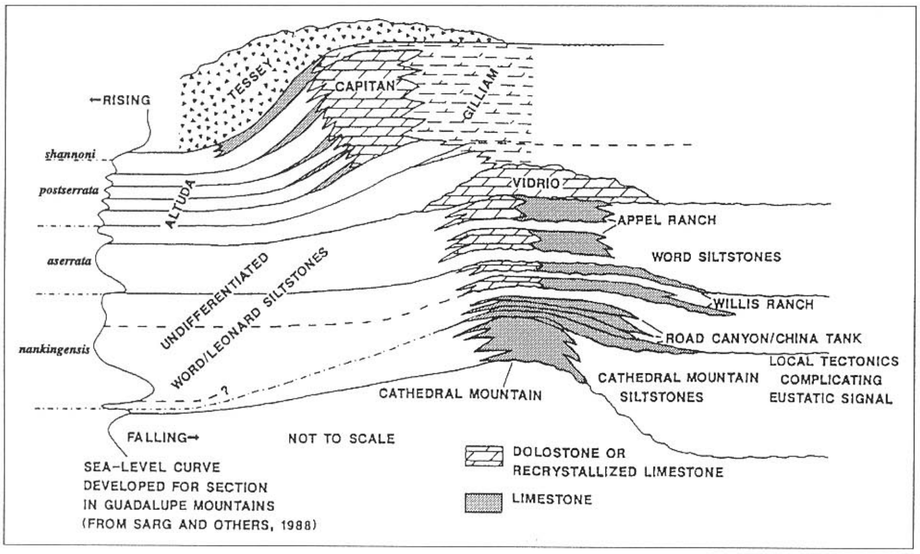

Fig. 7 Generalized depositional setting in the Glass Mountains (modified after ROHR et al., 1991).

Hindeodus gulloides n.sp. displays two rather large, broad denticles on a very short anterior blade.

Hindeodus gulloides n.sp.

(Pl. 1, Fig. 2)

Derivatio nominis: According to the transitional character to *Gullodus* KOZUR, 1993b.

Holotypus: The specimen on Pl. II, Fig. 2; rep.-no. 2-13/27/5/1993.

Locus typicus: Type locality of the Road Canyon Formation, Glass Mountains.

Stratum typicum: Sample KoUS-116, from the uppermost bed of the Road Canyon Formation.

Material: 12 specimens.

Diagnosis: Anterior blade very short, rather a denticulated anterior margin of the cusp, with two relatively large denticles, which are broader than all the denticles of the posterior blade. Cusp erect, very broad and distinctly larger than all other denticles. Posterior blade very high, moderately long, with 12-16 highly fused, rather slender denticles. The anterior half of the posterior blade is nearly straight, with erect denticles, the posterior part is curved downward, with slightly posteriorly inclined denticles. All denticles strongly striated. Basal cavity strongly expanded below the posterior blade, and narrow below the cusp.

Occurrence: Currently only known from the Road Canyon Formation of the Roadian type locality.

Remarks: *Hindeodus gulloides* n.sp. is a transitional form between *Hindeodus* REXROAD & FURNISH and *Gullodus* KOZUR, but a little more closely related to *Hindeodus* than to *Gullodus*. It is the forerunner of the Wordian *Gullodus catalanoi* (GULLO & KOZUR, 1992). In this species, the cusp is about of the same size as, or only a little larger and broader than the biggest denticle of the short anterior blade.

Hindeodus excavatus (BEHNKEN, 1975), the forerunner of *H. gulloides* has a similar high blade with similar denticulation of the posterior blade, but no broad denticles are present on the anterior blade.

In *Gullodus sicilianus* (BENDER & STOPPEL, 1965) no distinct cusp is present, the anterior blade is well developed and bears large broad denticles, far broader and larger than the largest denticles on the posterior blade.

If in a typical *Hindeodus denticles* are present on the anterior margin of the unit, they are always distinctly smaller and above all narrower than the largest denticles on the posterior blade. The presence of two broad denticles, broader than the denticles on the posterior blade, gives *H. gulloides* one of the features of the genus *Gullodus*. However, the cusp in *Gullodus* is either very indistinct or (in typical forms) missing.

The genus *Gullodus* is a typical representative of the reef slope facies and seemingly *H. gulloides* lived in a similar environment.

Hindeodus altudaensis n.sp.

(Pl. 4, Figs. 7, 9)

Derivatio nominis: From the occurrence in the Altuda Formation.

Holotypus: The specimen on Pl. 3, Fig. 9; rep.-no. 18-13/27/5/1993.

Locus typicus: Outcrop at the old quarry NW of the Old Blue Mountain, south of Easterwood Ranch, Glass Mountains (locality 2.3 of ROHR et al., 1991).

Stratum typicum: Upper Altuda Formation, limestone about 10 m below the base of the Tessey Formation. Uppermost Capitanian with *Mesogondolella shannoni* WARDLAW.

Material: 32 specimens.

Diagnosis: Cusp distinctly broader and somewhat longer than the denticles on the posterior blade, erect or slightly posteriorly inclined. The following three denticles of the posterior blade are parallel to the cusp and in their upper part always unfused. The following posterior denticles are completely fused and form a straight spatula that descends posteriorly. The last 1-3 denticles are broad, very low, but unfused at their tips. Basal cavity broadly flaring below the posterior blade, but narrow below the cusp.

Occurrence: Uppermost Altuda Formation with exception of the uppermost 5 m.

Remarks: CROFT (1978) described in his unpublished thesis a very similar form as *Diplognathodus ?posteroplanatus* n.sp. This species was derived from the Lamar Limestone SE of the Guadalupe Mountains. This form has, however, only two unfused denticles behind the cusp and all following denticles of the posterior blade are fused. It may be the immediate forerunner of *Hindeodus altudaensis*.

Hindeodus julfensis (SWEET, 1973) from the Late Dzhulfian and Changxingian has a distinctly convex, and in typical forms smooth hump (*H. julfensis* sensu SWEET, 1973 and KOZUR et al., 1975; *H. julfensis* sensu NESTELL & WARDLAW, 1987 additionally comprises adult forms with denticulated hump; such forms occur also in the Otoceras Beds of Greenland - see SWEET, 1976, pl. 16, fig. 9). This species occurs with very primitive forms, transitional to *H. altudaensis*, in the upper 5 m of the Altuda Formation of the same locality.

There are very rare specimens of *H. altudaensis*, in which the anterior 4 denticles are relatively long and followed by 5 broad, very short, but unfused denticles. These forms may be representatives of *H. altudaensis* with unfused posterior denticles. However, if further investigation does show that both forms have different, but partly overlapping ranges, these forms should be described as a further new species. At the moment, they are regarded as a morphotype of *H. altudaensis* (*H.* cf. *altudaensis*, Pl. 4, Fig. 10).

