



PERMIAN CONODONT ZONATION AND ITS IMPORTANCE FOR THE PERMIAN STRATIGRAPHIC STANDARD SCALE

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With 4 figures, 2 tables and 6 plates

Abstract:

Conodonts are the stratigraphically most important fossils in the Permian with numerous guide forms distributed world-wide in both shallow-water and pelagic deposits (figs. 1, 2). Conodont provincialism is insignificant, but the facies control of conodonts may be considerable. Problems of conodont zonation are caused by migrations due to large scale facies changes, especially in the Middle Permian Guadalupian Series and at the Guadalupian-Lopingian boundary. Migration events of conodonts are not suitable for definitions of stage boundaries and large scale correlations, because they are diachronous.

A new genus, *Wardlawella* n. gen., and a two new species are described.

Zusammenfassung:

Conodonten sind die stratigraphisch bedeutendsten permischen Fossilien und weisen sowohl im Flachwasser als auch in pelagischen Ablagerungen zahlreiche weltweit verbreitete Leitformen auf (Figs. 1, 2). Provinzialismus ist unbedeutend, aber die Faziesabhängigkeit permischer Conodonten kann beträchtlich sein. Probleme für die Conodontenzonierung ergeben sich aus Migrationen infolge großräumiger Faziesänderungen, besonders in der mittelpermischen Guadalupe-Serie und an der Guadalupe/Loping-Grenze. Migration-events sind diachron und daher ungeeignet für die Definition von Stufengrenzen und großräumige Korrelationen.

Eine neue Gattung, *Wardlawella* n. gen., und zwei neue Arten werden beschrieben.

1. Introduction

Detailed taxonomic and stratigraphic studies of Permian conodonts began considerably later than in other Paleozoic systems because in the classical areas of conodont studies in Middle and Western Europe and Eastern USA the Permian is mostly continental or missing. Conodont-bearing Permian pelagic and slope deposits are common in the Cis-Urals, the Tethys, western North America, the Circum-Pacific realm and partly in the Arctic and on the northern margin of Gondwana. Most of the Permian conodonts have been described during the last 20 years from these areas. These investigations have shown that conodonts are the stratigraphically most important

fossil group of marine deposits, as in the Devonian and Carboniferous. The most important conodont guide forms are not influenced by the strong Permian faunal provincialism and are therefore decisive fossils for definition of the C/P and P/T boundaries as well as for the definition and correlation of the stage boundaries within the Permian.

Based on previous publications, and my own conodont studies of material from the Cis-Urals, Arctic Canada, Eastern Greenland, Texas, New Mexico, Arizona, Germanic Zechstein, Italy, Greece, Turkey, Oman, Transcaucasia, Iran, Pamirs, Russian Far East, Japan and Bolivia, a detailed shallow-water and pelagic conodont zonation for the Permian System is introduced

(figs. 1, 2, see p. 188) and range charts of the Permian conodonts are presented (tabs. 1, 2, see p. 190–193). A few examples of insignificant conodont provincialism are shown (fig. 4, see p. 189).

Different stratigraphic scales are used in different regions and by different authors. In the present paper, the scale proposed by KOZUR (1993) is used (see columns Series and Stage in figs. 1, 2). A three-fold subdivision is preferred, with the Cisuralian Series (Asselian, Sakmarian, Artinskian, Cathedralian stages), the Guadalupian Series (Roadian, Wordian, Capitanian stages) and Lopingian Series (Dzhulfian or Wuchiapingian, Changhsingian stages). The Cisuralian Series is best known from its Cis-Uralian type area. Its lower boundary coincides with the base of the Permian defined in this area (proposed candidates Ajdaralash and Usolka). Asselian, Sakmarian and Artinskian stages have their stratotypes in this area. The Kungurian is hypersalinar and therefore the upper boundary of the Cisuralian Series cannot be defined in the Cis-Urals. However, the upper boundary of a stratigraphic unit must be always defined with the lower boundary of the following unit in the type area of the latter unit (Guadalupian Series). The Cathedralian stage is defined in the type area of the Guadalupian Series, the Delaware Basin and its shelves in the Guadalupe and Glass Mountains. It was introduced by ROSS & ROSS (1987) as a stage between the top of the Artinskian and the base of the Roadian. The Cathedralian-Roadian boundary can be defined in the Guadalupe Mountains within the permanent accessible proposed stratotype for the Guadalupian Series (GLENISTER et al., 1992, GLENISTER, 1993). There, the upper Cathedralian and all 3 stages of the Guadalupian Series are well exposed in a continuous section, rich in ammonoids, conodonts (CAI = 1), fusulinids and other fossils. The Lopingian Series is defined in South China. Its lower boundary was both by KOZUR (1992b, c, d, 1993) and MEI et al. (1994) defined with the base of the *Clarkina altudaensis* Zone, originally established in the Glass Mountains, West Texas (KOZUR, 1992c, d, 1993, 1994). Correlation and

subdivision of the Early Lopingian are still disputed.

The Middle Permian fusulinid ages, often used as stages (Kubergandinian, Murgabian, Midian) for the Tethys are not used in the present paper. No conodonts are known from the Midian stratotype and from the Midian of the entire Transcaucasian type area. Few conodonts are known from the Kubergandinian and Murgabian type area in SE Pamirs, but strong reworking prevent the recognition of a conodont succession. Only one conodont-bearing sample is present from the upper Jachtashian. If the conodonts are not reworked, they indicate an Early Artinskian age for this level. No conodonts are known from the Bolorian type area in the Darvas. Conodonts are common in the Bolorian of SE Pamir, but because no fusulinids are present in the conodont-bearing beds, the richest conodont fauna with *Vjalovognathus shindyensis* cannot be exactly assigned to the earliest Bolorian or latest Jachtashian. The Jachtashian, Bolorian, Kubergandinian, Murgabian and Midian stratotypes are no longer accessible after the disintegration of the former Soviet Union and they cannot be used as a world standard for the Permian (KOZUR et al., 1994).

Both the lower and upper boundary of the Permian are not yet finally defined. In the present paper the base of the Permian is placed at the base of the *Streptognathodus barskovi-S. invaginatus* Zone. For the upper boundary of the Permian the base of the *Hindeodus parvus* Zone is preferred (YIN, 1993; KOTLYAR et al., 1993; KOZUR, 1994a, b, PAULL & PAULL, 1994).

2. Previous work

CLARK & BEHNKEN (1971) established a first, coarse Permian conodont zonation. In later papers, detailed Permian conodont zonations have been established (e.g. BEHNKEN, 1975; KOZUR, 1975, 1978, 1990a, c, 1992d, 1993a; KOZUR et al., 1978; MOVSHOVICH, et al., 1979; BANDO et al., 1980; WARDLAW & COLLINSON,

1986) or detailed conodont range charts have been published (IGO, 1979, 1981; HAYASHI, 1981; CLARK & WANG, 1988; KOZUR, 1990a). In KOZUR (1978) and CLARK & BEHNKEN (1979), phylomorphogenetic lineages of Permian conodonts have been demonstrated.

The best investigated conodont succession is known from the Middle Permian Guadalupian Series (Roadian, Wordian and Capitanian stages) of western North America. In the warm-water pelagic faunas of the Delaware Basin and its surroundings (type area of the Guadalupian and its stages), the conodont succession is well known, and has been correlated in detail with the ammonoid- and fusulinid zonation as well as with stage boundaries (BEHNKEN, 1975; CLARK & BEHNKEN, 1979; WARDLAW & GRANT, 1990; GLENISTER et al., 1992; KOZUR, 1992b-d). The Upper Artinskian to Guadalupian conodont succession of the Phosphoria Basin in the western USA is also well known (CLARK et al., 1979; WARDLAW & COLLINSON, 1979, 1984, 1986; BEHNKEN et al., 1986), but the late Capitanian to early Wuchiapingian conodont ages for the uppermost part of the sequence (upper Gerster Formation) are not in agreement with the largely brachiopod based determination of a Wordian age (CLARK & WANG, 1988).

Similarly well-investigated are the Late Permian (Lopingian Series) conodont successions in Transcaucasia, NW and Central Iran (SWEET, 1973; KOZUR, 1975, 1978, 1990a; KOZUR, MOSTLER & RAHIMI-YAZD, 1975) and the Permian conodont successions of China, especially of South China (e.g. WANG & WANG, 1981a, b; ZHANG et al., 1984; DAI & ZHANG, 1989; DONG et al., 1987; KANG et al., 1987; WANG et al., 1987; CLARK & WANG, 1988; DING et al., 1990; WANG, 1991; WANG & DONG, 1991; TIAN, 1993a, b, c, 1994). In all other Tethyan regions, the Permian conodont distribution is not so well known. Either conodonts occur only in short stratigraphic intervals (e.g. RAMOVŠ, 1982; NESTELL & WARDLAW, 1987; KOZUR, 1978; BANDO et al., 1980), or they have been derived from tectonically complicated areas, such as the Upper Artinskian to Changhsingian of Western Sicily

(CATALANO et al., 1991, 1992; GULLO & KOZUR, 1992; KOZUR, 1990b, 1992a, 1993b, c).

Scattered Tethyan conodont faunas of different ages are also known from some displaced terranes in Canada and western USA (e.g. WARDLAW et al., 1982; ORCHARD, 1984; ORCHARD & FORSTER, 1988; BEYERS & ORCHARD, 1991). Also, the rather well known conodont successions of Japan (IGO, 1979, 1981, HAYASHI, 1981, IGO & HISHIDA, 1986) have a Tethyan character. The correlation of these successions is difficult because of tectonic and sedimentologic complications.

The conodont studies in the Cis-Uralian stratotype began later than in most other areas (KOZUR, 1975, 1978, KOZUR & MOSTLER, 1976, MOVSHOVICH et al., 1979). The Asselian to Artinskian conodont zonation established in these papers, was later modified for the Asselian (CHERNIKH & RESHETKOVA, 1987, 1988; CHERNIKH, in CHUVASHOV et al., 1990; CHUVASHOV et al., 1993), but no final conodont zonation was elaborated. Rather correlation of the conodont successions with the earlier elaborated fusulinid zonation was attempted.

Also well-known are low diversity conodont faunas of the Lower Wuchiapingian of Greenland and the contemporaneous Zechstein Limestone of central and northwestern Europe (e.g. BENDER & STOPPEL, 1965; SWEET, 1976; KOZUR, 1978; SWIFT, 1986; SWIFT & ALDRIDGE, 1986; RASMUSSEN et al., 1990). The Boreal Changhsingian conodont fauna is represented by the conodont faunas of the *Otoceras* beds (SWEET, 1976; HENDERSON, 1993), so far mostly placed into the Triassic. Upper Artinskian and Cathedralian Boreal conodont faunas are well-known from Svalbard (SZANIAWSKI & MALKOWSKI, 1979; NAKREM, 1991). From Arctic Canada, Asselian to Wordian conodont faunas have been described (KOZUR & NASSICHUK, 1977; NASSICHUK & HENDERSON, 1986; HENDERSON, 1988; BEAUCHAMP et al., 1989; and ORCHARD, 1991).

A few conodonts have been described from Gondwana (RABE, 1977; SUÁREZ RIGLOS et al., 1987), and they are exclusively Early Permian faunas. The Permian conodont faunas from the

eastern Gondwana margin of the Tethys are better known (KOZUR, 1975, 1978; VAN DEN BOOGAARD, 1987; REIMERS, 1991; KOZUR et al., 1994).

3. Taxonomic note

The genus *Wardlawella* n. gen. and the new species *Clarkina procerocarinata* n. sp. and *Isarcicella ? prisca* n. sp. are described in the present paper to avoid the use of nomina nuda.

Genus *Wardlawella* n. gen.

Derivatio nominis: In honour of Dr. B. R. WARDLAW, Reston

Type species: *Ozarkodina expansa* PERLMUTTER, 1975

Diagnosis: Pa element with large, asymmetrically triangular to asymmetrically oval cup. Free blade high, with 4–7 denticles. On the cup, the carina is fused to a ridge with distinct pustulate microsculpture, often arranged in narrow transverse lines or even fused to pustulate narrow transverse micro-ridges. Often the fused carina displays constrictions indicating the presence of denticles before fusion. Surface of cup smooth, rarely with spots or transverse stripes of small pustules. These pustulate areas on the cup surface are never elevated to nodes or ridges.

Occurrence: Asselian to Changhsingian, mostly in shallow-water deposits.

Assigned species:

Ozarkodina expansa PERLMUTTER, 1975

Diplognathodus movschovitschi KOZUR & PJATAKOVA, 1975

Synonym: *Iranognathus nudus* WANG, RITTER & CLARK, 1987

? *Diplognathodus lanceolatus* IGO, 1981

Diplognathodus paralanceolatus WANG & DONG, 1991

Sweetognathus adenticulatus RITTER, 1986

Diplognathodus triangularis DING & WAN, 1990

Remarks: *Wardlawella* is the ancestor of most shallow-water Permian gnathodids. It evolved from *Diplognathodus* KOZUR & MERRILL by development of the characteristic microsculpture on the fused part of the carina.

By development of a high, pustulate transverse ridge on one or both sides of the platform, *Xuzhounathus* DING & WAN, 1990, evolved from early *Wardlawella*.

Iranognathus KOZUR, MOSTLER & RAHIMI-YAZD, 1975, evolved from *Wardlawella* by development of pustulate nodes or ridges, parallel to the fused carina or to the cup margin.

Sweetognathus CLARK, 1972, is distinguished by pustulate nodes or pustulate transverse ribs on the carina that is often widened to a platform. These nodes or transverse ribs are mostly connected to each other by a single line of pustules that may be elevated to a very narrow ridge.

Pseudohindeodus GULLO & KOZUR, 1992, is distinguished by a ridge or double ridge near the margin of the cup. The fused carina is mostly separated into single unsculptured denticles.

Genus *Clarkina* KOZUR, 1990

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

Clarkina procerocarinata n. sp.

(Pl. 6, figs. 6–8)

Derivation of name: According to the slender form and similarity with *C. carinata*.

Holotype: The specimen figured on pl. 6, figs. 6–8, rep.-no. KoMo 121191/IX-3.

Type locality: Section about 500 m south of Pietra dei Saracini.

Type stratum: Red upper Changhsingian claystones, about 1 m below the P/T boundary (defined with the base of the *H. parvus* Zone).

Material: 23 specimens.

Diagnosis: Platform slender, widest in or somewhat behind the midlength. Posterior end nar-

rowly rounded, mostly at one or both sides incised. Lateral platform margins relatively narrow, slightly upturned, with honeycomb micro-sculpture. Adcarinate furrows broad, shallow, smooth. Carina with 7–10, laterally strongly compressed, posteriorly inclined denticles. Anterior part of carina highly fused. Cusp terminal, indistinct, fused with the posterior platform margin. Keel narrow, flat, with indistinctly elevated margin. Basal cavity elongated.

Occurrence: Late Changhsingian and *Isarcicella isarcica* Zone (basal Scythian) of the Sosio Valley area. The basal Scythian forms may be reworked because the *Isarcicella isarcica* Zone contains reworked Middle and Late Permian conodonts.

Remarks: *C. carinata* (CLARK, 1959) and the closely related (or identical) *C. planata* (CLARK, 1959) have a short, broad, flat platform with totally separated or only basally fused denticles even in the anterior part of the carina (compare pl. 6, figs. 19, 20), and the denticles are laterally slightly compressed to roundish.

Genus *Isarcicella* KOZUR, 1975

Type species: *Spathognathodus isarcicus* HUCKRIEDE, 1958

Isarcicella ? prisca n. sp.
(Pl. 6, figs. 3, 4)

1991 *Hindeodus typicalis* (SWEET), pars – PERRI, p. 40, 42, pl. 3, figs. 1, 3, 4

Derivatio of name: Stratigraphically oldest, most primitive *Isarcicella* species.

Holotype: The specimen on pl. 6, fig. 3, 4 (from PERRI, 1991, pl. 3, fig. 1), rep.-no. IC 1444.

Type locality: Bulla section SW of Ortisei, Southern Alps, Italy (see PERRI, 1991).

Type stratum: Sample Bu 10, lower Tesero Oolite, upper Changhsingian.

Diagnosis: Pa element rather small, with 6–9 denticles, which are largest in the posterior half.

Upper edge-line of the denticles away from the cusp slightly declined. Cusp considerably broader, somewhat to distinctly larger than the following denticles. Inner part of the cup distinctly thickened. Outer, not thickened part rather broad.

Occurrence: Late Changhsingian Tesero Oolite of Southern Alps. Latest Dorashamian of Transcaucasia (only broken specimens).

Remarks: The denticulation of the blade and the size of the cusp corresponds to *Hindeodus latidentatus* (KOZUR, MOSTLER & RAHIMI-YAZD). *I. ? prisca* n. sp. is distinguished from *H. latidentatus* by the distinct thickening of the inner part of the cup, typical for all *Isarcicella* species. The taxonomic importance of this feature is not yet clear (it may be facies-controlled).

Isarcicella ? turgida (KOZUR, MOSTLER & RAHIMI-YAZD) from the basal Triassic displays a more prominent cusp that is more than two times longer than the following denticles.

4. Temperature- and other facies dependence of the Permian conodonts and the importance of these factors for conodont zonation

4.1. Dependence of conodont distribution on water depth

In very shallow water intratidal deposits, conodonts are either missing or represented by the genus *Stepanovites*, and in North America by the very similar genus *Sweetina*, distinguished only by the presence of a lateral branch in the Pa (?) element. Like other fossils from this facies, these conodonts have little stratigraphic value.

Beside *Stepanovites*, numerous conodont genera occur in Permian shallow-water deposits below the tidal flats, but the typical pelagic gondolellid conodonts are missing in such faunas. Some Early Permian shallow-water conodonts have greater stratigraphic value than the pelagic ones. Also, the shallow-water conodonts of the uppermost Permian are stratigraphically very important.

The Permian shallow-water conodonts belong to the genera *Adetognathus* Lane (uppermost range in the Lower Artinskian, stratigraphically unimportant), *Gullodus* KOZUR (restricted to the upper part of reef slopes), *Hindeodus* REXROAD & FURNISH [with important guide forms in the Upper Permian, especially around the Permian-Triassic boundary; especially forms with partly fused carina, such as *H. julfensis* (SWEET), occur also in pelagic deposits], *Iranognathus* KOZUR, MOSTLER & RAHIMI-YAZD, junior synonym *Homeoiranognathus* Ritter (Artinskian-Changhsingian, some species are also present in pelagic deposits), *Merrillina* KOZUR (Capitanian to lower Wuchiapingian), *Neostreptognathodus* CLARK (with several excellent guide forms of the Upper Artinskian-Roadian), *Pseudohindeodus* GULLO & KOZUR (Artinskian-Middle Permian, partly also pelagic), *Rabeignathus* KOZUR (Upper Artinskian-lower Cathedralian, both shallow-water and pelagic), *Stepanovites* KOZUR (see above), *Streptognathodus* STAUFFER & PLUMMER (common in shallow-water and pelagic Asselian, rarely up to the Lower Artinskian), *Sweetocristatus* SZANIAWSKI (Artinskian-Changhsingian, shallow-water and pelagic), *Sweetognathus* CLARK (several Early-Middle Permian guide forms) and *Wardlawella* n. gen.

Gondolellid conodonts are restricted to pelagic deposits. Ribbed *Mesogondolella* are excellent guide forms, restricted to the Middle Permian. Among smooth forms are also numerous guide forms, but their identification is difficult, if they do not have characteristic outlines.

The pelagic conodonts are well-studied throughout most of Permian. Shallow-water conodonts are well-studied in the Early Permian, especially in the Upper Artinskian and Cathedralian, where they comprise the most important conodont guide forms. In the Middle Permian, except the Roadian, the succession of shallow-water conodonts is not yet well-known, whereas the Upper Permian shallow-water conodont succession is well-known and stratigraphically important, especially around the P/T boundary.

