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Contents

The primary aim of ALBERTIANA is to promote the interdisciplinary collaboration and understanding among members of the I.U.G.S. Subcommission on Triassic stratigraphy. Within this scope ALBERTIANA serves as the newsletter for the announcement of general information and as a platform for discussion of developments in the field of Triassic stratigraphy. ALBERTIANA thus encourages the publication of anouncements, literature reviews, progress reports, preliminary notes etc. - i. e. those contributions in which information is presented relevant to current interdisciplinary Triassic research.

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Cover: Picture of Norian rhythmic shale - limestone alternation (Zlambach, Austria) taken during a fieldwork (fall 2002) by Dr. W. M. Kürschner (Utrecht) together with Prof. Dr. L. Krystyn (Vienna) for a new initiative on integrated biostratigraphic – palynological studies of the Alpine Late Triassic.

Executive Notes

From The Chair

The STS meeting in Veszprum, Hungary announced elsewhere in this newsletter has come and gone. Due to the efforts of our secretary Geoff Warrington we are able to include herein the general minutes of the business meeting that took place. I will not repeat what is contained therein but simply emphasize that GSSP decision time is upon us and by now anyone with an interest in any of the 6 undefined boundaries should have made that know to the chair of the Task groups - there should be no reason for dissent by those opting out of the process. Please read the minutes and be reminded of where we are and what needs to be done. Hope to see many of you in Vancouver next May
(www.vancouver2003.com).

ICS Subcommission on Triassic Stratigraphy

Minutes of Business Meeting, Veszprém, Hungary, 8 September 2002

Chairman*: M. Orchard*

Secretary*: G. Warrington*

Present:
D. Aljinovic, V. Atudorei, M. Balini, A. Baud, P. Brack, T. Budai, H. Bucher, M. Gaetani, J. Haas, M. Hounslow, D. Ivanova, T. Kolar-Jurkovsev, S. Kovacs, H. Kozur, L. Krystyn, D. Lehrmann, V. Lozovsky, A. Marquez-Aliaga, P. Mietto, A. Nicora, J. Pálfy, L. Petrunova, O. Piros, N. Preto, H. Rieber, G. Roghi, A. Shevyrev, M. Shishkin, M. Siblik, M. Sudar, J. Szulc, Tong Jinnan, A. Vörös, Yin Hongfu.

Agenda**:**

1. Apologies for absence
2. Review of requirements for GSSPs, and the present state of Triassic GSSP studies
3. Future meetings
4. Any other business

Chairman opened the meeting at 10.50, welcomed participants and thanked J. Haas and his colleagues for the excellent organization that had ensured the success of the STS meeting in Veszprém.

Item 1.
Apology received from A. Oravecz-Scheffer.

Item 2.
Chairman announced a paper (*Future Directions in Stratigraphy*) issued by ICS following a meeting in Urbino in June, 2002. This includes a requirement for the completion of work on Phanerozoic boundary GSSPs by 2008.

Chairman emphasized the need for STS members to familiarize themselves with the ICS requirements and guidelines for GSSP selection, which appeared in *Albertiana* **26**.

Chairman had requested STS members to inform him of their interest in being involved in GSSP working groups but had only one response; he repeated this request. In the latest ICS statutes, ratified in February 2002, the GSSP working groups had been re-designated as ‘Task Forces’ (TF), with a working duration of 4 years.

Chairman proceeded to review the present situation with regard to each Triassic GSSP and the relevant TF.

A - Base Olenekian GSSP (TF Chairman: **Zakharov**): In the absence of the TF Chairman, **Tong Jinnan** was asked to review work on a possible candidate GSSP in China; this section had been the subject of a poster display during the scientific sessions, and might be visited during a meeting in China in 2005.
Chairman suggested that a proposal for the base Olenekian GSSP might be made after the meeting in China.
Kozur asked why a section in the Indus River area was not being considered
Chairman invited proposals for base Olenekian candidate GSSPs as quickly as possible, in view of the 2008 deadline set by ICS. Proposals should be sent to the TF Chairman.

B - Base Anisian GSSP (TF Chairman: **Gradinaru**): This had been the subject of extensive discussion during the STS meeting on 7 September. **Chairman** would contact **Gradinaru**, indicating that there is a concensus in favour of the GSSP being at the base of Bed 7 in the Desli Caira section, and that he is to proceed with this proposal. **Gradinaru** had indicated that a report on this candidate GSSP would be submitted early in 2003, for inclusion in *Albertiana* **28**. No other candidate was yet proposed; **Gradinaru** is to be informed of work in progress in China.

C - Base Ladinian GSSP (TF Chairman: **Baud**): This had been the subject of extensive discussion during the STS meeting on 7 September. **Chairman** reiterated the ICS schedule for completion of GSSP work and stressed that people involved with the two candidate GSSPs must take action, within the relevant guidelines, to have dossiers on their sections ready by the end of the year (2002). He did not intend that a vote would be carried out then but expected that this would be possible by September 2003, after circulation of the proposals and prompt receipt of responses. The proposal dossiers would appear in *Albertiana* **28**. The TF voting members would vote to select the preferred candidate GSSP on the basis of this published information and the STS voting members would vote on the preferred candidate by the end of 2003. This GSSP should, therefore, be ratified at or before the IGC in Florence in 2004. **Chariman** stressed the need to maintain momentum; slippage through inertia would not be accepted but relevant constructive discussion would not be impeded. The meeting in Vancouver in May 2003 could provide a timely opportunity for discussion of conodont taxonomy and resolution of problems; a similar opportunity might be required for discussion to resolve problems in ammonite taxonomy.

D - Base Carnian GSSP (TF Chairman: **Gaetani**): This had been discussed during the STS meeting earlier on 8 September. **Gaetani** outlined his schedule, leading to completion before the IGC in Florence in 2004.

E - Base Norian GSSP (TF Chairman: **Orchard**): **Orchard** mentioned the meeting in Vancouver in May, 2003, with a session on the Upper Triassic, and similar opportunities in the programme of the IGC in 2004. He expected to have enough information available to progress to the selection of a candidate GSSP by the end of 2004, and to vote on the candidate in 2005. He noted work on successions in Sicily by **Krystyn**, **Nicora** and others.

F - Base Rhaetian GSSP (TF Chairman: **Krystyn**): **Chairman** noted that this topic is covered by the Vancouver (2003) and IGC (2004) programmes. **Krystyn** stated that he is compiling the membership of his TF, with **Kozur** as Secretary. He asked interested people to submit their names for inclusion in the TF, and emphasized the need for palynological representation. **Chairman** suggested that a decision on this GSSP might be expected in 2005.

Chairman reviewed the above (A-F). He reiterated the need for the TFs to get organized, with the involvement of relevant workers, and for tangible progress to be made. He requires the names of the members of each TF, as these will be relevant to the voting procedures in due course; lists exist for the base Olenekian, base Ladinian and base Norian TFs.

Item 3.

Chairman introduced the subject of future meetings.

2003:

26-28 May: Vancouver, including participation of IGCP projects 467 (Triassic time and trans-Panthalassan correlations) and 458 (Triassic/Jurassic boundary events).

September: Croatia.

September/October: Italy. **Brack** said that the final meeting of the Seceda Borehole project would be held in September or October, 2003 [*now Sept. 11-15], possibly with field trips to Seceda and Latemar. This meeting would cover general issues but include relevant Triassic contributions. **Chairman** suggested that this meeting might be supported by STS, and could include the 2003 business meeting.

2004:

June-July: Spiti; because of the limit on participant numbers this would not be a full STS meeting

20-28 September: Florence; the IGC, including an STS business meeting and several thematic sessions covering Triassic issues. The STS executive will be changed at this time.

Márquez-Aliaga mentioned a meeting of the Spanish Mesozoic group, planned for June 2004, in the University of Valencia; the dates for this event might be moved to later in the year.

2005:

Possible meeting in China, with a focus on the base of the Olenekian.

Item 4:

Yin Hongfu asked about the continuation of work by the Base Triassic TF, with focus on terrestrial sequences. **Chairman** advised that a TF is dissolved when its remit of selecting a GSSP in a marine succession has been carried out and the GSSP ratified. **Secretary** commented that any subsequent work comprised the continuation of scientific study and the extension of correlations away from the GSSP. There was discussion on the creation of auxiliary non-marine GSSPs; **Chairman** advised that there is no provision for these under the ICS guidelines.

No further points were raised.

Chairman thanked those present for their participation, and declared the meeting closed at 11.48.

G. Warrington
Secretary: STS

From the Secretary

J. D. Campbell (1927-2001)

The death of Doug Campbell was recorded in Albertiana 26. Under the heading ‘Torlesse headstone for Doug Campbell’ (Geological Society of New Zealand Newsletter 128, July 2002), Hamish Campbell tells us that Doug’s ashes were buried at Matawara, near his birthplace, on Easter Sunday this year, and that the site is marked with a headstone of Torlesse sandstone from Horokiwi quarry near Wellington that is ‘almost certainly of Late Triassic age (Norian-Rhaetian)’. The use of this sandstone in a memorial for a man who spent much of his career working on Norian-Rhaetian (Oretian, Otamitan, Warepan and Otapirian) strata, and advocating research on the Torlesse, is particularly appropriate.

Professor W. A. S. Sarjeant, DSc, FRSC, (1935-2002)

It is with great sadness that I record the death of Bill Sarjeant, in Saskatoon, Canada, on 8th July, 2002. In geological circles Bill may be best known amongst palynologists, for his work on acritarchs and dinoflagellate cysts, and in this field may be thought of as particularly associated with Jurassic sequences. However, his interests, reflected in a prodigious publication record and other achievements, embraced many branches of geology and palaeontology, as well as non-geological topics. Involvements with the Trias included the first description of dinoflagellate cysts from the Late Triassic in the British Isles (Sarjeant 1963). These remains, observed by W. G. Chaloner in a palynology preparation from the ‘Cotham Beds’ (now the Cotham Member of the Lilstock Formation: Penarth Group, Rhaetian) in the British Geological Survey Stowell Park Borehole, Gloucestershire, were described by Bill who created the new species Gonyaulax chaloneri and G. rhaetica. These remains have subsequently, as Rhaetogonyaulax rhaetica, been found in abundance in the Penarth Group in the British Isles, and occur elsewhere; R. rhaetica is the index taxon for the Late Triassic Rr dinoflagellate cyst biozone of Woollam & Riding (1983). Other contributions on Triassic palynology included work on acritarchs and tasmanitids from Pakistan (Sarjeant 1973). A long-lasting involvement concerned vertebrate trace fossils, with publications on Triassic material from Nottinghamshire (Sarjeant 1967, 1970) and Worcestershire, (Wills & Sarjeant 1970). Material from these early studies was later revised by Bill (Sarjeant 1996) and critically reviewed by King and Benton (1996). An extensive review of British fossil vertebrate footprints (Sarjeant 1974) was followed by compilations of material in some British museums (Sarjeant 1984) and of photographs and other material produced by H. C. Beasley (Sarjeant 1985), and a supplement to the 1974 review (Delair & Sarjeant, 1985). Latterly, Bill collaborated in a volume on Triassic footprints from north-west England (Tresise & Sarjeant, 1997), and an article on Chirotherium, jointly authored with M. J. King, G. Tresise and D.B. Thompson, was completed and submitted for publication shortly before his death. Bill may truly be said to have left his ‘impression’ on the Trias.

Geoff Warrington, STS Secretary

References:

Delair, J. B. & Sarjeant, W. A. S. 1985. History and bibliography of the study of fossil vertebrate footprints in the British Isles: 1973-1983. Palaeogeography, Palaeoclimatology, Palaeoecology, 49: 265-378.

King, M. J. & Benton, M. J. 1996. Dinosaurs in the Early and Mid Triassic? – the footprint evidence from Britain. Palaeogeography, Palaeoclimatology, Palaeoecology, 122: 213-225.

Sarjeant, W. A. S. 1963. Fossil dinoflagellates from Upper Triassic sediments. Nature, 199: 353-354.

Sarjeant, W. A. S. 1967. Fossil footprints from the Middle Triassic of Nottinghamshire and Derbyshire. Mercian Geologist, 2 (3):327-342.

Sarjeant, W. A. S. 1970. Fossil footprints from the Middle Triassic of Nottinghamshire and the Middle Jurassic of Yorkshire. Mercian Geologist, 3 (3): 269-282.

Sarjeant, W. A. S. 1973. Acritarchs and tasmanitids from the Mianwali and Tredian formations (Triassic) of the Salt and Surghar ranges, west Pakistan. Canadian Society of Petroleum Geologists, Memoir 2: 35-73.

Sarjeant, W. A. S. 1974. A history and bibliography of the study of fossil vertebrate footprints in the British Isles. Palaeogeography, Palaeoclimatology, Palaeoecology, 16: 265-378.

Sarjeant, W. A. S. 1984. British fossil footprints in the collections of some principal British museums. The Geological Curator, 3 (9): 541-560.

Sarjeant, W. A. S. 1985. The Beasley collection of photographs and drawings of fossil footprints and bones, and of fossil and recent sedimentary structures. The Geological Curator, 4 (3): 133-163.

Sarjeant, W. A. S. 1996. A re-appraisal of some supposed dinosaur footprints from the Triassic of the English Midlands. Mercian Geologist, 14 (1): 22-30.

Tresise, G. & Sarjeant, W. A. S. 1997. The Tracks of Triassic vertebrates: fossil evidence from north-west England. London: The Stationery Office, xii+204pp.

