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Gullodus n. gen. – A New Conodont Genus and Remarks to the Pelagic Permian and Triassic of Western Sicily

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With 3 Text-Figures, 1 Table and 1 Plate

Sizilien
Perm
Trias
Conodonten
Taxonomie

Contents

Gullodus n. gen. – ein neues Conodontengenus und Bemerkungen zur pelagischen Permotrias von Westsizilien

Zusammenfassung

Conodontenfaunen aus Riffschuttkalken vom Sosiotal, Westsizilien, enthalten eine charakteristische neue Conodontengattung, *Gullodus* n. gen. Die Paläoökologie von *Gullodus* und im Zusammenhang damit die paläogeographische Position der permischen Kalksteinblöcke des Sosiotales innerhalb der Sicanischen paläogeographischen Einheit werden diskutiert. Neuergebnisse zur pelagischen Perm- und Triasabfolge von Westsizilien werden aufgezeigt.

Abstract

Conodont faunas from the Middle Permian limestone blocks of the Sosio Valley area, western Sicily, contain a very distinctive new conodont genus, *Gullodus* n. gen. The Paleoecology of *Gullodus* and, in connection with this, the paleogeographic position of the Sosio limestone blocks within the Sicanian paleogeographic domain are discussed. A revised stratigraphic column of the pelagic Permian and Triassic of western Sicily is presented.

1. Introduction

The Permian limestone blocks of the Sosio Valley area, western Sicily, well known and studied for more than 100 years, yielded the first Permian conodonts of Europe (MÜLLER, 1956; BENDER & STOPPEL, 1965). In both papers gondolellid conodonts have been described (*Gondolella* sp. sensu MÜLLER, 1956, *G. rosenkrantzi* sensu BENDER & STOPPEL, 1965). BENDER & STOPPEL (1965) described also other forms assigned to *Gnathodus* (*G. sicilianus* BENDER & STOPPEL), *Hindeodella* (*H. triassica* MÜLLER sensu BENDER & STOPPEL), *Lonchodina* (*L. muelleri* TATGE, *L. festiva* BENDER & STOPPEL), *Ozarkodina* (*O. tortilis* TATGE, *O. turgida* BENDER) and *Roundya* (*Roundya* sp.).

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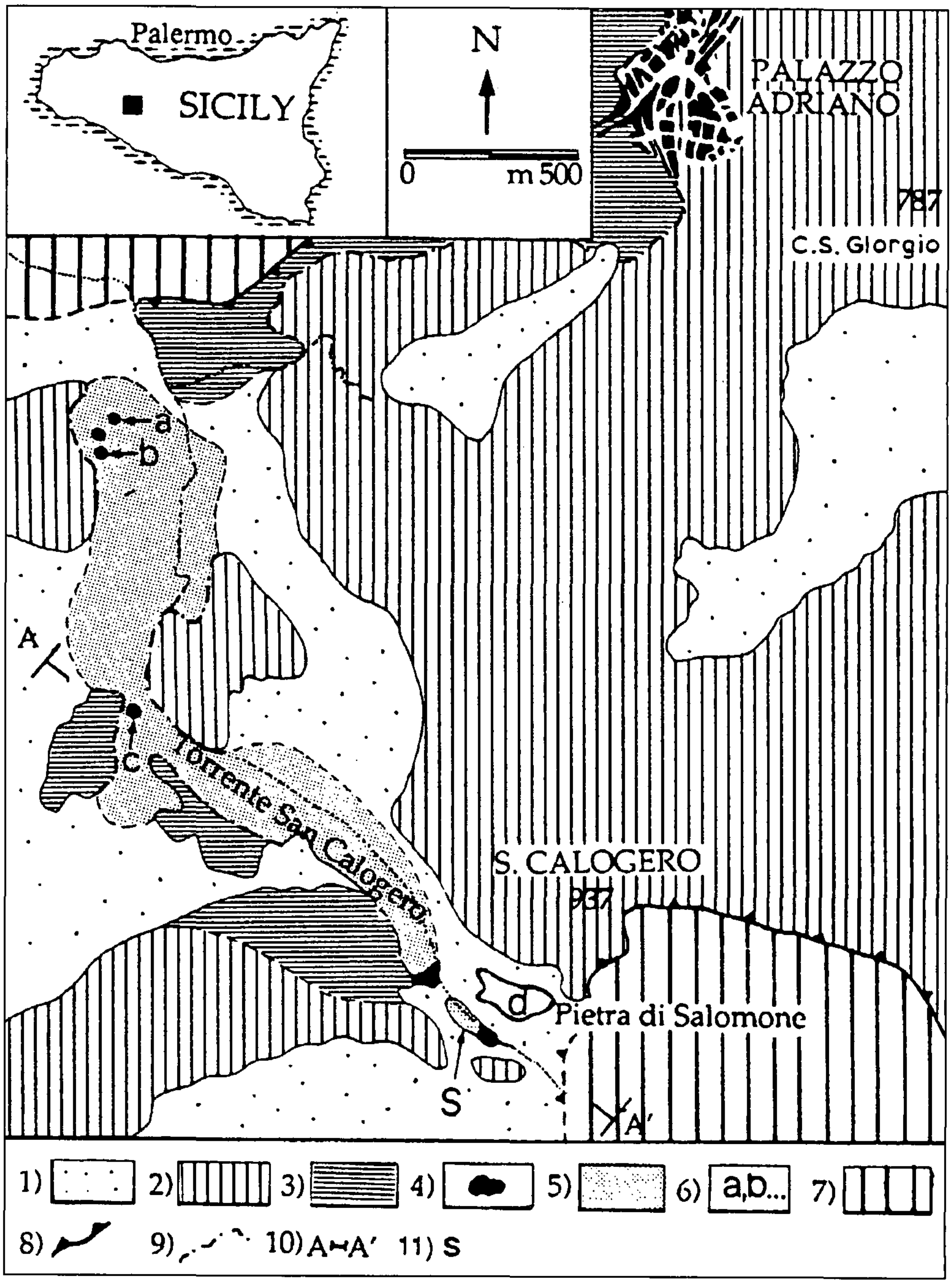
After the revision of the Sicilian Permian conodonts by Kozur (1975, 1989b), Gullo & Kozur (1992) and in the present paper, these species are now placed in *Mesogondolella siciliensis* (Kozur) (for *Gondolella* sp. Müller, 1956, and *G. rosenkrantzi* Bender & Stoppel, 1965, only the Sicilian specimens), *Gullodus sicilianus* (Bender & Stoppel) and *Pseudohindeodus oertlii* (Kozur) (both for *Gnathodus sicilianus* Bender & Stoppel), *Stepanovites festivus* (Bender & Stoppel) (for *Lonchodina festiva* Bender & Stoppel and for the Sicilian Middle Permian representatives of *Hindeodella triassica* Müller sensu Bender & Stoppel, 1965), and *Sweetocristatus galeatus* (Bender & Stoppel) (for *Spathognathodus galeatus* Bender & Stoppel). The remaining "species" listed by Bender & Stoppel (1965) from the Middle Permian of the Sosio Valley belong to the apparatus of *Mesogondolella siciliensis* (Kozur).