Genus *Pseudohindeodus* GULLO & KOZUR, 1992

Type species: *Pseudohindeodus ramovsi* GULLO & KOZUR, 1992

Pseudohindeodus ramovsi GULLO & KOZUR, 1992

(Pl. 1, Figs. 3, 10, 11; Pl. 2, Fig. 6)

Remarks: This species is very common in the Cathedralian to Wordian interval in western Sicily. In North America, it is also very common in this interval. It is however, mostly placed into *Diplognathodus stevensi* CLARK & CARR, 1982. The Pa element of the *D. stevensi* syntypes has, however, fused denticles on the posterior carina and corresponds to *Pseudohindeodus oertlii* (KOZUR, 1975), as shown by GULLO & KOZUR (1992). Beside typical *P. ramovsi*, the North American material contains numerous specimens with a double cusp, two large denticles of nearly the same size, which may be strongly fused with each other or clearly separated. These forms, to which the figured specimens also belong, may represent an independent subspecies.

Genus *Mesogondolella* KOZUR, 1990

Type species: *Mesogondolella bisselli* (CLARK & BEHNKEN, 1971)

Remarks: KOZUR (1990) pointed out that all gondolellid conodonts display an apparatus, similar to that of *Gondolella* STAUFFER & PLUMMER, 1932. Whereas the ozarkodiniform element (Pb element), the prioniodiniform element (M element), the hindeodelliform element (Sc element) and the hibbardelliform element (Sa element) are similar to those in other conodont apparatuses, the enantiognathiform element is a very specific element. Despite the fact that complete *Gondolella* type apparatuses are not only known in *Gondolella*, but also in *Neogondolella* and the near related *Pseudofurnishius* VAN DEN BOOGAARD, most American authors continue to regard the post-Carboniferous gondolellids as single element genera. The ramiform elements of *Mesogondolella* have been described as *Xaniognathus abstractus* BEHNKEN, originally established as form taxon for the ozarkodiniform element. However, CROFT (1978) found an apparatus with *Mesogondolella postserrata* (BEHNKEN) and *Xaniognathus abstractus* (CLARK & ETHINGTON). This apparatus clearly proves the view of KOZUR (1990 and earlier papers) that the post-Carboniferous gondolellids also display a multielement apparatus, similar to that of the Carboniferous true *Gondolella* STAUFFER & PLUMMER.

Mesogondolella nankingensis (CHING, 1960)

(Pl. 1, Figs. 4-9, 12-17; Pl. 2, Figs. 1-5, 7-13)

1960 *Gondolella nankingensis* CHING (sp. nov.) - CHING, p. 246, pl. 2, figs. 5-8.

1962 *Gondolella serrata* n.sp. - CLARK & ETHINGTON, p. 108-109, pl. 1, figs. 10, 11, 15, 19; pl. 2, figs. 1. 5, 8, 9, 11-14.

1992c *Mesogondolella serrata* (= ?*M. nankingensis*) - KOZUR, p. 918.

Remarks: KOZUR (1992c) assumed that *M. serrata* and *M. nankingensis* are synonyms. However, as long as he could not see material from the Kufeng stratotype of *M. nankingensis*, he did not finally place these forms into synonymy. In autumn 1991 KOZUR could study material of *M. nankingensis* from the type section in Nanjing, shown by Prof. WANG, Cheng-yuan during a visit in Nanjing. This material clearly proves that both species are identical. This synonymy had already been recognized by BEHNKEN (1975), but against the rules of the ICZN he placed *Mesogondolella nankingensis* (CHING, 1960) into synonymy of *Neogondolella serrata* CLARK & ETHINGTON, 1962 and used the latter name.

Mesogondolella nankingensis is a species that displays great morphological variability in the platform outline and ornamentation, but all morphotypes have the same range and are connected by a wide transitional field. Therefore, they cannot be separated as independent taxa.

In most of the specimens the entire anterior half or more than the anterior half are distinctly serrated or covered by transversal ribs. In extreme forms only the anterior third is slightly serrated.

In many specimens the posterior end is somewhat to distinctly pointed by fusion of the end of the carina with the posterior platform margin. Other forms display an oblique, blunt posterior end. Most of them (including the holotype of "*G.*" *serrata*) are slightly pointed below the place, in which the end of the carina is fused with the platform end. These latter forms are transitional between the morphotypes with pointed and those with an oblique, blunt posterior end. This variability is mostly caused by ontogeny. All juvenile forms have a pointed posterior end. Late juvenile forms or subadult forms mostly have a blunt posterior platform end, pointed in the place of fusion with the end of the carina. A third morphotype has a rounded posterior end, sometimes with a very narrow, indistinct platform brim. All transitions are known between forms with round and blunt posterior end and between forms with pointed and rounded posterior platform ends. On Plate 1 and 2 different ontogenetic stages and different morphotypes are shown.

It is very interesting that the same morphotypes occur also in *Mesogondolella aserrata* CLARK & BEHNKEN (1979), the successor of *M. nankingensis*. This is well demonstrated by CLARK & BEHNKEN (1979, pl. 1, figs. 1-11). These three morphotypes can be observed even in *Mesogondolella idahoensis* (YOUNGQUIST, HAWLEY & MILLER), the unserrated forerunner of *M. nankingensis*. For this reason, and because of the presence of transitional forms during the entire range of *M. nankingensis*, it is impossible to separate these morphotypes as independent taxa.

The development of the serrated *M. nankingensis* from the unserrated *M. idahoensis* is a first order event in Permian conodont evolution. Already KOZUR (1977, 1978), KOZUR & NASSICHUK (1977) and WARDLAW & GRANT (1987, 1990) regarded this phylomorphogenetic cline as the decisive marker for the world-wide definition of the base of the Middle Permian (base of the Guadalupian Series) in the Eurasiatic Tethys, in western North America and in the Boreal realm (Arctic Canada). This view is now accepted by all American Permian stratigraphers (GLENISTER et al., 1992) and by specialists from China (JIN et al., 1994).

The studies of typical *M. idahoensis* and typical *M. phosphoriensis* from North America have shown that *M. nankingensis* does not evolve directly from typical *M. idahoensis*, but from transitional forms between *M. idahoensis* and *M. phosphoriensis*. Some of these forms are rather primitive *M. phosphoriensis* more than *M. idahoensis*, but most forms are perfect transition forms between the two species. Typical *M. idahoensis* are broadest near to the posterior end, whereas typical *M. phosphoriensis* are broadest in or somewhat before the mid-length of the platform. Seemingly *M. phosphoriensis* and *M. nankingensis* evolved contemporaneously from *M. idahoensis*. Whereas *M. phosphoriensis* occupied cool-water areas and the cold bottom water of the open sea in tropical areas, *M. nankingensis* occupied the warm-water areas of restricted to semi-restricted basins and the upper slope of open seas in tropical areas. Unserrated forms, broadest in or a little before the mid-length of the platform, have their first appearance immediately before the first appearance of the serrated *M. nankingensis*. This is very important for correlation of the type Guadalupian base with open sea Tethyan sequences and with sequences at the Gondwana margin, where *M. nankingensis* is absent in cold bottom waters that are characteristic for these areas. Fusulinids are mostly absent in this facies, if not redeposited from the shallower margins. Therefore the beginning of *Mesogondolella* of the *N. idahoensis* lineage that are broadest in or before the mid-length, is important for recognition of the Guadalupian base in cold-water faunas or cold bottom water faunas.