Wills, L. J. & Sarjeant, W. A. S. 1970. Fossil vertebrate and invertebrate tracks from boreholes through the Bunter series (Triassic) of Worcestershire. Mercian Geologist, 3 (4): 399-414.

Woollam, R. & Riding, J. B. 1983. Dinoflagellate cyst zonation of the English Jurassic. Report of the Institute of Geological Sciences, No.83/2: ii+41pp.

Members contact information

All members are requested to advise the Secretary* immediately of any changes to their contact details (postal or e-mail addresses; phone or FAX numbers) to ensure that information from the Subcommission reaches them without delay. The following changes have been notified since the last list of members was published (Albertiana 26, December 2001):

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Dr Martini was added to the list of corresponding members in September 2000 (Albertiana, 24) but was inadvertently missed from the most recent list (Albertiana 26, December 2001). Her fields of interest are: *sedimentology, biostratigraphy (foraminifera) of Permian and Triassic of Tethys; sequence stratigraphy, palaeogeography, sea-level implications.*

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The Dorset and East Devon Coast World Heritage Site

by the Secretary

The coast between Exmouth, East Devon, and Studland Bay, Dorset, became Britain's first Natural World Heritage Site in December 2001. The site, 'The Jurassic Coast' (*Geoscientist*, **12** (4), April 2002), includes, in its 95-mile length, rocks that represent 185 million years of earth history, from the Early Triassic to the Late Cretaceous. Triassic rocks comprise the western part of the site, between Exmouth and Pinhay Bay near Lyme Regis, and are exposed entirely in East Devon. This section of the coast provides nearly continuous exposure through an almost complete Triassic sequence and in these respects is unique in the British Isles. The sequence comprises, from the base upwards, the Aylesbeare Mudstone, Sherwood Sandstone, Mercia Mudstone and Penarth groups, and the basal part of the Lias Group. The majority of the formations seen are continental in origin, and include the well-known braided river deposits of the Budleigh Salterton Pebble Beds, and the Otter Sandstone Formation, with its important Mid Triassic reptile fauna. Marine environments represented by the Penarth and Lias groups were established by a transgression that entered the region during the deposition of the highest Mercia Mudstone Group beds. The base of the Triassic is not yet clearly identified in this area but may be within the Ayesbeare Mudstone Group; rocks of Permian age are exposed in coast sections to the west of the site. The boundary with the Jurassic is placed at the appearance, slightly above the base of the Lias Group, of the ammonite *Psiloceras planorbis*, and is seen at Pinhay Bay.

A leaflet covering the general geological aspects of the site is available from the Dorset and East Devon Coast World Heritage Site Team, County Hall, Dorchester, Dorset DT1 1XJ, UK (www.jurassiccoast.com; Phone: +44 (0)1305 225101; e-mail: jurassiccoast@dorset-cc.gov.uk), and other publications are planned. Geological information may be accessed at www.dorsetrigs.com and www.devon-cc.gov.uk/geology.

Scientific Reports

Some preliminary observations on the association of ammonoids and conodonts about the Ladinian-Carnian boundary in North America.

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Recent discussions about placement of the Ladinian-Carnian boundary have considered the distribution of key ammonoid genera *Frankites*, *Daxatina*, and *Trachyceras*, and of the broadly co-eval conodonts belonging to the genera *Budurovignathus*, *Neogondolella*, *Metapolygnathus*, *Mosherella*, and *Pseudofurnishius*. Published data is now available for the candidate GSSP section at Stuores in Italy (Broglio Lorega et al., 1999), and from important sections in Spiti (Balini et al., 2001). In both areas, significant conodont datums have not been found to correspond to the base of an ammonoid zone (neither *Daxatina*, nor *Trachyceras*). In North America, significant ammonoids and their context have been described by Tozer (1967, 1994) but only a brief summary of the conodont record is available (Orchard & Tozer, 1997). This note provides details of both published and unpublished associations of ammonoids and conodonts presently known from the Ladinian-Carnian boundary interval in western Canada, with some additional information from the important section at New Pass in the USA.

Boundary conodont taxa.

Budurovignathus (*Sephardiella* of authors)

Species of this genus are characteristically Ladinian in age. By far the most common species in North America is *Budurovignathus mungoensis*, which is commonly associated with both *Frankites* and *Daxatina* ammonoids, but never with *Trachyceras*. New data provided here confirms the species also occurs in the subjacent Maclearni Zone. *Budurovignathus mungoensis* is known in numerous collections from Canada (e.g. Orchard, 1991; Orchard & Tozer, 1997) and sometimes occurs to the exclusion of other conodont taxa, although more commonly it is associated with *Neogondolella*, and rarely with both *Metapolygnathus* and *Mosherella.*

There are several additional species of *Budurovignathus* recognized in Europe that apparently do not occur in North America. However, some early growth stages of *B. mungoensis* resemble *B. mostleri*, and some late growth stages resemble *B. diebeli*. Growth series for these latter species need to be demonstrated. Several *Budurovignathus* species co-occur in European faunas (e.g. Mastandrea in Broglio Lorega et al., 1999) and it is not clear how much stratigraphic utility they truly have. Collections of *Budurovignathus* from sub-Desatoyense beds at New Pass (collected by L. Krystyn) are the most morphologically diverse in North America and include rare specimens resembling both *B. diebeli* and *B. longobardicus*, but this may well be intraspecific variation.

Neogondolella (*Gondolella*, *Paragondolella* of authors)

Reconstructed multielement assemblages indicate that the *Neogondolella* assemblage template (Orchard & Rieber, 1999) persists with only minor change from the Middle Permian up to the Ladinian-Carnian boundary interval. The youngest representatives of the genus are *N. inclinata* and probably *N. foliata*, the differentiation of which follows Kovacs (1983). Both species have previously been placed into the genera *Gondolella* or *Paragondolella* but there is no doubt that *N. inclinata* has an apparatus that differs from that of *Neogondolella* only in having a slightly different Sa element; the two former genera have significantly different apparatuses (Orchard, in prep.). The species *inclinata*, and by association *foliata*, are therefore referred to *Neogondolella*. These species show progressive reduction of the anterior platform and an increase in the abruptness of its termination within the Sutherlandi Zone and thus lead to *Metapolygnathus*, which retains the same apparatus.

Neogondolella inclinata varies in its blade-height and in the development of the anterior platform. In some specimens, the platform withdraws leaving a free blade but there are no geniculation points developed as in *Metapolygnathus tadpole*, and nor is the lateral profile straight as in *Neogondolella. foliata*. Most morphotypes of *N. inclinata* appear to occur with *Frankites*, *Daxatina* and *Trachyceras*, but the free-bladed forms (differentiated herein as morphotype F) are so far only known with *Daxatina* and from younger collections. *Neogondolella foliata* is rare in the present collections and its stratigraphic range is uncertain; it too may occur first with *Daxatina.*

Metapolygnathus (*Gondolella*, *Paragondolella* of authors)

The type species of *Metapolygnathus*, *M. communisti*, has two morphological features that set it apart from *Neogondolella*, namely a reduced platform with anterior geniculation points and an anteriorly shifted basal pit. The platform reduction occurred first in the youngest *Neogondolella* species but the abrupt down-turning of both platform margins is here taken as the essential criterion for separating *Metapolygnathus*, which shares the same multielement apparatus as *Neogondolella*. The free blade is also generally more differentiated and higher in

Metapolygnathus. The older *Metapolygnathus* species do not have an anteriorly shifted pit but in younger species this is progressive; this criterion alone is not adequate to separate the species at the generic level. *Metapolygnathus* species also develop nodose anterior platform margins, as do some specimens of *N. inclinata*. Transitional elements are quite variable and only those specimens that clearly have geniculation points on both platform margins are included in *M.* ex gr. *polygnathiformis*.

Metapolygnathus, represented by both *M. polygnathiformis* and *M. tadpole*, occurs in undisputed Lower Carnian strata (e.g. Obesum, Desatoyense zones) and in association with some but not all *Daxatina*-bearing collections. It is not known from faunas that include *Frankites*.

Mosherella, *Pseudofurnishius*

Mosherella was named for C. Mosher who first described *Neospathodus newpassensis* from the Lower Carnian Desatoyense Zone at New Pass, Nevada (Mosher, 1968). The species is abundant at that level (new collections of L. Krystyn and M. Balini) and may be found in monospecific collections allowing confident reconstruction of its apparatus, which is clearly different from contemporaneous conodonts. The origin of the genus has been suggested to lie in *Pseudofurnishius*, through total platform loss (Sadeddin & Kozur, 1992), although this has not been demonstrated in a single section. In fact, *Pseudofurnishius* has not been reported from North America whereas it is uncertain whether *Mosherella* occurs outside it! The trend toward overall reduction of (*Pseudofurnishius*-) *Mosherella* is supported by collections made by L. Krytsyn from post-Desatoyense Zone strata at New Pass. There, *Mosherella* n sp. A shows complete reduction of the posterior process. The same species occurs in one collection from strata above the *Daxatina limpida* fauna in the Callazon Creek area in British Columbia.

Sadeddin (1990) and Marquez-Aliaga et al. (1999) recorded *Pseudofurnishius* in association with *B. mungoensis* in Jordan and Spain respectively, and according to Mastandrea (in Broglio Lorega et al., 1999) the FAD of *P. muricianus* is slightly below that of *Metapolygnathus polygnathifomis*. This implies that *Mosherella* - if it truly does arise from *Pseudofurnishius* - would be unlikely to occur lower than the FAD of *Metapolygnathus polygnathiformis* and yet it does seem to occur prior to this species. In North America, *Mosherella* appears to occur exclusively above the range of *Budurovignathus* and is more commonly associated with *Metapolygnathus*. However, *Mosherella* is also known from collections with only *Frankites*.

Summary

The known distribution of conodonts in collections from about the Ladinian-Carnian boundary provide cosmopolitan indices belonging to the *Budurovignathus*, the *Neogondolella-Metapolygnathus*, and the *?Pseudofurnishius-Mosherella* lineages. Speciation within the first genus is problematic and needs work. The transition from *Neogondolella* to *Metapolygnathus* provides several stratigraphically useful morphotypes that need tighter definition. The *Pseudofurnishius -Mosherella* relationship is unclear due to apparent geographic separation and species appear to be useful only within separate faunal provinces.

The transition from *Neogondolella* to *Metapolygnathus*, and the appearance of *Metapolygnathus* occurs within the range of the ammonoid *Daxatina* and prior to the appearance of *Trachyceras* (ammonoid genera that are not known to co-occur in Canada). *Mosherella* also appears at about this time although it is also known in *Frankites* faunas lacking *Daxatina*. The appearance of *Neogondolella inclinata* Morphotype A, with a reduced platform, may be synchronous with that of *Daxatina*.

A base for the Carnian chosen at the appearance (FAD) of *Metapolygnathus* or *Mosherella* has correspondence to a boundary ammonoid datum neither in North America nor elsewhere. On the hand, the disappearance (LAD) of *Budurovignathus* may well correspond to the boundary between *Daxatina* and *Trachyceras*.

Ammonoid-conodont associations:

Liard River, Boiler Canyon (94N/6). Tozer 1967, p. 64-66; 1994, p. 329. This is probably the type locality for *Daxatina canadensis*. Datum is Cretaceous contact
GSC loc. 68229, -104 m: *Daxatina canadensis, Lobites ellipticus, Nathorstites macconnelli, Neogondolella inclinata.*
GSC loc. 68231, -140 m: *Daxatina canadensis, Asklepioceras laurenci, Nathorstites macconnelli, Neogondolella inclinata,* Morphotype F.

Liard River, Middle Canyon, 1 mile below Boiler Canyon (NTS map 94N/7). Tozer 1994, p. 330. Datum is Cretaceous contact. This locality is one of two in Canada that support the inclusion of *Daxatina* as an element of the Sutherlandi Zone.
GSC loc. 68272, -52.4 m: *Daxatina canadensis, Metapolygnathus ex gr. polygnathiformis, Mosherella newpassensis, Neogondolella inclinata*, Morphotype F.
GSC loc. 68266, -74.9 m: *Daxatina laubei, Frankites sutherlandi; Budurovignathus mungoensis, Nogondolella inclinata,* Morphotype F.

Ewe Mountain area (94N/3). Tozer 1967, p. 63; 1994, p. 328. Datum is base of section.
GSC loc. 42310, +800+ m: *Sirenites* sp., *Metapolygnathus ex gr. polygnathiformis, Neogondolella inclinata,* Morphotype F.
GSC loc. 42311, +800 m above 42308: *Clionitites arietinus, Sirenites nanseni, S. ovinus. Neogondolella?* sp.
GSC loc. 42308, +700 m above 42: *Austrotrachyceras*

obesum, Metapolygnathus ex gr. polygnathiformis
GSC loc. 42316, at 0 m: *Daxatina canadensis, Neogondolella?* sp.