According to the facies model for Permian and Triassic conodonts by Kozur (1974, 1976) *Mesogondolella siciliensis* (Kozur) is a pelagic, open-sea conodont. This was in strong contrast to the generally accepted view that the Sosio limestone blocks are Middle Permian reef-like rocks on a large carbonate platform. However, ammonoid studies and micropaleontologic and microfacies investigations have changed this former view. Zhou, Zuren (1986) studied the ecologic patterns of the Permian ammonoids in a gobal scale. According to his important model, the Sosio ammonoid faunas belong to the open-sea faunas. Kozur & Mostler (1989), DiStefano (1990) and Flügel, DiStefano & Senowbari-Daryan (1991) regarded the Sosio limestone blocks as reef slope or base-off-slope limestones with pelagic matrix and shallow-water or slope limestones as clasts. This view is confirmed by the present conodont investigations because all conodont faunas contain the pelagic *Mesogondolella siciliensis* beside different percentages of shallow-water conodonts.



Text-Fig. 1.
Geological map of the Torrente San Calogero area, Sosio Valley (western Sicily, Italy).
1 = Debris; 2–6 Upper tectonic Unit: 2 = Cherty limestones (Upper Carnian – Rhaetian), 3 = Platy limestones and marls (Middle Carnian and lower Tuvalian), 4 = Bedded cherts, nodular limestones and marls (Ladinian – Lower Carnian), 5 = Undifferentiated Permian and Lower Triassic, mostly pelagic deep-water deposits (Roadian Olistostrome Unit, Wordian and Capitanian gray clays, Dzhulfian – Changxingian Red Clay Unit, Lower Triassic graded, often conglomeratic limestones, yellowish weathering marls, siltstones, red marls and red Hallstatt Limestone. Anisian greenish-gray siliceous limestones, 6 = Sosio limestone blocks (a = Rupe di San Calogero, b = Pietra dei Saracini, c = Rupe del Passo di Burgio, d = Pietra di Salomone); 7 = Lower tectonic unit: Triassic – Miocene deposits; 8 = Main tectonic boundaries; 9 = Minor thrust planes; 10 = Cross section line (cross section published by Catalano, DiStefano & Kozur, 1991b). Age determinations of the lithologic units partly changed.

2. Geological Setting

All investigated material has been derived from the Permian limestone blocks of the Sosio Valley area (western Sicily). The geologialc setting, microfaunas, facies, and age determinations of these blocks and the surrounding Permian deep-water sequence have been discussed by Catalano, DiStefano & Kozur (1988a,b, 1989, 1991a,b),

KOZUR & MOSTLER (1989), DISTEFANO (1990), KOZUR (1991c,d), FLÜGEL, DISTEFANO & SENOWBARI-DARYAN (1991) and GULLO & KOZUR (1992); for locality data see these papers and Text-Fig. 1 of the present paper.

3. Systematic Paleontology

Order Conodontophorida EICHENBERG, 1930
Superfamily Polygnathacea BASSLER, 1925
Family Anchignathodontidae CLARK, 1972

Genus *Gullodus* n. gen.

Derivatio nominis: In honour of Dr. Maria GULLO, Palermo

Type species: *Gnathodus sicilianus* BENDER & STOPPEL, 1965.

Diagnosis: Spathognathodiform element with short to moderately long anterior blade that bears 3–6 broad denticles. In the anterior part of the anterior blade one to two small denticles are present. The following two denticles are large, the third or fourth denticle is the largest one. After the largest denticle two smaller, but also broad denticles may be present.

The posterior blade is somewhat to very much longer than the anterior one. It consists mostly of numerous (more than 10, mostly 13–15) small triangular denticles of nearly equal size. Only in the stratigraphically oldest form the posterior blade has 7, rather long subtriangular denticles.

Under the entire posterior blade a large cup is present. Basal cavity strongly expanded. Under the posterior blade a broad basal furrow is present that becomes narrower against the anterior end of the blade.

Occurrence: Latest Artinskian to Wordian.

Assigned species:

Gnathodus sicilianus BENDER & STOPPEL, 1965: Roadian to Wordian

"Pseudohindeodus" catalanoi GULLO & KOZUR, 1992: Wordian

Gullodus hemicircularis n. sp. (= *Hindeodus* ? sp. VAN DEN BOOGAARD, 1987): Latest Artinskian or Early Leonardian.

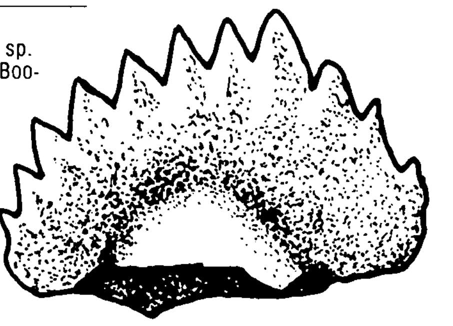
Remarks: The type species is morphologically similar to *Diplognathodus* KOZUR & MERRILL, 1975. However, *Gullodus* species with short anterior blade indicate a derivation from *Pseudohindeodus* GULLO & KOZUR, 1992. *Gullodus catalanoi* (GULLO & KOZUR, 1992) has been assigned tentatively to *Pseudohindeodus* by GULLO & KOZUR (1992), but the authors pointed out that this species and *Hindeodus* ? sp. VAN DEN BOOGAARD, 1987 (*Gullodus hemicircularis* n. sp.) belong to a new genus. However, the relations between these two species and *"Gnathodus" sicilianus* BENDER & STOPPEL, 1965, were unclear in this time. Only the study of material sampled by Prof. MOSTLER, Innsbruck, has demonstrated the near relations of *"Pseudohindeodus" catalanoi* to *"Gnathodus" sicilianus*. In this material transition forms between both species are present.