Mesogondolella postserrata (BEHNKEN, 1975)

(Pl. 3, Figs. 1-11; Pl. 4, Figs. 1-5)

Remarks: The first appearance of this species is a suitable marker to define the Wordian-Capitanian boundary (KOZUR, 1992c, 1993a, e). However, the rather rare unserrated or very indistinctly serrated morphotypes of *M. postserrata* are difficult to separate from *M. aserrata* (CLARK & BEHNKEN). Whereas rich populations are easy to distinguish because of the clearly higher percentage of serrated forms in *M. postserrata* populations, single specimens of both species may be inseparable.

Mesogondolella shannoni WARDLAW, in press

(Pl. 4, Figs. 6, 8, 11)

1992a *Mesogondolella "babcocki"* (CLARK & BEHNKEN) - KOZUR, pl. 1, figs. 5, 6.

1992b *Mesogondolella "babcocki"* (CLARK & BEHNKEN) - KOZUR, p. 103, figs. 5, 6.

Remarks: CLARK & BEHNKEN (1979) established the rather well defined "*Neogondolella*" *babcocki*. This species occurs in the Lamar Member of the Bell Canyon Formation. "*N.*" *babcocki* has on both sides a rounded transition of the posterior margin into the lateral margins. The posterior platform margin is rounded, obliquely rounded or pointed. CLARK & BEHNKEN (1979) also placed some older forms from the basal Lamar and somewhat older beds into "*N.*" *babcocki*. These forms display an oblique, blunt posterior platform end, sharply set off (at least on one side) from the lateral margin, the typical posterior end of *M. postserrata*. The holotype of "*N.*" *babcocki* unfortunately belongs to these forms and cannot be distinguished from *M. postserrata*. Because a species is defined by its holotype, "*Neogondolella*" *babcocki* CLARK & BEHNKEN, 1979 is a junior synonym of *Mesogondolella postserrata* BEHNKEN, 1975. For this reason, WARDLAW (in press) will describe a new species, *Mesogondolella shannoni* WARDLAW, to which most of "*N.*" *babcocki* sensu CLARK & BEHNKEN belong, but not the holotype of "*N.*" *babcocki*. We agree with WARDLAW that *M. shannoni* is a new species. Because KOZUR (1992a, b) has known that WARDLAW will describe this new species, he described this new species as *Mesogondolella* "*babcocki*".

M. shannoni WARDLAW is very common in the Lamar Limestone and in the upper, but not uppermost Altuda Formation, where it is replaced by its successor *Clarkina altudaensis* KOZUR, 1992, which has no serrations of the anterior platform margin. MEI et al. (1994a, b) identified serrated forms erroneously as *Mesogondolella altudaensis*. These forms belong mostly to *Mesogondolella shannoni*. Only the specimen figured by MEI et al. (1994a, pl. 2, fig. 1) shows no serration. But in this form the indistinct adcarinal furrows display honeycomb microsculpture, whereas *C. altudaensis* displays broad, smooth adcarinal furrows. Moreover, the denticulation of the carina is different (very low anterior carina, distinct "double cusp") from that of *C. altudaensis*.

The phylomorphogenetic cline from *M. shannoni* to *C. altudaensis* is a first order event in the Permian conodont evolution. *M. shannoni* and contemporaneous to slightly younger forms, as *M. nuchalina* (DAI & ZHANG) (= *M. xuanhanensis* MEI & WARDLAW), *M. praexuanhanensis* MEI & WARDLAW and *M. granti* MEI & WARDLAW are the last serrated *Mesogondolella*, which occur near to the top of the Capitanian. With this event the top of the Capitanian can be well correlated with the Tethys (KOZUR, 1992a, b, c, 1993a, 1995a; JIN et al., 1993; MEI et al., 1994a, b, c).

Genus *Clarkina* KOZUR, 1990

Type species: *Gondolella leveni* KOZUR, MOSTLER & PJATAKOVA, 1976

Clarkina altudaensis KOZUR, 1992

1992c *Clarkina altudaensis* n.sp. - KOZUR, p. 103-106, figs. 9-12. 14-17.

1994 *Neogondolella aserrata* CLARK & BEHNKEN, pars - WANG, p. 237, pl. 50, fig. 20.

Remarks: As mentioned above, the specimens figured by MEI et al. (1994a, b) as *Mesogondolella altudaensis*, do not belong to this species, but mostly to *Mesogondolella shannoni*. On the other hand, typical representatives of *C. shannoni* (determined as *Neogondolella aserrata* by WANG, 1994) are present in the uppermost Wuxue Formation of the Zhoushan section at Shusoon, Anhui (South China), like the Delaware Basin in shallow pelagic beds of an intraplatform basin. In the lower part of this formation, *Mesogondolella praexuanhanensis* MEI & WARDLAW and *M. nuchalina* (DAI & ZHANG) (= *M. xuanhanensis* MEI & WARDLAW) are present.

Because *C. altudaensis* is seemingly restricted to shallow pelagic facies of intraplatform basins, it is difficult to correlate the first appearance of *C. altudaensis* with the first appearance of other typical early *Clarkina* species, like *C. crofti* KOZUR & LUCAS n.sp. and *C. postbitteri* MEI & WARDLAW. These latter species are either restricted to deep basin facies or to pelagic open sea environments. In the shallow pelagic Altuda, *M. shannoni* is replaced in a phylomorphogenetic lineage by *C. altudaensis*. In the deep pelagic part of the same basin (basinal facies of the Delaware Basin), *M. shannoni* is replaced by *C. crofti* and *M. altudaensis* is missing. In the uppermost Altuda, *C. crofti* invaded the Glass Mts. slope together with huge numbers of radiolarians, indicating deepening of the sea. This *C. crofti* fauna of the uppermost Altuda already belongs to the *C. crofti*-*C. postbitteri* Zone, because the first, primitive specimens of *C. postbitteri* are present.

In the deep basin facies, *C. crofti* follows immediately after *M. shannoni* and in the shallow pelagic slope facies *C. altudaensis* occurs immediately above *M. shannoni*. Consequently, there seems to be a considerable or even total overlap of the ranges of *C. crofti* and *C. altudaensis*. As *C. postbitteri* is present at least in the upper range of *C. crofti*, there seemingly exists an overlap of the *C. crofti*-*C. postbitteri* and the *C. altudaensis* zones. If we define the Guadalupian-Lopingian boundary with the appearance of *C. postbitteri*, then at least the upper *C. altudaensis* Zone of Texas would belong to the Lopingian (see also remarks to *C. crofti*).

C. postbitteri first occurs in China without a forerunner, above different *Mesogondolella faunas* (*M. granti* fauna, *M. shannoni* fauna, *M. nuchalina* fauna), mostly after a short gap. None of these *Mesogondolella* are the direct forerunner of *C. postbitteri*. This species probably evolved from those specimens of *C. crofti* that have a nearly unreduced platform.