Clearwater Lake/ Callazon Creek area (93O/10). Tozer 1994, p. 167, 336-9; McRoberts, 2000. This area includes the record of *Daxatina limpida* in a fauna tentatively regarded as a Lower Carnian equivalent of the Desatoyense Zone (Tozer, 1994, p. 35).
GSC loc. 84212: *Trachyceras desatoyense, Neogondolella foliata?, N. inclinata,* Morphotype F.
GSC loc. 84270: brachiopods, bivalves indet., *Neogondolella foliata, N. inclinata.*
GSC loc. 83822: *Daxatina*? sp. *Neogondolella inclinata, ?Budurovignathus* sp.
GSC loc. 83825, +~150 m above 83824: *Halobia* sp., *Mosherella* n.sp. A, *Neogondolella inclinata*.
GSC loc. 83824 contains *Stolleyites sp., Clionitites callazonensis, C. reesidei, Daxatina limpida, Coroceras sp., Halobia daonellaformis.*

NW Besa River (94G/5)
GSC loc. C-416001, C-305045: *Daxatina canadensis, Daonella* sp., *Neogondolella inclinata, B, Neogondolella inclinata,* Morphotype F, *?Metapolygnathus ex gr. polygnathiformis.*
Datum is base of section:
GSC loc. C-416013, C-305050, +147 m: *Frankites sutherlandi, Nathorstites macconnelli, Mosherella newpassensis, Neogondolella inclinata.*
GSC loc. C-416012, C-305049, +144 m: *Neogondolella inclinata.*
GSC loc. C-416010, C-305048, +120 m: *Daonella elegans, Nathorstites* sp., *Budurovignathus mungoensis, Neogondolella inclinata.*
GSC loc. C-305047, +37.5 m: *Budurovignathus mungoensis, Neogondolella inclinata.*

'Keilly's Tendon' (94G/5). Datum is base of section.
GSC loc. C-416030, C-146042 (talus), C-305224, +137 m: *Daxatina canadensis, Frankites sutherlandi, Nathorstites macconnelli,* nautiloids, brachiopods, *Mosherella newpassensis, Neogondolella inclinata.*
GSC loc. 416029, +135 m: *Nathorstites* sp.,
GSC loc. 416044, +129.75: *Nathorstites* sp.; *Maclearnoceras*? sp.
GSC loc. 305223, +87 m: *Budurovignathus sp., ?Neogondolella inclinata.*
GSC loc. 305222, +81 m: *Budurovignathus mungoensis, Neogondolella sp.*
GSC loc. 416023, +77.5 m: *Maclearnoceras ensio*
GSC loc. 305221, +72-75 m: *Budurovignathus mungoensis*

Mount Trimble (94G/5).
GSC loc. C-304828: *Aspekioceras laurenci, Nathorstites* sp., *Neogondolella inclinata, Neogondolella inclinata,* Morphotype F.

Williston Lake, West Glacier Spur (94B/2). This locality is one of two in Canada that support the inclusion of *Daxatina* as an element of the Sutherlandi Zone.
GSC loc. C-304349, +8 m: *Lobites ellipticus, Neogondolella inclinata,* Morphotype F.
GSC loc. C-304348, +0.6 m: *Daxatina canadensis, Frankites sutherlandi, Lobites ellipticus, Muensterites glaciensis, Nathorstites macconnelli, Budurovignathus mungoensis, Neogondolella inclinata.*
GSC loc. C-304347, +0.4: *Frankites sutherlandi, Lobites ellipticus, Nathorstites macconnelli,* brachiopods, *Budurovignathus mungoensis, Neogondolella inclinata.*
GSC loc. C-304346, 0 m: *Muensterites glaciensis, Nathorstites sp., Neogondolella inclinata.*

References:

Balini, M., Krystyn, L., Nicora, A., & Torti, V. 2001. The Ladinian-Carnian boundary succession in Spiti (Tethys Himalaya) and its bearing to the definition of the GSSP for the Carnian stage (Upper Triassic). Journal of Asian Earth Sciences, 19 (3A): 3-4.

Broglio Lorega, C., Cirilli, S., De Zanche, V., Di Bari, D., Gianolla, P., Laghi, G.F., Lowrie, W., Manfrin, S., Mastandrea, A., Mietto, P., Muttoni, G., Neri, C., Posenato, R., Rechichi, M., Rettori, R., & Roghi, G. 1999. The Prati di Stuores/Stuores Wiesen section (Dolomites, Italy): a candidate global stratotype section and point for the base of the Carnian Stage. Rivista Italiana di Paleontologia e Stratigrafia, 105 (1): 37-78.

Kovács, S. 1983. On the evolution of *excelsa*-stock in the Upper Ladinian-Carnian (Conodonta, Genus *Gondolella*, Triassic); New contributions to the biostratigraphy of the Tethyan Triassic, 5: 107-120

Márquez-Aliaga, A., Valenzuela-Ríos, J.I., & Plasencia, P. 1999. Nuevos datos sobre *Pseudofurnishius* (Conodonta, Triásico) en EspaH a. Temas Geológico-Mineros ITGE, 26: 262-264.

MRoberts, C.A. 2000. A primitive *Halobia* (Bivalvia: Halobioidea) from the Triassic of northeast British Columbia. Journal Paleontology, 74 (4): 599-603.

Mosher, L.C. 1968. Triassic conodonts from western North America and Europe and their correlation. Journal of Paleontology, 42 (4): 895-946.

Orchard, M.J. 1991. Conodonts, time and terranes: an overview of the biostratigraphic record in the western Canadian Cordillera. In M.J. Orchard and A.D. McCracken, (eds.), Ordovician to Triassic conodont paleontology of the Canadian Cordillera: Geological Survey of Canada, Bulletin 417: 1-26.

Orchard, M.J. & Rieber, H. 1999. Multielement *Neogondolella* (Conodonta, Upper Permian-Middle Triassic). Proceedings of ECOS7, Bologna-Modena, Italy, June 1998. Bollettino della Societa Palaeontologica Italiana, 37 (2/3): 475-488.

Orchard, M.J. & E.T. Tozer. 1997. Triassic conodont biochronology, its calibration with the ammonoid standard, and a biostratigraphic summary for the Western Canada Sedimentary Basin. In Moslow, T. and Wittenberg, J. (eds.), Triassic of Western Canada Basin; Canadian Society of Petroleum Geologists, Bulletin 45(4): 675-692..

Sadeddin, W. 1990. *Pseudofurnisius priscus* n. sp. (Conodonta) and its stratigraphical significance for the Ladinian (Middle Triassic) in Jordan. Neues Jahrbuch für Geologie und Paläontologie Abhandlungen, 178 (3): 369-382.

Sadeddin, W. & Kozur, H. 1992. *Pseudofurnishius siyalaensis* n. sp. (Conodonta) from the Lower Ladinian of Wadi Siyala (Jordan). Neues Jahrbuch für Geologie und Paläontologie Monatshefte, 1992 (6): 359-368.

Tozer, E.T., 1967. A Standard for Triassic time; Geological Survey of Canada, Bulletin 156, 103 pp.

Tozer, E.T. 1994. Canadian Triassic ammonoid faunas. Geological Survey of Canada, Bulletin 467: 663 pp.

Towards a Tethyan Carnian–Norian boundary GSSP

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Abstract

Long distance correlation of the Carnian-Norian (C-N) boundary is possible by ammonoids, conodonts and likely by pelagic bivalves of the genus *Halobia*. Depending on the chosen fossil group and bioevent, this boundary may be located at the base of the *Guembelites jandianus* Zone of the current Tethyan ammonoid scale and/or at the coeval FO of *Metapolygnathus communisti* B within the Tethyan conodont zonal framework as applied in this paper. A second and slightly earlier conodont event, the FO *of M. communisti*, may have the potential for worldwide recognition but it is presently not well individualized in the ammonoid and halobiid Tethyan successions. Other conodont events are less favourable: the incoming of *Norigondolella navicula* is unsatisfactory because its stratigraphic level appears to differ from one area to another and the potential of *Epigondolella abneptis* A as boundary guide needs additional clarification. The first two mentioned conodont FOs are well constrained by magnetostratigraphic data: the *communisti* event and the *communisti* B event occurring respectively at the base and at the top of a reversed polarity interval during the topmost part of the Carnian. If *M. communisti* B turns out to be missing in North America, the communisti event may remain as the only reliable time indicator for intercontinental correlation of the C–N boundary in low paleolatitudes between the Panthalassa and Tethys oceans. In this study, pelagic sequences from three Western Tethys regions (Slovakia, Turkey and Sicily) are documented, correlated with each other and compared for their sedimentary and magnetobiochronological potential to serve as GSSP candidates for the Carnian–Norian boundary. Sections from Turkey and Slovakia are suitable for magnetostratigraphy, are rich in conodonts and also display megafossil data (halobiids, ammonoids), but they are developed as sedimentary condensed Hallstatt limestones and thus reduced in thickness. A thick and stratigraphically expanded section in Sicily (Pizzo Mondello) shows the most complete magnetostratigraphic sequence but a qualitatively unsatisfying conodont record and it presently misses any megafossil support. If the fossil record from this section could be improved, Pizzo Mondello would become the best available Tethyan locality for the implementation of a GSSP.

Introduction

Compared with many disputed Triassic stage boundaries, the Carnian-Norian boundary is a rare exception because of its well defined and undisputed status. This is surprising since no reliable historical reference section has been mentioned so far and that the presumable Norian stratotype in Sommeraukogel near Hallstatt (Salzkammergut) lacks an age-diagnostic megafauna at the base (Krystyn et al., 1971). The earliest Norian ammonoid Sommeraukogel record belongs to the “Zone des *Discophyllites patens*” (Mojsisovics, 1873-1902) and represents an interval now known as corresponding to the top-Lower Norian *Juvavites magnus* Zone. A more appropiate age for the base of the Norian stage may be obtained from the analysis of those faunas which were included by Mojsisovics (1893) in the Upper Carnian or Tuvalian substage (in Mojsisovics et al., 1895). According to our present knowledge, the youngest Mojsisovics s Carnian fauna is from the “Linse mit *Thisbites agricolae*” and correlates to a very short-ranging level (*Euisculites* Biohorizon) of less than one ammonoid subzone within the topmost Carnian *Spinosus* Zone of the Tethys (level b in fig. 1). The North American equivalent is found in the *Klamathites macrolobatus* Zone of Canada (Tozer, 1994) and Nevada (Silberling, 1959). Norian faunas above this level were included in the *Guembelites* Zone by Silberling (1959) and later referred to the Zone of *Mojsisovicsites* (now *Stikinoceras*) *kerri* by Tozer (1967). *Dimorphites*, *Griesbachites* and *Guembelites* are characteristic genera of the zone which was first identified in the Tethys at Feuerkogel (Krystyn, 1974) and later named as *Guembelites jandianus* Zone (Krystyn, 1980).

Beside the Alps, Tethyan places with a reliable Upper Carnian to lower Norian ammonoid record across the C-N boundary are known from Sicily (Gemmellaro, 1904) and from the Himalayas (Diener, 1906; Jeannet, 1959; Krystyn, 1982). However, a detailed faunal sequence information is still restricted to Feuerkogel and this locality is thus the only one which provides direct intercalibration between ammonoid, halobiid and conodont zonal schemes. Magnetostratigraphic results unfortunately could not be obtained from Feuerkogel (J. Besse, pers. comm.) but several conodont-dated pelagic limestone sections from Turkey have provided numerous magnetostratigraphic data allowing the construction of a geomagnetic polarity time scale for this time interval (Gallet et al., 1992; 2000; Krystyn et al., in press). These data are in good agreement with the most complete Tethyan C-N magnetostratigraphic record recently obtained by Muttoni et al. (2001) at Pizzo Mondello (Sicily), although the lack of time diagnostic fossils prevented Muttoni et al. 2001 to locate the boundary to better than a 40 m-thick interval. Based on a combined analysis of all available data, we discuss here the significance of the various bioevents with respect to faunistic, magnetostratigraphic and interregional cross-correlations,

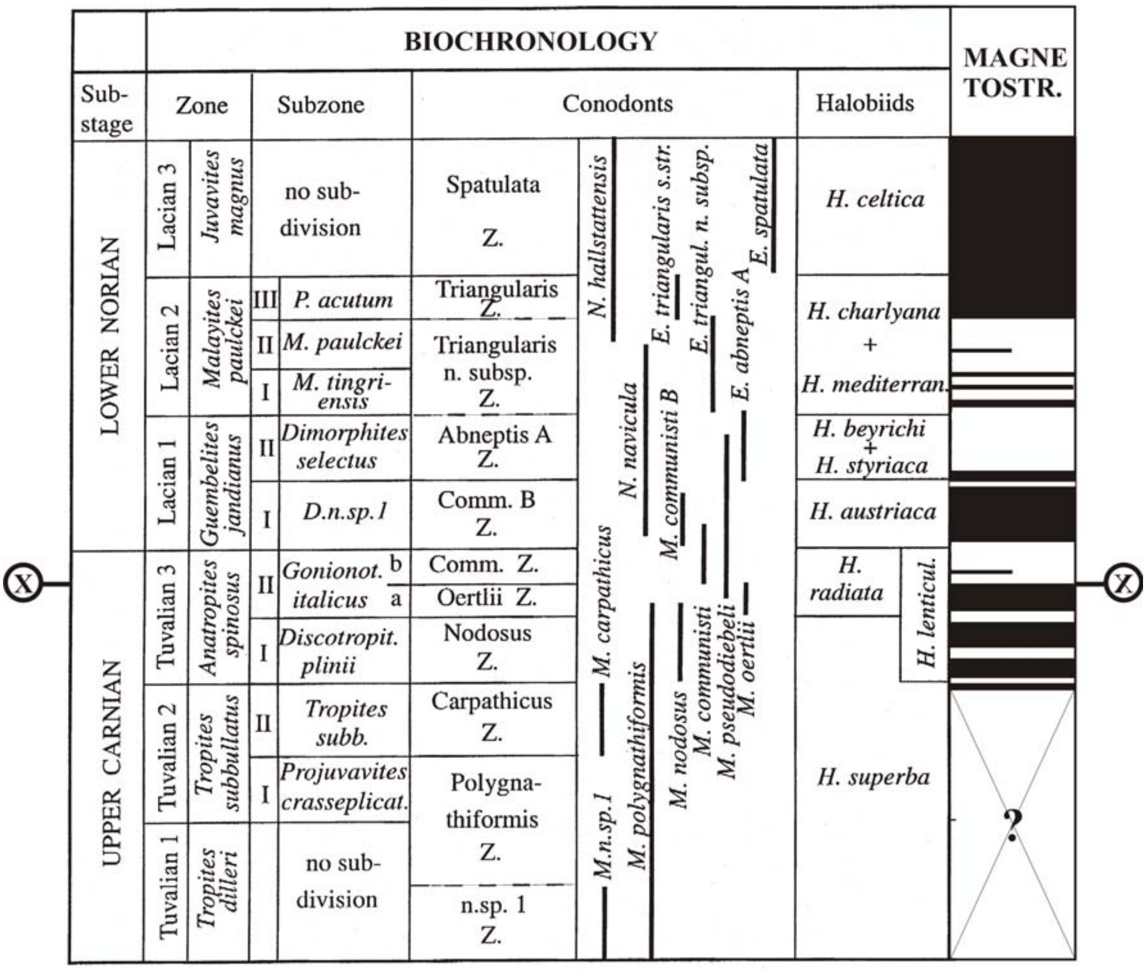

Fig. 1: Upper Carnian to Lower Norian Tethyan magnetobiochronology . The encircled X marks the Carnian-Norian boundary proposed by Orchard et al. (2000) for the *communisti* event.

and we evaluate the sequential and fossiliferous potential of the studied sections as C-N boundary GSSP candidates.