Fortunately, the shallow-water and pelagic conodont succession can be easily correlated

(figs. 1, 2). In many samples, especially from slope deposits, pelagic and shallow-water conodonts occur together and some conodonts occur both in shallow-water and pelagic rocks (see above). Thus, in the marginal parts of the Delaware Basin practically every conodont-rich sample has both the shallow-water and pelagic conodonts, which makes this area extremely important for Permian stratigraphy and a key area for defining world-wide applicable stages. Moreover, in this area also an abundance of other stratigraphically significant fossil groups are present, such as ammonoids, brachiopods, radiolarians and fusulinids. Their zonations can be well correlated with the conodont standard in this area. The same situation is present in the Asselian to Artinskian of the Cis-Urals. However, in many places reworking of older material can be observed. In the Tethys and in Japan, however, there are in many areas only pelagic or only shallow-water associations, and if both conodont faunas occur together, then they are mostly from tectonically and sedimentologically highly complicated areas, often with reworked older elements. In several Late Permian Tethyan sections shallow-water and pelagic conodonts occur together. This is a fortunate situation, because at this time there are only few conodonts known from other areas.

In the Delaware Basin, partly in the Cis-Urals and at several levels in the Tethyan Upper Permian joint pelagic/shallow-water zonations can be established that are partly more detailed than the pelagic or shallow-water zonations alone and can be used as standard zonations that are applicable world-wide (figs. 1, 2).

4. 2. Temperature dependence of Permian conodonts

Conodonts are to a certain degree temperature dependent. If the temperature was too low, e.g., in glacio-marine deposits, conodonts are absent. Conodont-bearing cool-water faunas have a very low diversity (e.g. lower Wuchiapingian

conodont fauna of East Greenland, from where only two species are known in conodont faunas very rich in specimens).

More problematical is an other kind of temperature-dependence, which was not known previously. There exist not only simple pelagic gondolellid faunas, but pelagic warm-water and cold-water (or cool-water) faunas. Pelagic warm-water faunas lived in the tropical-subtropical belt in the basinal facies of seas with narrow deep-water connection to the world-ocean. These seas were fully marine, but they were not connected to the cold bottom-water currents of the oceans and their marginal seas. The Delaware Basin is a typical example of this basin type, but also in South China such semi-restricted basins are present (ZHOU, 1986). Today, we have such an example in the Mediterranean Sea.

The other pelagic conodont fauna lived in open seas or at the margin of oceans. In these areas, cold oceanic bottom currents occurred and therefore below 200–500 m psychrospheric conditions were present. This is indicated by the presence of archaic paleopsychrospheric ostracods (KOZUR, 1991). Pelagic cold-water or cool-water faunas are therefore not restricted to the Boreal realm, but can be also found in tropical seas, if these were open seas (e.g. Sosio Valley, Sicily, Oman) and they also occur in marginal seas with cold-water upwelling (Phosphoria Basin in western USA). Similar differences were observed in ammonoid faunas (ZHOU, 1986).

This temperature dependence is not known in the Early Permian, but it is easily recognizable in the Middle and Late Permian. The ribbed Middle Permian *Mesogondolella* species and the *Clarkina leveni* lineage belong to the pelagic warm water faunas. To the pelagic cold or cool water forms belong *Mesogondolella phosphoriensis*, *M. siciliensis* and *Clarkina sosioensis*. These faunas are so different from the pelagic warm-water faunas that CLARK (1979) regarded them as a Tethyan stock, but the ribbed *Mesogondolella* species as a North American stock (regarding the areas of the first discovery of these different contemporaneous faunas). How-

ever, in South China facial conditions similar to those in the Delaware Basin are known, and there all ribbed forms from Texas have been also found (CLARK & WANG, 1988). In the Upper Permian, pelagic warm-water conodonts are widely distributed in the Tethys. Contemporaneous cold-water forms from deep-water deposits have been recently found in Sicily, dominated by *Clarkina sosioensis* (GULLO & KOZUR, 1992). They are also known from Upper Permian cherts of Japan. Shallow-pelagic Wuchiapingian cold-water faunas are characterized by *C. rosenkrantzi* (BENDER & STOPPEL).

Some pelagic Middle and Late Permian gondolellids occur both in cold and warm water. *Clarkina changxingensis* (WANG & WANG) belongs to these forms. However, *C. changxingensis* preferred deeper water. It invaded the Tethyan sea during periods of deepening. In South China, this species therefore characterizes the Upper Changhsingian. In the Sosio Permian, where open sea deep-water deposits occur throughout the Permian, *C. changxingensis* already begins in the Wuchiapingian. In the uppermost Altuda Formation of the Glass Mountains, the derivation of *C. changxingensis* from *C. altudaensis* can be observed in beds that belong to the basal Lopingian.

Cold-(cool)-water pelagic and warm-water pelagic conodont faunas in general mutually exclude each other. Therefore, their successions are difficult to correlate. Often the exact range of the cold-water deep pelagic conodonts is not clear because they mostly occur in beds where no stratigraphically important forms (except radiolarians) are present. Only in a few places slope deposits are known, in which ammonoids and fusulinids occur together with these cold-water forms (e.g. *M. siciliensis* occurs in western Sicily and in Oman together with Wordian ammonoids and in the slope facies of Sicily additionally together with Wordian fusulinids). The stratigraphic evaluation of the conodont successions is especially difficult in areas where warm-water pelagic and cold-water pelagic faunas replaced each other in stratigraphic successions (above all in areas with cold-water upwell-

ing). The first appearance of a species often marks a facies-controlled immigration event. Some difficulties in the stratigraphic evaluation of the conodont faunas in the Phosphoria Basin are seemingly related to these problems. For instance, *M. phosphoriensis* occurs there in Wordian beds above Roadian beds with *M. nankinensis*. However, in Western Sicily, *M. phosphoriensis* is a common species in Roadian deposits with cold bottom water ostracod faunas and the interval with *M. nankinensis* is missing. Differences in the age determinations of conodonts from the Phosphoria Basin (WARDLAW & COLLINSON, 1979, 1986; CLARK & WANG, 1988) may be caused by restricted range due to migrations.

5. Provincialism and Permian conodonts

The Permian system has the strongest floral and faunal provincialism in Earth history. Almost all stratigraphically important faunal groups have few species and genera in common in Permian low latitudes (Tethyan realm) and high latitudes (Boreal and Notal realms). Benthonic faunas, like fusulinids, show very strong provincialism even within the low latitude faunas, especially in the Middle Permian, where fusulinids are missing in the Boreal realm and therefore the migration route between the Tethyan and North American low latitude faunas was interrupted.

This very strong provincialism among the above mentioned stratigraphically important fossil groups causes big correlation problems within the Permian. These correlation problems are a serious obstacle for establishment of an universally accepted Permian stratigraphic world standard, because the Cis-Uralian Permian stratotype lies in the Boreal realm, and because there is no area in the world where all Permian stages are known in sequence in pelagic facies. Therefore we have to combine the Permian standard from different regions belonging to different faunal provinces and even realms. The conodonts are

the only stratigraphically important Permian faunal group, in which provincialism affects only few stratigraphically important forms. They are therefore the only fossils suitable to correlate the 3 above mentioned proposed type areas for the Permian stratigraphic standard scale.

Most Permian conodont guideforms can be traced through areas as distant as Bolivia, Texas, Svalbard, Cis-Urals, Pamirs and China, allowing an exact correlation between these areas that belong to different faunal provinces and even to different faunal realms (Notal, Tethyan and Boreal realms). However, some provincialism is also known among the conodonts. The Asselian *Gondolelloides* HENDERSON & ORCHARD occurs in the entire Arctic and in non-Tethyan displaced terranes of the American west coast. It is an endemic element of the Boreal realm. Otherwise, the conodont faunas of the Boreal realm are identical with the Tethyan ones until the Artinskian. The so far known Boreal Cathedralian to Wuchiapingian faunas are less diverse than the Tethyan ones, but contain no endemic elements. The Tethyan and Boreal Changhsingian conodont faunas are similar, despite the fact that the ammonoid faunas are totally different from each other (Tethyan *Paratirolites-Pleuronodoceras* faunas and Boreal *Otoceras* faunas). *Hindeodus* is represented by the same species and species successions, whereas the gondolellids show distinct differences. The *Clarkina carinata* lineage invaded the Tethyan realm only at the base of the Triassic with advanced *C. carinata* (Clark) and *C. planata* (CLARK), whereas some species of the *C. leveni* lineage are missing in the Boreal realm and on the Gondwana margin of the Tethys.

Vjalovognathus shindyensis (KOZUR) is a typical Upper Artinskian – Cathedralian species from the eastern Gondwana margin of the Tethys (e.g. Pamirs, Timor) unknown from any other area. It is also present in eastern Gondwana (eastern Australia) (pers. comm. Prof. I. METCALFE). *Neostreptognathodus leonovae* KOZUR and *Gullodus hemicircularis* KOZUR may also be restricted to this faunal realm. Other species known so far only from the eastern Gondwana

province (see tab. 1, species distribution G-E) are very closely related to Tethyan and North American species and in these areas probably not yet found.

Sweetina WARDLAW & COLLINSON is restricted to western North America. *Mesogondolella gracilis* (CLARK & ETHINGTON) and *M. prolongata* (WARDLAW & COLLINSON) are seemingly also restricted to the Guadalupian of the western USA (but not known from the Delaware Basin).

Very important for Permian stratigraphy is the provincialism of *Neostreptognathodus pnevi* KOZUR & MOVSHOVICH. The cline *N. pequopen-sis* – *N. pnevi* is the only biostratigraphic marker to correlate the top of the Artinskian with any scale outside the Cis-Uralian Permian type area. The correlation of this conodont event is the only possibility to leave the Cis-Uralian standard with the beginning of the hypersaline and non-marine succession in the Cis-Urals. This cline is present in the Boreal realm, including the Cis-Urals, and in the marginal parts of the Delaware Basin, the type area of the Cathedralian stage (uppermost stage of the Early Permian) and of the Guadalupian Series (Roadian, Wordian and Capitanian stages). However, *N. pnevi* is missing in the Tethys and in Gondwana. For this reason the Tethyan regional scale (Jachtashian, Chihisian or Bolorian, Kubergandinian, Murgabian and Midian regional stages, in reality regional fusulinid ages of the Tethys) cannot be correlated with the Cis-Uralian standard and it is impossible to leave the Cis-Uralian standard at the top of the Artinskian into the Tethyan regional scale.

6. Remarks on the conodont successions and their importance for Permian stratigraphy

6.1. The Carboniferous-Permian boundary in the conodont zonation

The C/P boundary was tentatively defined by the appearance of the ammonoid *Artinskia ka-*

zakhstanica at the base of bed 20 in the Ajdaralash section, Cis-Urals (DAVYDOV et al., 1992). According to these authors, the base of the *Sphaeroschwagerina fusiformis* – *S. vulgaris* Zone lies 12 m below this level, whereas *Streptognathodus constrictus* CHERNIKH & RESHETKOVA and *S. barskovi* (KOZUR) begin somewhat above this level. The exact conodont zonation of the Ajdaralash section will be studied by an American-Russian research group. Conodonts are in most levels rather rare and often reworked. Even Upper Devonian conodonts with *Palmatolepis* are known. The reworked conodonts are mostly not recognizable by preservation differences. The Usolka section, next to Ajdaralash the second candidate for the C/P boundary stratotype (decision of the ISPS meeting in Jekaterinburg, formerly Sverdlovsk, 1991) is very suitable for the definition of the C/P boundary by conodonts. The Gzhelian to Asselian part of this well exposed section consists of grey, pelagic, bedded, often marly limestones, marls and claystones which are very rich in conodonts. Reworking cannot be observed in the important Gzhelian-Middle Asselian interval. The view of SPINOSA & SNYDER (1993) that the Usolka section is condensed in the C/P boundary interval cannot be confirmed by the investigation of about 30 kg rock material from the critical interval, neither from conodont succession nor from lithology and microfacies. The conodont succession was well described by CHERNIKH & RESHETKOVA (1987, 1988). The first appearances of *S. barskovi* (pl. 1, figs. 4, 6) and *S. invaginatus* (pl. 1, fig. 20) in bed 15 indicate distinct changes in the conodont fauna that can be used for definition of the C/P boundary. The correlation of this succession with the conodont succession of Ajdaralash (consisting of a by far poorer fauna with an unknown degree of reworking) by CHUVASHOV et al. (1993) is premature and not yet possible as long as no rich, definitely unreworked conodont faunas are available from this horizon in the Ajdaralash section.

In the Permian low latitude fauna from the Tethys and western North America, the first appearance of *S. barskovi* is the best recognizable

conodont event near the C/P boundary. It coincides roughly with the first appearance of the typical Permian perrinitid ammonoids (documented both in USA and in China). A little earlier, but also between the Americus- and Neva limestones of Kansas, *Wardlawella expansa* appears for the first time (NESTELL, lecture in Calgary, 1993). Therefore, this boundary is also recognizable conodont faunas of shallow-water environment. Before the C/P boundary is finally defined, the first appearance of *S. barskovi* is used in the present paper for defining this boundary.

6.2. Conodont successions of the Early Permian (Cisuralian) Series (fig. 1)

Streptognathodus species (pl. 1) are decisive for Asselian subdivision (tab. 1). *Mesogondolella* is present in some pelagic Middle and Upper Asselian deposits, but known only from very few occurrences in the world. Shallow subtidal deposits contain only *Wardlawella expansa* (pl. 1, figs. 17, 18) throughout the entire Asselian, and *Adetognathus paralautus* ORCHARD (pl. 2, fig. 1), a long-ranging Late Pennsylvanian – Early Permian shallow-water conodont.

The Sakmarian and Lower Artinskian conodont faunas are not yet well studied. In pelagic deposits, both contain the rather long-ranging *M. bisselli* (CLARK & BEHNKEN) accompanied by a not very specific and poor *Streptognathodus* fauna. In the Sakmarian, *M. bisselli* (pl. 2, figs. 10–12) is accompanied by other *Mesogondolella* species (pl. 2, figs. 8, 9, 13). The gondolellid conodonts of this level have been taxonomically split too much. *M. pseudostriata* CHERNIKH is assigned to *M. obliquimarginata* CHERNIKH (pl. 2, figs. 8, 9). Both taxa have the same range and are only morphotypes. The holotype of “*Neogondolella*” *lata* CHERNIKH is more similar to the holotype of *M. bisselli* than the forms figured by CHERNIKH (in CHUVASHOV et al., 1990) as “*N.*” *bisselli*. *M. lata* is regarded as junior synonym of *M. bisselli*. Some forms with blunt posterior end and subtriangular shape, assigned to

“*N.*” *lata*, may be separated as subspecies, but the holotype is inseparable from *M. bisselli*.

The Sakmarian to Lower Artinskian shallow-water conodont faunas are more differentiated and consist above all of different *Sweetognathus* species. The Sakmarian is characterized by *S. merrilli* KOZUR (pl. 2, figs. 4–7) and *Wardlawella adenticulata* (pl. 2, fig. 19), in the Upper Sakmarian begins *S. inornatus* RITTER (pl. 2, figs. 16, 17, 21) and in the uppermost Sakmarina *S. whitei* (RHODES). The Sakmarian *Sweetognathus* n. sp. (pl. 2, figs. 14, 15) is very similar to *S. whitei* and was often placed in this species (WANG & ZHANG, 1985, WAN & DING, 1987; DING et al., 1990). CHERNIKH (in CHUVASHOV et al., 1990) described this form as *S. primus* CHERNIKH, but the holotype of this species is unfortunately a *S. inornatus* RITTER and *S. primus* therefore a junior synonym of *S. inornatus*.

The Upper Artinskian (Baigendzhinian) and Cathedralian conodont zonation both in pelagic and shallow-water deposits is well established (KOZUR, 1978; MOVSHOVICH et al., 1979; KOZUR, 1993a). In the basal Baigendzhinian *M. bisselli* – *S. whitei* Zone, all Carboniferous holdovers (*Streptognathodus* and *Adetognathus*) are absent. A little later, the first *Neostreptognathodus* (pl. 3, tab. 1) began. The development within this genus (e.g. BEHNKEN, 1975; KOZUR, 1975, 1978) allows a detailed zonation of the late Artinskian to Roadian deposits (fig. 1). A distinct and world-wide distributed latest Artinskian and lower Cathedralian shallow-water conodont is *Rabeignathus* (pl. 3, fig. 14). Its upper range is in the lower Cathedralian *M. intermedia* – *N. exsculptus* Zone, but its first appearance within the Upper Artinskian is not yet well dated.

Within the middle Skinner Ranch Formation, *N. exsculptus* Igo (pl. 3, fig. 16), *Sichuanognathus foliatus* Igo (pl. 3, fig. 17) and *N. pnevi* (pl. 3, fig. 19) evolved nearly in the same level. The first appearance of *N. exsculptus* and *S. foliatus* allows a correlation with the Japanese and Tethyan conodont successions. Also, *Mesogondolella intermedia* (IGO) (pl. 3, fig. 12) and *M. gujioensis* (IGO) (pl. 3, fig. 21) evolved nearly at the same level. These two species are therefore

also good markers for the base of the Cathedralian in pelagic facies. Somewhat above this level the first *M. idahoensis* (YOUNGQUIST et al.) (pl. 3, fig. 18) begins, which is the most characteristic and world-wide distributed pelagic guide form of nearly the entire Cathedralian (with the exception of its very base). A very characteristic form of the pelagic middle Cathedralian is *M. asiatica* (IGO) (pl. 3, fig. 15), known from Japan, several localities of the Tethys and from West Texas. The exact total range of this form is unfortunately unknown, but it is surely restricted to an interval within the Cathedralian. Also, *M. zsuzsannae* KOZUR (pl. 3, fig. 20) of the *M. idahoensis* group is restricted to a rather short interval within the Cathedralian. This species is common in the Cathedralian of western Sicily, but also present in Texas.

In shallow-water a very rapid evolution of *Neostreptognathodus* during the Cathedralian stage allows the discrimination of at least 4 zones in this stage. This zonation is well documented by phylogenetic lines, whereas the zonation of the pelagic Cathedralian is based on species that are not all part of a known phylogenetic continuum. Often only the *M. gujioensis* – *M. intermedia* Zone and a wide *N. idahoensis* Zone (mostly with a *M. zsuzsannae* fauna in its middle part) can be discriminated (e.g. in the Sosio Valley, Sicily, CATALANO et al., 1991, 1992; GULLO & KOZUR, 1992). The Cathedralian is therefore an exceptional level in conodont evolution, where the shallow-water conodont zonation is more detailed and better proven by phylomorphogenetic lines than the pelagic zonation. In the combined shallow-water/pelagic standard zonation, 5 zones can be discriminated within the Cathedralian.

6.3. The Artinskian-Kungurian boundary and its conodont-based correlation with the North American scale and with the Tethys scale

The cline *N. pequopensis* - *N. pnevi* is suitable for definition of the top of the type Artinskian

and for correlation of this level with the American standard, because it is also recognizable in the middle part of the Skinner Ranch Formation of Texas. This is especially important, because other fossil groups do not allow an exact correlation of any level close to the Artinskian-Kungurian boundary with any sequence outside the Cis-Urals. Because *N. pnevi* KOZUR & MOVSHOVICH is absent in the Tethys, the correlation is only possible with the Boreal realm and with the Texas standard, which is most suitable as a world standard for the Cathedralian to Capitanian interval.

N. pnevi developed in Texas in a rather short interval from *N. pequopensis* BEHNKEN (pl. 3, figs 4, 5). The overlap in the range of both species is rather short. The same can be observed within the Shurtan Formation of the Cis-Urals (near the town Kungur, for geographic position of the sections and the lithologic successions see MOVSHOVICH et al., 1979), which is often placed in the uppermost Artinskian, but was regarded as Kungurian by KOZUR (1993a). *N. pequopensis* has its highest occurrence in beds with forms transitional to *N. pnevi* at the base of this formation. The next younger fauna of the middle Shurtan Formation yielded *N. pnevi*, *N. ruzhenzevi* KOZUR and *N. pseudoclinei* KOZUR & MOVSHOVICH, a typical fauna of the *N. pnevi* Zone.