The different correlation of the *C. altudaensis* Zone by JIN et al. (1993), MEI et al. (1994a, b, c) is caused by erroneous determinations of *M. shannoni* and similar forms as *C. altudaensis*. A zonation was established, in which the *C. altudaensis* Zone lies two or three zones below the base of the Lopingian. The base of the *C. altudaensis* Zone was therefore erroneously correlated with the base of the Abadehian in Central Iran that corresponds roughly to the base of the Capitanian. However, in the Capitanian type area, the base of the Capitanian is characterized by the base of the *M. postserrata* Zone, which is followed by the *M. shannoni* Zone, and the *C. altudaensis* Zone occurs only above this latter zone.

In Texas, at least *M. praexuanhanensis* first appears before *C. altudaensis* and there is a short overlap of both species. *M. nuchalina* (= *M. xuanhanensis*) occurs in Texas in the lower *C. altudaensis* Zone. *C. granti* occurs in Texas in a short interval within the *C. altudaensis* Zone. In the upper *C. altudaensis* Zone serrated

Series	Stage		Conodont Standard-Zonation (this paper)		Subdivision after Mei et al. (1994 a)			Mei et al. (1994 a, c)		
					Conodont Zones	Stages	Series	Conodont Zones		
Upper Permian = Lopin=gian (pars)	Wuchiapingian	Dzhulfian	Clarkina mediconstricta		Clarkina orientalis	Wuchia=pingian	Lopingian (pars)	C. inflecta	Wuchiapingian	Lopingian
			Clarkina orientalis					C. orientalis		
			Clarkina transcaucasica					C. transcaucasica		
			Clarkina leveni		Clarkina leveni			C. guangyuanensis		
				M. divergens- M. rosenkrantzi				C. leveni		
			Clarkina niuzhuangensis		C. liangshanensis ?			C. asymmetrica		
								C. dukouensis		
			Clarkina postbitteri- Clarkina crofti					C. postbitteri		
	disputed		? Clarkina altudaensis			Unnamed Stage			Capitanian	Guadalupian
								M. granti		
					M. xuanhanensis			M. xuanhanensis		
Middle Permian = Guada=lupian (pars)	Capi=tanian		Mesogondolella shannoni		M. praexuanhanensis			M. praexuanhanensis		
					"M. altudaensis"			"M. altudaensis"		
								M. shannoni		
			Mesogondolella postserrata		M. postserrata	Capitanian	Guadalupian	M. postserrata		

Table 3 Assumed correlation of the Chinese conodont zonation (MEI et al., 1994a, b, c) with the proposed conodont zonation around the Guadalupian-Lopinginian boundary. *M. xuanhanensis* MEI & WARDLAW, 1994 is a junior synonym of *M. nuchalina* (DAI & ZHANG, 1984), see KOZUR (1995a). *C. asymmetrica* MEI & WARDLAW, 1994 is a junior synonym of *C. niuzhuangensis* (LI, 1991). *M. dukouensis* MEI & WARDLAW, 1994 is a junior synonym of *Clarkina liuchangensis* (DING, 1987). According to a letter of Prof. DING to Prof. WANG, the age of the type stratum of *C. liuchangensis* is not clear (Wuchiapingian or Changxingian); according to the conodonts it should be Wuchiapingian. "*Gondolella*" *serrata liuchangensis* DING, 1987 is rejected as homonym of *C. liuchangensis* (DING, 1987).

Mesogondolella are no longer present.

The distribution of advanced *Mesogondolella* and *C. altudaensis* in the Wuxue Fm. of the Zhoushan section (intraplatform basin) at Shushoon (South China) corresponds to the distribution of these conodonts in West Texas. Also in this formation, *C. altudaensis* occurs above *M. praexuanhanensis* and *M. nuchalina* (= *M. xuanhanensis*) and slightly overlaps the upper ranges of the latter two species. Evaluation of these data suggests that at least the *upper C. altudaensis* Zone corresponds to the Wuchiapingian. A correlation of the different conodont zonations at the Guadalupian-Lopingian boundary is shown in Table 3.

Clarkina crofti KOZUR & LUCAS n.sp.

1978 *Neogondolella incohata* n.sp. - CROFT, p. 51-52, pl. 5, figs. 1-10.

1992c *Clarkina* cf. *bitteri* (KOZUR) - KOZUR, figs. 1B/17 a, b.

Derivatio nominis: In honour of Dr. J. S. CROFT, who discovered this species for the first time.

Holotype: The specimen, figured in KOZUR (1992c) on figs. 1B/17 a, b; rep.-no. N 4065, collection of the Museum of Northern Arizona.

Locus typicus: Outcrop about 1 km east of locality H after ORMISTON & BABCOCK (1979), Culberson County, Texas.

Stratum typicum: Sample 243, uppermost Lamar, 40 cm below its top.

Diagnosis: *Clarkina* with long free blade, narrow platform with strongly upturned margins along the posterior two-thirds of the platform element, which is also at the posterior end mostly rudimentary. Carina high, lowest in the posterior part.

Description: Platform element small, moderately arched, straight or laterally slightly bent. The platform is strongly reduced and extends only along the posterior two-thirds of the unit. In some specimens the platform is rudimentary throughout its length. The platform is narrow even in its widest part behind the midlength or at the beginning of the posterior third of the unit. Near the posterior end the platform width is distinctly reduced. The free blade is very long and comprises the anterior third of the unit. Along its anterior part no platform rudiments are present, while along its posterior part very narrow, ridge-like platform rudiments are present. The platform margins are strongly upturned and display honeycomb microreticulations. No serration is present.

The basal cavity is subterminal, and in forms with strongly reduced platform nearly terminal. Keel narrow.

Carina high, with long, unfused denticles. The height of the carina decreases slowly toward the posterior end. A cusp is never present. All denticles are nearly straight or only slightly inclined.

Occurrence: Rare in the topmost Lamar, common in post-Lamar/pre-Castile limestone intercalations in the deep basin facies.

Remarks: Specimens with a strongly reduced platform, which consists only of a broadened ridge, are very similar to Early Triassic to basal Anisian genera in the transitional field from platform-bearing gondolellids to the bladelike *Neospathodus* MOSHER, 1968 and vice versa: *Kashmirella* BUDUROV, SUDAR & GUPTA, 1988, the transitional genus from *Clarkina* to *Neospathodus*, *Chengyuania* KOZUR, 1994[3], the transitional genus from *Neospathodus* to *Paragondolella* MOSHER, 1968, and *Chiosella* KOZUR, 1990, the transitional genus from *Neospathodus* to *Neogondolella* BENDER & STOPPEL, 1965.

Despite the strong platform reduction, *C. crofti* is probably not the direct forerunner of *Neospathodus* that first appears in the Gandarian Substage (= Dienerian) of the Brahmanian Stage (= Induan stage, the original Induan comprises also the lower substage of the Olenekian, KOZUR, 1993d).