Magnetobiochronology

We recently carried out a study on the Carnian-Norian magnetobiochronology (Krystyn et al., in press). We summarize below our general conclusions.

The Upper Carnian (Tuvalian) Tethyan ammonoid biochronology was previously proposed by Krystyn (1980) and it was summarized in Gallet et. al. (1994). We also consider the Lower Norian (Lacian) ammonoid zones and subzones defined by Krystyn (1980) and Krystyn (1982), respectively. Originally established in rather thin and sediment-reduced red cephalopod limestones of the so-called Hallstatt facies in Austria, this zonation has meanwhile been found applicable to many Tethys regions (e.g., Timor, Oman, Himalayas). The Carnian-Norian boundary has been defined at the base of the North American Kerri Zone (Tozer, 1967) which correlates with the Tethyan Jandianus Zone as both zones share the FO of the distinct juvavitid genus Dimorphites (Figure 1; Krystyn, 1980). This boundary reflects the strong faunistic changes observed between the *Euisculites* Biohorizon and the *Dimorphites* n. sp. 1 Subzone which are well demonstrated in the faunal record of sections 4 and 5 in Feuerkogel (Austria). The Tuvalian and Lacian substages are each divided into 3 standard zones with twofold subzonal divisions in most cases.

Halobiids form easily recognizable species with little chance of taxonomic confusion and are extremely useful for independent calibration when tied into the ammonoid time scale. This is the case for the Carnian-Norian boundary interval where *H. radiata*, *H. austriaca* and *H. styriaca* constitute a sequence of short successive ranges in many areas of the Tethys, from Sicily to the Himalayas (Krystyn et al., in press). Data from the Alps show that the FAD of *H. austriaca* corresponds with the base of the Jandianus Zone (and thus with the C-N boundary; Krystyn, 1980), and suggest an age range of one ammonoid subzone for each of the forementioned halobiid species. In addition, the widespread geographic distribution of halobiids provides a firm basis for long distance correlation of the Carnian-Norian boundary in ammonoid free *Halobia*-bearing Tethyan rocks.

Previous Tethyan Upper Triassic conodont zonations have

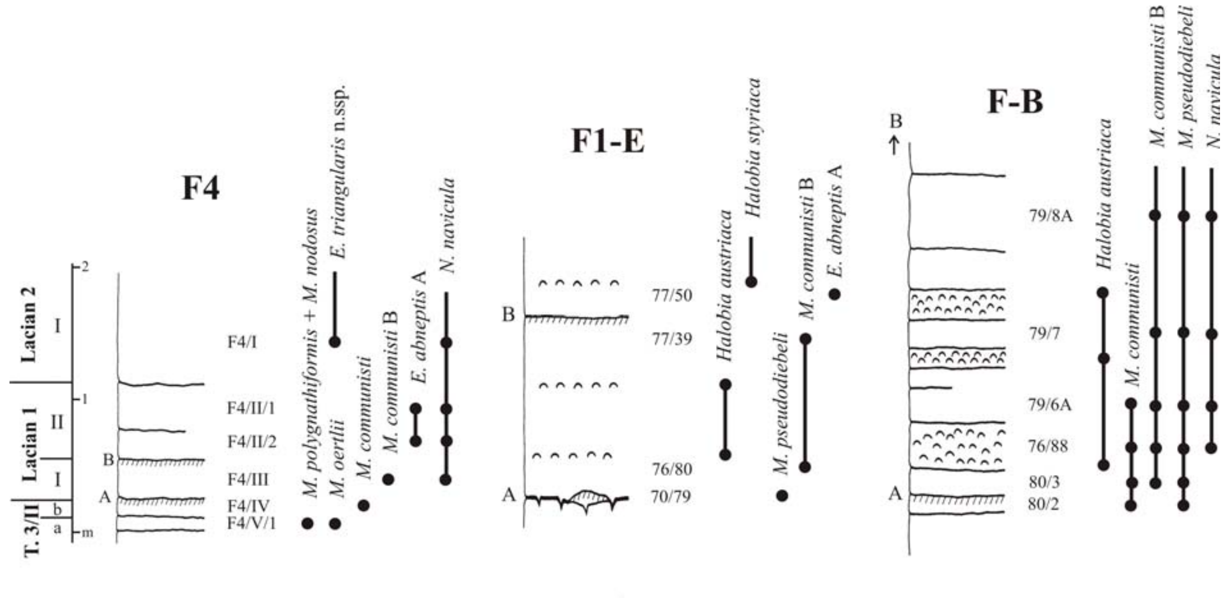

Fig. 2: Halobiid and conodont biochronology of three sections in Feuerkogel. Note the lithostratigraphic marker levels A and B (“A” corresponding to the Carnian-Norian boundary).

been proposed by several authors since the early seventies (Kozur and Mostler, 1973; Kozur, 1980; Krystyn, 1980; Vrielynck, 1987; Budurov and Sudar, 1990). All of them are rough, with long ranging zonal intervals exceeding the duration of the ammonoid zones by two or three times. None of the cited studies, but Krystyn (1980), has provided accurate sequential information on the ranges of stratigraphically relevant taxa against the ammonoid zonal frame. In a more detailed subdivision, Kozur (1990) increased the number of Upper Carnian and Lower Norian zones to six but missed again a direct integration into the ammonoid scale. Based on conodont collections obtained from ammonite-controlled sections in Austria and Timor (Indonesia), completed by material from newly measured sequences in Turkey, Krystyn et al. (in press) improved and refined this zonation to a sequence of 11 zones for the same time interval (Figure 1). The zonal guides of the Upper Carnian to basalmost Norian are thereby based on the genus *Metapolygnathus*, and those of the Norian on *Epigondolella* species. Each zone is defined by the FAD of its index species and is ended by the FAD of the succeeding zonal guide. This allows to define zonal boundaries independently from the total range of the zonal marker which may extend into the next younger zone or beyond. This procedure avoids problems in taxonomy used differently by the various authors, what ultimately leads to strongly differing ranges of many zonal index species in the literature. Reference sections for the new resp. redefined conodont zones have been named in Turkey (see below).

In order to avoid any misleading interpretations, the following remarks on some conodont boundary interval species are necessary. *Metapolygnathus primitius* is typical for North America and obviously missing in the Tethys as many other Pacific metapolygnathids and epigondolellids (Orchard, 1991). It is replaced in Tethyan sections by the time-equivalent *M. pseudodiebeli* long used as zonal index for the Carnian-Norian boundary interval (Kozur, 1973). *Metapolygnathus communisti* A of Krystyn, 1980 corresponds to *Metapolygnathus communisti* Hayashi, 1968 (see Krystyn, 1980, pl. 12, fig.8-14). The usefulness of *Metapolygnathus communisti* B for determining the base of the Norian by conodonts has been questioned by Muttoni et al. (2001) who considered the species as doubtful and held it in synonymy with *M. nodosus* although there is a distinct time break between the two species (Figure 1). There is now convincing morphological evidence that *M. communisti* B is closely related to *M. oertlii* (Kozur) and this latter species bridges the stratigraphic gap between *M. nodosus* and *M. communisti* linking perhaps the three taxa in a phylomorphogenetic cline. *M. nodosus* sensu Orchard is morphologically close to *M. carpathicus* (Mock) and may have been misinterpreted in North America. *Epigondolella abneptis* A is identical to *E. abneptis* sensu Kozur and very similar to *E .quadrata* Orchard. *E. triangularis* n. ssp. is distinguished from *E. abneptis* A by the asymmetrically expanding semi-triangular posterior platform end. The newly discriminated subspecies of *Epigondolella triangularis* (Budurov & Stefanov) has smaller platform nodes and a less widening posterior platform than *E. triangularis* sensu stricto. Note that all epigondolellid species can be safely distinguished only in adult stages.

Carnian- Norian boundary sections

Feuerkogel

Located in the classical Hallstatt region of the Northern Calcareous Alps, the Feuerkogel has gained wide attention as historical reference both for the Tuvalian substage and for the base of the Norian (Krystyn and Schlager, 1971). Pelagic megafossils from this place are therefore

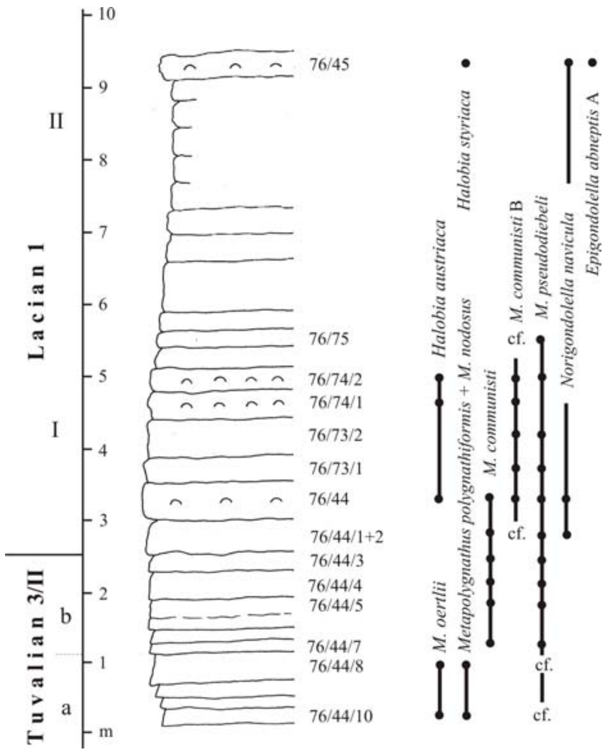

Fig. 3: Biochronology of the Silicka Brezova section.

of great importance for our understanding of the stratigraphic subdivision of the Carnian-Norian boundary interval. Rich ammonoid faunas were found in quarry F4 (and F5), where the accumulation rate was stongly reduced during the interval. The present top-Carnian *Euisculites* Biohorizon consists of a 15 cm thin bed (F4/IV) containing the genera *Euisculites*, *Thisbites*, *Hadrothisbites*, *Microtropites* and *Margarijuvavites*. From the overlying 30 cm thick bed F4/III (fig. 2), a different fauna is observed, marked by the appearance of the juvavitid genera *Dimorphites* and *Griesbachites*, and, except *Thisbites*, all forementioned genera have disappeared. Bed F4/III further yields the FO of *Halobia austriaca* replacing *H. lenticularis* found in F4/IV. The tops of the two beds in quarries F4 and F5 are developed as thin white limestone layers with characteristic mm-thick ichnoburrows, numbered A and B in fig.2. These levels are distinct lithostratigaphic marker horizons which are followed laterally over relatively large distances. Level A allows the exact recognition of the C-N boundary in other ammonoid free areas of the Feuerkogel where a more expanded sedimentary record is present (F 1-E and F-B on fig.2). They have been described by Krystyn (1980) and provide a more detailed insight on the ranges of stratigraphically significant *Halobia* and conodont species. The two sections indicate: 1) the FAD of *Halobia austriaca* and the FO of *Norigondolella navicula* are close to the base of the Norian, 2) the range of *Halobia styriaca* is directly above the one of *H. austriaca*, 3) each species are restricted to just one ammonite subzone, 4) the FO *of Metapolygnathus communisti* postdates both *M. polygnathiformis* and *M. nodosus*, and 5) the FO of *M. communisti* B is at the very base of the Norian. All these data provide the basis for an exact correlation of the current C-N boundary in ammonoid free pelagic sections throughout the Tethys realm with pelagic bivalves of *Halobia* type and/or conodonts. With the exception of section F-B, Feuerkogel is clearly unsatisfying as GSSP candidate due to the reduced sedimentation rate. The lack of any primary palaeomagnetic record, likely due to lightning effect, is also a negative point for this locality (J. Besse, pers. comm.).