Because the Artinskian-Kungurian boundary is generally defined by the change from fully marine to hypersaline beds, a diachronous Artinskian-Kungurian boundary is possible. In more marginal and shallower deposits the hypersaline facies may begin earlier. Moreover, because the only marine connection of the rather narrow Cis-Uralian seaway was in the north, the hypersaline Kungurian type of deposits should begin earlier in the south than in the north. Indeed, the fully marine development with the *N. pnevi* Zone (without *N. pequopensis*) at the top occurs only in the northernmost investigated outcrop (Kamajskij Log near the town of Kungur). About 800 km to the south (locality Zhil-Tau), the deposits immediately below the Kungurian hypersaline deposits contain *S. bogoslovskajae* Kozur, a species with an upper range

in the middle *N. pequopensis* Zone. Thus, the boundary between the continuous fully marine (Artinskian) development and the hypersaline (Kungurian) development around the town of Kungur lies at least one conodont zone (the upper Shurtan Formation has not yielded conodonts) above the level of this boundary about 800 km to the south.

Through the Texas standard, the Tethyan Artinskian-Cathedralian fusulinid scale (Jachtashian, Chihisian = Bolorian) can be indirectly correlated with the Uralian standard. The present correlation of the Tethyan scale with the Uralian standard can be partly confirmed. The Jachtashian is thought to be Artinskian, the Chihisian (Bolorian) stage is assumed to be Kungurian in age. *Mesogondolella bisselli* and *Sweetognathus inornatus* occur in the lower part of upper Jachtashian in its stratotype (REIMERS, 1991, KOZUR et al., 1994). This indicates an Early Artinskian (Aktastinian) age for this level, so far assigned to the Upper Artinskian (Baigendzhinian). An Artinskian age of the Jachtashian makes this stage name unnecessary. The richest conodont fauna occurs at the base of the Bolorian of SE Pamirs (KOZUR & MOSTLER, 1976; KOZUR, 1978; REIMERS, 1991, KOZUR et al., 1994). It contains both elements of the eastern Gondwana conodont province [*Vjalovognathus shindyensis* (KOZUR), pl. 4, fig. 1] and world-wide distributed forms. The presence of *Neostreptognathodus exsculptus* (formerly assigned to *N. sulcopicatus* by KOZUR, 1978; and REIMERS, 1991), *S. foliatus* (IGO) and *Mesogondolella gujioensis* (IGO) allows a correlation with the basal Cathedralian of West Texas. According to the above data, this fauna therefore belongs to the Kungurian.

6.4. Guadalupian and Lopingian conodont zonations (fig. 2) and the Guadalupian-Lopingian boundary

As already pointed out by KOZUR (1977 b, 1978), the phylomorphogenetic cline from *M. idahoensis* to *M. nankingensis* (CHING) (junior

synonym: *Gondolella serrata* CLARK & ETHINGTON) is a well-recognizable boundary between the Early Permian (Cisuralian) and the Middle Permian (Guadalupian) Series. This boundary is now widely accepted (GLENISTER et al., 1992). However, *M. nankingensis* did not evolve directly from typical *M. idahoensis*, but from a somewhat different form (successor of *M. idahoensis*) that is the common ancestor of *M. phosphoriensis*, *M. nankingensis* and probably also of *M. siciliensis*.

The pelagic conodont zonation of the Guadalupian Series has been well studied (e.g. BEHNKEN, 1975; CLARK & BEHNKEN, 1979; CLARK & WANG, 1988, KOZUR, 1992b, c, d, 1993a). It is based on the lineage *Mesogondolella nankingensis*-*M. aserrata*-*M. postserrata*-*M. shannoni* (pl. 4, figs. 2-10). However, this lineage is missing in open sea deep-water deposits at the margin of oceans, connected with cold bottom water currents. In these areas (e.g. Sicily, Oman) it is replaced by the unserrated *M. siciliensis* (KOZUR) (pl. 4, fig. 21), *M. phosphoriensis* (YOUNGQUIST et al.) and closely related species. The correlation of the different lineages of serrated and unserrated Guadalupian *Mesogondolella* is difficult. If warm pelagic and cold pelagic faunas or vice versa occur in superposition, restricted ranges of certain species can be observed that cannot be correlated with the ranges of these species in other areas, in which only warm-water pelagic or only cold-water pelagic conodont faunas occur. For instance, in western Sicily, a Roadian conodont fauna with *M. phosphoriensis* (YOUNGQUIST et al.) and *N. subsymmetricus* (WANG et al.) (pl. 4, fig. 26) occurs between the last occurrence of the Cathedralian *M. idahoensis* and the first occurrence of Wordian ammonoids and conodonts. In the Phosphoria Basin, a Roadian conodont fauna with *M. nankingensis* is overlain by a Wordian fauna with *M. phosphoriensis* (WARDLAW & COLLISON, 1986).

The Middle Permian shallow-water conodont faunas and especially the stratigraphic range of the species are insufficiently known.

The base of the type Dzhulfian in Transcaucasia can be well defined by the development of *C. leveni* (KOZUR, MOSTLER & PJATAKOVA) (pl. 5, fig. 3) from *C. niuzhuangensis* (LI, 1991) (pl. 5, fig. 19) near the base of the *Araxilevis* Beds. However, the base of the thus defined type Dzhulfian lies immediately above an immigration event of pelagic and other faunal elements (ammonoids, brachiopods, conodonts etc.) due to increase in water depth after a long time of intratidal to shallow subtidal deposition. In China, Late Permian (Lopingian Series) faunal elements began considerably before the base of the *C. leveni* Zone. The cline *C. niuzhuangensis* – *C. leveni* can be recognized in the middle part of the Wuchiaping Formation, but already the lower Wuchiaping Fm. has among all faunal elements a typical Late Permian (Lopingian Series) fauna.

The opinions about the first appearance of these Lopingian faunas differ, and probably the first appearance of the Lopingian elements is not contemporaneous among different faunal elements. According to KOZUR (1992b, c, d, 1993a) and MEI et al. (1994 a) the first appearance of *Clarkina altudaensis* Kozur (pl. 4, fig. 11; pl. 5, fig. 1) within the phylomorphogenetic lineage *Mesogondolella postserrata* – *Mesogondolella shannoni* – *C. altudaensis* would be a good Guadalupian/Lopingian boundary. This level is recognizable both in North America and in the Tethys (KOZUR, 1992b, c, d, 1993a; JIN et al. 1993; MEI et al., 1994 a), and it can be defined by a phylomorphogenetic cline both in North America and in China. Moreover, the characteristic Lopingian radiolarian fauna with *Follicucullus ventricosus* ORMISTON & BABCOCK and *Ishigaconus scholasticus* (ORMISTON & BABCOCK) begins in this level (KOZUR, 1992d, 1993a, c). The uppermost part of the Kufeng (Gufeng, Kuhfeng) Formation, in which the unserrated *C. altudaensis* evolved from serrated *Mesogondolella shannoni* WARDLAW (pl. 4, figs. 9, 10), corresponds, according to HE (1980), to the Lengwu Member of the Tinjiashan Formation of Zhejiang Province. In this stratigraphic level a very interesting brachiopod fauna occurs

that contains both typical elements of the Guadalupian Maokou Formation, such as *Unisteges maceus* (H) and *Orthotichia nana* (GRABAU), and also typical and common elements of the Lopingian Longtan Formation, such as *Cathaysia chonetoides* (CHAO), *Haydenella wenganensis* (HUANG), *Leptodus nobilis* (WAAGEN), *Neochonetes substrophomenoides* (HUANG), *Tschernyschewia sinensis* CHAO and *Tyloplecta yangtzeensis* (CHAO). Therefore the brachiopod faunas also show distinct changes at about the level of the assumed Guadalupian-Lopingian boundary.

The subdivision of the Early Lopingian and its correlation between West Texas and China is disputed. ZHOU et al. (1989) assumed that the Dzhulfian immediately follows the Capitanian (Late Guadalupian) with a certain overlap of both units. This view seems to be confirmed by conodont data of KOZUR (1992b, c, d, 1993a). *Clarkina altudaensis* from the Guadalupian upper Altuda Formation is present in the Early Lopingian of the Tethys (Pamirs, intraplateform basins of South China). In the uppermost 0.2 m of the Altuda Formation, so far regarded as latest Guadalupian, *Clarkina lanceolata* (Ding) occurs that is restricted to the Wuchiapingian of South China. WARDLAW (lecture in Guiyang, August 1994) recognized *Clarkina crofti* KOZUR & LUCAS (pl. 4, fig. 19) and first *C. postbitteri* MEI & WARDLAW (pl. 5, fig. 26) in this level.

MEI et al. (1994 a) assumed in the Dukou section (South China) a succession *Mesogondolella postserrata* – “*M. altudaensis*” – *M. praexuanhanensis* – *M. “xuanhanensis*”. After a short gap the *Clarkina* aff. *liangshanensis* fauna begins. They proposed, as JIN et al. (1993) did, to place the base of the Wuchiapingian at the base of the *C. aff. liangshanensis* Zone at the first appearance of the *C. leveni* lineage in South China, and to introduce a new Early Lopingian stage for the “*M. altudaensis*”-, *M. praexuanhanensis*- and *M. “xuanhanensis*” zones. However, this latter conclusion cannot be confirmed. These 3 zones, in MEI et al. (1994b, c) 5 zones (see fig. 3, p. 189) occur in about 20 m of rapidly sedimented bioclastic limestones from the slope of an

open sea environment near to the ecologically controlled distribution boundary of ribbed *Mesogondolella*. For this reason some of the species may be missing in some continuous sections (e.g. *M. praexuanhanensis* in the Fengshan and Penglaitan section). The "sequence" of the zonal index species is only a facies-controlled succession of longer ranging species. Moreover, the phylomorphogenetic lineage "*M.*" *altudaensis* - *M. praexuanhanensis* - *M. "xuanhanensis"* could not be confirmed. As clearly seen in western Texas, *M. praexuanhanensis* (pl. 4, figs. 12–15) developed from *M. shannoni* and appeared considerably before *C. altudaensis*, whereas *M. "xuanhanensis"* (= *M. nuchalina*) (pl. 4, figs. 16, 17) occurs there within the lower *C. altudaensis* Zone. In the intraplatform basin Zhoushan section at Shushoon, Anhui, 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"* appeared already at the base of the Wuxue Fm. In the type stratum of *M. nuchalina* (DAI & ZHANG) in the uppermost Maokou Fm. of the Shangsi section (Guangyuan), both the *M. nuchalina* morphotype and the *M. xuanhanensis* morphotype occur in several samples and all transitions are present between these two morphotypes. This indicates that *M. xuanhanensis* MEI & WARDLAW, 1994 is a junior synonym of *M. nuchalina* (DAI & ZHANG, 1989). Independent from this synonymy, this species evolved directly from *M. postserrata*, as documented by transitional forms. Thus, the "inverse occurrences" of *C. altudaensis* and of last advanced *Mesogondolella* in the Delaware Basin and in the Zhoushan section is easily to explain.

The specimens figured by MEI et al. (1994 a) as "*M.*" *altudaensis* are mostly *M. shannoni* WARDLAW with serrated anterior platform margins, a species characteristic for the upper (but not uppermost) Altuda and for the Lamar above the basal Lamar with the fusulinid *Yabeina*. Only the specimen figured by MEI et al. (1994 a, pl. 2, fig. 1) has no serration, but it displays a distinct cusp, no more present in *C. altudaensis*.

For this reason the *C. altudaensis* Zone of MEI et al. (1994 a) corresponds to the *M. shannoni* Zone or part of it (see fig. 3). MEI et al. (1994c) separated *M. shannoni* from "*M.*" *altudaensis*, but under the latter species they figured a broken specimen with distinct serration that belongs to *M. shannoni*. Seemingly they use an other definition of "*M.*" *altudaensis* then the original definition of *Clarkina altudaensis*. According to WARDLAW (lecture in Guiyang, August 1994), the holotype of "*M.*" *altudaensis* has been derived from a bed with totally abraded conodonts and therefore the "relic serration" is not visible in the holotype. The re-figured holotype (pl. 4, fig. 11) clearly shows that even the details of the microsculpture are present. It has been derived from a sample without any corroded or abraded conodonts. Such badly preserved conodonts occur in a layer below the type stratum of *C. altudaensis*, but this fauna has not been used in the paper of KOZUR (1992b, c).

True *C. altudaensis* may be absent in the material of MEI et al. (1994a, b, c), whereas it is surely present in the material from the Zhoushan intraplatform basin succession figured by WANG (1994, pl. 50, fig. 20) under *Neogondolella aserrata*. In the deep basin sequences of the Delaware Basin in West Texas, *C. altudaensis* is likewise absent. There the *M. shannoni* fauna is abruptly overlain by the *C. crofti* fauna without the shallow pelagic *C. altudaensis*.

The study of several sections across the Guadalupian-Lopingian boundary in the Tethys and in the Delaware Basin has shown that above undoubtedly Capitanian *M. postserrata* fauna and below undoubtedly Wuchiapingian *C. postbitteri*-*C. crofti* fauna only two conodont zones, the *M. shannoni* Zone and the *C. altudaensis* Zone can be discriminated. Because *C. postbitteri* is already present in the (upper) *C. altudaensis* Zone, the final definition of the Guadalupian-Lopingian boundary needs the consideration of all present faunal elements.

The correlations of the South Chinese conodont succession with other sequences presented by JIN et al. (1993) cannot be confirmed. JIN et al. (1993) pointed out that their "*M. altudaen-*

sis", *M. praexuanhanensis* and *M. "xuanhanensis"* zones correspond to the *Yabeina-Metadololina* fusulinid zone, but no data were given, whether this is an assumed correlation or *Yabeina* and *Metadololina* are present in the Dukou section. The *M. shannoni*-*M. "xuanhanensis"* fauna of the Fengshan section occurs together with fusulinids, seemingly younger than the *Yabeina* fauna.

The entire uppermost Altuda (*C. altudaensis* Zone sensu KOZUR, 1992 c) is surely not pre-Wuchiapingian and time-equivalent of the entire Abadehian as stated by JIN et al. (1993). *C. lanceolata* (DING) and *C. postbitteri*, typical Wuchiapingian conodonts of South China, are present in the uppermost Altuda. The base of the lower Abadehian *Sweetognathus sweeti* Zone (the conodont fauna of this level of the Abadeh section was first investigated by KOZUR et al., 1975) does not correspond to the base of the *C. altudaensis* Zone, but to the lower part of the *M. postserrata* Zone, and is therefore two major conodont zones older than assumed by Jin et al. (1993). The *C. altudaensis* Zone corresponds to the *Merrillina divergens* fauna of the Abadeh section, which is placed into the Lopingian by JIN et al. (1993) as well. According to the correlation of JIN et al. (1993) the Abadehian would be a post-Guadalupian/pre-Wuchiapingian stage as assumed in former correlations, a view shown to be incorrect by ammonoid-based and other studies (ZHOU et al., 1989, GLENISTER et al., 1992).

The Wuchiapingian and Changhsingian conodont zonation has been established by KOZUR (1975, 1978) and is slightly modified in the present paper. A *C. transcaucasica* Zone is introduced between the *C. leveni* Zone and the *C. orientalis* Zone. Its lower boundary is defined by the first appearance of *C. transcaucasica* (pl. 5, fig. 4), its upper boundary by the first appearance of *C. orientalis* (pl. 5, fig. 5).

The *C. mediconstricta* Zone is introduced between the *C. orientalis* Zone and the *C. subcarinata* Zone. Its lower and upper boundary is defined by the first appearance of *C. mediconstricta* (WANG & WANG) (pl. 5, fig. 6) and *C. subcarinata* (pl. 5, fig. 7) respectively.

A new Lopingian conodont subdivision was proposed by MEI et al. (1994 b, c). As for the latest Guadalupian, also this zonation is characterized by oversplitting of species and zones. Unproven assumptions lead to serious mistakes in correlations. Thus, MEI et al. (1994c, p. 131) wrote that "based on few horizons and few specimens, KOZUR (1975) erected three conodont zones for Dzhulfian rocks in Achura, Transcaucasia". However, the conodont zonation by KOZUR (1975, 1978) was based on numerous samples from the section Kuh-e-Ali-Bashi and Kuh-e-Hambast (both Iran), Dorsham II and Achura in former Soviet Transcaucasia (data of about 200 Dzhulfian/Dorashamian samples and conodont ranges from these sections were published in KOZUR et al., 1975, 1978), Sovetashen and further Transcaucasian sections. For the sections Dorasham II and Achura for every sample even the number of conodonts (more than 10 000) have been listed. As a whole, the Lopingian zonation by KOZUR (1975, 1978) was based on more than 300 samples with more than 20 000 conodonts, more samples and conodonts as so far investigated by MEI et al. (1994a-c) from this stratigraphic level in the Tethys. MEI et al. (1994c) correlated the zones proposed by KOZUR (1975, 1978) and other authors mostly in totally wrong manner. The Changhsingian *C. subcarinata*-*H. julfensis* Zone by KOZUR (1975, 1978, 1992) was placed into the upper Wuchiapingian. The lower boundary of this zone is defined by the first appearance of *C. subcarinata*, the upper boundary by the first appearance of *H. parvus*. By the correlation in MEI et al. (1994c) the upper boundary of the Wuchiapingian was equated with the base of the Triassic defined by the first appearance of *H. parvus*. The base for this incorrect correlation were specimens of *C. subcarinata* from the uppermost *Paratirolites* beds of Achura (uppermost occurrence of *C. subcarinata* in this outcrop), erroneously placed into *C. inflecta* by MEI et al. (1994c). This fauna is from a distinctly younger horizon than the type material of *C. subcarinata* published by SWEET (1973) that was in turn correctly placed into the Changhsingian by MEI et al. (1994c). As

clearly to be seen from the figures and discussed by KOZUR, the material figured by KOZUR (1975, 1978) belong to advanced specimens of *C. subcarinata* (partly placed into *C. carinata* by SWEET, 1973). Like the type material of *C. subcarinata*, also the specimens figured by KOZUR (1975, 1978) display a bended carina what has seemingly caused the erroneous assignment by MEI et al. (1994c). Moreover, they have not regarded the definitions of the erroneously correlated zones and the sample data.

C. asymmetrica MEI & WARDLAW, 1994, is a junior synonym of *C. niuzhuangensis*. As recognizable on the figured material by LI (1991) and also known in material from other sections (also in Transcaucasia), this species and *C. dukouensis* MEI & WARDLAW occur together and are connected by transitional forms. *C. dukouensis* is often clearly dominating in the top of the "asymmetrica Zone". Therefore only one zone (*C. niuzhuangensis* Zone) is discriminated between the *C. postbitteri* Zone and *C. leveni* Zone.

6.5. Permian-Triassic boundary at the base of the *Hindeodus parvus* Zone

The P/T boundary is placed at the base of the *H. parvus* Zone (YIN, 1985; KOTLYAR et al., 1993; PAULL & PAULL, 1994; KOZUR, 1994). At the base of this zone, all Permian *Clarkina* (*C. changxingensis*, *C. subcarinata*, *C. deflecta* etc.) disappeared and the first rare *Isarcicella* with a denticle on one side of the thickened cup appeared. *H. parvus* (pl. 6, figs. 9–13, 16, 17) has a world-wide distribution both in ammonoid-bearing pelagic deposits (rare) and in ammonoid-free shallow-water deposits (common). It evolved in a phylomorphogenetic cline from *H. latidentatus* (Kozur et al.) emend. (pl. 6, figs. 2, 5). In the Meishan sections, the best GSSP candidate for the P/T boundary, the first appearance of *H. parvus* within this lineage is in the middle part of Boundary Bed 2 (bed 27) within a monofacies bed. This biostratigraphic boundary lies in the Meishan sections 15 cm above the lithostratigraphic event boundary, the base of a tuffitic layer (lower Boundary Bed 1, bed 25) and about 5 cm above the minimum in the δC^{13} values.

tigraphic event boundary, the base of a tuffitic layer (lower Boundary Bed 1, bed 25) and about 5 cm above the minimum in the δC^{13} values.