Gullodus hemicircularis n. sp.
(Fig. 2)

1987 *Hindeodus* ? sp. VAN DEN BOOGAARD, p. 25, Fig. 10E

Holotype: The specimen of Fig. 2.

Text-Fig. 2.
Gullodus hemicircularis n. sp.
Refigured from VAN DEN BOOGARD (1987, Fig. 10E).
Holotype.



Type locality: Bitauni, Timor (see VAN DEN BOOGAARD, 1987).

Type stratum: Brown-red marls with nautiloids, latest Artinskian or Early Leonardian s. str.

Diagnosis: Blade short, high, of subhemicircular outline, highest a little before the midlength at the boundary between the anterior and posterior blade. Anterior blade moderately long, with 4 denticles that become increasingly larger posteriorly. The last denticle of the anterior blade is the largest denticle of the unit. Posterior bar longer than anterior bar, but relatively short for the genus. It bears 7 slender-subtriangular denticles of nearly equal size. Only the last two denticles are smaller.

Occurrence: Bitauni (Timor). Latest Artinskian or Early Leonardian s. str.

Remarks: *Gullodus hemicircularis* n. sp. is clearly distinguished from the Middle Permian *Gullodus* species by its subhemicircular outline, the very high and relatively short blade and by the minor size differentiation between the denticles of the anterior and posterior blade. As in *G. catalanoi* (GULLO & KOZUR, 1992) the last denticle of the anterior blade in *G. hemicircularis* is the largest one, whereas in *G. sicilianus* two shorter, but broad denticles are present behind the largest denticle of the anterior bar. In *G. catalanoi* the blade is rather high, but because of the short anterior and long posterior blade the outline of the unit is not hemicircular. The blade of *G. sicilianus* is considerably lower than in the other known two species and the posterior bar is considerably longer than in *G. hemicircularis*.

4. Biostratigraphic Evaluation

Gullodus species occur in all blocks of the Sosio limestone (Fig. 1, Tab. 1). As most of the material from the Sosio limestone blocks, our material with *Gullodus* has Roadian ("Kubergandinian")*) and Wordian ages. According to the conodont faunas some components of the Pietra di Salomone block display Leonardian s. str. (Chihsian) age. Marginal parts contain also Capitanian and perhaps Upper Permian conodonts (DISTEFANO & KOZUR, in prep.) and fusulinids (FLÜGEL, DISTEFANO & SENOWBARI-DARYAN, 1991).

*) No conodonts are known from the Kubergandinian type area so that this stage is not correlable, if no Tethyan fusulinids are present (e. g. in the whole Boreal and Notal realms and in western North America, with exception of some terranes). The Roadian, Wordian and Capitanian stages should be used as world standard (GLENISTER, 1991; KOZUR, 1991a,b). They are well defined and world-wide recognizable by different microfaunas and ammonoids; their type localities are easily accessible. In contrast the type localities of the Kubergandinian and Murghabian are hardly accessible.

Table 1.
Conodont faunas from *Gullodus*-bearing samples of the Sosio Limestone blocks.
x = very rare; xx = rare; xxx = abundant; (x) = not in all samples present, if present, very rare; x(xx) = different frequencies in different samples.

	Rocca di San Benedetto	Rupe del Passo di Burgio	Pietra di Salomone		
	(BENDER & STOPPEL, 1965)	(23 samples)	2070	PSK-12	S 20
Gullodus catalanoi		x(xx)		xx	
Gullodus sicilianus	xx	(xx)	x		x
Mesogondolella siciliensis	x	xxx	xx	x	x
Pseudohindeodus ramovsi		(x)	xx		x
Pseudohindeodus oertlii			xxx		xx
Stepanovites festivus		x(x)	x	x	x
Sweetocristatus galeatus		x(x)	xx	x	x
Sweetognathus guizhouensis			x		
Sweetognathus subsymmetricus			x		x

The samples S 20 and 2070 from the Pietra di Salomone block display a characteristic Roadian fauna. *Sweetognathus subsymmetricus* WANG, RITTER & CLARK is restricted to the type Roadian and to time equivalent beds in South China. It occurs also in the Roadian matrix of the Olistostrome Unit (CATALANO, DiSTEFANO & KOZUR, 1991a,b). *S. subsymmetricus* is accompanied in sample 2070 by *S. guizhouensis* BANDO et al., 1980 (junior synonym: *S. paraguizhouensis* WANG, RITTER & CLARK, 1987). In the Roadian of South China the same *Sweetognathus* association (*S. subsymmetricus* and *S. guizhouensis*) occurs together with *Mesogondolella nankingensis* CHING.

Sample PSK-12 from the Pietra di Salomone block and the conodont fauna from the Rocca di San Benedetto block investigated by BENDER & STOPPEL (1965) contain only *Mesogondolella siciliensis* as guide form that indicates Roadian to Wordian ages (see below).

All investigated conodont bearing samples from the small Rupe del Passo di Burgio block contain Wordian conodont faunas. This age is also indicated by the *Waagenoceras* bearing ammonoid fauna. 23 samples of the Rupe del Passo di Burgi block collected by KOZUR and by MOSTLER contain *Gullodus* beside other conodonts. Mostly *G. catalanoi* is present, but some samples contain *G. sicilianus* or transitional forms between both species.

In all samples of Rupe del Passo di Burgio typical *Mesogondolella siciliensis* are very frequent. *Stepanovites festivus* (BENDER & STOPPEL) and *Sweetognathus galeatus* (BENDER & STOPPEL) are rare to common.