Mesogondolella ? *denticulata* CLARK & BEHNKEN, 1979 may be the forerunner of *Clarkina crofti*, but is easy to distinguish from this species. With the exception of the anteriormost part, a distinct platform extends along the free blade and the platform width is unreduced near the posterior end of the unit. Moreover, the height of the carina does not decrease toward the posterior end.

There is also the possibility that forms of *C. crofti* with a very narrow platform have evolved from platform-less forerunners (*Xaniognathus* sensu WARDLAW). As shown by KOZUR (1974, 1975, 1976, 1990), but already partly recognized by KOZUR & MOSTLER (1971) all gondolellid conodonts display a very similar apparatus. The Pa element displays mostly a distinct platform, but there are also representatives with a platform-less Pa element (*Celsigondolella* KOZUR, *Mosherella* KOZUR, *Neospathodus* MOSHER, *Nicoraella* KOZUR, *Parvigondolella* KOZUR & MOCK). According to WARDLAW (pers. comm.) the apparatus of *Xaniognathus* is such a gondolellid apparatus with platform-less (ozarkodiniform) Pa element. We do not exclude this possibility. However, this is currently difficult to prove, because all faunas with such a type of *Xaniognathus* apparatus display also gondolellid conodonts (including *Neospathodus*, see KOZUR, 1990). On the other hand, the presence of a long-ranging multielement genus *Xaniognathus*, in which the Pa element displays no platform, would enable the explanation of specimens of *C. crofti* with very narrow, rudimentary platform as forms, in which the platform evolved from platform-less ancestors (like *Chiosella* KOZUR). In this case, *C. crofti* would have originated from *Xanioganthus* by the same process of development of a platform as *Chiosella* KOZUR evolved near the Olenekian/Anisian boundary from the platform-less *Neospathodus* MOSHER. In this case, the first appearance of *C. crofti* would be a first order event in Permian conodont evolution and could be used for defining the base of the Lopingian that would be near to, but probably a little older than the base of the Lopingian defined by the first appearance of *C. postbitteri*. The first appearance of *C. crofti* coincides in the topmost Lamar with the appearance of a typical Lopingian radiolarian fauna with *Follicucullus ventricosus* ORMISTON & BABCOCK, *F. bispinosus* KOZUR and *Ishigaconus scholasticus* (ORMISTON & BABCOCK). In the shallow pelagic development this boundary is near to the base of *the C. altudaensis* Zone, because *C. altudaensis* replaced its forerunner *M. shannoni* approximately in the same level, in which *C. crofti* replaced *M. shannoni* in deep basin facies.

Clarkina crofti may be the forerunner of *C. postbitteri* MEI & WARDLAW. In any case, it is the first true *Clarkina*.

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[3] *Chengyuania* KOZUR replaces *Pseudogondolella* KOZUR, 1990, a homonym of *Pseudogondolella* YANG, 1984 (hybodont fish teeth).

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PLATE I

All figured specimens are from the Road Canyon Formation of the Roadian type section in the Glass Mountains (see Figs. 2, 4).

1 *Hindeodus excavatus* (BEHNKEN), lateral view, sample KoUS 116, uppermost bed of the Road Canyon Formation, uppermost Roadian, x100, rep.-no. 1-13/27/5/1993.

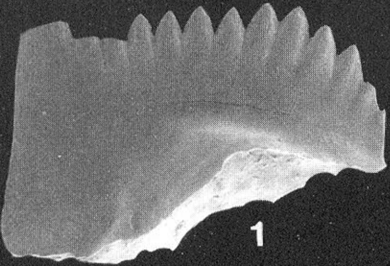
2 *Hindeodus gulloides* n.sp., holotype, lateral view, sample KoUS 116, uppermost bed of the Road Canyon Formation, uppermost Roadian, x100, rep.-no. 2-13/27/5/1993.

3 *Pseudohindeodus ramovsi* GULLO & KOZUR, upper view, sample KoUS 116, uppermost bed of the Road Canyon Formation, uppermost Roadian, x150, rep.-no. 2-13/27/5/1993.

4-5 *Mesogondolella nankingensis* (CHING), upper view of two somewhat different ontogenetic stages, sample KoUS 116, uppermost bed of the Road Canyon Formation, uppermost Roadian, x100; fig. 4: juvenile specimen, rep.-no. 4-13/27/5/1993; fig. 5: late juvenile specimen, rep.-no. 5-13/27/5/1993.

6-9, 12-17 *Mesogondolella nankingensis* (CHING), different ontogenetic stages, sample KoUS-112, spongiolitic limestone immediately above the second conglomeratic limestone horizon of the Road Canyon Formation, Roadian; fig. 6: adult specimen, upper view, x80, rep.-no. 15-5/275/1993; figs. 7-9: late juvenile stage, x100, rep.-no. 13-13/27/5/1993, fig. 7: upper view, fig. 8: lateral view, fig. 9: lower view; figs. 12, 14, 16: adult specimen, x80, rep.-no. 16-13/27/5/1993, fig. 12: upper view, fig. 14, lateral view, fig. 16: lower view; figs. 13, 15, 17: medium ontogenetic stage, rep.-no. 14-13/27/5/1993, fig. 13: lateral view, fig. 15: upper view, fig. 17: lower view.