The base of the *H. parvus* Zone lies also in other areas a little above the minimum in the δC^{13} values at the P/T boundary and it coincides with the beginning of a distinct anoxic event that can be observed in nearly all basinal facies in the world (anoxic event at the P/T boundary sensu WIGNALL & HALLAM, 1991).

Moreover, the first appearance of *H. parvus* is very important for the correlation of the Boreal faunas with the Tethyan standard. *H. parvus* appeared in the uppermost part of the Transitional Beds of South China and in a phylomorphogenetic lineage immediately above the *Otoceras boreale* Zone in Greenland (KOZUR & SWEET, in prep.). This proves the time equivalence of the Boreal *Otoceras* faunas with the Changhsingian as pointed out by KOZUR (1972 and later papers). In the Gondwana margin of the Tethys, *H. parvus* begins in a phylomorphogenetic cline in the middle part of the *O. woodwardi* Zone (Matsuda, 1981). Therefore, the *O. woodwardi* Zone ranges into the *Ophiceras commune* Zone of the Arctic. This explains not only the occurrence of *Ophiceras* in the upper part of the Gondwana Tethyan *Otoceras* faunas, but also the unusual stratigraphic occurrence of *Otoceras* in Svalbard together with *Claraia stachei* and *Ophiceras* (NAKAZAWA ET AL., 1987; WEITSCHAT & DAGYS, 1989).

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References

- BANDO, Y., BHATT, D.K., GUPTA, V.J., HAYASHI, S., KOZUR, H., NAKAZAWA, K. & WANG, Zhi-hao (1980): Some remarks on the conodont zonation and stratigraphy of the Permian. – *Rec. Res. Geol.* **5**, 1–53.
- BARSKOV, I.S. & KOROLEVA, N.V. (1970): Pervaja nachodka verchneperskich konodontov na teritorii SSSR. – *Dokl. AN SSSR*, **194**, 4, 933–934.
- BEAUCHAMP, B., HARRISON, J.C., & HENDERSON, C.M. (1989): Upper Paleozoic stratigraphy and basin analysis of the Sverdrup Basin, Canadian Arctic Archipelago: Part 1, time frame and tectonic evolution. – *Current Research, Part G, Geol. Surv. Canada, Paper 89-1G*, 105–113.
- BEHNKEN, F.H. (1975): Leonardian and Guadalupian (Permian) conodont biostratigraphy in western and southwestern United States. – *J. Paleont.* **49**, 2, 284–315.
- BEHNKEN, F.H. WARDLAW, B.R. & STOUT, L.N. (1986): Conodont biostratigraphy of the Permian Meade Peak Phosphatic Shale Member, Phosphoria Formation, southeastern Idaho. – *Contr. Geol., Univ. Wyoming*, **24**, 2, 169–190.
- BENDER, H. & STOPPEL, D. (1965): Perm-Conodonten. – *Geol. Jb.* **82**, 331–364.
- BEYERS, J.M. & ORCHARD, M.J. (1991): Upper Permian and Triassic conodont faunas from the type area of the Cache Creek Complex, south-central British Columbia, Canada. – In: ORCHARD, M.J. & MCCrackEN, A. D. (eds.): Ordovician to Triassic conodont paleontology of the Canadian Cordillera. – *Geol. Surv. Canada, Bulletin* **417**, 269–297.
- CATALANO, R., DI STEFANO, P. & KOZUR, H. (1991): Permian Circumpacific deep-water faunas from the Western Tethys (Sicily, Italy) – new evidences for the position of the Permian Tethys. – *Palaeogeogr., Palaeoclimatol., Palaeoecol.* **87**, 1–4, 75–108.
- CATALANO, R., DI STEFANO, P. & KOZUR, H. (1992): New data on the Permian and Triassic stratigraphy of western Sicily. – *N. Jb. Geol. Paläont., Abh.* **184**, 1, 25–61.
- CHERNIKH, V.V. (1986): Konodonty pograničnyh otlozhenij karbona i permi zapadnogo sklona Urala. – In: CHUVASHOV, B.I., LEVEN, E. Ja., DAVYDOV, V. I. et al. (eds.): Pograničnye otlozhenija karbona i permi Urala, Priuralja i Srednej Azii., 129–130, Moskva (“NAUKA”).
- CHERNIKH, V.V. & CHUVASHOV, B.I. (1986): Konodontnye komplekxy v pograničnyh otlozhenijach karbona i permi. – In: CHUVASHOV, B.I., LEVEN, E. Ja., DAVYDOV, V. I. et al. (eds.): Pograničnye otlozhenija karbona i permi Urala, Priuralja i Srednej Azii., 63–67, Moskva (“NAUKA”).
- CHERNIKH, V.V. & RESHETKOVA, N.P. (1987): Biostratigrafija i konodonty pograničnyh otlozhenij karbona i permi zapadnogo sklona južnogo i srednego Urala. – 45 pp., Sverdlovsk.
- CHERNIKH, V.V. & RESHETKOVA, N.P. (1988): Zonalnoe rasčlenenie pograničnyh otlozhenija karbona i permi zapadnogo sklona srednego i južnogo Urala po konodontam. – In: Biostratigrafija i litologija verchnego paleozoja Urala, 62–78, Sverdlovsk.
- CHUVASHOV, B.I., CHERNYKH, V.V. & MIZENS, G.A. (1993): Zonal divisions of the boundary deposits of the Carboniferous and Permian in sections of different facies in the South Urals. – *Permophiles*, **22**, 11–16.
- CHUVASHOV, B.I., DJUPINA, G.V., MIZENS, G.A. & CHERNYKH, V.V. (1990): Opornye razrezy verchnego karbona i nizhnej permi zapadnogo sklona Urala i Priuralja. – 369 pp., Sverdlovsk.
- CLARK, D.L. (1979): Permian-Triassic boundary: Great Basin conodont perspective. – In: CLARK, D.L. (ed.): Great Basin stratigraphy and paleontology. – Brigham Young Univ. Geol. Studies, **26**(1), 85–90.
- CLARK, D.L. & BEHNKEN, F.H. (1971): Conodonts and biostratigraphy of the Permian. – In: SWEET, W.C. & BERGSTRÖM, S.M. (eds.): Symposium on Conodont Biostratigraphy. – *Geol. Soc. America Memoir*, **127**, 415–439.
- CLARK, D.L. & BEHNKEN, F.H. (1979): Evolution and taxonomy of the North American Upper Permian *Neogondolella serrata* complex. – *J. Paleont.* **53**, 2, 263–275.

- CLARK, D.L. & CARR, T.R. (1982): Permian *Hindeodus* and *Diplognathodus*: Implications for Late Paleozoic conodont multielement taxonomy. – *Geologica et Palaeontologica*, **15**, 125–138.
- CLARK, D.L. & ETHINGTON, R.L. (1962): Survey of Permian conodonts in western North America. – *Brigham Young Univ. Geol. Studies*, **9**, 2, 102–104.
- CLARK, D.L. & WANG, Cheng-yuan (1988): Permian neogondolellids from South China: Significance for evolution of the *serrata* and *carinata* groups in North America. – *J Paleont.* **62**, 1, 132–138.
- DAI, Jinye & ZHANG, Jinghua (1989): Conodonts. In: Li, Zhishun, Zhan, Lipai et al. (eds.): Study on the Permian-Triassic biostratigraphy and event stratigraphy of northern Sichuan and southern Shaanxi. – *Geol. Mem.* **2**, 9, 428–435.
- DAVYDOV, V.I., BARSKOV, I.S., BOGOSLOVSKAYA, M.F., LEVEN, E.Y., POPOV, A.V., AKHMETSHINA, L.Z. & KOZITSKAYA, R.I. (1992): The Carboniferous/Permian boundary in the former USSR and its correlation. – *Internat. Geol. Rev.*, **34**, 9, 889–906.
- DING, Hui, QIU, Tieqiang & DUAN, Xiaoping (1990): The Carboniferous-Permian conodont biostratigraphy and the *Sweetognathus* fauna evolution in the boundary area of Jiangsu and Anhui. – *Shanxi Mining Inst. Learned Journ.*, **8**, 3, 250–258.
- DING, Hui & WAN, Shilu (1990): The Carboniferous-Permian conodont event-stratigraphy in the South of the North China Platform. – *Cour. Forschungsinst. Seckenberg*, **118**, 131–155.
- DING, Meihua (1987): Conodonta. Appendix 2: Systematic descriptions. – In: YANG, Zunyi, YIN, Hongfu et al. (eds.): Permian-Triassic boundary, stratigraphy and fauna of South China. – *Geol. Mem., Ser.* **2**, 6, 272–277, 342–347.
- DONG, Zhi-zhong, WANG, Cheng-yuan & WANG, Zhi-hao (1987): Carboniferous and Permian conodont sequence in northwestern Yunnan. – *Acta Palaeont. Sinica*, **26**, 4, 411–419.
- FURNISH, W. M. (1973): Permian stage names. – In: LOGAN, A. & HILLS, L. V. (eds.): The Permian and Triassic Systems and their mutual boundary. – *Canadian Soc. Petrol. Geologists, Mem.* **2**, 522–548.
- GLENISTER, B.F. (1993): Stratotype of Guadalupian Series. – *Permophiles*, **23**, 20–21.
- GLENISTER, B.F., BOYD, D.W., FURNISH, W.M., GRANT, R.E., HARRIS, M.T., KOZUR, H., LAMBERT, L.L., NASICHUK, W.W., Newell, N.D., Pray, L.C., Spinosa, C., Wardlaw, B.R., Wilde, G.L. & Yancey, T.E. (1992): The Guadalupian. Proposed international standard for a Middle Permian Series. – *Internat. Geol. Rev.*, **34**, 9, 857–888.
- GULLO, M. & KOZUR, H. (1992): Conodonts from the pelagic deep-water Permian of central Western Sicily (Italy). – *N. Jb. Geol. Paläont., Abh.* **184**, 2, 203–234.
- HAYASHI, Sh. (1981): Phyletic chart on conodonts. – The Association for the Geological Collaboration in Japan, *Monogr.*, **23**, 1–38.
- HE, Xilin (1980): The sequence of Permian brachiopod assemblages in South China. – 11 pp., China Institute of Mining Technology.
- HENDERSON, C.M. (1988): Conodont paleontology and biostratigraphy of the Upper Carboniferous to Early Permian Canyon Fiord, Belcher Channel, Nansen, an unnamed, and Van Hauen formations, Canadian Arctic Archipelago. – Unpublished Ph.D. thesis, University of Calgary, 287 pp.
- HENDERSON, C.M. (1993): Are Permian-Triassic boundary events diachronous? Evidence from the Canadian Arctic. – *Carboniferous to Jurassic Pangea, Program and Abstracts*, p. 136.
- HENDERSON, C.M. & ORCHARD, M.J. (1991): *Gondolelloides*, a new Lower Permian conodont genus from western and northern Canada. – In: ORCHARD, M.J. & MCCracken, A.D. (eds.): Ordovician to Triassic conodont paleontology of the Canadian Cordillera. – *Geol. Surv. Canada, Bulletin* **417**, 253–267.
- IGO, H. (1979): Biostratigraphy of Permian conodonts. In: *Biostratigraphy of Permian and Triassic conodonts and holothurian sclerites in Japan*. pp. 5–20.
- IGO, H. (1981): Permian conodont biostratigraphy of Japan. – *Palaeont. Soc. Japan, Spec. Papers*, **24**, 1–51.
- IGO, H. & HISIDA, K. (1986): Lower Permian conodonts from the Kawanori Formation of the southwestern Kanto Mountains, Tokyo. – *Transact. Proc. Palaeont. Soc. Japan, N. S.*, **144**, 516–527.
- JIANG, Wu, Zhang, Fang et al. (1986): Conodonts-Palaeontology. – 287 pp., Nangzhong (Southwestern Petroleum Institute).
- JIN, Yugan, MEI, Silong & ZHU, Zili (1993): The potential stratigraphic levels for Guadalupian/Lopingian boundary. – *Permophiles*, **23**, 17–20.
- KANG, Pei-quan, WANG, Cheng-yuan & WANG, Zhi-hao (1987): Carboniferous-Permian conodont conodont

- biostratigraphy in the shelf facies of Ziyun County, Guizhou. – *Acta Micropalaeontol. Sinica*, **4**, 2, 179–192.
- KOTLYAR, G. V., KOZUR, H. & ZAKHAROV, YU. D. (1993): The Transcaucasian sections Dorasham 2 (Azerbaijan) and Sovetashen (Armenia), two candidates for P/T boundary reference sections. – *Albertiana*, **12**, 36–38.
- KOZUR, H. (1972): Vorläufige Mitteilung zur Parallelisierung der germanischen und tethyalen Trias sowie einige Bemerkungen zur Stufen- und Unterstufengliederung der Trias. – *Mitt. Ges. Geol. Bergbaustud.*, **21**, 363–412.
- KOZUR, H. (1974): Zur Altersstellung des Zechsteinkalkes (ca 1) innerhalb der „tethyalen“ Permgliederung. – *Freiberger Forsch.-H.*, **C 298**, 45–50.
- KOZUR, H. (1975): Beiträge zur Conodontenfauna des Perm. – *Geol.-Paläont. Mitt. Innsbruck*, **5**, 4, 1–44.
- KOZUR, H. (1977a): Revision der Conodontengattung *Anchignathodus* und ihrer Typusart. – *Zeitschr. geol. Wiss.*, **5**, 9, 1113–1127.
- KOZUR, H. (1977b): Beiträge zur Stratigraphie des Perm. Teil I: Probleme der Abgrenzung und Gliederung des Perm. – *Freiberger Forsch.-H.*, **C 319**, 79–121.
- KOZUR, H. (1978): Beiträge zur Stratigraphie des Perms. Teil II: Die Conodontenchronologie des Perms. – *Freiberger Forsch.-H.*, **C 334**, 85–161.
- KOZUR, H. (1980): The main events in the Upper Permian and Triassic conodont evolution and its bearing to the Upper Permian and Triassic stratigraphy. – *Rivista Ital. Paleont.*, **85**, 3–4, 741–766.
- KOZUR, H. (1989): The Permian-Triassic boundary in marine and continental sediments. – *Zentralbl. Geol. Paläont.*, **1988**, 11/12, 1245–1277.
- KOZUR, H. (1990a): Significance of events in conodont evolution for the Permian and Triassic stratigraphy. – *Cour. Forschungsinst. Senckenberg*, **117**, 385–408.
- KOZUR, H. (1990b): The taxonomy of the gondolellid conodonts in the Permian and Triassic. – *Cour. Forschungsinst. Senckenberg*, **117**, 409–469.
- KOZUR, H. (1990c): Significance of conodonts for stratigraphic and biofacial evaluations in the Permian. – 1st Latin American Conodont Symposium, LACON-I, part 2: Abstracts of Meeting, pp. 87–89.
- KOZUR, H. (1991): Permian deep-water ostracods from Sicily (Italy). Part 2: Biofacial evaluation and remarks to the Silurian to Triassic paleopsychrospheric ostracods. – *Geol.-Paläont. Mitt. Innsbruck, Sdb.*, **3**, 25–38.
- KOZUR, H. (1992a): Age and paleoecology of the conodont *Clarkina changxingensis* (Wang & Wang). – *Geol.-Paläont. Mitt. Innsbruck*, **18**, 83–86.
- KOZUR, H. (1992b): Late Permian Tethyan conodonts from West Texas and their significance for worldwide correlation of the Guadalupian-Dzhulfian boundary. – *Geol.-Paläont. Mitt. Innsbruck*, **18**, 179–186.
- KOZUR, H. (1992c): Dzhulfian and Early Changxingian (Late Permian) Tethyan conodonts from the Glass Mountains, West Texas. – *N. Jb. Geol. Paläont., Abh.*, **187**, 1, 99–114.
- KOZUR, H. (1992d): Boundaries and Stage subdivision of the Mid-Permian (Guadalupian Series) in the light of new micropaleontological data. – *Internat. Geol. Rev.*, **34**, 9, 907–932.
- KOZUR, H. (1993a): Boundaries and subdivision of the Permian System. – *Occasional Publications ESRI, N.S.*, **9 B**, 139–154.
- KOZUR, H. (1993b): *Gulloodus* n. gen. – a new conodont genus and remarks to the pelagic Permian and Triassic of western Sicily. – *Jb. Geol. B.-A.*, **136**, 1, 87–88.
- KOZUR, H. (1993c): Upper Permian radiolarians from the Sosio Valley area, western Sicily (Italy) and from the uppermost Lamar Limestone of West Texas. – *Jb. Geol. B.-A.*, **136**, 1, 99–123.
- KOZUR, H. (1994a): Permian pelagic and shallow-water conodont zonation. – *Permophiles*, **24**, 16–20.
- KOZUR, H. (1994b): Permian/Triassic boundary and possible causes of the faunal change near the P/T boundary. – *Permophiles*, **24**, 51–54.
- KOZUR, H., DAVYDOV, V. & KOTLYAR, G. V. (1994): Preliminary report on the Permian conodont fauna of Darvas and SE Pamir and its importance for the Permian time scale. – *Permophiles*, **24**, 13–15.
- KOZUR, H., LEVEN, E. Ja. LOZOVSKIJ, V. R. & PJATAKOVA, M. V. (1978): Rasclenenie po konodontam pogrannichnykh sloev permi i triasa Zakavkazja. – *Bjul. MOIP, otd., geol.*, **1978**, 5, 15–24.
- KOZUR, H. & LUCAS, S. (in press): *Clarkina crofti* n. sp., a new conodont species from the uppermost Lamar of the Delaware Basin (West-Texas). – *Texas Journ. Sci.*
- KOZUR, H. & MOSTLER, H. (1976): Neue Conodonten aus dem Jungpaläozoikum und der Trias. – *Geol.-Paläont. Mitt. Innsbruck*, **6**, 2, 1–40.