Mesogondolella siciliensis is common in ammonoid proven Wordian of Sicily and Oman. However, in sample 2070 this species occurs together with Roadian conodonts. May be that the matrix of this sample was pelagic Wordian, the components shallow-water Roadian.

However, neither the exact lower and upper range of *M. siciliensis* is known. *M. siciliensis saraciniensis* GULLO & KOZUR occurs near the Leonardian–Roadian boundary. For this reason an occurrence of typical *M. siciliensis* (*M. siciliensis siciliensis*) in the Roadian is possible. This is supported by the fact that the accompanying conodont fauna of sample 2070 indicates that the fauna is not younger than Roadian (*S. subsymmetricus*: Roadian guideform, *S. ghuizhouensis*: Upper Leondardian–Roadian).

The two *Gullodus* species of the Sosio limestone blocks are rather facies fossils than guideforms. According to our present data they occur in the Roadian and Wordian. Capitanian rocks of this facies have not yet been investigated. In the uppermost Artinskian and Lower Leonardian s. str. a rather different other species (*G. hemicircularis*) is present. Therefore the presence of *G. catalanoi* and *G. sicilianus* in the Lower Permian below the Upper Leonardian is not probable.

5. Biofacial Interpretation

All samples with *Gullodus* from the Sosio limestone blocks contain both pelagic open sea elements (*Mesogondolella siciliensis*) and shallow-water conodonts or conodonts that occur mainly in shallow-water deposits (species of *Pseudohindeodus, Stepanovites, Sweetognathus*). In fully pelagic contemporaneous rocks (deep-water clays of the Sosio Valley area) *M. siciliensis* is very abundant, *Pseudohindeodus, Hindeodus* and *Sweetocristatus* are rare, but often present, whereas *Gullodus* is never present. For this reason, *Gullodus* must be a shallow-water conodont.

However, *Gullodus* has a different facies dependence compared with other Permian shallow-water conodonts. *Gullodus* is missing on Permian carbonate platforms or intraplatform shallow basins, where all other Permian shallow-water conodonts are common. For this reason, *G. catalanoi* and *G. sicilianus* may be species that lived in reefs or on the upper reef slope. In contrast, *Neostreptognathodus, Pseudohindeodus* (and *Hindeodus*), *Stepanovites* and *Sweetognathus* are common species of shallow-water carbonate platforms, shallow intra-platform basins and the upper slope of carbonate platforms with or without marginal reefs. *Stepanovites* occurs even in slightly hypersaline of brachyaline beds. *Pseudohindeodus* and *Hindeodus* occur additionally in pelagic rocks, but not so frequent as in shallow-water rocks. *Sweetocristatus* occurs both in pelagic and in shallow-water deposits.

The more or less abundant occurrence of *Mesogondolella siciliensis* and other *Mesogondolella* species without macrosculpture in all investigated samples from the Sosio limestone blocks excludes that these limestones are reef limestones or reef-like limestones as assumed formerly. These *Mesogondolella* species are characteristic for open pelagic environments. These conodonts have derived from the matrix, deposited under basinal conditions, or from clasts, deposited on the reef slope. The shallow-water fossils are transported in this basin as single grains or inside clasts of shallow-water (reef) limestones. The transport occurred both in debris flows and in turbidity currents (FLÜGEL, DiSTEFANO & SENOWBARI-DARYAN, 1991).

The conodont data confirm the view of KOZUR & MOSTLER (1989), DiSTEFANO (1990) and FLÜGEL, DiSTEFANO & SENOWBARI-DARYAN (1991) that the Sosio limestone blocks are reef-slope or base-of-reef deposits.

The paleogeographic position of the reefs is very interesting. Conodont faunas from the slope of carbonate platforms with or without marginal reefs consist in the Middle Permian of the *Mesogondolella nankingensis – M. postserrata* complex. These conodonts are missing in all investigated samples of the Sosio Valley area, where both the deep-water claystones and the reef slope or base-of-slope deposits contain the *Mesogondolella phosphoriensis – M. siciliensis* fauna. The *M. nankingensis – M. postserrata* fauna occurs in restricted, relatively shallow basins with its restricted basin ammonoid fauna, like in South China (ZHOU, Zuren, 1986), and in those deep-water basins that have an unrestricted faunal connection with the open sea in the upper part of the water body, but are not enclosed in the open sea deep-water circulation, like the Delaware Basin of West Texas. This basin displays open sea ammonoid faunas (ZHOU, Zuren, 1986) and rich radiolarian faunas, but has only a relatively narrow deep-water connection (Howey Channel) with the open sea in the south. The ostracod faunas of the Delaware Basin indicate thermospheric conditions (warm bottom waters, deep-water ostracods, but without archaic elements characteristic for the contemporaneous paleopsychrospheric ostracod faunas [KOZUR, 1991 c,d and in prep.]).

In contrast, the Middle and Upper Permian paleopsychrospheric ostracod faunas of the Sicanian paleogeographic realm contain a lot of archaic elements. These faunas indicate cold bottom waters in an open sea area enclosed in the oceanic deep-water circulation (KOZUR, 1991 c,d).

As pointed out above, the *M. nankingensis – M. postserrata* fauna occurs both in shallow restricted basins and in partly restricted deep-water basins of the tropical/subtropical realm. In the Delaware Basin, where the present slope of the Guadalupe Mts. coincide with the paleoslope, this conodont fauna occurs in water depth between about 30 m and below 500 m. The distribution of these conodonts with serrated anterior platform is therefore not depth-controlled.

Also the distribution of the *M. phosphorensis – M. siciliensis* conodont complex is not water depth controlled. *M. siciliensis* occurs both in Oman (BLENDINGER & KOZUR, in prep.) and in the Sicanian Basin in pelagic deep-water deposits. In the Sosio limestone blocks it occurs also in reef slope and base-of-slope deposits. The matrix of the Rupe del Passo di Burgio block, rich in *M. siciliensis* does not contain any deep-water fauna. Water depth below 200 m can be excluded for the depositional area of these rocks.