Slovakia

The section (fig. 3), called Silicka Brezova from the name of a nearby village located in the eastern part of the West Carpathians, was documented by various authors (Mock, 1980; Korte, 1999). It contains reddish fine-grained pelagic limestones of Hallstatt type and has some importance as type locality of Upper Carnian conodont zones (Kozur, 1980). Materials mentioned below have been collected together with the late J. Bistricky more than 20 years ago when only rare natural outcrops partly covered by grass were accessible. A trench was recently digged providing now a much better exposed bed-by-bed sequence which is currently under study for detailed magnetobiochronology (H. Kozur and others, pers. comm.).

The section is included to this paper for discussing its potential as boundary GSSP in comparison with the other described localities. It is very similar to Feuerkogel F-B by the joint appearance of *H. austriaca*, *M. communisti* B and *N. navicula* at or closely above the C-N boundary (fig. 3). The top Tuvalian is less than 2 m thick with a rather late occurrence of *M. polygnathiformis* and *M .nodosus* just below *M. communisti*. This may be explained by a short stratigraphic gap or by faulting not visible at that time due to the restricted outcrop situation. Based on our data elsewhere, the magnetostratigraphy is predicted as follow: Reversed polarity between 1 m and 3 m, Normal polarity from 3 m to approximately 6 m.

Turkey

Three sections (KA, BT and EM2) are presented which all belong to the Bakirli Dag unit of the Upper Antalya Nappes (Marcoux, 1987). They are located relatively close to each other. Two sections have been described earlier, the Bölücektasi Tepe (BT) section by Gallet et al. (1992) and the Kavaalani (KA) section by Gallet et al. (2000). Erenkolu Mezarlik 2 (EM2), located 4 km SSW of BT, is a new and hitherto undescribed section with the most expanded and complete Carnian sedimentary record known to date from any Upper Antalya Nappe outlier. The magnetobiochronology (fig. 4, 5) of the C-N boundary interval is figured for the first time in detail and allows a better insight on the faunal sequences and on the magnetostratigraphic correlation between the Turkish data.

The three Turkish sections give us the opportunity to refine the ages of C-N boundary conodont datums in the Tethys and, in particular, to establish true first appear-

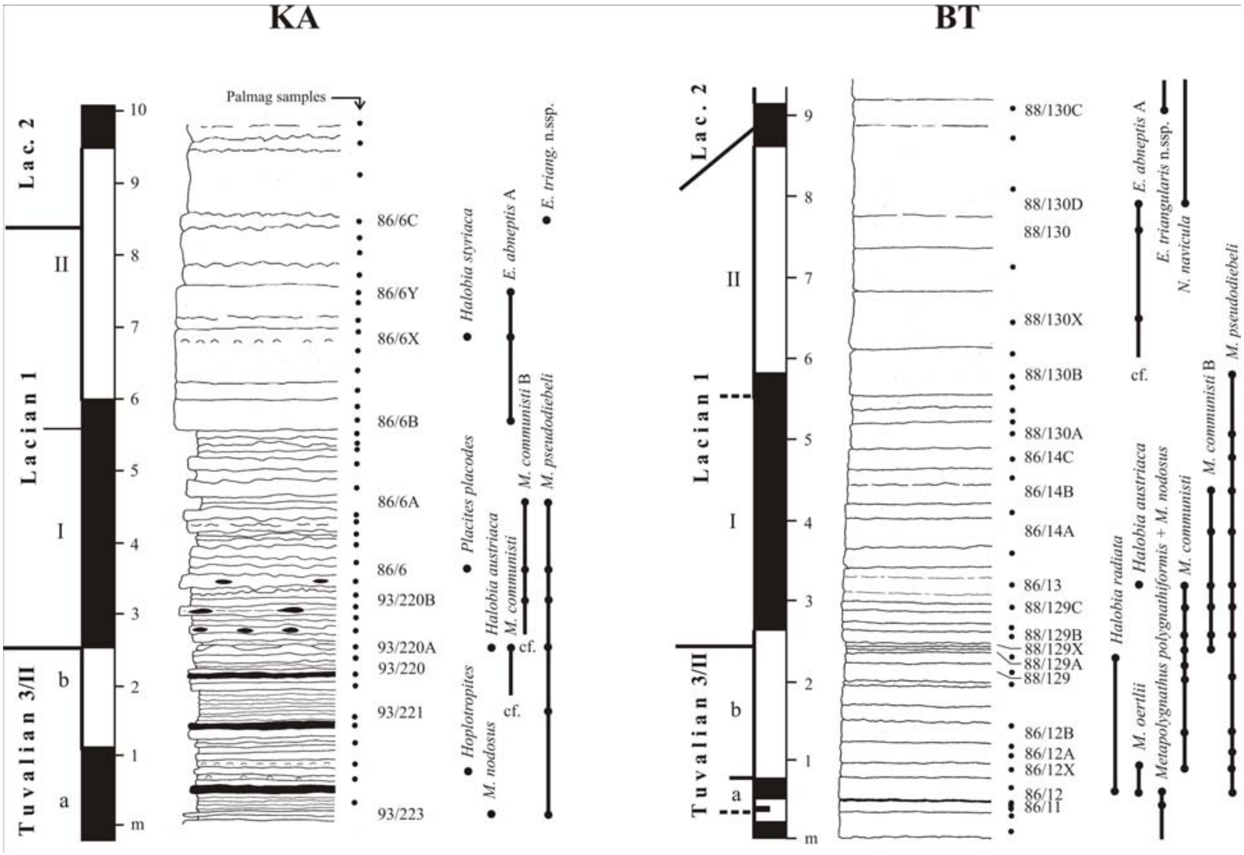

Fig. 4: Magnetobiochronology of Kavaalani (left) and Bölücektasi Tepe (right) sections. Note the short sedimentary break at the Carnian-Norian boundary in KA and the strongly reduced early Tuvalian 3 in BT, further indicated by the magnetostratigraphic record.

ance datums (FADs) for the species concerned. These sections display similar lithologies of Hallstatt-type consisting in fine-grained pelagic limestones with mostly reddish to light grey thin beds for the Carnian and whitish, thicker beds for the lowermost Norian. The basal beds of KA contain additional rare chert layers resp. nodules (fig.3). The thickness of BT and KA is nearly identical which makes very easy the comparison between the two sections. EM2 is much thinner and may represent short-termed hiati close to the C-N boundary but stratigraphic condensation can be clearly excluded by the normal, i.e. non-mixed conodont record. A discontinuity surface also marks the C-N boundary in KA and the occurrence of the Norian exactly at the onset of a magnetic polarity interval further suggests a short sedimentary break at this level. Distinct ammonoid genera (*Tropiceltites*, *Griesbachites*) allow the control of the conodont-based determination of the C-N boundary in EM2 (fig.5). The Kavaaalani and BT sections yield a Tuvalian 3 to Lacian 1 halobiid succession identical to the one obtained from Feuerkogel whose time stratigraphic validity can be proven by a cross-correlation with the conodont zonation. Both BT and EM 2 show an excellent conodont record with a complete zonal succession from the Upper Carnian to the lowermost Norian (fig. 4, 5). For this reason, we consider the two sections as references for the following conodont zones: *M. oertlii* (EM2), *M. communisti* (BT), *M. communisti* B (EM2) and *E. abneptis* A (EM2).

Sicily

The Pizzo Mondello sequence has been studied in detail by Muttoni et al. (2001) to establish the Carnian–Norian boundary interval magnetostratigraphy. The section is well exposed and rather thick in the basal Tuvalian 3 (80 m) and from the Lacian 2 upward. Across the C-N boundary, the sedimentation rate is reduced, to 7 m within the topmost Tuvalian equivalent of the *Euisculites* Biohorizon and to 18 m in the basalmost Norian (Lacian 1 zone). However, these thicknesses are still three to four times higher than in the coeval parts of the Slovakian and Turkish sections. Pizzo Mondello was therefore an ideal place for magnetostratigraphic investigations and it has indeeed provided the most complete magnetostratigraphic record (fig.5).

According to Muttoni et al. (2001), the greyish to light grey fine-grained calcilutites are almost barren of megafossils and contain a diversity reduced conodont fauna in which boundary diagnostic species such as *N. navicula* and *M. communisti* B are missing. As a result, Muttoni et al. (2001) failed to locate precisely the C-N boundary and introduced instead a 40 m-thick boundary interval. To improve its potential for correlation with other sections, one of us (LK) collected there megafossils and

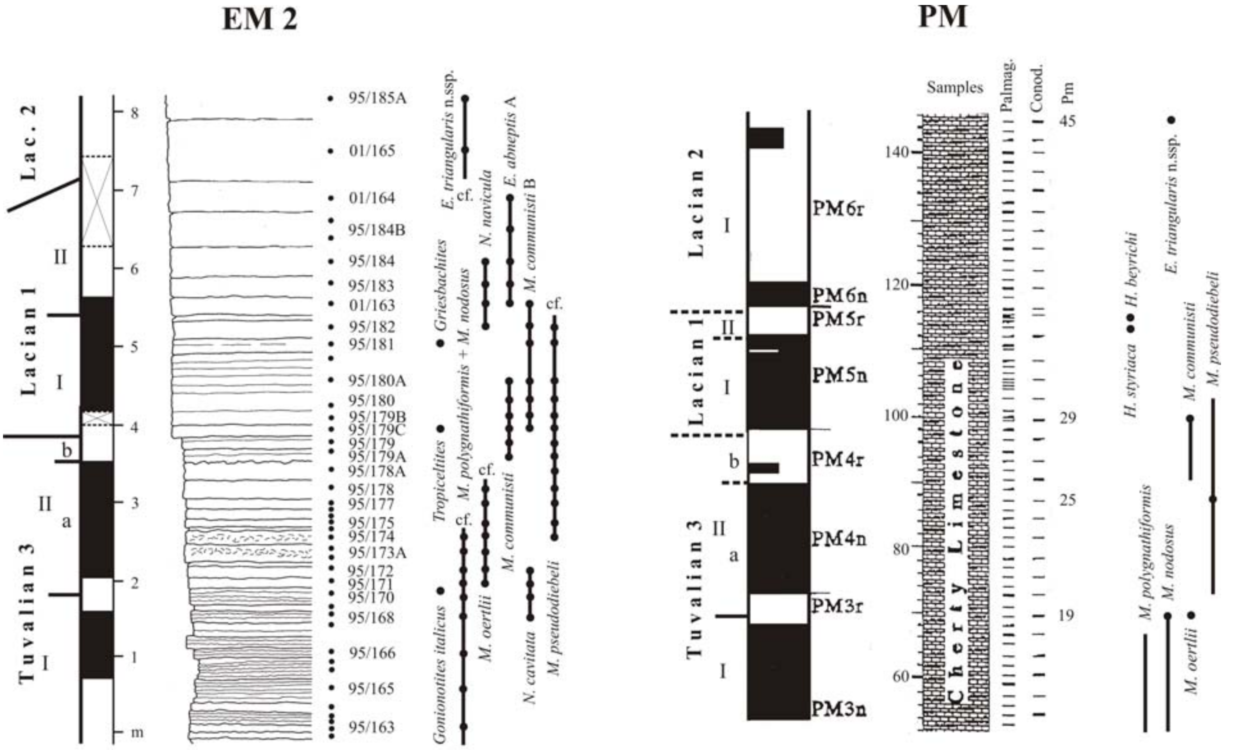

Fig. 5: Magnetobiochronology of Erenkolu Mezarlik 2 (left) and Pizzo Mondello (right). We underline the almost perfect agreement between the two magnetostratigraphic records for the Tuvalian 3 and the Lacian 1 despite strongly differing thicknesses.

some new conodont samples (Krystyn et al., in press). The new sampling clearly indicate different ranges for stratigraphical conodont guides as those cited in Muttoni et al. (2001). These differences may be explained in different ways but we interprete them as resulting from an inadequate taxonomy. The biochronology shown in fig. 5 is a combination of our (black dots) and reinterpreted range data (black bars). The reinterpretations are based on the presence of *M. nodosus* together with *M. oertli* at 70 m (sample PM 19), the exclusive occurrence of *M. pseudodiebeli* without *M. communisti* at 88 m (PM 25) and the last (?) appearance of *M. communisti* at 100 m (PM29). An independent confirmation of the different chronostratigraphic correlations is given by the presence of *H. styriaca* within the first longer reversed polarity interval (PM 5r) above the Carnian-Norian boundary. Following our reference frame (fig.1), the current C-N boundary occurs below the last occurrence of *M. communisti*. The alternative boundary proposed by Orchard et al. (2000) at the FO of the forementioned species is located 7-8 m below and the base of the Lacian 2 zone approximately corresponds to 116 m, slightly above the disappearance of *H. beyrichi*. Here we point out the excellent agreement between the magnetostratigraphic data from Pizzo Mondello and those previously obtained from Turkey (Krystyn et al., in press).

The Pizzo Mondello section constitutes a part of the Upper Triassic deep marine Sicani basin (Catalano and D’Argenio, 1978), which has a minimal size of more than 200 square kilometers on mainland Sicily, where many sections contain the Carnian- Norian time interval. Within a distance of less than 10 km from Pizzo Mondello, there are at least 4 outcrop regions (Monte Triona, Contrada Votana, Monte Cammerata and Contrada Modanesi) which, according to the large faunas described in Gemmelaro’s (1888 and 1904) monographs, may provide the missing megafaunal evidence. This will be the task of future work to recollect those data and integrate them into a new stratigraphic network. If this happens, Pizzo Mondello will become the best Tethyan GSSP candidate for the C-N boundary.