10, 11 *Pseudohindeodus ramovsi* (GULLO & KOZUR), x100, sample KoUS-112, spongiolitic limestone immediately above the second conglomeratic limestone horizon of the Road Canyon Formation, Roadian; fig. 10: lateral view, rep.-no. 18-5/27/5/1993; fig. 11: upper view, rep.-no. 17-5/27/5/1993.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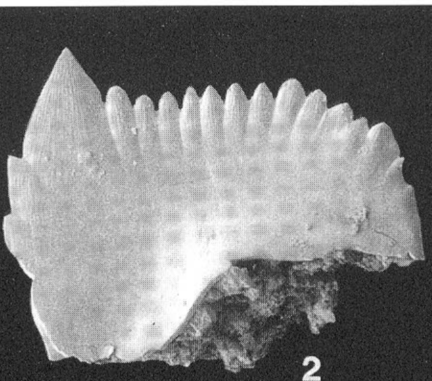
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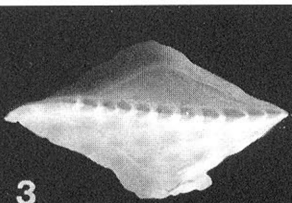
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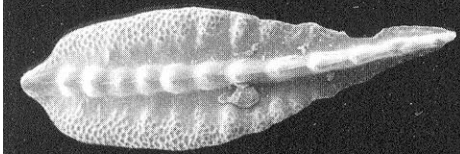
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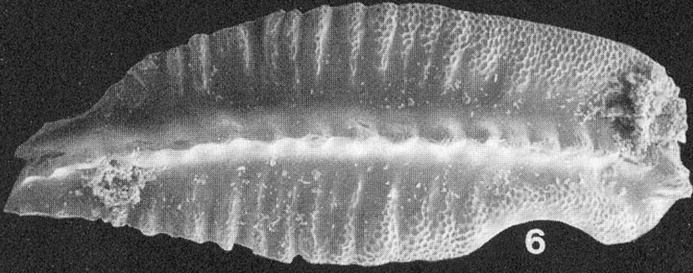
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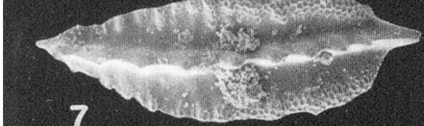
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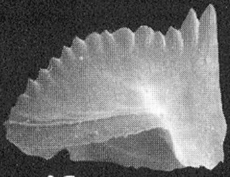
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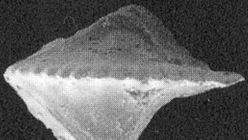
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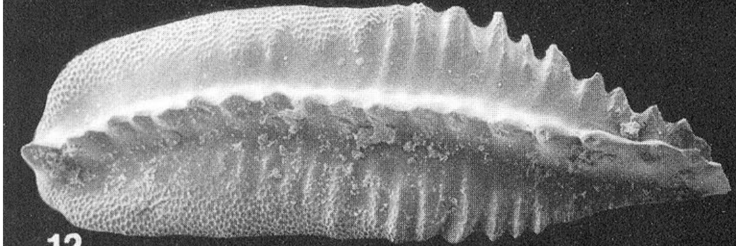
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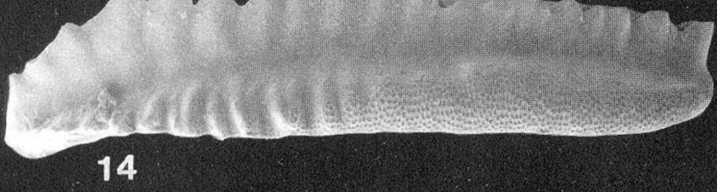
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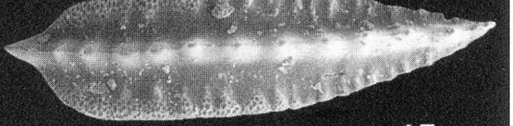
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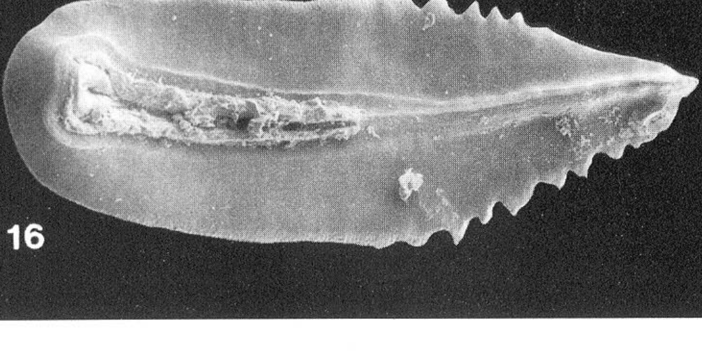
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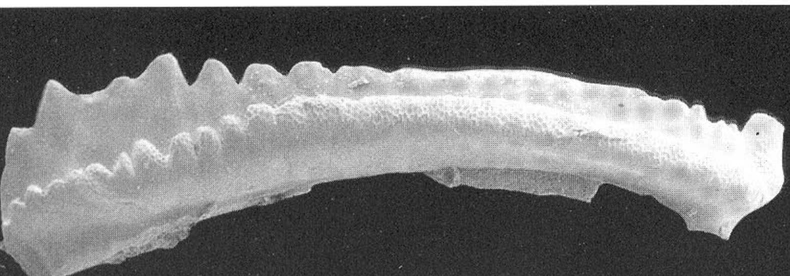
PLATE II

All figured specimens are from the type locality of the Roadian stage in the Glass Mountains.

1-5 *Mesogondolella nankingensis* (CHING), adult specimens, sample KoUS-112, spongiolitic limestone immediately above the second conglomeratic limestone horizon of the Road Canyon Formation, Roadian; figs. 1, 2: x80, rep.-no. 17-13/27/5/1993, fig. 1: lateral view, fig. 2: upper view; figs. 3-5: x100, rep.-no 15-13/27/5/1993, fig 3: upper view, fig. 4: lateral view, fig. 5: lower view.

6 *Pseudohindeodus ramovsi* GULLO & KOZUR, lateral view, sample KoUS-120, lower Word Formation, 7.5 m above the base of the Word Formation, Early Wordian, x150, rep.-no. 40-5/27/5/1993.