- KOZUR, H. & MOSTLER, H. (1991): Pelagic Permian conodonts from an oceanic sequence at Sang-e-Sefid (Fariman, NE-Iran). – In: RUTNER, A.W. (ed.): The Triassic of Aghdarband (AqDarband), NE-Iran, and its Pre-Triassic frame. – *Abh. Geol. B.-A.*, **38**, 101–110.
- KOZUR, H., MOSTLER, H. & RAHIMI-YAZD, A. (1975): Beiträge zur Mikropaläontologie permotriadischer Schichtfolgen. Teil II: Neue Conodonten aus dem Oberperm und der basalen Trias von Nord- und Zentraliran. – *Geol.-Paläont. Mitt. Innsbruck*, **5**, 3, 1–23.
- KOZUR, H. & NASSICHUK, W.W. (1977): Permian conodonts in the Canadian Arctic Archipelago – biostratigraphic discussion. – *Geol. Surv. Canada, Paper*, **77-1 A**, 139–143.
- LI, Zhihong (1991): Conodont fauna from the lower part of the Upper Permian Wujiaping Formation in Wufeng County, Hubei Province. – *Bull. Yichang Inst. Geol. Min. Res., CAGS*, **17**, 95–103.
- MATSUDA, T. (1981): Early Triassic conodonts from Kashmir, India. Part I: *Hindeodus* and *Isarcicella*. – *J. Geosci., Osaka City Univ.*, **24**, 3, 75–108.
- MEI, Shilong, JIN, Yugan & WARDLAW, B. R. (1994a): Succession of conodont zones from the permian “Kuhfeng” Formation, Xuanhan, sichuan and its implication in global correlation. – *Acta Palaeont. Sinica*, **33**, 1, 1–23.
- MEI, Shilong, JIN, Yugan & WARDLAW, B. R. (1994b): Zonation of conodonts from the Maokouan-Wuchiapingian boundary strata, South China. – *Palaeoworld*, **4**, 225–233.
- MEI, Shi-long, JIN, Yu-gan & WARDLAW, B. R. (1994c): Succession of Wuchiapingian conodonts from northeastern Sichuan and its worldwide correlation. – *Acta Micropaleont. Sinica*, **11**, 2, 121–139.
- MOVSHOVICH, E. V., KOZUR, H. PAVLOV, A. M., PNEV, V. P., POLOZOVA, A. N., CHUVASHOV, B. I. & BOGOSLOVSKAJA, M. F. (1979): Kompleksy konodonty niznej permi Priuralja i problemy koreljacii niznepermских otlozhenij. – In: PAPULOV, G.N. & PUCKOV, N.N. (eds.): *Konodonty Urala i ich stratigraficheskoe znachenie*. 94–131, Sverdlovsk.
- NAKAZAWA, K., NAKAMURA, K. & KIMURA, G. (1987): Discovery of *Otoceras boreale* Spath from West Spitsbergen. – *Proc. Japan. Acad. Sci., Ser. B*, **63**, 171–174.
- NAKREM, H.N. (1991): Conodonts from the Permian succession of Bjørnøya (Svalbard). – *Norsk Geol. Tidsskrift*, **71**, 235–248.
- NASSICHUK, W.W. & HENDERSON, C.M. (1986): Lower Permian (Asselian) ammonoids and conodonts from the Belcher Channel Formation, southwestern Ellesmere Island. – *Current Research, Part B, Geol. Surv. Canada, Paper* **86-1B**, 411–416.
- NESTELL, M.K. & WARDLAW, B.R. (1987): Upper Permian conodonts from Hydra, Greece. – *J. Paleont.* **61**, 4, 758–772.
- ORCHARD, M. J. (1984): Early Permian conodonts from the Harper Ranch Beds, Kamloops area, southern British Columbia. – *Current Research, Part B, Geol. Surv. Canada, Paper* **84-1B**, 207–215.
- ORCHARD, M.J. & FORSTER, P.J.L. (1988): Permian conodont biostratigraphy of the Harper Ranch Beds, near Kamloops, south-central British Columbia. – *Geol. Surv. Canada, Paper* **88-8**, 1–27.
- ORMISTON, A. R. & BABCOCK, L. (1979): *Follicucullus*, new radiolarian genus from the Guadalupian (Permian) Lamar Limestone of the Delaware Basin. – *J. Paleont.* **53**, 2, 328–334.
- PARK, S. (1989): Study on the Lower Permian conodonts in the Machari area of Yeongweolgun, Kangweondo. – *J. Sci. Technol.*, **28**, 90–104.
- PARK, Soo-In (1993): Conodont fauna and its biostratigraphy of the Bamchi Formation (Lower Permian) in Yobong-Bamchi area, Yeongweolgun, Korea. – *J. Geol. Soc. Korea*, **29**, 4, 360–374.
- PAULL, R.K. & PAULL, R.A. (1994): *Hindeodus parvus* as index fossil for the Permian-Triassic boundary: A response to the Chinese Working Group. – *Albertiana*, **13**, 3–7.
- PERLMUTTER, B. (1975): Conodonts from the uppermost Wabaunsee Group (Pennsylvanian) and the Admire and Council Grove Groups (Permian) in Kansas. – *Geologica et Paleontologica*, **9**, 95–115.
- PERRI, M. C. 1991. Conodont biostratigraphy of the Werfen Formation (Lower Triassic), Southern Alps, Italy. *Bolletino della Società Paleontologica Italiana*, **30**, 1, 23–46.
- RABE, E.H. (1977): Zur Stratigraphie des ostandinischen Raumes von Kolumbien. II: Conodonten des jüngeren Paläozoikum der Ostkordillere, Sierra Nevada de Santa Marta und der Serranía de Perijá. – *Gies-sener geol. Schriften*, **11**, 101–223.

- RAMOVŠ, A. (1982): Unterperm-Conodonten aus den Karawanken (Slowenien, NW Jugoslawien). – N. Jb. Geol. Paläont., Abh., **164**, 3, 414–427.
- RASMUSSEN, J.A., PIASECKI, S., Stemmerik, L., Stouge, S. (1990): Late Permian conodonts from central East Greenland. – N. Jb. Geol. Paläont., Abh. **178**, 3, 309–324.
- REIMERS, A.N. (1991): Nizhnepermskie konodonty Pamira i Darvaza. – Bjul. MOIP, otd. geol. **66**, 6, 59–71.
- RITTER, S.M. (1986): Taxonomic revision and phylogeny of post-Early Permian crisis *bisselli* – *whitei* Zone conodonts with comments on Late Paleozoic diversity. – *Geologica et Palaeontologica*, **20**, 139–165.
- ROHR, D., M. Wardlaw, B. R., Rudine, S. F., Hall, A. J., Grant, R. E. & Haneef, M. (1991): Guidebook to the Guadalupian Symposium. – Proc. Guadalupian Symp., 18–111, Alpine.
- ROSS, C.A. & Ross, J.R.P. (1987): Late Paleozoic sea levels and depositional sequences. – *Cushman Found. For. Res., Spec. Publ.* **24**, 137–149.
- SPINOSA, C. & Snyder, W.S. (1993): A progress report. Ajaralash as candidate stratotype section for the Carboniferous-Permian boundary. – *Permophiles*, **23**, 9–11.
- SUÁREZ RIGLOS, M., Hünicken, M.A. & Merino, D. (1987): Conodont biostratigraphy of the Upper Carboniferous-Lower Permian rocks of Bolivia. In: Austin, R. L. (ed.): *Conodonts: Investigative techniques and applications*. 316–332.
- SWEET, W.C., in Teichert, C., Kummel, B. & Sweet, W. (1973): Permian-Triassic strata, Kuh-E-Ali Bashi, northwestern Iran. – *Bull. Mus. Comp. Zool.* **145**, 8, 359–472.
- SWEET, W.C. (1976): Conodonts from the Permian-Triassic boundary beds at Kap Stosch, East Greenland. – *Medd. Grønland*, **197**, 5, 51–54.
- SWIFT, A. (1986): The conodont *Merrillina divergens* (Bender and Stoppel) from the Upper Permian of England. – In: HARWOOD, G. M. & SMITH, D. B. (eds.): *The English Zechstein and Related Topics*. *Geol. Soc. Spec. Publ.* **22**, 55–62.
- SWIFT, A. & ALDRIDGE, R.J. (1986): Conodonts from the Upper Permian strata of Nottinghamshire and North Yorkshire. – *Palaeontology*, **25**, 4, 845–856.
- SZANIAWSKI, H. & MALKOWSKI, K. (1979): Conodonts from the Kapp Starostin Formation (Permian) of Spitsbergen. – *Acta Palaeont. Polonica*, **24**, 2, 231–264.
- TIAN, Chuan-rong (1983): Permian conodont zones. In: *Paleontological Atlas of Southwest China*, p. 407.
- TIAN, Shu-gang (1993 a): Late Permian-earliest Triassic conodont paleoecology in northwestern Hunan: *Acta Palaeont. Sinica*, **32**, 3, 332–345.
- TIAN, Shu-gang (1993 b): A new conodont genus *Dicergondolella* (gen. nov.). – *Bull. Inst. Geol. Chinese Acad. Geol. Sci.*, **23**, 203–214.
- TIAN, Shu-gang (1993 c): The Permo-Triassic boundary and conodont zones in northwestern Hunan Province. – *Bull. Chinese Acad. Geol. Sci.*, **26**, 134–150.
- TIAN, Shu-gang (1994): Evolutions of conodont genera *Neogondolella*, *Hindeodus* and *Isarcicella* in northwestern Hunan, China. – *Strat. Paleont. China*, **2**, 1993, 173–191.
- VAN DEN BOOGAARD, M. (1987): Lower Permian conodonts from western Timor (Indonesia). – *Proc. Kon. Nederland. Akad. Wetensch., Ser. B*, **90**, 1, 15–39.
- VON BITTER, P. & MERRILL, G.K. (1983): Late Paleozoic species of *Ellisonia* (Conodontophorida). Evolutionary and palaeoecological significance. – *Royal Ontario Mus. Life Sci. Contr.* **136**, 1–57.
- WAN, Shilu & DING, Hui (1987): The Carboniferous-Permian conodont sequence of north China Platform. In: *Proc. Symposium on Permo-Carboniferous coal-bearing strata and geology*, 78–83.
- WANG, Cheng-yuan (1994a): A conodont-based high-resolution eventostratigraphy and biostratigraphy for the Permian-Triassic boundaries in South China. – *Palaeoworld*, **4**, 234–248.
- WANG, Chengyuan (ed.) (1994b): *Conodonts of lower Yangtze Valley – an index to biostratigraphy and organic metamorphic maturity*. 326 pp., Nanjing.
- WANG, Cheng-yuan & DONG, Zheng-chang (1991): Permian conodonts from Suoxiyu in Cili County, Hunan. – *Acta Micropalaeont. Sinica*, **8**, 1, 41–56.
- WANG, Cheng-yuan, Ritter, S.M. & Clark, D.L. (1987): The *Sweetognathus* complex in the Permian of China: Implications for evolution and homeomorphy. – *J. Paleont.* **61**, 5, 1047–1057.
- WANG, Cheng-Yuan & Wang, Zhi-Hao (1979): Permian conodonts from the Longtan Formation and Changhsing Formation of Changxing, Zhejiang and their stratigraphical and paleoecological significance: *Se-*

- lected Papers 1st Convention of the Micropaleontological Society of China, 114–120.
- WANG, Cheng-yuan & Wang, Zhi-hao (1981a): Conodonts. – In: ZHAO, Jin-ke, SHENG, Jin-zhang et al. (eds.): Late Changhsingian and Permian-Triassic boundary in South China. – Bull. Nanjing Inst. Geol. Palaeont., Acad. Sinica, **2**, 79–81.
- WANG, Chengyuan & Wang, Zhihao (1981b): Permian conodont biostratigraphy of China. – Geol. Soc. America, Spec. Paper, **187**, 227–236.
- WANG, Zhi-hao (1991): Conodonts from the Carboniferous-Permian boundary strata in China with comments on the boundary. – Acta Palaeont. Sinica, **30**, 1, 6–41.
- WANG, Zhi-hao (1994): Early Permian conodonts from the Nashui section, Luodian of Guizhou. – Palaeoworld, **4**, 203–224.
- WANG, Zhi-hao & ZHANG, Wen-sheng (1985): Discovery of conodonts from the upper part of the Taiyuan Formation in Yuxian, Henan. – Journ. Strat. **9**, 3, 228–230.
- WARDLAW, B.R. (in press): Guadalupian conodont biostratigraphy of the Glass and Del Norte Mountains. – Smithsonian Contr. Paleobiol.
- WARDLAW, B.R. & COLLINSON, J.W. (1979): Youngest Permian conodont faunas from the Great Basin and Rocky mountain regions. – In: SANDBERG, C.A. & CLARK, D.L. (eds.): Conodont biostratigraphy of the Great Basin and Rocky Mountains. – Brigham Young Univ. Geol. Studies, **26**, 3, 151–163.
- WARDLAW, B.R. & COLLINSON, J.W. (1984): Conodont paleoecology of the Permian Phosphoria Formation and related rocks of Wyoming and adjacent areas. – In: CLARK, D.L. (ed.): Conodont biofacies and provincialism. Geol. Soc. America, Spec. Paper **196**, 263–281.
- WARDLAW, B.R. & COLLINSON, J.W. (1986): Paleontology and deposition of the Phosphoria Formation. – Contr. Geol., Univ. Wyoming, **24**, 2, 107–14.
- WARDLAW, B.R. & Grant, R.E. (1990): Conodont biostratigraphy of the Permian Road Canyon Formation, Glass Mountains, Texas. – U.S. Geol. Surv. Bull. **1895**, 1–18.
- WARDLAW, B.R., Nestell, M.K. & Dutro, J.T. (1982): Biostratigraphy and structural setting of the Permian Coyote Butte Formation of central Oregon. – Geology, **10**, 13–16.
- WEITSCHAT, W. & Dagys, A.S. (1989): Triassic biostratigraphy of Svalbard and a comparison with NE-Siberia. – Mitt. Geol.-Paläont. Inst. Univ. Hamburg, **68**, 179–213.
- WIGNALL, P.B. & Hallam, A. (1992): Anoxia as a cause of the Permian/Triassic mass extinction: facies evidence from northern Italy and the western United States. – Palaeogeogr., Palaeoclimatol., Palaeoecol., **93**, 21–46.
- XIA, Fengshen & Zhang, Binggao (1992): Age of the Selong Group, Selong of Xizang (Tibet) and the Permian-Triassic boundary. – Journ. Strat., **16**, 4, 256–263.
- YIN, Hongfu (1993): A proposal for the global stratotype section and point (GSSP) of the Permian-Triassic boundary. – Albertiana, **11**, 45–30.
- YOUNGQUIST, W. HAWLEY, R.W. & MILLER, A.K. (1951): Phosphoria conodonts from southeastern Idaho. – J. Paleont., **25**, 3, 356–364.
- ZHANG, Jinghua, DAI, Jinye & TIAN, Shugang (1984): Biostratigraphy of Late Permian and Early Triassic conodonts in Shangsi, Guangyuan County, Sichuan, China. In: Scientific Papers on Geology for International Exchange, 163–178.
- ZHOU, Zuren (1986): Two ecological patterns of the Permian ammonoids. – Sci. Sinica, Ser. B, **29**, 1, 96–112.
- ZHOU, Zuren, Glenister, B. F., & Furnish, W. M. (1989): Two-fold or three-fold? – Concerning geological time scale of Permian period. – Acta Palaeont. Sinica, **28**, 269–282.

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Figures, tables and plates

	Series	Stage	Conodont Zones and Assemblage Zones		Conodont Standard-Zonation
			Shallow-water	pelagic	
P E R M I A N	Guadalupian (pars)	Roadian	Sweetognathus subsymmetricus Neostreptognathodus clinei	Mesogondolella nankingensis (pars)	Mesogondolella nankingensis- Sweetognathus subsymmetricus
	Cathedralian		Neostreptogn. sulcopicatus	Mesogondolella idahoensis	M. idahoensis-N. sulcopicatus
			Sichuanognathus ? prayi	Mesogondolella zsuzsannae	M. zsuzsannae-S. ? prayi
			Neostreptogn. exsculptus- Neostreptognathodus pnevi	Mesogondolella idahoensis Mesogondolella asiatica	M. idahoensis-S. ? prayi
				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
	Sakmarian		S. inornatus-Sweetogn. n.sp.	M. bisselli-M. visibilis	M. bisselli-M. visibilis
			Sweetognathus merrilli	M. obliquimarginata	M. obliquimarginata-S. merrilli
	Asselian		Wardlawella expansa- Streptognathodus postfusus	Mesogondolella adentata- Streptognathodus postfusus	Streptognathodus postfusus
			Wardlawella expansa- Streptognathodus constrictus	Mesogondolella adentata- Streptognathodus constrictus	Streptognathodus constrictus
			Wardlawella expansa- Streptognathodus barskovi	Streptognathodus barskovi Streptognathodus invaginatus	Streptognathodus barskovi Streptognathodus invaginatus

Fig. 1: Cisuralian (Early Permian) conodont zonation.

T R I A S S I C	Series	Stage	Conodont Zones and Assemblage Zones		Conodont Standard Zonation		
			Shallow-water	pelagic			
A E r l y T r i a s s i c = S c y t h i a n		Brahmanian ("Induan")	Isarcicella isarcica	Clarkina carinata	Isarcicella isarcica		
			Hindeodus parvus		Hindeodus parvus		
U p p e r P e r m i a n = L o p i n g i a n		Changxingian	Hindeodus latidentatus	C. deflecta- C. changxin= C. postwangi	H. latidentatus- C. xiangxiensis C. postwangi		
			Hindeodus julfensis	Clarkina subcarinata	C. subcarinata-H. julfensis		
			W u c h u l i a p i n g i a n	D z h u l f i a n	Iranognathus tarazi	Clarkina mediconstricta	Clarkina mediconstricta
						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- Clarkian crofti	
			disputed	Hindeodus altudaensis	Clarkina altudaensis ?	Clarkina altudaensis ?	
			M i d d l e P e r m i a n = G u a d a l u p i a n		Capitanian	Mesogondolella shannoni	Mesogondolella shannoni
M. postserratata	M. postserratata						
Wordian	Gullodus catalanoi	M. aserrata			Mesogondolella aserrata		
	Roadian	S. subsymmetricus Neostreptogn. clinei			M. nankingensis siciliensis	Mesogondolella nankingensis Sweetognathus subsymmetricus	

Fig. 2: Guadalupian and Lopingian conodont zonation.

Series	Stage	Conodont Standard-Zonation (this paper)	Subdivision after Mei et al. (1994 a) Conodont Zones	Stages	Series	Mei et al. (1994 a, c) Conodont Zones			
Upper Permian = Lopin-gian (pars)	D W z u h c u h l i f a i p i n g i a n	Clarkina mediconstricta	Clarkina orientalis	Wuchia= pingian	Lopingian (pars)	C. inflecta			
		Clarkina orientalis				C. orientalis			
		Clarkina transcucasica				C. transcucasica			
		Clarkina leveni	Clarkina leveni			C. guangyuanensis			
		M. divergens- M. rosenkrantzi	C. leveni						
		Clarkina niuzhuangensis	C. liangshanensis ?			C. asymmetrica			
		Clarkina postbitteri- Clarkina crofti				C. dukouensis			
						C. postbitteri			
		disputed	Clarkina altudaensis			M. xuanhanensis	Unnamed Stage		M. granti
						M. praexuanhanensis			M. xuanhanensis
Middle Permian = Guadalupian (pars)	Capi=tanian	Mesogondolella shannoni	"M. altudaensis"			M. praexuanhanensis			
						"M. altudaensis"			
						M. shannoni			
		Mesogondolella postserrata	M. postserrata	Capitanian	Guadalupian	M. postserrata			

Fig. 3: Assumed correlation of the Chinese conodont zonation (MEI et al., 1994a-c) with the proposed conodont zonation around the Guadalupian-Lopingian boundary. *M. xuanhanensis* MEI & WARDLAW, 1994, is a junior synonym of *M. nuchalina* (DAI & ZHANG, 1984); *C. asymmetrica* MEI & WARDLAW, 1994, is a junior synonym of *C. niuzhuangensis* (LI, 1991).