Conclusions

Any selection of the Carnian-Norian GSSP will depend on the event chosen to define the boundary. A combination of different events would be preferable to strengthen the adopted boundary as a single event could not be safe enough to insure the validity of long distance correlations. Concerning bioevents, a decision has to be taken about the favourite fossil group. If priority is given to conodonts, their events should preferably correlate to one or more megafossil datums to represent a biochronologically more significant level. This is the case with the FO of M. communisti B which equals the traditional ammonoid-defined base of the Norian and which is close to the FO of *Halobia austriaca* (F-B, SB, BT). The communisti B date is also close to a magnetic polarity reversal (top of PM 4r sensu Muttoni et al., 2001) and may therefore be independently approximated by magnetostratigraphy. *M. communisti* B, however seems to have a facies-restricted and palaeogeographically limited distribution. It is presently not known from Pizzo Mondello and may not be found outside the Tethys what would exclude its use as a worldwide correlation tool. The slightly older FO of *M. communisti* is currently not reproducable by any other bioevent. It may correspond to the onset of one or more diagnostic ammonoids of the *Euisculites* Biohorizon but this needs future verification. An advantage of the *communisti* event is its magnetostratigraphic correlation with the base of the top-Carnian reversed polarity interval PM 4r (fig. 5). However, this almost perfect fit may be incidental because of the slow sedimentation rate in the Turkish sections and it needs a confirmation from a detailed resampling of the uncondensed Pizzo Mondello section. The lowering of the C-N boundary towards the *communisti* event as proposed by Orchard et al. (2000) seems therefore premature but this may remain the single alternative for an intercontinental recognition of the boundary by conodonts. The *abneptis* A event is the youngest possible C-N boundary level. Favoured by H. Kozur (pers. comm.), it may be recognized worldwide but it is not unequivocal constrained in the Turkish sections (Fig. 4,5). Another sometimes favoured alternative, the FO of *Norigondella navicula* is clearly undermined by the presented data.

Finally, we summarize below the results presented in our paper:

- The *abneptis* A event is presently not well constrained and the often mentioned *navicula* date is completely inadequat.
- The *communisti* B event can be determined in the Slovakian and Turkish sections which are all thin but not condensed. The biochronological records are similar and no section can be clearly favoured.
- The *communisti* event is found in all discussed sequences but Pizzo Mondello should be clearly preferred because of its expanded sedimentary thickness and of the most detailed magnetostratigraphic record obtained there. However, additional studies are necessary to improve the fossil record from this section before any formal steps may be initiated.
- Classical sections in Feuerkogel (Salzkammergut, Austria) though preparing the base for the ammonoid defined C-N boundary, are useless because they are highly condensed and they do not provide a primary magnetostratigraphic record.
- Chemostratigraphy may provide other constraints, but which are still not available from any of the described section. Stable isotope studies are in progress both from Bolücektasi Tepe and Pizzo Mondello.

Acknowledgments

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References

Budurov, K., and Sudar, M., 1990. Late Triassic conodont stratigraphy. Courier Forschungs-Institut Senckenberg, 118: 203-239.

Catalano, R.. and D’Argenio, B., 1978. An essay of palinspastic restoration across the western Sicily. Geologica Romana, 17, 145-159.

Diener, C., 1906. The Fauna of the Tropites-Limestone of Byans. Paleontologica. Indica, Ser. 15, Mem. 1, 201 p.

Gemmellaro, G. G., 1882. Sul Trias della regione occidentale della Sicilia. Memorii Accademia Lincei, 3, 12: 451-473.

Gemmellaro, G. G., 1904. Cefalopodi del Trias Superiore della regione occidentale della Sicilia. Giornale Scientie Naturale e Econom. Palermo: 21, 319 p.

Gallet, Y., Besse, J., Krystyn, L., Marcoux, J., Théveniaut, H., 1992, Magnetostratigraphy of the late Triassic Bolücektasi Tepe section (southwestern Turkey): implications for changes in magnetic reversal frequency. Physics of the Earth and Planetary Interiors, 93:273-282.

Gallet, Y., Besse, J., Krystyn, L., Theveniaut, H., and Marcoux, J., 1994. Magnetostratigraphy of the Mayerling (Austria) and Erenkolu Mezarlik (Turkey) sections: Improvement of the Carnian (late Triassic) magnetic polarity time scale: Earth Planetary Science Letters, 125: 173-191.

Gallet, Y., Besse, J. Krystyn, L., Marcoux, J., Guex, J., Théveniaut, H., 2000. Magnetostratigraphy of the Kavaalani section (southwestern Turkey): Consequence for the origin of the Antalya Calcareous Nappes (Turkey) and for the Norian (Late Triassic) magnetic polarity timescale. Geophysical Research Letters, 27: 2033-2036.

Jeannet, A., 1959. Ammonites Permiennes et Faunes Triassiques de l’Himalaya Central (Expedition Siusse A. Heim et A. Gansser, 1936). Paleontologica.lndica, New Ser., 34, Mem.1: 168 p.

Korte, C., 1999. ^{87}Sr/^{86}Sr-, ä^{18}0 und ä^{13}C-Evolution des triassischen Meerwassers: Geochemische und stratigraphische Untersuchungen an Conodonten und Brachiopoden. Bochumer geologische und geotechnische Arbeiten, 52: 171 p.

Kozur, H. and Mostler, H., 1973. Die Bedeutung der Conodonten für stratigraphische und paläogeographische Untersuchungen in der Trias. Mitteilungen Gesellschaft der Geologie- und Bergbaustudenten, 212: 777-810.

Kozur, H., 1973: Beiträge zur Stratigraphie und Paläontologie der Trias. Geologisch- Paläontologische Mitteilungen Innsbruck, 3/ 1: 1-30.

Kozur, H., 1980. Revision der Conodontenzonierung der

Mittel- und Obertrias des Tethyalen Faunenreiches. Geologisch-Paläontologische Mitteilungen Innsbruck, 2: 1-20.

Kozur, H., l990. Significance of events in conodont evolution for the Permian and Triassic stratigraphy. Courier Forschungs-Institut Senckenberg, 117: 385-408.

Krystyn, L., 1974: Zur Grenzziehung Karn-Nor mit Ammoniten und Conodonten. Anzeiger der mathematisch-naturwissenschaftlichen Klasse der Österrichischen Akademie der Wissenschaften, 1972, 4, 47-53.

Krystyn, L. 1980. Triassic conodont localities of the Salzkammergut region (northern Calcareous Alps). In H.P. Schönlaub (ed.), Second European Conodont Symposium, Guidebook and Abstracts. Abhandlungen der Geologischen Bundesanstalt, 35: 61-98.

Krystyn, L., 1982. Obertriassische Ammonoideen aus dem Zentralnepalesischen Himalaya. Abhandlungen der Geologischen Bundesanstalt, 36: 63 p.

Krystyn, L. & Schlager, W., 1971. Der Stratotyp desTuval. Annales Instituti Geologici Publici Hungarici, 54/2: 591-606.

Krystyn, L., Schäffer, G. und Schlager, W., 1971: Der Stratotyp des Nor. Annales Institut Geologici Publici Hungarici, 54/2: 607-629.

Krystyn, L., Gallet, Y., Besse, J. and Marcoux, J., in press. Integrated Upper Carnian to Lower Norian biochronology and implications for the Upper Triassic magnetic polarity time scale. Earth and Planetary Science Letter,

Mock, R., 1980: Triassic of the Western Carpathian Mountains. In H.P. Schönlaub (ed.), Second European Conodont Symposium, Guidebook and Abstracts. Abhandlungen der Geologischen Bundesanstalt, 35: 129-147.

Mojsisovics, E. v., 1873-1902. Das Gebirge um Hallstatt: Abhandlungen der Geologischen Reichsanstalt 6/1 (1873), 356 p., (Suppl. Bd.) 1902, 6/2, 835 p.

Mojsisovics, E. von, Waagen, W., and Diener, C., 1895. Entwurf einer Gliederung der pelagischen Sedimente des Triassystems. Sitzungsberichte der Akademie der Wissenschaften Wien, 104: 1271-1302.

Muttoni, G., Kent, D., Di Stephano, P., Gullo, M., Nicora, A., Tait, J., Lowrie, W., 2001, Magnetostratigraphy and biostratigraphy of the Carnian/Norian boundary interval from the Pizzo Mondello section (Sicani Mountains, Sicily). Palaeogeography Palaeoclimatology Palaeoecology, 166: 383-399.

Orchard, M. J., Carter, E. S., Tozer, E. T. 2002. Fossil data and their bearing on defining a Carnian-Norian (Upper Triassic) boundary in Western Canada. Albertiana, 24: 42-43.

Silberling, N.J., 1959. Pre-Tertiary stratigraphy and Upper Triassic paleontology of the Union District, Shoshone Mountains, Nevada: U.S. Geological Survey, Prof. Paper 322.

Tozer, E.T., 1967. A standard for Triassic time: Geologic Survey Canada Bulletin, 156: 103 p.

Vrielynck, B., 1987. Conodontes du Trias perimediterraneen. Systematique, Stratigraphie. Document Laboratoire Geolologie du Lyon: 97, 301p.

Recent Studies on the Lower Triassic of Chaohu, Anhui Province, China

Chinese Lower Triassic Working Group

The Lower Triassic in Chaohu area, Anhui Province, China is well developed and the sequence is typical in South China, yielding rich fossils and relatively complete biostratigraphical sequence. It is one of the classic Lower Triassic sequences in South China and received considerable study in early years.

During the Early Triassic Chaohu was on the same carbonate ramp as Meishan, where the GSSP of the Permian-Triassic boundary is situated, but it was in a deeper part than Meishan. Fossils are abundant throughout the Lower Triassic in Chaohu, including ammonoids, bivalves and conodonts, while rich only at the base of the Triassic in Meishan. Therefore, Chaohu becomes the key area to study the Lower Triassic. During the past year some works have been done in the Lower Triassic of Chaohu and some new data achieved, which properly enhance the study of the Lower Triassic of South China. Here we would provide a brief introduction of the study on the Lower Triassic of Chaohu last year and present some material new data. We will not discuss here these data but provide a reference and ask experts for advice.

1. Research activity

Since the lower part of the classic Majiashan Section in Chaohu is heavily covered due to the composition of predominating argillaceous rocks, it is hardly possible to do further works there. Early time last year we found some better well-exposed Lower Triassic sections in the near north of the Majiashan Section, which were excavated by road-building (see figure 1 in Albertiana 25, p.23). The lower part of the Lower Triassic is best developed at the North Pingdingshan and West Pingdingshan sections on both limbs of the Pingdingshan Syncline, so most of the works last year focused on these sections. A considerable amount of new work has continued this year. The study has been speeded and we went to work there over times only last year. The study focused on the biostratigraphy, especially the conodont and ammonoid biostratigraphic sequences, as well as the carbon and oxygen isotopic stratigraphy, magnetic stratigraphy, lithostratigraphy and sedimentology. Special attention has been paid to the strata from the Permian-Triassic boundary to the lower part of the Olenekian.

A post-symposium field excursion to Chaohu was executed on August 14-15, 2001 after the International Symposium on the Global Stratotype of the Permian-Triassic Boundary and the Paleozoic-Mesozoic Events in Changxing. Ten Permian and Triassic experts including the STS chairman and vice-chairmen attended this excursion to visit mainly the Lower Triassic sequences except for the Permian sequence and the base of the Chinese Permian.

In April 2002 Dr. Yuri Zakharov was invited to Chaohu again to scrutinize the ammonoid biostratigraphy. Based upon the investigation in field and the examination of the collected specimens in door, the horizon of the Induan-Olenekian boundary was concluded, which is quite close to the boundary defined by conodonts. At the West Pingdingshan Section the base of ammonoid *Flemingites* Zone is 30-50cm below the FAD of conodont *Neospathodus waageni*. At the same time Dr. Hans Hansen at the Copenhagen University was invited as well to Chaohu to study magnetostratigraphy as well as organic carbon isotopes.

The studies performed in the Lower Triassic of Chaohu last year include: 1200 conodont samples have been collected and analyzed, including many recollected samples and closer spaced samples, and about 1500 conodont specimens recovered; about 2000 macrofossil specimens have been obtained, mostly ammonoids and bivalves and a few specimens of fish; the inorganic carbon and oxygen isotopes of 246 samples and the organic carbon isotopes of 67 samples have been measured, and about 500 samples have been analyzed for the organic carbon isotopes; 67 samples have been detected for the macroelements and some microelements; and 42 orientated samples have been analyzed for the magnetostratigraphy.

2. Main Lower Triassic sections

The strata from the Permian-Triassic boundary to the Induan-Olenekian boundary are continuously exposed at the North Pingdingshan Section (Fig.1). The topmost of the Permian in this area is the Dalong Formation composed of siliceous rocks and chert beds, which are coeval with the Changxing Formation but in different facies. The stratigraphic sequence at the Permian-Triassic boundary (see Picture 1 in Albertiana 26, p.41, which was misplaced in the report of the field excursion to Guizhou) is clearly coinciding with that at the Meishan Section. The “boundary clay bed” and “boundary limestone” are distinctive in the Permian-Triassic boundary sequence. The repeated conodont works indicate that the FAD of conodont *Neospathodus waageni* is in Bed 45 and the FAD of *N. pakistanensis* is in Bed 43, about 1.5 m below *N. waageni* (The stratigraphic sequence can be seen on Picture 2 in Albertiana 26, p.42). No significant ammonoids have been observed in a few meters of strata above these horizons. The upper part of the section extends into the core of the Pingdingshan syncline and the decollement structure associated with the syncline might have caused the thinning of the middle Olenekian strata.