7-13 *Mesogondolella nankingensis* (CHING), different ontogenetic stages, x100, sample KoUS-120, lower Word Formation, 7.5 m above the base of the Word Formation, Early Wordian; figs. 7, 8: juvenile stage, rep.-no. 42-5/27/5/1993, fig. 7: upper view, fig. 8: lateral view; fig. 9: juvenile stage, upper view, rep.-no. 41-5/27/5/1993; figs. 10, 11: subadult specimen, rep.-no. 43-5/27/5/1993, fig. 10: upper view, fig. 11: lateral view; figs. 12-13: subadult specimen, rep.-no. 39-5/27/5/1993, fig. 12: somewhat oblique upper view, fig. 13: lower view.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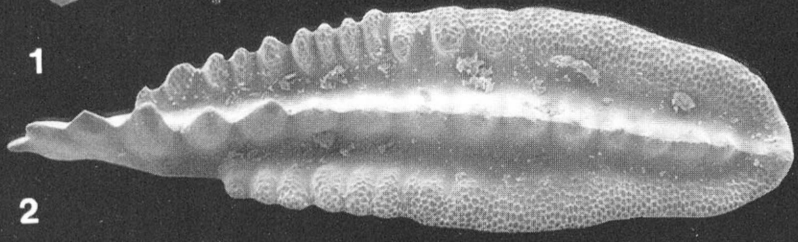
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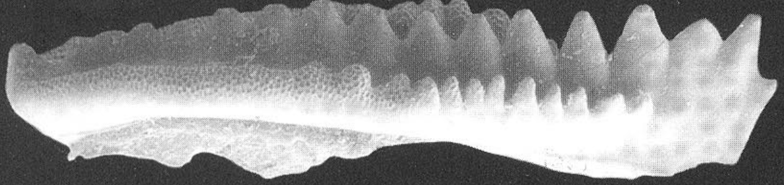
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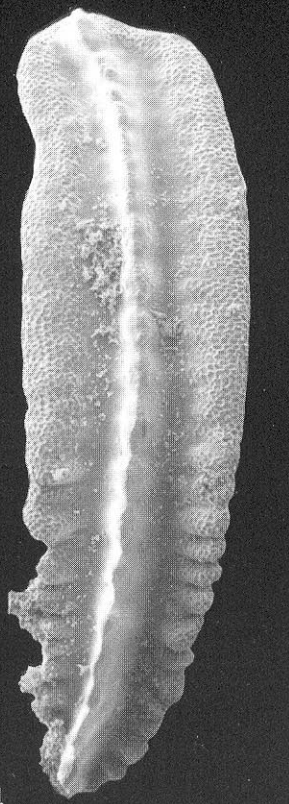
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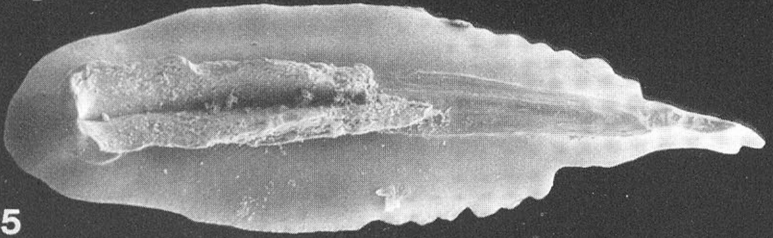
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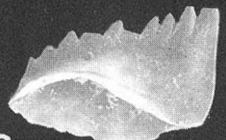
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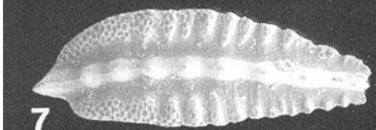
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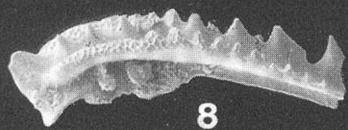
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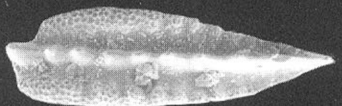
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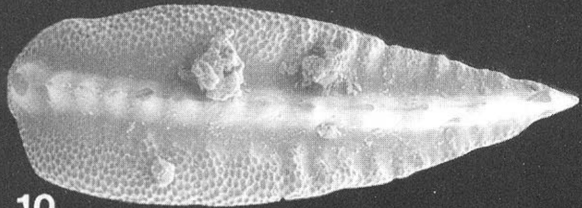
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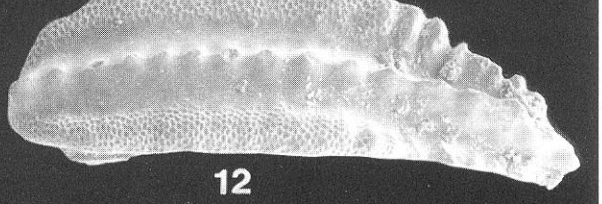
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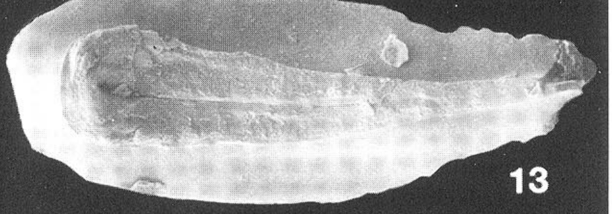
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PLATE III

All specimens are from micrograded bedded limestones above a spectacular debris-flow, upper Rader Member of the Bell Canyon Formation, Capitanian, road cut at the eastern side of the US Highway 62/180, southeast of the Guadalupe Mountains, locality 2-4 in fig. 3.

1-7, 9, 11 *Mesogondolella postserrata* (BEHNKEN), sample KoUS 55 C, 0.50 m above the debris-flow; figs. 1-3: x50, rep.-no. 23-13/27/5/1993, fig. 1: lateral view, fig. 2: upper view, fig. 3: lower view after separation of the basal body; fig. 4: separated basal body of the same specimen, attachment surface to the keel of the platform element with coarse lamellae, x300, rep.-no. 24-13/27/5/1993; figs. 5-7: adult form, x80, rep.-no. 25-13/27/5/1993; fig. 5: lateral view, basal body easily visible, fig. 6: upper view, fig. 7: lower side, basal body obvious; fig. 9: adult form, nearly the entire anterior platform margin strongly serrated, upper view, x80, rep.-no. 28-5/27/5/1993; fig. 11: adult form with unserrated platform margin, lateral view, x80, rep.-no. 33-5/27/5/1993.

8, 10 *Mesogondolella postserrata* (BEHNKEN), adult, slightly serrated to unserrated specimen, x80, sample KoUS 55 E, micrograded bedded limestone immediately above the debris-flow, upper Rader Member of the Bell Canyon Formation, Capitanian, road cut at the eastern side of the US Highway 62/180, rep. 37-5/27/5/1993, fig. 8: upper view, fig. 10: lateral view.

PLATE IV

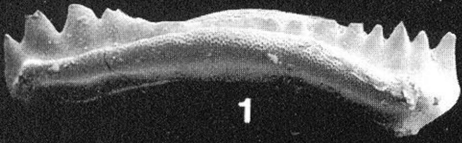
1-5 *Mesogondolella postserrata* (BEHNKEN), adult, slightly serrated to unserrated specimens, all x80; figs. 1, 3: adult specimen with nearly undenticulated anterior platform, sample KoUS 55 E, micrograded bedded limestone immediately above the debris-flow, upper Rader Member of the Bell Canyon Formation, Capitanian, road cut at the eastern side of the US Highway 62/180, rep.-no. 22-13/27/5/1993, fig. 1: upper view, fig. 3: lateral view, basal body visible; figs. 2, 4, 5: adult specimen with slightly denticulated anterior platform, sample KoUS 55 G, micrograded bedded limestone 1 m above the debris-flow, upper Rader Member of the Bell Canyon Formation, Capitanian, road cut at the eastern side of the US Highway 62/180, rep. 21-13/27/5/1993, fig. 2: upper view, fig. 4: lower view, basal body preserved in the posterior part of the unit, fig. 5: lateral view.

6, 8, 11 *Mesogondolella shannoni* WARDLAW, in press, sample KoUS 141, upper Altuda Formation, 10 m below the Tessey Formation, uppermost Capitanian, section 2.3 after ROHR et al. (1991), outcrop at the old quarry NW of the Old Blue Mountain south of Easterwood Ranch, Glass Mountains; figs. 6, 8. x 70, rep.-no. 28-13/27/5/1993, fig. 6: upper view, fig. 8: lateral view; fig. 11: x 80, upper view, rep.-no. 35-5/27/5/1993.

7, 9 *Hindeodus altudaensis* n.sp., lateral view, x100, sample KoUS 141, upper Altuda Formation, 10 m below the Tessey Formation, uppermost Capitanian, section 2.3 after ROHR et al. (1991), outcrop at the old quarry NW of the Old Blue Mountain, about 2 km S of Easterwood Ranch, Glass Mountains; fig. 7: rep.-no. 23-13/27/5/1993; fig. 9: holotype, rep.-no. 18-13/27/5/1993.

10 *Hindeodus* cf. *altudaensis* n.sp., lateral view, x100, sample KoUS 141, upper Altuda Formation, 10 m below the Tessey Formation, uppermost Capitanian, section 2.3 after ROHR et al. (1991), outcrop at the old quarry NW of the Old Blue Mountain, about 2 km S of Easterwood Ranch, Glass Mountains, rep.-no. 21-5/27/5/1993.