M. phosphoriensis (YOUNGQUIST, HAWLEY & MILLER) has in western Sicily the same facies-controlled distribution as *M. siciliensis* (deep-water deposits and reef slope or base-of-slope deposits), but it is stratigraphically more restricted. So far it has been only found in Roadian rocks of the Sicanian paleogeographic realms. *M. phosphoriensis* is present also in the Phosphoria Formation of western USA. According to sedimentological data the Phosphoria Formation was deposited in an area with upwelling of cold water. According to a lecture of B. WARDLAW in Perm, Russia, this species occurs also in the Salt Range of the margin of Gondwana. This area was situated during the Middle Permian in the temperate climatic belt.

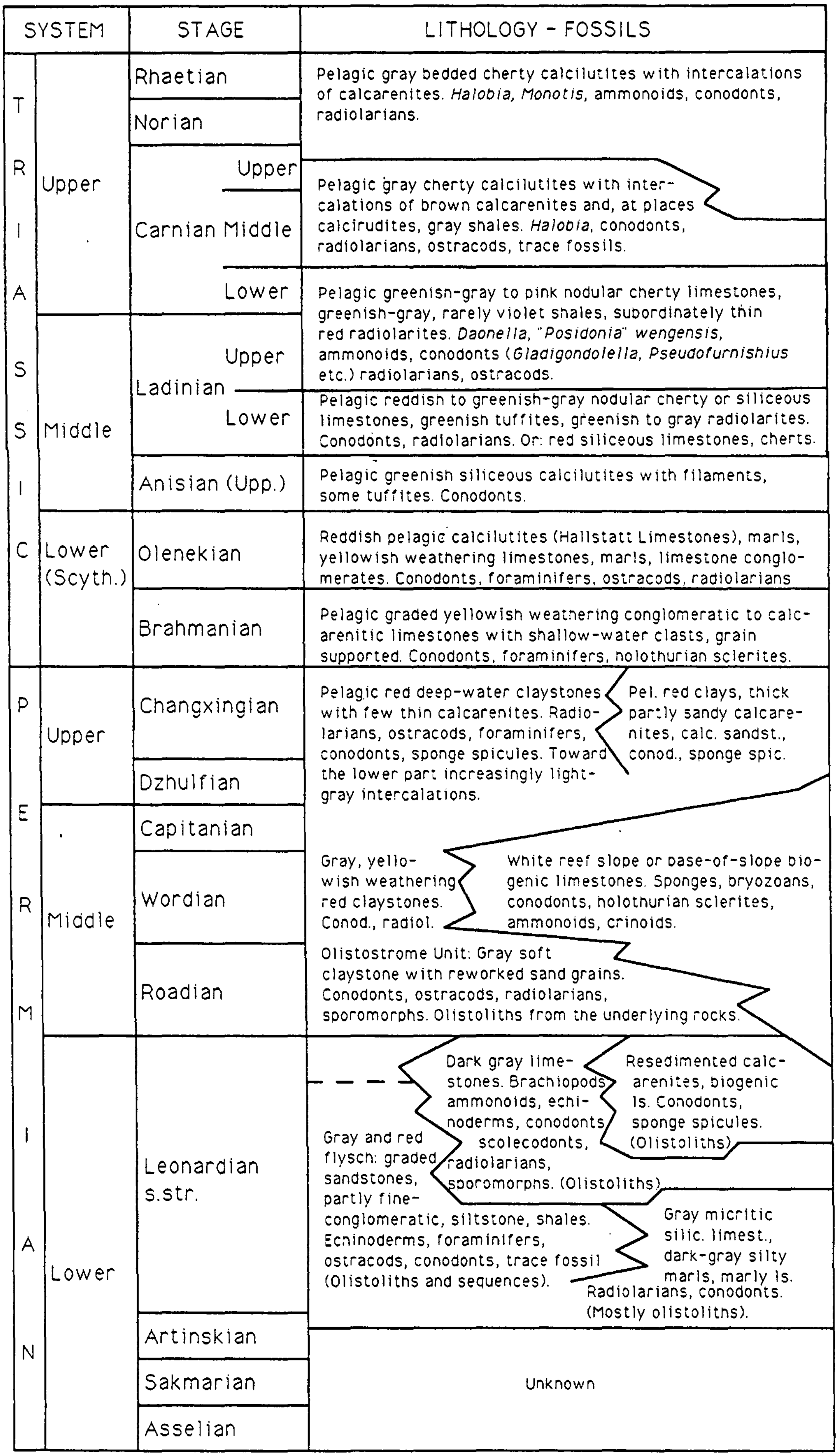
All occurrences of the *M. phosphoriensis – M. siciliensis* conodont complex are restricted to cool water facies. Western Sicily was situated during the Middle Permian in the tropical/subtropical belt, indicated by warm-water fossils in shallow-water limestones, described in numerous papers since the last century. However, the Sicanian paleogeographic domain was situated at the passive margin of the Permian Tethys enclosed in the oceanic deep-water circulation. Because the Permian ocean was psychrospheric, also in this warm climatic belt the water temperature in greater water depth was low. This is clearly indicated by the presence of paleopsychrospheric ostracods in Permian deep-water deposits of western Sicily (KOZUR, 1991 c,d).

The above data indicate that the distribution of the *M. nankingensis – M. postserrata* complex and the *M. phosphoriensis – M. siciliensis* complex is temperature controlled. Shallow basinal warm-water biotopes and warm-water faunas from thermospheric deep-water basins are occupied by the *M. nankingensis – M. postserrata* conodont complex. Shallow pelagic cool to temperate and psychrospheric cold deep-water environments are occupied by the *M. phosphoriensis – M. siciliensis* conodont complex. This palaeoecologic pattern of the Middle Permian conodonts is very important for the conodont biozonation and world-wide correlation of Permian deposits by conodonts.

Moreover, the conodont and ammonoid faunas of western Sicily indicate fore-reef character for all Permian limestone blocks of the Sosio Valley area, because in the back-reef facies the *M. nankingensis – M. postserrata* conodont complex and the restricted basin ammonoid fauna sensu ZHOU, Zuren (1986) are present.