At the West Pingdingshan Section the Lower Triassic is even better exposed except that about 10m strata at the base of the Lower Triassic is covered by a road to the quarry on the hill side though the Permian-Triassic boundary is observable (Fig.2). The sequence around the Induan-Olenekian boundary, up to the lower part of Spathian, is extremely good for study (see Picture 3 in Albertiana 26, p.42). According to Dr. Zakharov’s observation in field, the Induan-Olenekian boundary defined by ammonoids is at the top part of Bed 24. The repeated conodont analysis shows that the FADs of both *Neospathodus waageni*

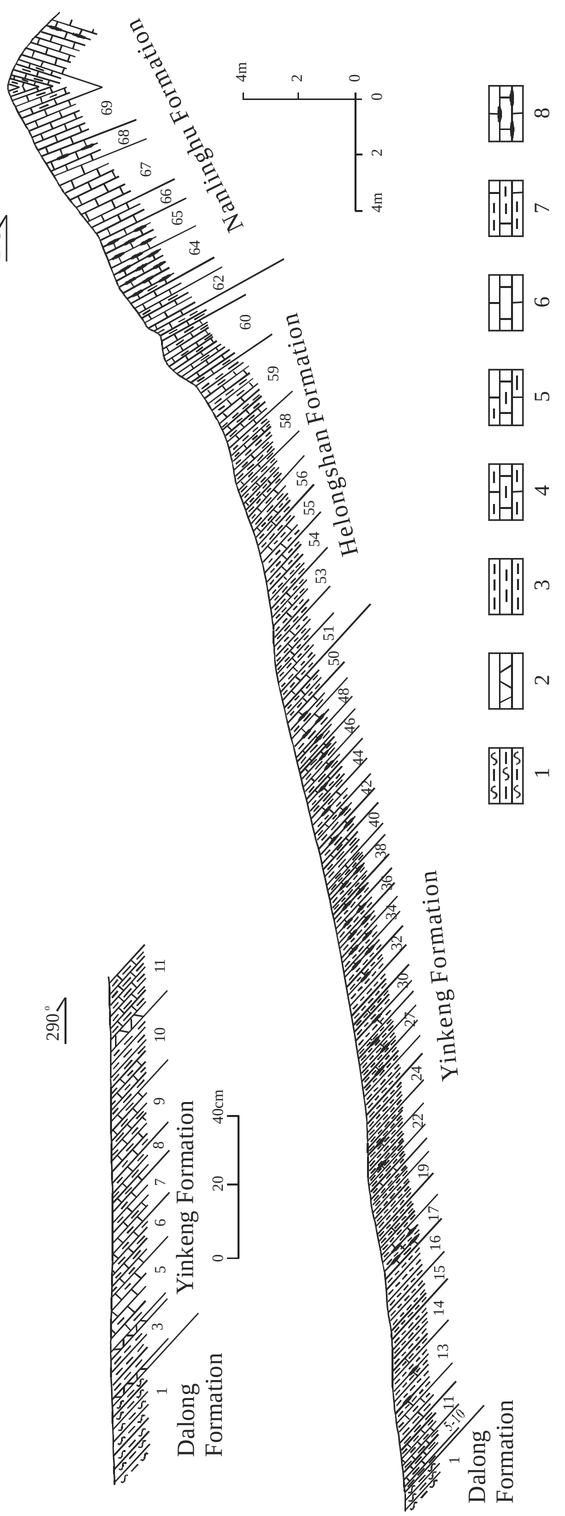

Fig.1 Profile of the Lower Triassic at the North Pingdingshan Section

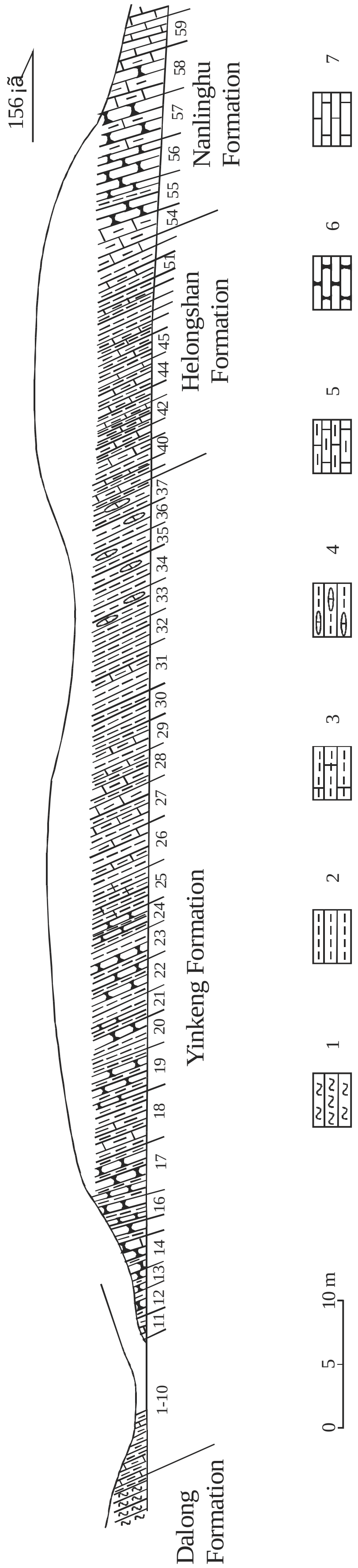

Fig.2 Profile of the Lower Triassic at the West Pingdingshan Section
1. Siliceous mudrock and cherty beds; 2. Mudrock and calcareous mudrock; 3. Alternations of very thin-bedded mudrock and limestone; 4. Mudrock with lenticular limestone; 5. Marl; 6. Nodular limestone; 7. Limestone

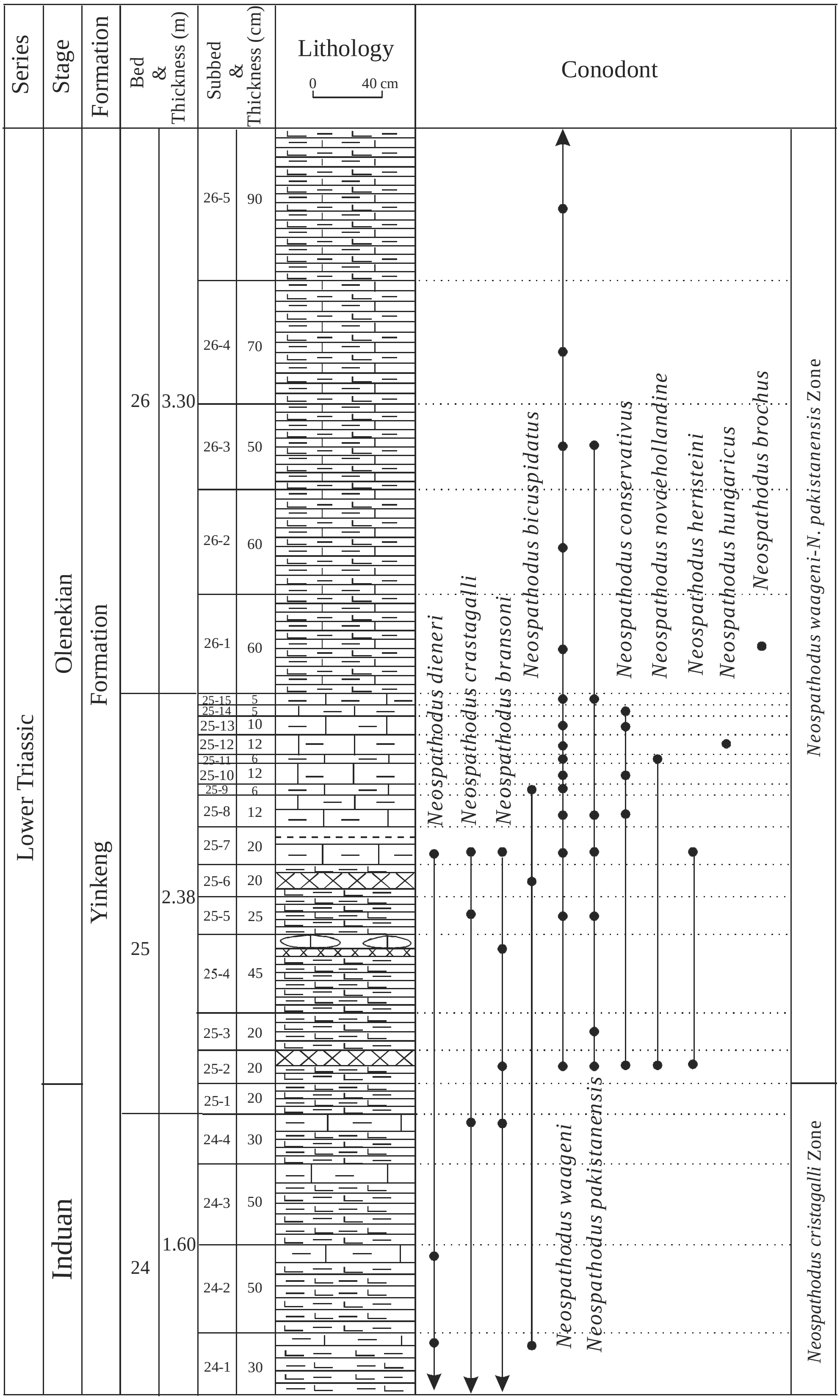

Fig.3 Distribution of some conodonts around the Induan-Olenekian boundary at the West Pingdingshan Section

and *N. pakistanensis* are at 20cm above the base of Bed 25. The upper part of the Lower Triassic at this section is also in the core of the Pingdingshan Syncline but the decollement structure is not evident at the section and the thickness in the lower part of the Olenekian, e.g. the Smithian, is much bigger than that at the North Pingdingshan Section. The whole Olenekian sequence till the lower Anisian is exposed in the Majiashan Hill, about 500m in the south of the West Pingdingshan Section.

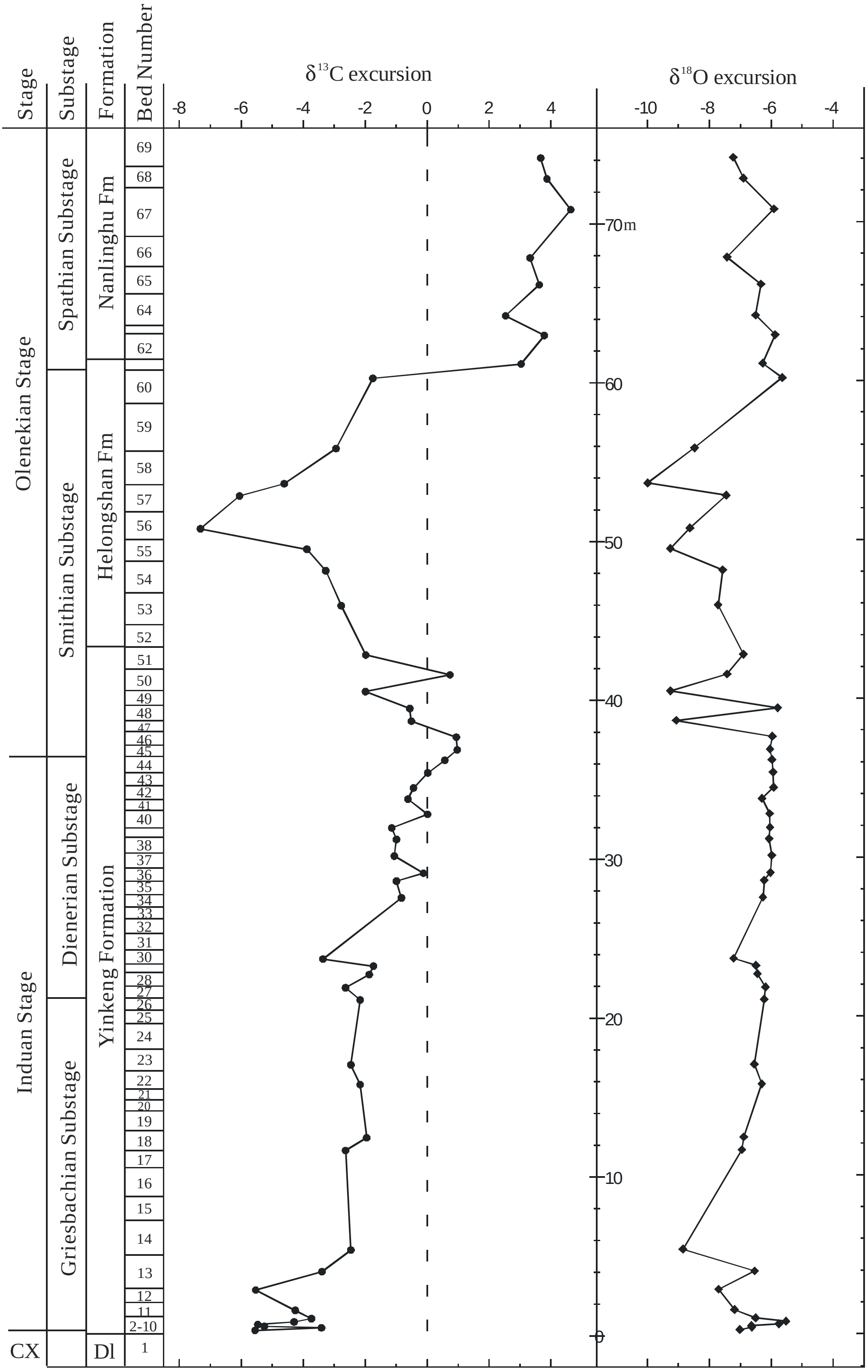

Fig.4 Excursions of inorganic carbon and oxygen isotopes in the Lower Triassic of the North Pingdingshan Section, CX-Changhsingian, DL-Dalong Formation