Stage	Conodont Standard-Zonation	Conodont Zones of the Eastern Gondwana conodont Province		
		shallow-water	pelagic	Eastern Gondwanide Standard
Cathedralian	M. idahoensis-N. sulcopicatus	unknown	unknown	unknown
	M. zsuksannae-N. prayi			
	M. idahoensis-N. prayi	N. leonovae	M. idahoensis	N. idahoensis-N. leonovae
	M. idahoensis-N. exsculptus			
	M. intermedia-N. exsculptus	N. exsculptus- R. bucarangus	M. intermedia- V. shindyensis	N. exsculptus-V. shindyensis
Late Artinskian	M. bisselli-N. pequopensis	unknown	M. bisselli- V. shindyensis	M. bisselli-V. shindyensis
	M. bisselli-S. whitei			

Fig. 4: Correlation of the conodont zonation of the Eastern Gondwana province with the standard zonation.

species	Facies	Area	Asselian	Sakmarian	Artinskian	Cathedralian	pl./fig.
<i>Streptognathodus wabaunsensis</i>	I	TN BG	<x+				1/1,2
<i>Streptognathodus nodularis</i>	I	TBN	<x+				1/8
<i>Streptognathodus invaginatus</i>	I	TBN	xx				1/20
<i>Streptognathodus cristellaris</i>	I	BN	o+++				1/3
<i>Wardlawella expansa</i>	S	TBN	xxxxx+++				1/17,18
<i>Streptognathodus barskovi</i>	I	TN BG	++xxxx+o				1/4,6
<i>Streptognathodus elongatus</i>	I	TN BG	<xxx++o	oo			1/7
<i>Adetognathus paralautus</i>	S	TNB	<xxxxxxxx	+++++++	oo		2/1
<i>Streptognathodus simplex</i>	I	TN BG	<xxxxxxxx	+++++++	ooo		1/5
<i>Hindeodus minutus</i>	S	TN BG	<xxxxxxxx	xxxxxxxxx	+++++++		
<i>Streptognathodus tulkassensis</i>	I	B	+++				
<i>Streptognathodus constrictus</i>	I	TNB	o+xxx+				1/11
<i>Mesogondolella belladontae</i>	P	B	++				
<i>Streptognathodus longissimus</i>	I	TN BG	xxx				1/13
<i>Mesogondolella dentiseparata</i>	P	TB	xxxx+				1/9
<i>Mesogondolella adentata</i>	P	TB	xxxx+				1/12
<i>Gondolelloides canadensis</i>	I	B-A	xxx+++	??			1/19,21
<i>Streptognathodus fusus</i>	I	BN	xx				1/10
<i>Mesogondolella simulata</i>	P	B	o+++	o0000			
<i>Streptognathodus postfusus</i>	I	BN	oxo				1/16
<i>Mesogondolella corpulenta</i>	P	T	++	+++			
<i>Mesogondolella striata</i>	P	B	xx	o0000			
<i>Mesogondolella longifolia</i>	P	B	x	xxxxx			
<i>Mesogondolella foliosa</i>	P	B	+	xxxxx			1/14,15
<i>Mesogondolella obliquimarginata</i> ¹	P	B	o	xxxxx			2/8,9
<i>Diplognathodus sakmaraensis</i>	S	B		o0000			
<i>Mesogondolella uralensis</i>	P	B		++++			
<i>Mesogondolella caudata</i>	P	T		++++			
<i>Mesogondolella bisselli</i> n. subsp.	P	TB		++++			2/18, 20
<i>Streptognathodus irregularis</i>	I	TN		+++++o000			
<i>Sweetognathus merrilli</i>	S	TNB		xxxxx+++o			2/4-7
<i>Mesogondolella luodianensis</i>	P	T		+++++++			
<i>Mesogondolella bisselli</i>	P	TN BG		+xxxxxxxx	xxxxxxxxx	x+	2/10-12
<i>Wardlawella triangularis</i>	S	T		+++			
<i>Xuzhougnathus monoridgosis</i>	S	T		o000			2/2,3
<i>Sweetognathus</i> n. sp.	S	TB		+xxxxx+			2/14,15
<i>Mesogondolella visibilis</i>	P	B		++++			2/13
<i>Sweetognathus inornatus</i> ²	S	TN BG		+xxxx	xxxx+		2/16,17,21
<i>Wardlawella adenticulata</i> ³	S	TNB		++++	++o0000000	o00000000000	2/19
<i>Sweetognathus whitei</i>	S	TN BG		++	xxxxx+		3/1
" <i>Sweetognathus</i> " <i>sulcatus</i>	S	N			o		

Table 1: Stratigraphic range of the most important Cisuralian (Early Permian) conodonts.

Frequency: x = common, + = rare, o = very rare, < = present also in older beds, > = present also in younger beds.

Facies: S = mostly in shallow-water or restricted to shallow-water, P = restricted to pelagic environments, I = both in shallow- and deep-water, W = restricted to warm-water, C = restricted to cold- and cool-water, including cold bottom water of open tropical seas.

Distribution: T = Tethys, G = Gondwana and Gondwana margin of eastern Tethys, G-E = exclusively in eastern Gondwana and Gondwana margin of eastern Tethys, N = North America (except Arctic), B = Boreal realm (including Cis-Urals), B-A = exclusively in the Arctic. The outer column refers to figured species on plates 1-6. Junior synonyma: 1: *Neogondolella pseudostrata* CHERNIKH; 2: *Sweetognathus primus* CHERNIKH (only the holotype); 3: *Iranognathus ziyunensis* WANG, CHENG-YUAN et al.

species	Facies	Area	Asselian	Sakmarian	Artinskian	Cathedralian	pl./fig.
<i>Neostreptognathodus clarki</i>	S	NB			+++		
<i>Sweetognathus windi</i>	S	N			++++		3/8
<i>Sweetocristatus oertlii</i>	I	TB			++++		
<i>Hindeodus excavatus</i>	S	TNBG			++++	XXXXXXXXXXXX>	
<i>Neostreptognathodus transitus</i> ⁴	S	B			++		
<i>Neostreptognathodus peguopensis</i>	S	TNBG			XXXX +		3/4,5
<i>Sweetognathus behnkeni</i> ⁵	S	TNG			+XXX ++		3/2
<i>Sweetognathus bogoslovskajae</i>	S	B			++		3/7
<i>Neostreptognathodus ruzhencevi</i>	S	NB			XXX +		3/6,10,11
<i>Neostreptognathodus tschuvaschovi</i>	S	NB			+++ +		3/3
<i>Sichuanognathodus yangchangensis</i> ⁷	S	TG			000 ++		
<i>Iranognathus huecoensis</i>	S	N			+++ +++++		3/13
<i>Pseudohindeodus augustus</i> ⁶	I	TNG			+++ XXXXXXX+++00		
<i>Sweetognathus nodocostatus</i> ⁸	S	T			00+ ++++++++		
<i>Mesogondolella luosuensis</i>	P	TB			++ ++		
<i>Sweetocristatus arcticus</i>	I	B			++ ++		
<i>Rabeignathus asymmetricus</i>	S	N			00 00		
<i>Gulldodus hemircularis</i>	P?	G-E			+		
<i>Rabeignathus bucuramangus</i>	S	TNBG			+ XX		3/14
<i>Vjalovognathus shindyensis</i>	P	G-E			x XX		4/1
<i>Mesogondolella shindyensis</i>	P	TBG			XX		3/9
<i>Mesogondolella intermedia</i>	P	TNBG			XX		3/12
<i>Mesogondolella gujioensis</i>	P	TNG			XX		3/21
<i>Sichuanognathodus foliatus</i>	S	TNG			XX		3/17
<i>Neostreptognathodus kamajensis</i>	S	B			X+		
<i>Rabeignathus pamiricus</i>	S	NG			++		
<i>Sweetognathus flexsus</i>	S	G-E			++		
<i>Sweetognathus venustus</i>	S	G-E			++		
<i>Neostreptognathodus pseudoclinei</i>	S	B			++		
<i>Stepanovites alienus</i>	S	B			++		
<i>Neostreptognathodus pnevi</i>	S	NB			X++		3/19
<i>Neostreptognathodus exsculptus</i>	S	TNG			XX++		3/16
<i>Neostreptognathodus leonovae</i>	S	GT			+XXXX++		
<i>Pseudohindeodus nassichuki</i>	S	TG			XXXXXXXXXXXX		
<i>Pseudohindeodus ramovsi</i> ⁹	S	TNG			XXXXXXXXXXXX>		4/24
<i>Stepanovites festivus</i>	S	TNB			+++++++>		
<i>Sweetognathus quizhouensis</i> ¹⁰	S	TG			00+++++XXX>		4/23
<i>Mesogondolella asiatica</i>	P	TNG			0XXXX		3/15
<i>Mesogondolella idahoensis</i>	P	TNBG			0XXXXXXXXXX		3/18
<i>Pseudosweetognathus costatus</i>	S	T			00+++++++>		
<i>Sichuanognathodus ? prayi</i>	S	TN			XXXX		3/22
<i>Pseudosweetognathus adjunctus</i>	S	NT			00000		
<i>Mesogondolella zszsannae</i>	P	TN			XX		3/20
<i>Pseudosweetognathus denticulatus</i>	S	T			+++		
<i>Pseudosweetognathus adenticulatus</i>	S	T			+++++		
<i>Sichuanognathodus monocornus</i> ¹¹	S	TN			0+XX>		
<i>Neostreptognathodus sulcopicatus</i>	S	TN			XXX0		3/23
<i>Mesogondolella saraciniensis</i> ¹²	P	T			XXX		
<i>Hindeodus permicus</i>	S	TNG			++>		
<i>Sweetognathus semiornatus</i>	S	T			00		
<i>Mesogondolella slovenica</i>	P	T			++		
<i>Mesogondolella orchardi</i>	P	T			++		
<i>Sweetognathus expansus</i>	S	T			X>		

Table 1 (continued)

Junior synonyma: 4: *Neostreptognathodus svalbardensis* SZANIAWSKI; 5: *Neostreptognathodus toriyamai* IGO; 6: *Diplognathodus stevensi* CLARK & CARR; 7: *Sweetognathus murgabicus* REIMERS; 8: *Sweetognathus variabilis* WANG, Cheng-Yuan et al.; 9: *Diplognathodus paraaugustus* WANG, Cheng-Yuan; 10: *Sweetognathus paraguizhouensis* WANG, RITTER & CLARK; 11: *Neostreptognathodus pseudoprayi* WANG, Cheng-Yuan 12: *Mesogondolella parasiciensis* WANG, ZHI-HAO.

species	Facies	Area	Roadian	Wordian	Capitanian	Wuchiapingian	Changxingian	pl./fig.
<i>Pseudosweetognathus costatus</i>	S	T	<o					
<i>Sichuanognathodus monocornus</i>	S	TN	<+0000					
<i>Sweetognathus expansus</i>	S	T	<000000					
<i>Mesogondolella gracilis</i>	PC	N	xxxxxxx					
<i>Neostreptognathodus clinei</i>	S	N	+++++					4/25
<i>Neostreptognathodus newelli</i>	S	N	+++++					
<i>Mesogondolella nashuiensis</i>	P	T	0000000					
<i>Mesogondolella prorosenkrantzi</i>	P	T	0000000					
<i>Mesogondolella nankingensis</i> ¹³	PW	TNB	xxxxxxx	xxxx				4/2-4
<i>Sweetognathus subsymmetricus</i>	S	TN	xxxxxxx	x+++				4/26
<i>Sweetina tritica</i>	S	N	+++++	++++				
<i>Pseudohindeodus ramovsi</i>	S	TN	<xxxxxx	+++++				4/24
<i>Sweetognathus guizhouensis</i>	S	TG	<xxxxxx	+++++				4/23
<i>Stepanovites festivus</i>	S	TNB	<+++++	+++++				
<i>Pseudohindeodus oertlii</i>	S	TNG	+++++	0000000				
<i>Mesogondolella phosphoriensis</i>	PC	TNG	+++++	xxxxxxx				
<i>Gullodus catalanoi</i>	S	T	0000000	+++++				4/22
<i>Gullodus sicilianus</i>	S	T	???????	+++++				4/18
<i>Sweetognathus iranicus</i> ¹⁴	S	TNG	00++++	++++xxx	xx+o			
<i>Mesogondolella siciliensis</i>	PC	TG	0000000	xxxxxxx	000???			4/21
<i>Hindeodus excavatus</i>	S	TNBG	<xxxxxx	xxxxxxx	xxxxx++++			
<i>Hindeodus permicus</i>	S	TNG	<+++++	+++++	++++000000			
<i>Wardlawella ? lanceolata</i>	S	T	++++	+++++				
<i>Stepanovites meyeri</i>	S	B	+++	+++				
<i>Iranognathus nodosus</i>	S	T	+++	+++++				
<i>Sweetocristatus arcucristatus</i>	S	N	oo	+++++				
<i>Mesogondolella prolongata</i>	PC	N		xxx+				
<i>Sweetognathus hanzhongensis</i>	S	T		++++xxx				
<i>Sweetocristatus galeatus</i> ¹⁵	S	TN		xxxxxxx	xxxxxxxxxxx	+++++	+++00000	
<i>Mesogondolella aserrata</i>	PW	TN		xxxx				4/5,6
<i>Merrillina praedivergens</i>	S	TNG		+++	+++++			
<i>Sweetognathus sweeti</i>	S	T		+++				
<i>Mesogondolella postserrata</i> ¹⁶	PW	TNG			xxxxxxxo			4/7,8
<i>Mesogondolella behnkeni</i>	PW	TN			+++++			
<i>Clarkina bitteri</i>	PC	TN			+++++			
<i>Wardlawella paralanceolata</i>	S	T			+++++			
<i>Clarkina denticulata</i>	PW	TN			+++++			
<i>Wardlawella movschovitschi</i> ¹⁷	S	TN			000000000	+++++	+++++	5/20
<i>Hindeodus typicalis</i> ¹⁸	S	TNBG			o+++	xxxxxxxxxxxxx	xxxxxxxxxxx+++	5/18
<i>Mesogondolella shannoni</i>	PW	TN			xxo			4/9,10
<i>Mesogondolella nuchalina</i> ¹⁹	PW	TN			ox+			4/16,17
<i>Hindeodus altudaensis</i>	PW	N			+++	+oo		4/20
<i>Merrillina divergens</i>	S	TNBG			+++	xxx++o		5/24
<i>Mesogondolella praexuanhanensis</i>	PW	TN			x			4/12-15
<i>Mesogondolella granti</i>	PW	TN			+			

Table 2: Stratigraphic range of the most important Guadalupian and Lopingian conodonts.

Explanations see table 1.

Junior synonyma: 13: *Gondolella serrata* CLARK & ETHINGTON; 14: *Sweetognathus parvus* WANG, Cheng-Yun et al.; 15: *Xaniognathus sweeti* IGO; 16: *Neogondolella babcocki* CLARK & BEHNKEN; 17: *Iranognathus nudus* WANG, RITTER & CLARK; 18: *Anchignathodus zhenanensis* DAI & ZHANG; 18: *Mesogondolella xuanhanensis* MEI & WARDLAW.

species	Facies	Area	Roadian	Wordian	Capitanian	Wuchiapingian	Changxingian	pl./fig.
<i>Clarkina altudaensis</i>	PW	TNG				+ X		4/11;5/1
<i>Clarkina wilcoxi</i>	P	TN				o ++		
<i>Clarkina crofti</i>	PW	N				XO		4/19
<i>Clarkina rosenkrantzi</i>	PC	BT?				+XXXX		5/22,23
<i>Stepanovites inflatus</i>	S	TB				+++XX++		
<i>Clarkina postbitteri</i>	PW	TN				OXO		5/26
<i>Clarkina lanceolata</i>	PW	TN				000		
<i>Clarkina dukouensis</i>	PW	T				XXO		5/25
<i>Clarkina niuzhuangensis</i> ¹⁹	PW	T				OXO		5/19
<i>Clarkina daxianensis</i>	PW	T				+++o		5/27
<i>Clarkina leveni</i> ²⁰	PW	T				+XX		5/3
<i>Stepanovites dobruskinae</i>	S	T				+++++++	+++++++	
<i>Clarkina transcaucasica</i> ²¹	PW	TN				+XXX		5/4
<i>Clarkina liangshanensis</i>	PW	T				o+++o		5/2
<i>Clarkina jesmondi</i>	P	N				XX		
<i>Iranognathus unicastatus</i>	S	T				++++	++	
<i>Clarkina orientalis</i> ²²	PW	T				OXXX	X+++++	5/5
<i>Hindeodus julfensis</i> s. str.	PW	TBG				0000	XXXXXXXXXX	6/1
<i>Iranognathus tarazi</i>	S	T				+++	XX+++	5/21
<i>Clarkina mononica</i>	PW	T				000		
<i>Clarkina inflecta</i>	PW	T				XX		
<i>Clarkina demicornis</i>	PW	T				++		
<i>Clarkina mediconstricta</i> ²³	PW	T				XX	+o	5/6
<i>Clarkina puqiensis</i> ²⁴	PW	T				XX	++	
<i>Clarkina subcarinata</i>	P	TNB					+XXXXX+o	5/7
<i>Clarkina wangi</i> ²⁵	PW	T					XXXXXX+o	5/17
<i>Clarkina changxingensis</i> ²⁶	P	TNBS					0000+XXX	5/8
<i>Clarkina deflecta</i>	PW	T					+XXXXXX	5/9
<i>Clarkina postwangi</i>	PW	T					+++X	5/10,11
<i>Clarkina dicerocarinata</i> ²⁷	PW	T					+XXXXX	
<i>Clarkina sosioensis</i>	PC	T					XXXX	5/14-16
<i>Clarkina xiangxiensis</i>	PW	T					+XXX	5/12,13
<i>Hindeodus latidentatus</i>	S	TNBS					o+x>	6/2,5
<i>Clarkina unilaticarinata</i>	P	T					oo	
<i>Clarkina zhongliangshanensis</i> ²⁸	P	TBG					x>	
<i>Clarkina tulongensis</i>	PC	TG					+>	
<i>Clarkina procerocarinata</i>	P	TB					+>	6/6-8
<i>Isarcicella ? prisca</i>	S	T					x	6/3,4

Table 2 (continued).

Junior synonyma: 19: *Clarkina asymmetrica* MEI & WARDLAW; 20: *Neogondolella guangyuanensis* DAI & ZHANG (advanced *C. leveni*); 21: *Clarkina bizarrens* MEI & WARDLAW; 22: *Neogondolella paralella* TIAN (pars); 23: *Neogondolella latimarginata* CLARK & WANG, Cheng-Yuan; *Clarkina yanjinxinensis* DING, Meihua (pathologic *C. wangi*); 26: ? *Gondolella liuchangensis* DING, Meihua; *Gondolella beifengjingsis* DING, Meihua; *Gondolella serrata liuchangensis* DING, Meihua (homonym of *Gondolella liuchangensis*, DING, Meihua).

All plates have been prepared from low quality copies, because the originals have been lost during the control of the private mail by the Hungarian post office.

All figures on plates 1–6 are upper views unless otherwise noted.

Plate 1

- Figs. 1, 2: *Streptognathodus wabaunsensis* GUNNELL, fig. 1: x 40, basal Asselian, Bennett Shale, Council Grove Group, Kansas; from PERLMUTTER (1975); fig. 2: x 90, Asselian, Dafenko (North China); from DING & WAN (1990).
- Fig. 3: *Streptognathodus cristellaris* CHERNIKH & RESHETKOVA, x 55, Lower Asselian, Juresan (Cis-Urals); from CHERNIKH & RESHETKOVA (1987).
- Figs. 4, 6: *Streptognathodus barskovi* (KOZUR), Lower Asselian; fig. 4: x 77, Neva Limestone, Grenola Fm., Council Grove Group, Kansas; from KOZUR (1978); fig. 6: x 140, Xishan (North China); from DING & WAN (1990, assigned to *S. fuchengensis* Zhao).
- Fig. 5: *Streptognathodus simplex* GUNNELL, x 42, uppermost Gzhelian, Youlchi section, Korea; from PARK (1989).
- Fig. 7: *Streptognathodus elongatus* GUNNELL, x 42, as for fig. 5.
- Fig. 8: *Streptognathodus nodularis* CHERNIKH & RESHETKOVA, x 46, Lower Asselian, Usolka (Cis-Urals), from CHERNIKH & RESHETKOVA (1987).
- Fig. 9: *Mesogondolella dentiseparata* (RESHETKOVA & CHERNIKH), holotype, x 45, Middle Asselian, right bank of river Kojva (Cis-Urals); from CHUVASHOV et al. (1986).
- Fig. 10: *Streptognathodus fusus* CHERNIKH & RESHETKOVA, holotype, x 55, Middle Asselian, Juresan (Cis-Ural); from CHERNIKH & RESHETKOVA (1988).
- Fig. 11: *Streptognathodus constrictus* CHERNIKH & RESHETKOVA, x 50, as for fig. 10; from CHERNIKH & RESHETKOVA (1986).
- Fig. 12: *Mesogondolella adentata* (CHERNIKH & RESHETKOVA), x 55, Middle Asselian, Usolka (Cis-Urals); from CHERNIKH & RESHETKOVA (1987).
- Fig. 13: *Streptognathodus longissimus* CHERNIKH & RESHETKOVA, x 55, Upper Asselian, Usolka (Cis-Urals); from CHERNIKH & RESHETKOVA (1988).
- Figs. 14, 15: *Mesogondolella foliosa* (CHERNIKH & RESHETKOVA), x 50, sample 21/3, upper Asselian, Kondurovka (Cis-Urals), fig. 15: lateral view.
- Fig. 16: *Streptognathodus postfusus* CHERNIKH & RESHETKOVA, x 55, Upper Asselian, Usolka (Cis-Urals), from CHERNIKH & RESHETKOVA (1987).
- Figs. 17, 18: *Wardlawella expansa* (PERLMUTTER), Asselian, Funston Limestone, Council Grove Group, Kansas; fig. 17: x 150, fig. 18: detail of carina, x 360; from VON BITTER & MERRILL (1990).
- Figs. 19, 21: *Gondolelloides canadensis* HENDERSON & ORCHARD, holotype, x 46, Middle Asselian, 262 m above base of Hare Fiord Fm., Van Hauen Pass area, Ellesmere Island, Canada; fig. 21: oblique lateral-lower view; from HENDERSON & ORCHARD (1991).
- Fig. 20: *Streptognathodus invaginatus* CHERNIKH & RESHETKOVA, x 45, bed 15-4 (basal Asselian), Usolka; from CHERNIKH & RESHETKOVA (1987).