The limestone blocks of the Sosio Valley are interpreted as reef slope or base-of-slope deposits around insular reefs. This is indicated by the absence of any back-reef deposits and faunas and by the rather shallow water depth, in which *M. phosphoriensis* and *M. siciliensis* are present in the Sosio limestone blocks. This indicates that the thermocline was higher than in costal areas. Upwelling of cold-water is not indicated (e. g. glauconite and phosphorites are absent).

This interpretation is confirmed by the fact that the coast line of the Middle Permian Tethys was far in the south, in North Africa. In Djebel Tebaga (Tunisia) shallow-water Wordian and Capitanian rocks with high content of silicoclastic material are present. In the Sicanian paleogeographic realm of western Sicily both in the Wordian–Capitanian deep-water deposits and in the contemporaneous reef-slope and base-of-slope deposits silicoclastic components are missing. A position of the reefs near the southern coast of the Permian Tethys can be excluded. The distance of the reefs from the western and northern coast of the Permian Tethys is unknown. However, silicoclastic Permian rocks are known from the northern margin of the Permian Tethys (CATALANO, DiSTEFANO & KOZUR, 1991 a) and the absence of back-reef deposits excludes a reef position immediately adjacent to the coast also for the western and northern coast of the Permian Tethys in the meridian of western Sicily.



Text-Fig. 3.
Revised stratigraphic column of the pelagic Permian and Triassic of the Sicanian paleogeographic domain in western Sicily. Vertical distances not time or thickness related.

For the above reasons, the Sicanian paleogeographic domain is interpreted as a deep-water area at the passive margin of the Permian Tethyan ocean near to some reef islands with steep flanks from which through long time shallow-water debris was transported into the basin. This situation is similar to the recent Barrier Reef of Australia, where the reefs and reef Islands are rather far from the coast. These reefs are separated from each other and from the coast by rather deep and often relatively broad seaways with pelagic open sea faunas. Typical lagoonal back-reef associations are only present inside of reef complexes, but not in all places.

The model of the Australian Barrier Reef was applied by DONOFRIO, HEISSEL & MOSTLER (1979) for explanation of Triassic basin, reef and back-reef facies pattern of the Northern Calcareous Alps. Own studies on the Australian Barrier Reef in comparison with reefs in other oceans (Yukatan, Gulf of Aqaba) have confirmed this model. It can be applied also for the Middle Permian reef slope and base-of-slope facies and the adjacent deep-water deposits of the Sicanian paleogeographic realm of western Sicily. Both areas had a similar paleogeographic position: The passive margin of an oceanic basin. The Northern Calcareous Alps were situated at the passive margin of the Triassic Meliata-Hallstatt ocean (KOZUR, 1991e), the Sicanian paleogeographic realm was situated at the passive margin of the Permian Tethys ocean. Likewise the Barrier Reef lies at the continental slope of the passive margin of the Pacific ocean.

6. Annotations to Text-Fig. 3

In an one day excursion to the famous limestone blocks of Middle Permian age in the Sosio Valley area (western Sicily) in 1987, KOZUR found pelagic Ladinian with rich *Daonella* and conodont faunas and deep-water Lower Permian rocks with a lot of Circumpacific albaillellacean radiolarians and conodonts, before unknown in Sicily. The Circumpacific Lower Permian albaillellacean radiolarian faunas were in this time unknown from the entire Eurasiatic Tethys. These results initiated a re-investigation of the Permian and Triassic in the Sicanian paleogeographic domain of western Sicily, to which the Permian and Triassic of the Sosio Valley area belongs. These investigations have been carried out by a working group of the Palermo University under leadership of Prof. R. CATALANO in cooperation with the present author.

The above mentioned stratigraphic, facial and paleogeographic results have been published in several papers, e. g. CATALANO, DISTEFANO & KOZUR (1988a,b, 1989, 1991a,b), KOZUR (1989a,b, 1991c,d), KOZUR & MOSTLER (1989), GULLO & KOZUR (1992). A first stratigraphic column of the Permian and Triassic in the Sicanian paleogeographic domain was published in CATALANO, DISTEFANO & KOZUR (1988b, 1989, 1991a,b). The stratigraphic and facial data were based on conodonts (KOZUR, later GULLO & KOZUR), radiolarians (KOZUR), echinoderm remains (KOZUR & MOSTLER), sponge spicules (KOZUR & MOSTLER) and in the slope or base-of-slope deposits microfacies investigations (DISTEFANO); the regional geological and tectonic data were based on investigations of CATALANO.

New stratigraphic results by the present author in West Texas, the Cis-Urals (both sponsored by the Deutsche Forschungsgemeinschaft, excursions in West Texas guided by Prof. D. LEMONE, El Paso, and Prof. B. GLENISTER, Iowa City) and in China (sponsored by the Sanxi Mining College, excursions guided by Prof. DING, Hui and Prof. WANG, Cheng-Yuan) have required a modification of the Permian Stage subdivision. First discoveries of Scythian conodonts in Sicily by Dr. M. GULLO, Palermo and of Anisian conodonts by the present author have completed the stratigraphic column of the pelagic Permian and Triassic from the uppermost Artinskian up to the Rhaetian, shown in Fig. 3. These modifications of the stratigraphic column and of the Stage subdivision are shortly explained below.

① KOZUR (1991a,b) has discovered Tethyan Lower Dzhulfian conodonts in the uppermost part of the type Capitanian Lamar Limestone, the uppermost lithostratigraphic unit of the Capitanian Stage (and Middle Permian Guadalupian Series) in its type area. The type Dzhulfian (or Wuchiapingian) follows therefore without gap or major overlap directly on the Capitanian as assumed by ammonoid data by GLENISTER (1991). An Abadehian Stage between the type Capitanian and the type Dzhulfian is therefore not present. The Abadehian Stage (and its junior synonym, the Midian Stage) is a junior synonym of the Capitanian Stage (KOZUR, in press).