PLATE III



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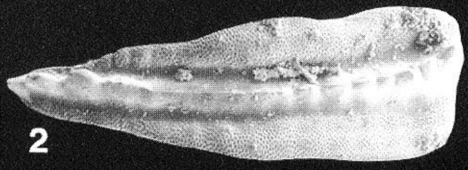

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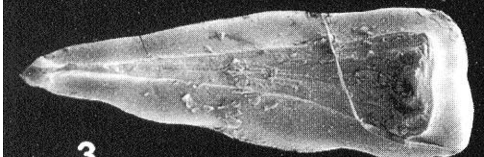

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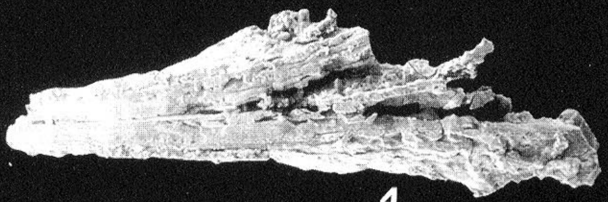

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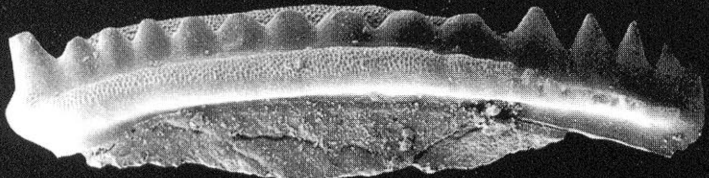

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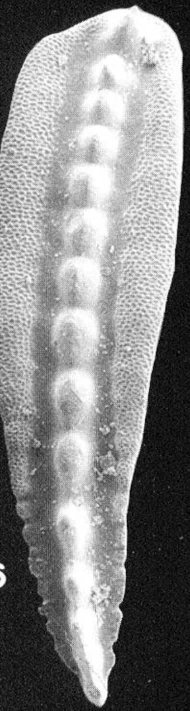

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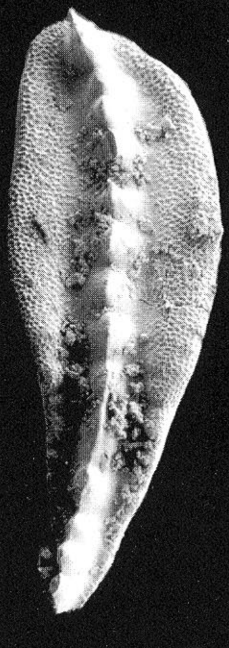

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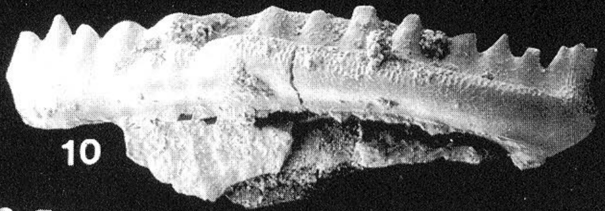

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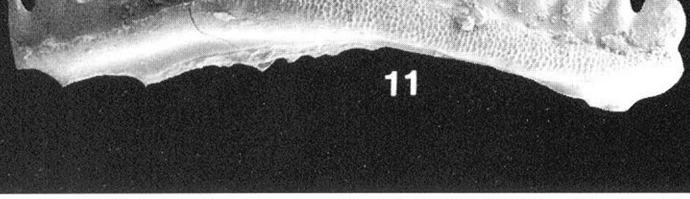

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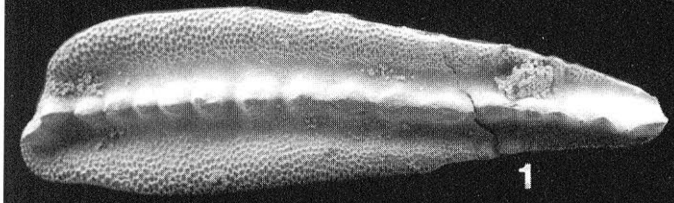
PLATE IV



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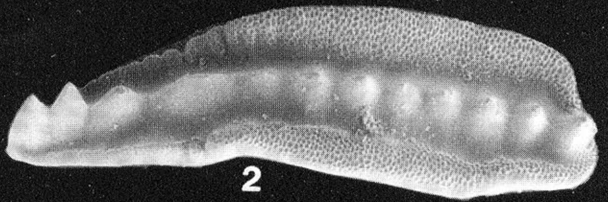

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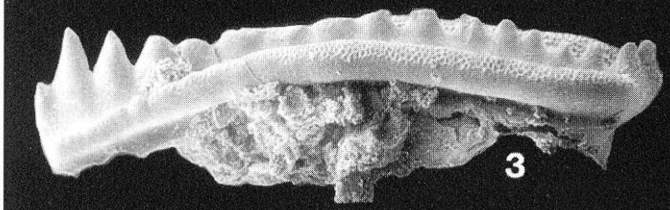

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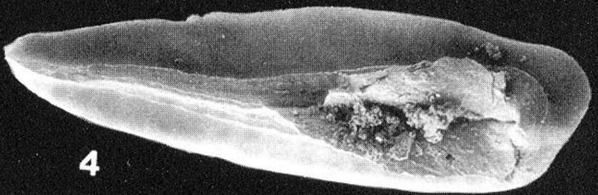

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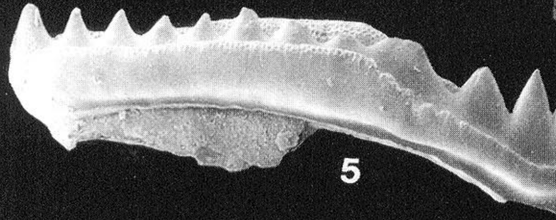

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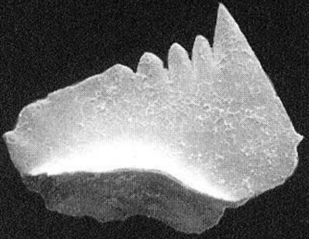

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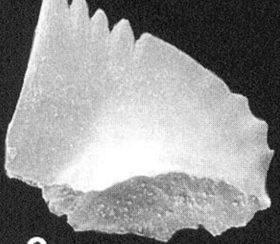

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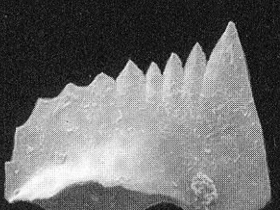

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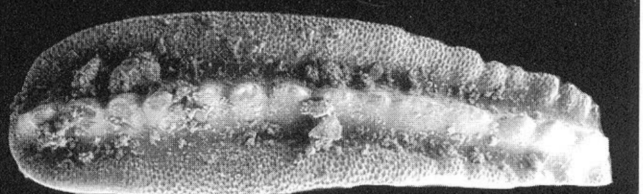

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