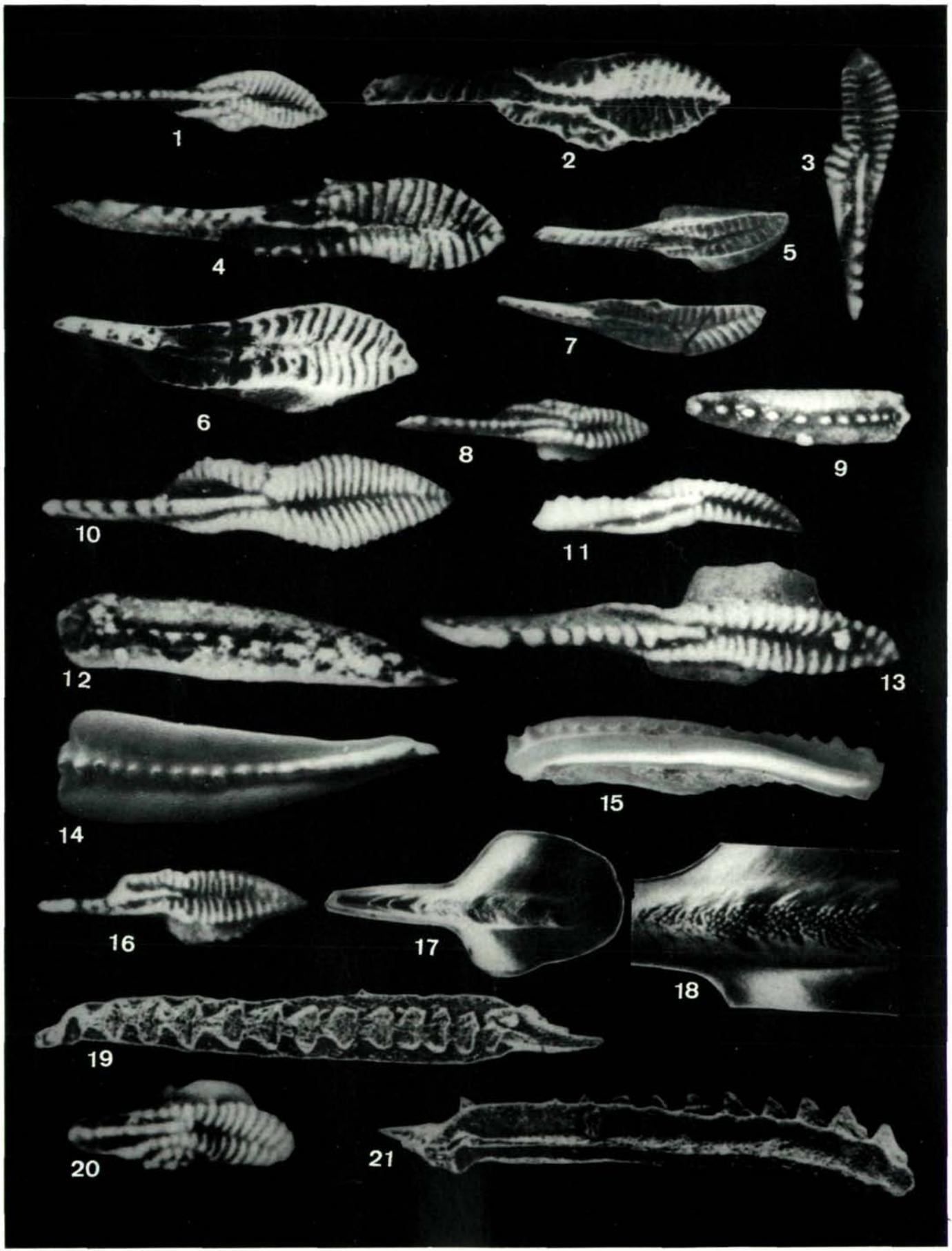


Plate 2

- Fig. 1: *Adetognathus paralautus* ORCHARD, holotype, x 70, fauna 1 (Upper Sakmarian or Lower Artinskian) of Harper Ranch Group, Kamloops (British Columbia, Canada); from ORCHARD & FORSTER (1988).
- Figs. 2, 3: *Xuzhognathus monoridgosis* DING & WAN, holotype, Sakmarian, Huaibei (North China; fig. 2: x 220, fig. 3: detail with microsculpture of carina and side branch, x 440; from DING & WAN (1990).
- Figs. 4–7: *Sweetognathus merrilli* KOZUR, no gap between carina and denticles of free blade (compare *S. inornatus*, figs. 16, 17, 21); figs. 4, 6: Sakmarian, Huainan (North China), fig. 4: x 130, fig. 6: x 175; from DING & WAN (1990, assigned to *S. inornatus*, material studied in China at Prof. DING, Taiyuan); figs. 5, 7 (lateral view): x 73, Lower Sakmarian (Tastubian), Eiss Limestone Mbr., Bader Limestone Fm., upper Council Grove Group, Kansas; from KOZUR (1978).
- Figs. 8, 9: *Mesogondolella obliquimarginata* (CHERNIKH), x 50, sample 21/8, Lower Sakmarian (Tastubian), Kondurovka (Cis-Urals), fig. 8: lateral view.
- Figs. 10–12: *Mesogondolella bisselli* (CLARK & BEHNKEN), primitive form, x 50, sample 21/24, Lower Sakmarian (Tastubian), Kondurovka (Cis-Urals), fig. 11: lower view, fig. 12: lateral view.
- Fig. 13: *Mesogondolella visibilis* (CHERNIKH), x 45, Upper Sakmarian (Sterlitamakian), Sim (Cis-Urals); from CHUVASHOV et al. (1990).
- Figs. 14, 15: *Sweetognathus* n. sp.; fig. 14: x 82, Sakmarian, Huainan (North China); from DING & WAN (1990, assigned to *S. whitei*); fig. 15: x 45, Upper Sakmarian (Sterlitamakian), Sim (Cis-Urals); from CHUVASHOV et al. (1990, assigned to *S. primus*, compare figs. 16, 17).
- Figs. 16, 17, 21: *Sweetognathus inornatus* RITTER, distinct gap between carina and denticles of free blade (compare figs. 4–7: *S. merrilli*); figs. 16, 17 (lateral view): holotype of *S. primus* Chernikh, x 45, Upper Sakmarian (Sterlitamakian), Sim (Cis-Urals); from Chuvashov et al. (1990); fig. 21: holotype, x 80, Lower Artinskian (Aktastinian), Burbank Hills, Utah; from RITTER (1986).
- Figs. 18, 20: *Mesogondolella bisselli* n. subsp., x 50, sample 21/12, Lower Sakmarian (Tastubian), Kondurovka (Cis-Urals), fig. 18: lateral view.
- Fig. 19: *Wardlawella adenticulata* (RITTER), holotype, x 90, basal Threemile Limestone, Chase Group, Kansas, from RITTER (1986).

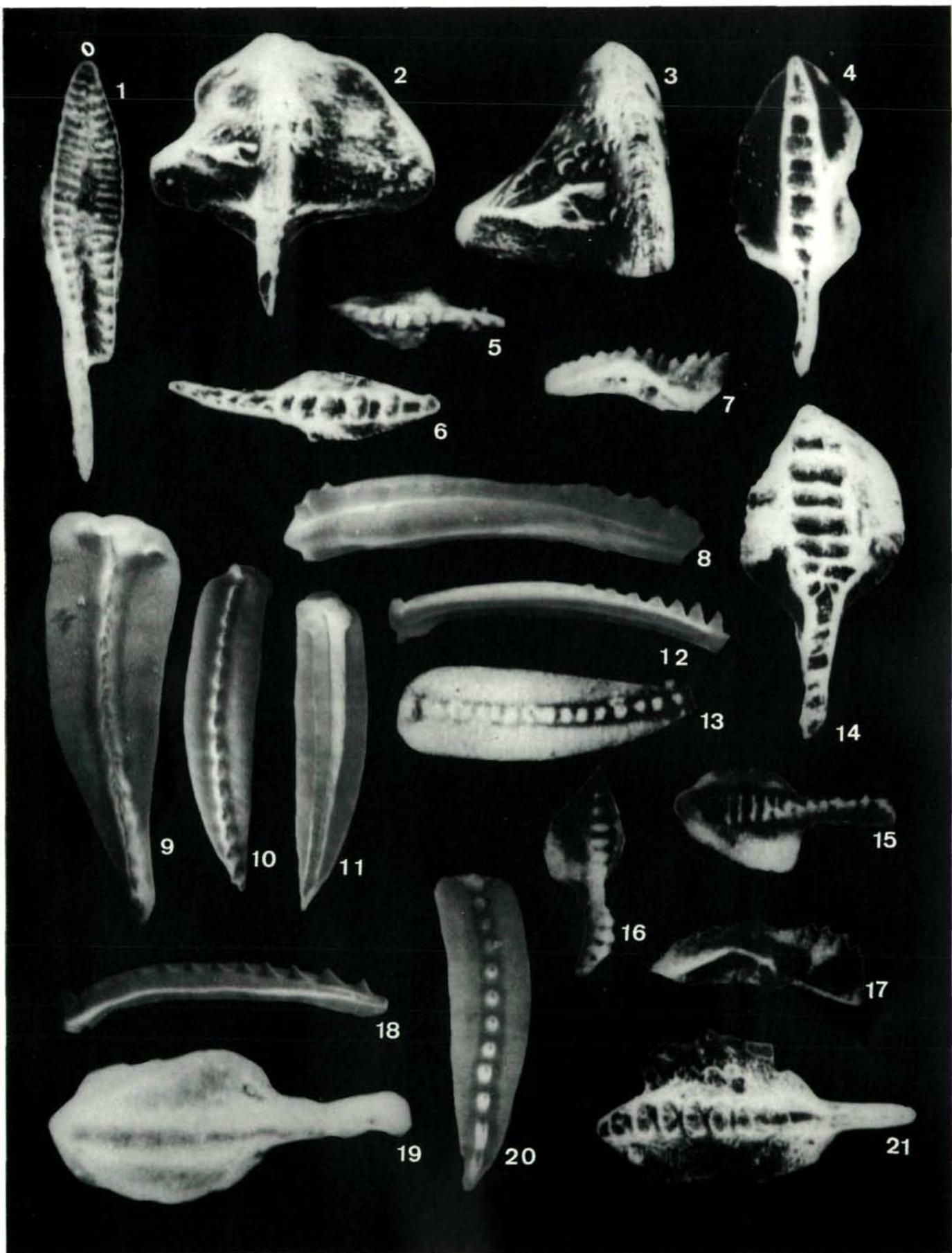


Plate 3

- Fig. 1: *Sweetognathus whitei* (RHODES), x 80, fauna 2 (Artinskian) of Harper Ranch Beds, Kamloops (British Columbia, Canada); from ORCHARD & FORSTER (1988).
- Fig. 2: *Sweetognathus behnkeni* KOZUR, x 82, Upper Artinskian (Baigendzhinian), Copacabana Fm., Yaurichambi, Bolivia; from SUÁREZ RIGLOS et al. (1987).
- Fig. 3: *Neostreptognathodus tschuvashovi* KOZUR, x 65, Upper Artinskian (Baigendzhinian), Hambergfjellet Fm., Svalbard; from NAKREM (1991, assigned to *N. clarki*).
- Figs. 4, 5: *Neostreptognathodus pequopensis* BEHNKEN, fig. 4: x 58, holotype, Upper Artinskian (Baigendzhinian), lower Arcturus Limestone, Nevada; from BEHNKEN (1975); fig. 5: x 100, as fig. 3, from NAKREM, 1991).
- Figs. 6, 10, 11: *Neostreptognathodus ruzhencevi* KOZUR; fig. 6: primitive form, holotype of *N. obliquidentatus* CHERNIKH, x 80, Artinskian, right bank of Dalnij Tjulkas (Cis-Urals); from CHUVASHOV et al. (1990); fig. 10: holotype, x 60, Upper Artinskian (Baigendzhinian), Aktasti (Cis-Urals); from KOZUR & MOSTLER (1976); fig. 11: advanced specimen, x 80, as fig. 1; from ORCHARD & FORSTER (1988, assigned to *N. sulcopicatus*).
- Fig. 7: *Sweetognathus bogoslovskajae* KOZUR, lateral view, x 60, Upper Artinskian (Baigendzhinian), Zhil-Tau (Cis-Urals); from KOZUR & MOSTLER (1976).
- Fig. 8: *Sweetognathus windi* RITTER, holotype, lateral view, x 80, Upper Artinskian (Baigendzhinian), Fort Riley Limestone, Chase Group, Kansas; from RITTER (1986).
- Fig. 9: *Mesogondolella shindyensis* KOZUR, x 73, basal Cathedralian (basal Bolorian or uppermost Jachtashian), Shindy (Pamirs); from KOZUR (1978).
- Fig. 12: *Mesogondolella intermedia* (IGO), holotype, x 72, Cathedralian, Ichinose, Japan; from IGO (1981).
- Fig. 13: *Iranognathus huecoensis* (RITTER), holotype, x 70, Upper Artinskian or basal Cathedralian, Franklin Mts, Texas; from RITTER (1986).
- Fig. 14: *Rabeignathus bucuramangus* (RABE), x 80, Upper Artinskian (Baigendzhinian), Burbank Hills, Utah, from RITTER (1986).
- Fig. 15: *Mesogondolella asiatica* (IGO), holotype, x 73, lower Cathedralian, Akuda Fm., Gifu Prefecture, Japan; from IGO (1981).
- Fig. 16: *Neostreptognathodus exsculptus* IGO, holotype, x 68, lower Cathedralian, Yoro, Japan; from IGO (1981).
- Fig. 17: *Sichuanognathus foliatus* IGO, holotype, x 43, lower Cathedralian, Gujio Hachiman, Japan; from IGO (1981).
- Fig. 18: *Mesogondolella idahoensis* (YOUNGQUIST, HAWLEY & MILLER), x 60, uppermost Cathedralian, basal Road Canyon Fm., Glass Mts, Texas; from WARDLAW & GRANT (1990).
- Fig. 19: *Neostreptognathodus pnevi* KOZUR & MOVSHOVICH, x 76, Cathedralian, Phosphoria Fm., Idaho; from BEHNKEN et al. (1986).
- Fig. 20: *Mesogondolella zszsanna* KOZUR, x 80, Cathedralian, Torrente San Calogero (Sicily).
- Fig. 21: *Mesogondolella gujioensis* (IGO), x 75, Cathedralian, Gujio Hachiman, Japan; from IGO (1981).
- Fig. 22: *Sichuanognathus ? prayi* BEHNKEN, holotype, x 57, Cathedralian, Bone Spring Fm., Guadalupe Mts, Texas; from BEHNKEN (1975).
- Fig. 23: *Neostreptognathodus sulcopicatus* (YOUNGQUIST, HAWLEY & MILLER), x 57, upper Cathedralian, Kaibab Fm., Nevada, from BEHNKEN (1975).