② The Roadian Stage is both by conodonts and by ammonoids better defined than the Kubergandinian Stage, is in contrast to this Stage worldwide correlable and has an easily accessible stratotype. The base of the Roadian corresponds to the phylomorphogenetic change from *Mesogondolella idahoensis* to *M. nankingensis* (junior synonym: *M. serrata*). This boundary was chosen as Lower/Middle Permian boundary by KOZUR (1978) and is now accepted by all leading American Permian stratigraphers as base of the Roadian Stage and of the Middle Permian Guadalupian Series.

③ The Leonardian Stage was defined originally by the Skinner Ranch Formation and the Cathedral Mountains Formation. The conodont fauna of the Skinner Ranch Formation starts with the *Mesogondolella bisselli – Sweetognathus whitei* Zone that is overlain by the *Neostreptognathodus pequopensis* Zone. These conodont associations and their succession are characteristic for the Upper Artinskian of its Cis-Uralian type area. The following conodont faunas of the Skinner Ranch Formation with *N. pequopensis, N. pnevi, N. intermedia* and a little younger *N. exsculpta* and *N. foliata* are already post-Artinskian. Therefore the upper boundary of the Skinner Ranch Formation lies within the middle Skinner Ranch Formation. The uppermost Skinner Ranch Formation contains *M. idahoensis* and *N. prayi*, a fauna that continues in the Cathedral Mountains Formation. In the middle and upper Cathedral Mountains Formation *N. idahoensis* and *N. sulcoplicatus* are present. This fauna continues into the basal Road Canyon Formation. At the base of the Roadian within the lower Road Canyon Formation *M. idahoensis* is replaced by *M. nankingensis*.
The upper half of the Skinner Ranch Formation, the Cathedral Mountains Formation and the basal Road Canyon Formation are therefore post-Artinskian and pre-Roadian. For this interval the term Leonardian stage s. str. is here used.
The *M. idahoensis* fauna (uppermost Skinner Ranch Formation, Cathedral Mountains Formation and basal Road Canyon Formation) corresponds to the Chihsian Stage of South China. The Chihsian is therefore a time-equivalent of the Middle and Upper Leonardian s. str. In the moment, only one stage, the Leonardian

s. str. is used for the post-Artinskian – pre-Roadian time interval.

④ GULLO (in press) found 1991 for the first time Scythian conodonts in Sicily in a section south of Pietra dei Saracini. She found mostly Werfen type shallow-water conodonts determined as *Isarcicella isarcica* (determination by the author: *Hindeodus parvus* and *Isarcicella turgida*), *Hadrodontina aequabilis* (determination by the author: *Ellisonia transita* n. sp. and *E. praenevadensis* n. sp.) and one specimen of *Neospathodus* sp. (determination by the author: *Neospathodus* ex gr. *homeri*). Additional samples taken by the author yielded a lot of Scythian conodonts, both pelagic and shallow-water species. In the Brahmanian *Clarkina carinata, C. planata, Hindeodus parvus, H. postparvus, I. turgida, Ellisonia transita* and *Ellisonia praenevadensis* are very common. In the Upper Scythian (Olenekian) *Neospathodus homeri, Neohindeodella triassica* and *Gladigondolella carinata* are the most common species.
Especially in the basal Scythian many reworked Permian conodonts are present (Middle Permian *M. siciliensis*, Dzhulfian *Clarkina orientalis* and Changxingian *C. subcarinata*). But also Permian shallow-water algal limestones are reworked. Therefore this Scythian sequence probably does not belong to the Torrente San Calogero Permian–Triassic deep-water sequence, in which the Scythian and Anisian are tectonically missing. The paleogeographic position of this Scythian sequence is rather similar to that of the reef slope and base-of-slope deposits. This is confirmed by differences in the Changxingian and Ladinian deposits in both sequences. The Changxingian below the Scythian sequence consists of red clays that contain numerous thick calcarenites, sandy calcarenites, partly calcareous sandstones. In the Torrente San Calogero section the Changxingian contains no silicoclastic rocks and the few calcarenites are very thin. The Lower Ladinian of the section south of Pietra dei Saracini consists of red, strongly siliceous limestones and red cherts. The Lower Ladinian of the Torrente San Calogero section consists of gray and greenish-gray cherts and siliceous limestones.

The depositional area of the discussed sequence south of Pietra dei Saracini was in the Changxingian and Scythian on the shelf slope or on the base of this slope. Periodically shallow water or shallow pelagic deposits have been transported in this basin. The Changxingian and Scythian shallow-water clasts are not reef limestones.

The Permian–Triassic boundary in the section south of Pietra dei Saracini is the first P/T boundary in a pelagic sequence of the open-sea environment sensu ZHOU, Zuren (1986). This section will be investigated in detail by KOZUR & MOSTLER (in prep.). In the same section, greenish-gray siliceous limestones with *Neogondolella constricta* are present. This Upper Anisian fauna, discovered by the present author, is the first faunistically proven Anisian in the Sicanian paleogeographic domain of western Sicily.

With these new results, all Permian stages from the uppermost Artinskian up to the Changxingian and all Triassic stages from the Brahmanian Stage (Lower Scythian) up to the Rhaetian Stage have been recognized in the Sicanian paleogeographic domain of western Sicily. All these stages are documented by pelagic conodonts and (or) radiolarians, partly also by ammonoids, bivalves and ostracods. With exception of the Sosio limestone blocks and partly of the Scythian the entire documented Permian and Triassic are represented by open sea deep-water rocks. The Sosio limestone blocks consist of reef slope and base-of-slope rocks (shallow-water and shallow pelagic clasts and shallow pelagic matrix) deposited in water depth of 10–200 m. The Scythian limestone conglomerates and graded limestones consist of slope and base-of-slope rocks with pelagic matrix and shallow-water clasts. The shallow-water clasts contain a Werfen type conodont fauna that lived in water depth above 20 m. The pelagic matrix contains a conodont and foraminifer fauna that lived in water depth of more than 50 m, partly more than 200 m (the red pelagic Hallstatt Limestones of the Upper Scythian that do not contain shallow-water clasts or fossils).

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Prof. H. MOSTLER, Innsbruck, has shown numerous samples from the Sosio Valley area, especially from the Rupe del Passo di Burgio and Pietra di Salomone blocks.