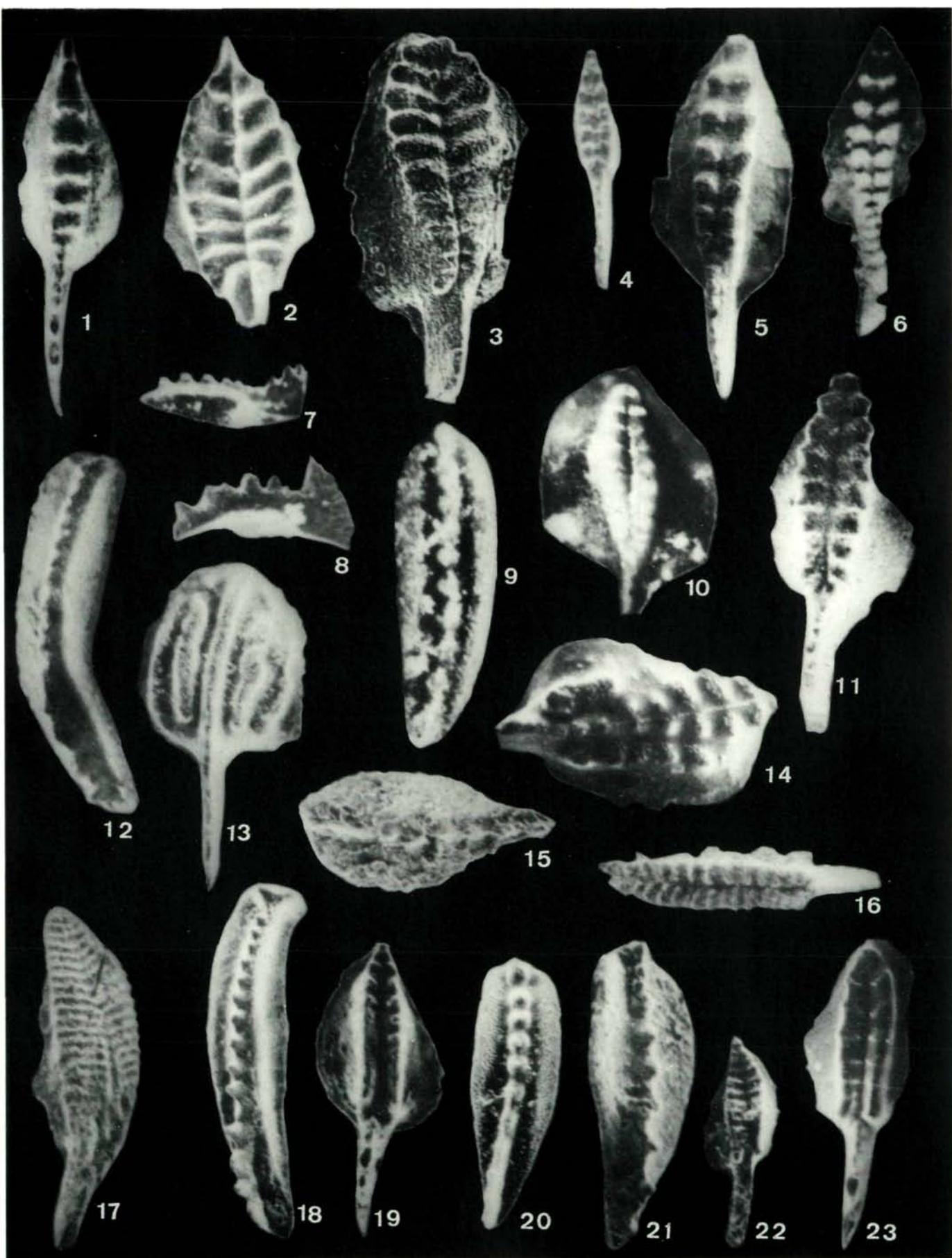


Plate 4

- Fig. 1: *Vjalovognathus shindyensis* (KOZUR), lateral view, x 100, Upper Artinskian (Baigendzhinian), Timor; from VAN DEN BOOGAARD (1987).
- Figs. 2–4: *Mesogondolella nankingensis* (Ching), type locality of Roadian, Glass Mts, Texas; figs. 2 (lateral view), 3: x 42, Roadian, Road Canyon Fm.; fig. 4: juvenile specimen, x 53, lower Wordian, 7.5. m above the base of Word Fm.
- Figs. 5, 6: *Mesogondolella aserrata* (CLARK & BEHNKEN), Wordian, Cherry Canyon Fm.; fig. 5: x 69; fig. 6: holotype, x 58; from CLARK & BEHNKEN (1969).
- Figs. 7, 8: *Mesogondolella postserrata* (BEHNKEN), x 42, Capitanian, upper Rader Mbr., Bell Canyon Fm., Delaware Basin, Texas, fig. 8: lateral view.
- Figs. 9, 10: *Mesogondolella shannoni* WARDLAW (in press), uppermost Capitanian, upper Altuda Fm., 10 m below Tessey Fm., locality 2.3 after ROHR et al. (1991), Glass Mts, Texas; fig. 9: x 36; fig. 10: x 42.
- Fig. 11: *Clarkina altudaensis* KOZUR, holotype, x 70, basal Lopingian Series, uppermost Altuda Fm., 5 m below Tessey Fm., locality 2.3 after ROHR et al. (1991), Glass Mts, Texas; from KOZUR (1992c).
- Figs. 12–15: *Mesogondolella praexuanhanensis* MEI & WARDLAW, Early Lopingian Series; fig. 12: x 70, uppermost Altuda Fm., 3 m below Tessey Fm., locality 2.3 after ROHR et al. (1991), Glass Mts, Texas; figs. 13–15: x 60, Dukou (South China); fig. 14: lateral view; fig. 15: holotype; figs. 13–15 from MEI et al. (1994).
- Figs. 16, 17: *Mesogondolella nuchalina* (DAI & ZHANG), Early Lopingian Series; fig. 16: advanced specimen, x 50, uppermost Altuda Fm., 2.50 m below Tessey Fm., locality 2.3 after ROHR et al. (1991), Glass Mts, Texas; fig. 17: x 60, Dukou (South China); fig. 17 from MEI et al. (1994), assigned to *M. xuanhanensis* MEI & WARDLAW, a junior synonym of *M. nuchalina*.
- Fig. 18: *Gullodus sicilianus* (BENDER & STOPPEL), x 75, lateral view, Roadian limestone block, Pietra di Salomone, Sicily; from KOZUR (1993).
- Fig. 19: *Clarkina crofti* KOZUR & LUCAS (in press), x 100, basal Lopingian, 0.40 m below top of Lamar, 1 km east of locality H sensu ORMISTON & BABCOCK (1979), Delaware Basin, Texas.
- Fig. 20: *Hindeodus altudaensis* KOZUR & MOSTLER (in press), holotype, x 51, lateral view of Pa element, uppermost Capitanian, upper Altuda Fm. 10 m below Tessey Fm., section 2.3 after ROHR et al. (1991), Glass Mts, Texas.
- Fig. 21: *Mesogondolella siciliensis* (KOZUR), x 100, Wordian limestone block, Rupe del Passo di Burgio, Sosio Valley, Sicily; from KOZUR (1990b).
- Fig. 22: *Gullodus catalanoi* (GULLO & KOZUR), holotype, lateral view, x 108, as fig. 21; from GULLO & KOZUR (1992).
- Fig. 23: *Sweetognathus guizhouensis* BANDO et al., x 55, Cathedralian, Cozzo Intronata, Sicily; from GULLO & KOZUR (1992).
- Fig. 24: *Pseudohindeodus ramovsi* GULLO & KOZUR, x 140, Roadian limestone block, Pietra di Salomone, Sicily; from KOZUR (1993).
- Fig. 25: *Neostreptognathodus clinei* BEHNKEN, holotype, x 116, Roadian, uppermost Pequop Fm., Nevada; from BEHNKEN (1975).
- Fig. 26: *Sweetognathus subsymmetricus* WANG, RITTER & CLARK, x 190, Roadian, matrix of Olistostrome Unit, Torrente San Calogero, Sicily.

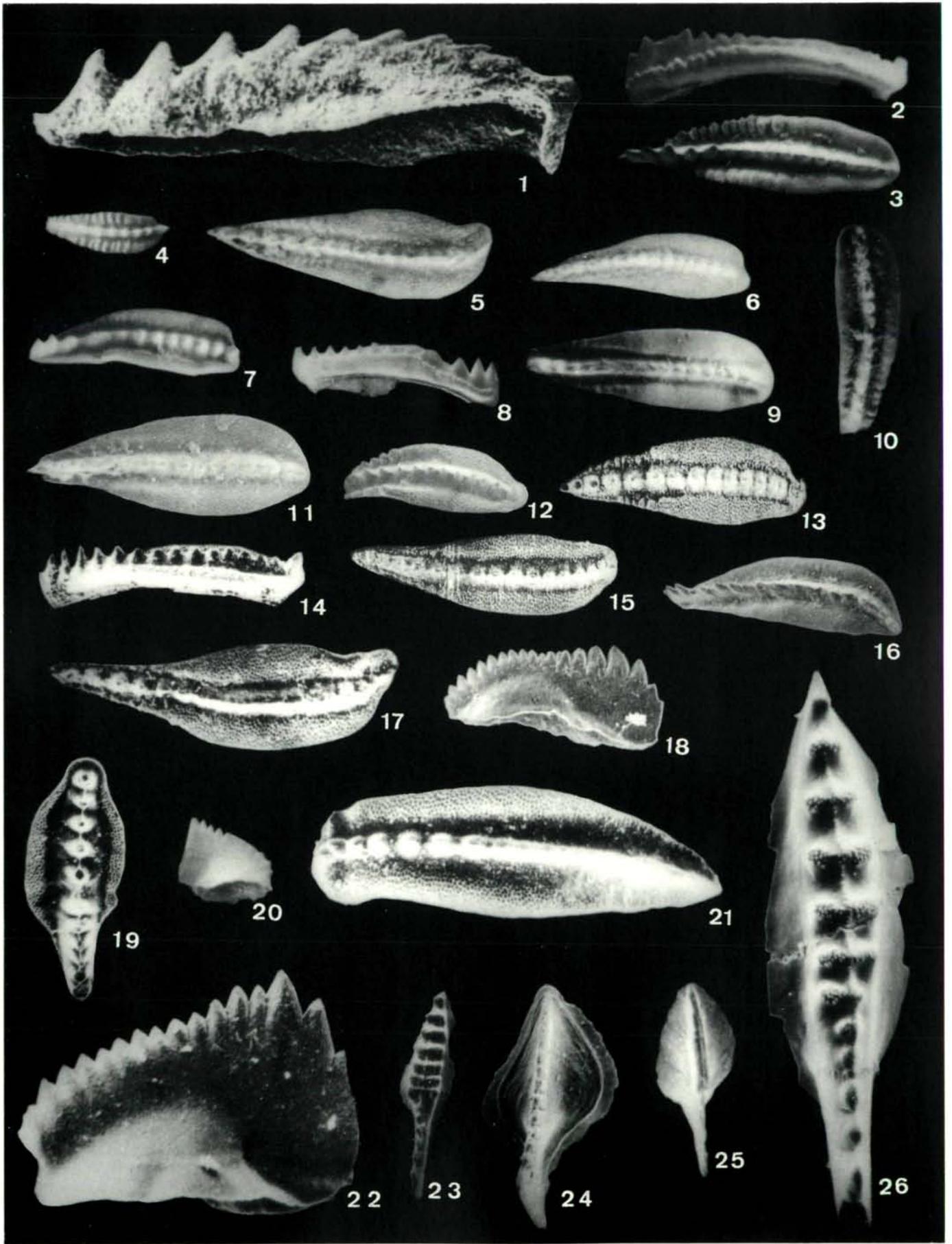


Plate 5

- Fig. 1: *Clarkina altudaensis* KOZUR, transitional to *C. changxingensis* (WANG & WANG), x 100, basal Lopingian Series, Altuda Fm., 9 m below Tessey, locality 2.3 after ROHR et al. (1991), Glass Mts, Texas.
- Fig. 2: *Clarkina liangshanensis* (WANG), x 67, Wuchiapingian, lower Wuchiaping Formation, Liangshan (southern Shaanxi, South China); from WANG (1978).
- Fig. 3: *Clarkina leveni* (KOZUR, MOSTLER & PJATAKOVA), x 100, middle Wuchiapingian (lower Dzhulfian), Kuh-e-Ali Bashi, NW Iran; from KOZUR et al. (1975).
- Fig. 4: *Clarkina transcaucasica* GULLO & KOZUR, holotype, x 60, middle Wuchiapingian (middle Dzhulfian), Achura (Azerbaijan), from KOZUR (1975).
- Fig. 5: *Clarkina orientalis* (BARSKOV & KOROLEVA), x 69, upper Wuchiapingian (upper Dzhulfian), Hydra (Greece), from NESTELL & WARDLAW (1987).
- Fig. 6: *Clarkina mediconstricta* (WANG & WANG), holotype of *Neogondolella latimarginata* CLARK & WANG, x 45, Wuchiapingian, 11 m below top of Shangxi Fm., Nanjing (China); from CLARK & WANG (1988).
- Fig. 7: *Clarkina subcarinata* (SWEET), medium ontogenetic stage, x 110, Changhsingian, Torrente San Calogero, Sicily; from GULLO & KOZUR (1992).
- Fig. 8: *Clarkina changxingensis* (WANG & WANG), x 50, age and locality as fig. 7; from GULLO & KOZUR (1992).
- Fig. 9: *Clarkina deflecta* (WANG & WANG), x 60, calcarenite within upper Changhsingian red claystones, P/T boundary section 500 m south of Pietra dei Saracini, Sosio Valley area, Sicily.
- Figs. 10, 11: *Clarkina postwangi* (TIAN), x 50, uppermost Changhsingian, Hunan (South China), fig. 10: lower view; from TIAN (1993c).
- Figs. 12, 13: *Clarkina xiangxiensis* (TIAN), x 50, as figs. 10, 11; fig. 12: lower view; from TIAN (1993c).
- Figs. 14–16: *Clarkina sosioensis* GULLO & KOZUR, uppermost Changhsingian, Red Claystone Unit, Torrente San Calogero, Sicily; fig. 14: holotype, x 110, fig. 15 (lateral view), 16: x 115; from GULLO & KOZUR (1992).
- Fig. 17: *Clarkina wangi* (DAI, TIAN & ZHANG), x 50, Changhsingian, Hunan (South China), from TIAN (1993c).
- Fig. 18: *Hindeodus typicalis* (SWEET), x 100, Wuchiapingian (Dzhulfian), Kuh-e-Ali Bashi, NW Iran.
- Fig. 19: *Clarkina niuzhuangensis* (LI), x 60, lower Wuchiapingian, bed 13, Nanjiang 1, Sichuan (South China); from MEI et al. (1994c), assigned to *C. asymmetrica* MEI & WARDLAW.
- Fig. 20: *Wardlawella movschovitschi* (KOZUR & PJATAKOVA), x 100, upper Changhsingian, Red Claystone Unit, Torrente San Calogero, Sicily; from GULLO & KOZUR (1992).
- Fig. 21: *Iranognathus tarazi* KOZUR, MOSTLER & RAHIMI-YAZD, x 62, Changhsingian, Qiaoting (Sichuan Province, South China); from WANG et al. (1987).
- Figs. 22, 23: *Clarkina rosenkrantzi* (BENDER & STOPPEL), Wuchiapingian; fig. 22: x 60, *Posidonia* Shale, Kap Stosch, East Greenland; from SWEET (1976); fig. 23: x 80, lower Zechstein (Marl Slate), Great Britain; from SWIFT & ALDRIDGE (1986).
- Fig. 24: *Merrillina divergens* (BENDER & STOPPEL), lateral view of Pa element, x 80, Wuchiapingian, Raisby Fm. (lower Zechstein), Great Britain; from SWIFT & ALDRIDGE (1986).
- Fig. 25: *Clarkina dukouensis* MEI & WARDLAW, holotype, x 50, lower Wuchiapingian, bed 8, Dukou (South China); from MEI et al. (1994c).
- Fig. 26: *Clarkina postbitteri* MEI & WARDLAW, x 50, lower Wuchiapingian, bed 18, Fengshan (South China); from MEI et al. (1994b).
- Fig. 27: *Clarkina daxianensis* MEI & WARDLAW, holotype, x 50, middle Wuchiapingian, upper part of bed 8, Dukou (South China); from MEI et al. (1994c).

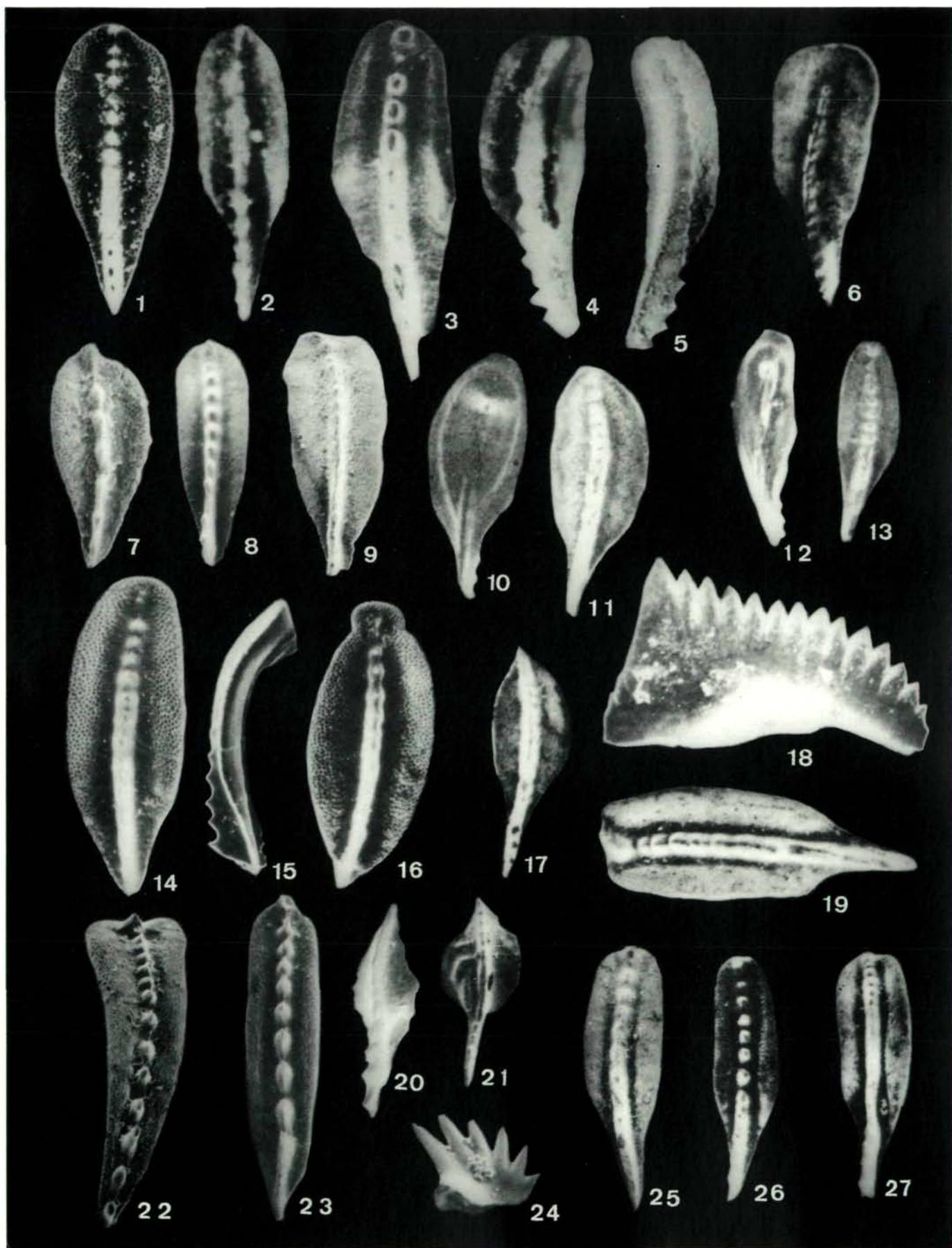


Plate 6

- Fig. 1: *Hindeodus julfensis* (SWEET), x 210, lower Dorashamian (lower Changhsingian), bed 54, Kuh-e-Ali Bashi, NW Iran; from KOZUR et al. (1975).
- Figs. 2, 5: *Hindeodus latidentatus* (KOZUR, MOSTLER & RAHIMI-YAZD), Tesero Oolite, 2 m above the Bellerophon Limestone, horizon with Changhsingian brachiopods, upper Changhsingian, Tesero (Southern Alps, Italy); fig. 2: Pa element, specimen very similar to the holotype (such morphotypes are characteristic for upper Changhsingian of Transcaucasia and China), x 150; fig. 5: Sb element, cusp immediately behind the inward bent part of the bar, x 160, rep.-no. Ko 9208.
- Figs. 3, 4: *Isarcicella ? prisca* n. sp., holotype, re-figured from PERRI (1991, pl. 3, fig. 1), x 95, sample Bu 10, lower Tesero Oolite, upper Changhsingian, Bulla section, SW of Ortisei (Southern Alps, Italy), locality and sample data see PERRI (1991), rep.-no. IC 1444; fig. 3: lateral view; fig. 4: upper view.
- Figs. 6–8: *Clarkina procerocarinata* n. sp., holotype, red Changhsingian claystones, about 1 m below the base of the Triassic, P/T boundary section 500 m south of Pietra dei Saracini, Sosio Valley area, Sicily, rep.-no. KoMo 121191/IX-3; fig. 6: lateral view, x 130; fig. 7: lower view, x 145; fig. 8: upper view, x 120.
- Figs. 9–11, 16, 17: *Hindeodus parvus* (KOZUR & PJATAKOVA), apparatus from a monospecies fauna with about 100 exclusively juvenile specimens of *H. parvus*, sample 14 (thin laminated limestone intercalation in 2 m thick anoxic, yellowish-brown weathered, laminated, originally pyritic claystone immediately above upper Changhsingian red claystones, *H. parvus* Zone of basal Triassic, rep.-no. Ko 1994/I-1; fig. 9: Pa element, x 230; fig. 10: Pb element, x 210; fig. 11: M element, x 170; fig. 16: Sb element, cusp (and one denticle behind it) situated on the inward curved part of the bar (compare Sb element of *H. latidentatus* on fig. 5), x 140; fig. 17: Sc element, x 130 .
- Figs. 12, 13: *Hindeodus parvus* (KOZUR & PJATAKOVA), x 95; fig. 12: morphotype 1, sample 10/13a-1 below the lower stromatolite horizon, *H. parvus* Zone, Achura (Azerbaijan), rep.-no. PK 1-4; fig. 13: morphotype 2, sample 10/13 a-2, *I. isarcica* Zone, Achura (Azerbaijan), rep.-no. PK 1-7.
- Figs. 14, 15: *Isarcicella ? turgida* (KOZUR, MOSTLER & RAHIMI-YAZD); fig. 14: lateral view, x 120, sample 2092, lower *I. isarcica* Zone, basal Brahmanian (“Induan”), section 500 m south of Pietra dei Saracini, Sosio Valley area, Sicily, rep.-no. G 91/IX-15; fig. 15: upper view of an other specimen, x 80, sample Ko 12 B, age and locality as for fig. 14.
- Fig. 18: *Isarcicella isarcica staeschei* (DAI & ZHANG), upper view, x 150, sample 21.4, *I. isarcica* Zone, basal Brahmanian (“Induan”), Dorasham II (Azerbaijan), rep.-no. Ko 1465.
- Figs. 19, 20: *Clarkina planata* (CLARK), x 120, sample Ko 11 a, *H. postparvus* Zone, basal Brahmanian (“Induan”), locality as for figs. 6-8, rep.-no. KoMo 121191/IX-8; fig. 19: upper view; fig. 20: lateral view.