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Plate 1

Figs. 1–3: ***Pseudohindeodus oertlii*** **(KOZUR).**
Sample S 20, Pietra di Salomone, Roadian, rep.-no. KoMo 1991/V-7.
Fig. 1: Lateral view, microsculpture on undenticulated posterior blade visible, × 300.
Fig. 2: Upper view, × 150.
Fig. 3: Upper view, × 380; microsculpture on undenticulated posterior blade well visible.

Figs. 4,5: ***Pseudohindeodus oertlii*** **(KOZUR).**
Sample S 20, Pietra di Salomone, Roadian rep.-no. KoMo 1991/V-16;.Fig. 4: Upper view, strongly magnified, undenticulated posterior blade with distinct microsculpture, × 380;
Fig. 5: Upper view, × 140.

Fig. 6: ***Sweetognathus galeatus*** **(BENDER & STOPPEL).**
Anterior blade broken away, the same preservation as for the holotype, × 100.
Sample 2070, Pietra di Salomone, Roadian, rep.-no. G 91/V-63, material and photo Dr. M. GULLO.

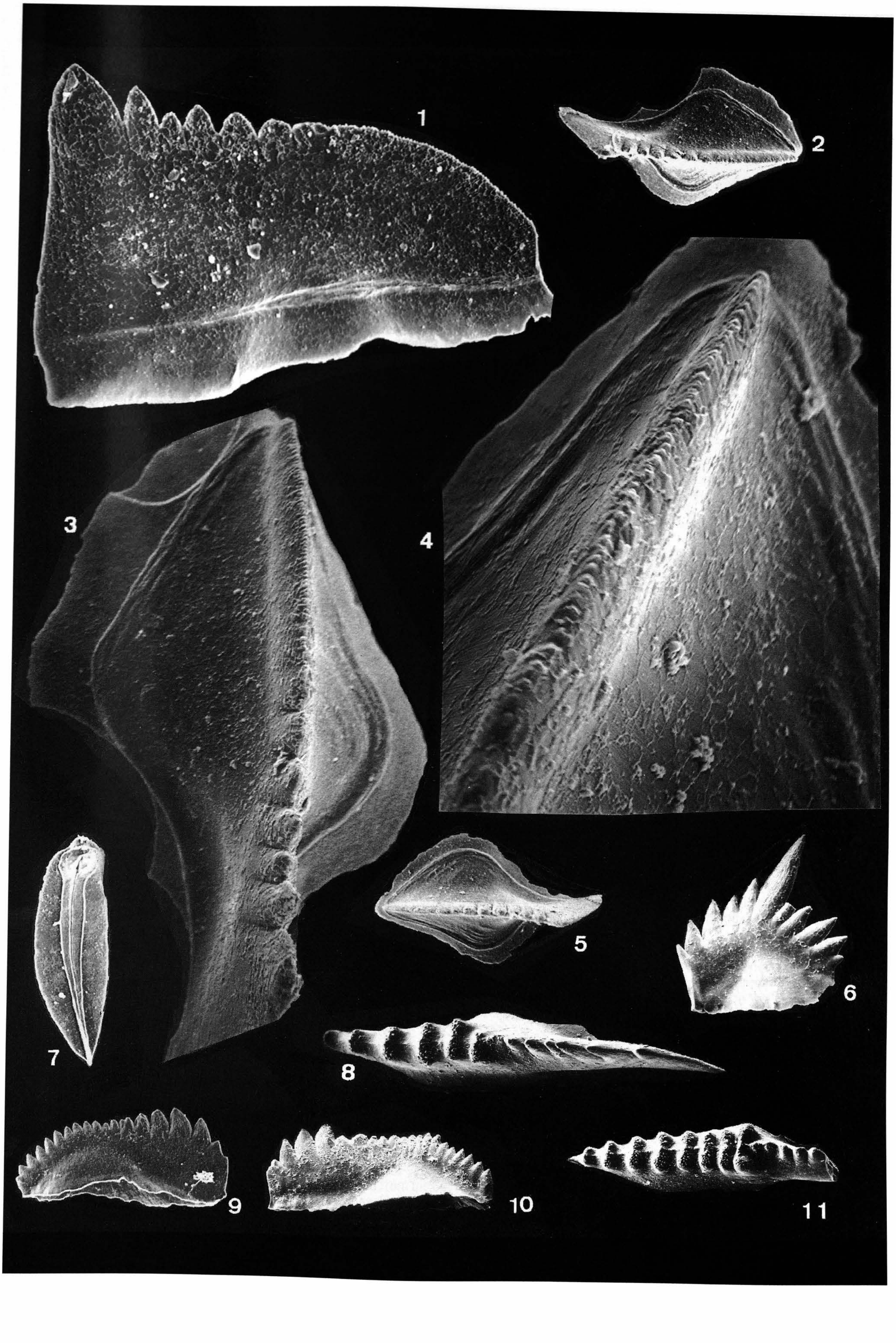
Fig. 7: ***Mesogondolella siciliensis*** **(KOZUR).**
Subadult specimen, lower view, × 90.
Sample 2070, Roadian, rep.-no. KoMo 1991/V-15, material Dr. M. GULLO, Palermo.

Fig. 8: ***Sweetognathus subsymmetricus*** **WANG, RITTER & CLARK.**
Upper view, × 300.
Sample 2070, Roadian, rep.-no. G 91/V-64, material and photo Dr. M. GULLO, Palermo.

Fig. 9: ***Gullodus sicilianus*** **(BENDER & STOPPEL).**
Lateral view, × 75.
Sample S 20, Pietra di Salomone, Roadian, rep.-no. KoMo 91/V-17.

Fig. 10: ***Gullodus sicilianus*** **(BENDER & STOPPEL).**
Lateral view, × 50.
Sample 2070, Pietra di Salomone, Roadian, rep.-no. G 91/V-48, material and photo Dr. M. GULLO, Palermo.

Fig. 11: ***Sweetognathus guizhouensis*** **(BANDO et al.).**
Upper view, × 100.
Sample 2070, Roadian, rep.-no. G 91/V-50, material and photo Dr. M. GULLO, Palermo.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