3. Conodonts around the Induan-Olenekian boundary at the West Pingdingshan Section

Figure 3 shows the distribution of some key conodonts around the Induan-Olenekian boundary at the West Pingdingshan Section based on the conodont analysis and primary identification of samples from the section. The Induan-Olenekian boundary is placed at the base of Bed 25-2, which is the FAD of conodont *Neospathodus waageni*. The first appearance of conodont *Neospathodus*

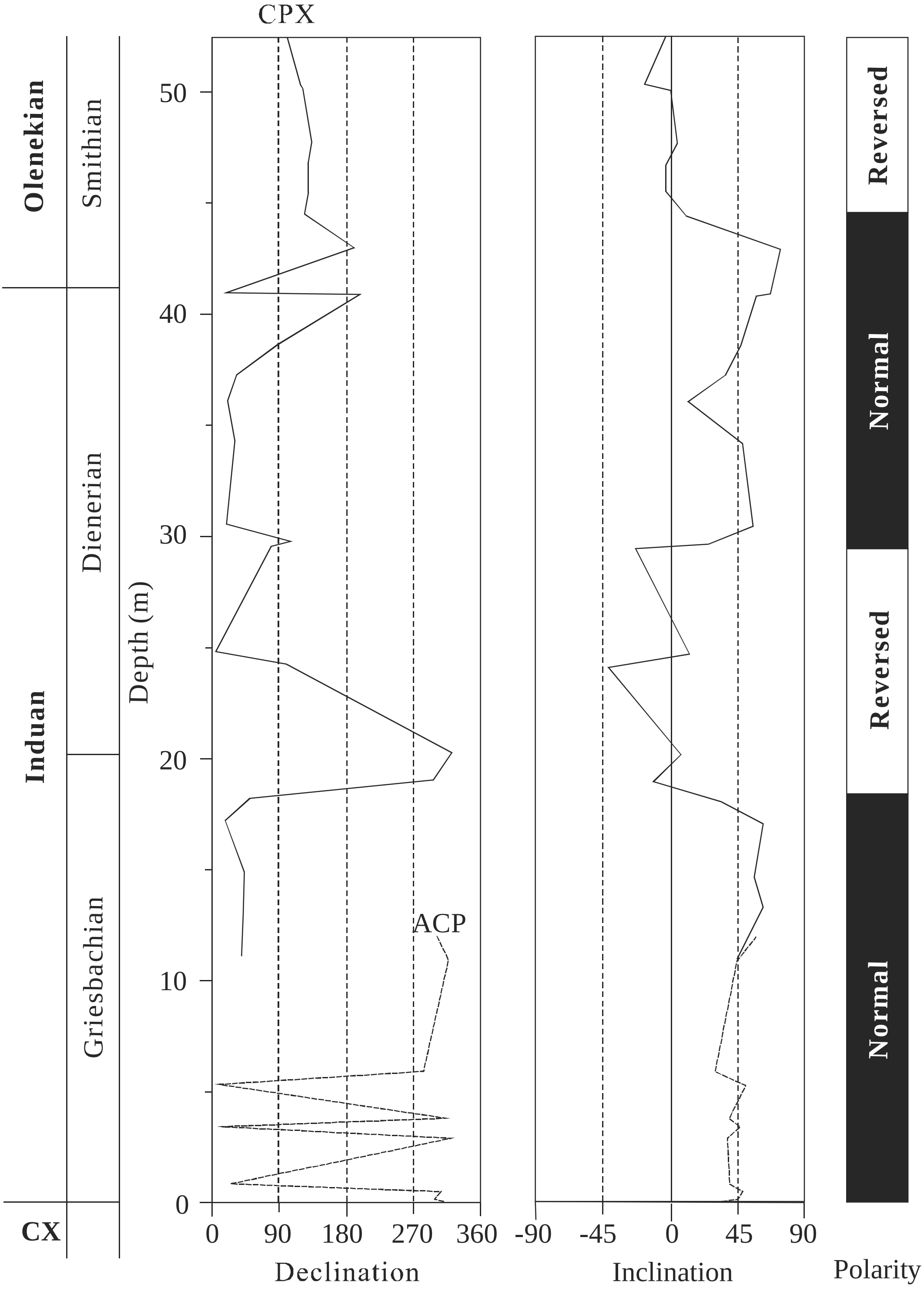

Fig.5 Lower Triassic magnetostratigraphical column in Chaohu
The lower part (ACP) is from the North Pingdingshan Section and the upper (CPX) from the West Pingdingshan Section. CX£-Changhsingian

pakistanensis is also in Bed 25-2. According Dr. Zakharov's investigation at the section in field, the Induan-Olenekian boundary defined by ammonoids is between two limestone beds at the top of Bed 24, i.e. the lower part of Bed 24-4, which is slightly lower than the conodont boundary.

4. Inorganic carbon isotope excursion

Fig.4 plots the excursions of inorganic carbon and oxygen isotopes in 67 samples from the Lower Triassic at the North Pingdingshan Section, which were collected in October 2001. In April 2002 we re-sampled the section and the West Pingdingshan Section was sampled as well for correlation. 180 samples were selected for the analysis of inorganic carbon and oxygen isotopes. The result shows the same excursions as those in Fig.4. The values of carbon isotopes are believed to reflect initial ratios, but the oxygen isotopes should have been fully altered. The excursion of the carbon isotopes is not only crucial in stratigraphy but greatly significant to study the situation of the ecosystems and their evolution during the survival and recovery time following the end-Permian mass extinction.

5. Magnetostratigraphy

With the help of Dr. Hans Hansen at the Copenhagen University, 32 orientated samples collected from the limestone or argillaceous limestone beds interbedded with mudrocks at the North Pingdingshan Section (lower Induan) and the West Pingdingshan Section (middle Induan to lower Olenekian) were analyzed. The result is drawn in Fig.5. The rubble in the breccia limestone at the base of the Middle Triassic provide a particular chance to test the demagnetization. Meanwhile, the studied two sections are on the different limbs of the Pingdingshan Syncline, thus they provide a unique condition to verify the results. As a result, the analysis is reliable. The Induan-Olenekian boundary locates close to the top of the second main normal polarity zone in the Triassic. Unfortunately, as the samples were taken only from the limited limestone beds intercalated in mudrocks, the resolution might be low in some parts at the sections.

In addition, there are some beds of rhyolitic tuff around the Induan-Olenekian boundary, which might be used for the isotope dating. However, the further study is necessary.

Conodonts might be the better index fossils to define the Induan-Olenekian boundary but whether *Neospathodus waageni* or *N. pakistanensis* is selected as the key fossil needs more work. According to the data from Chaohu and the distribution of the conodonts over the world, *Neospathodus waageni* is better for the boundary definition.

Meanwhile, in the scheme of the Chinese chronostratigraphic division the Lower Triassic is divided into two stages. The lower stage, Yinkengian Stage, has its type area in Meishan, where the GSSP of the Permian-Triassic boundary locates, while the upper stage, Chaohuan Stage, is named in Chaohu.

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(Tong Jinnan, Zhao Laishi, Zuo Jingxun)

Report on the Field Excursion to Chaohu, Anhui Province, South China

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A two-day field excursion to Chaohu, Anhui Province was undertaken after the International Symposium on the Global Stratotype of the Permian-Triassic Boundary and the Paleozoic-Mesozoic Events in Changxing, Zhejiang Province on August 10-13. Twelve of the symposium participants took part in this excursion, including the chairman of the STS, Dr. Michael Orchard, the vice-chairman of the STS, Prof. Yin Hongfu (leader of the Permian-Triassic Boundary Working Group), the vice-chairman of the STS, Dr. Yuri Zakharov (leader of the Induan-Olenekian Boundary Working Group), and the secretary-general of the SPS, Dr. Charles Henderson.

Chaohu is a medium-sized city in Anhui Province, 60 km from Hefei, the capital of the province, and is served by railway and freeway. Moreover, it is only 90 km from Chaohu to Nanjing, the capital of the Jiangsu Province. The excursion group drove five hours by bus from Changxing, where the GSSP of the Permian-Triassic Boundary is located, to Chaohu. Five stops were scheduled to visit the Permian and Triassic sequences in the suburbs of Chaohu City, with emphasis on the Lower Triassic.

At the first stop the Carboniferous and Permian boundary sequence was examined. Here the difference between the global and the traditional Chinese Carboniferous-Permian boundaries were noted and the Lower and Middle Permian lithostratigraphic sequence was viewed. In most parts of South China, including Chaohu, the rocks from the Upper Carboniferous to the Middle Permian are mainly composed of carbonate sediments except that the lowest part of the Qixia Formation is a thin member of clastic rocks, the so-called “Liangshan Coal-Series”, usually less than one meter in thickness. An unconformity exists at the base of the “Liangshan Coal-Series”, thus the traditional Chinese Carboniferous-Permian boundary is placed there. But the global Carboniferous-Permian boundary is roughly at the base of the Chuanshan Formation or moderately higher according to the fusulinid correlation to the GSSP of the Carboniferous-Permian Boundary. It is located within a uniform carbonate sequence without a distinctive lithostratigraphic indicator perceptible in the field. The five members of the Qixia Formation above the “Liangshan Coal-Series” were observed in a mining quarry but the overlying cherty beds of the Gufeng Formation and the sandstones of the Yinping Formation were inspected only in some isolated outcrops.

The other four stops (four sections) focused on the Upper

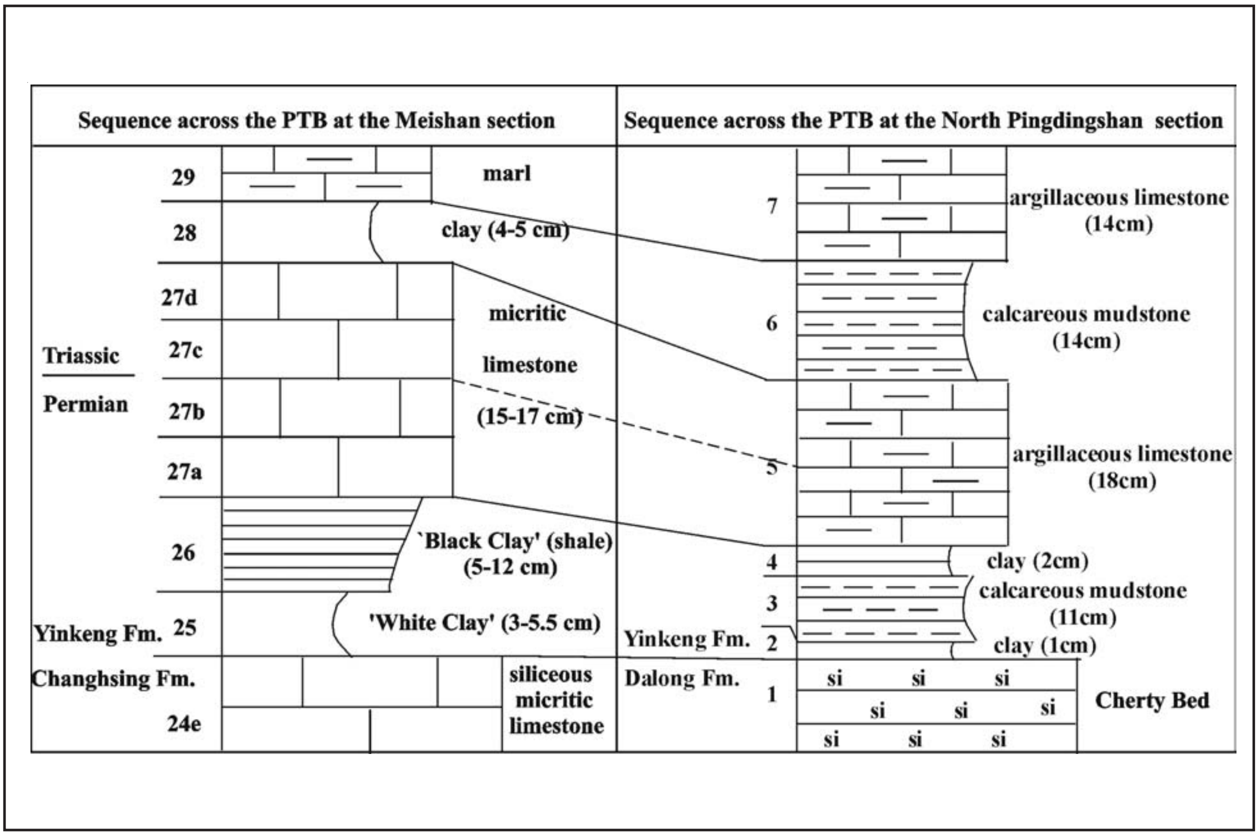

Figure 1 Correlation of the Permian-Triassic boundary sequences between the Chaohu and Meishan sections

Picture 1 The Permian-Triassic boundary at Stop 2 (North Pingdingshan Section)

Permian and Lower Triassic with emphasis on some key boundaries, i.e. the Permian-Triassic boundary, the Induan-Olenekian boundary and the Lower-Middle Triassic boundary. The sequences were well exposed by some local highways. Stop 2 and Stop 3 are on the flanks of the Pingdingshan Hill, where the whole sequence from the Upper Permian to the middle Lower Triassic was investigated. The two stops have similar sequences as they are on the different limbs of the Pingdingshan syncline. The Upper Permian includes the Longtan Formation of coal-bearing clastic rocks and the Dalong Formation of siliceous and argillaceous rocks, which is the same age as the Changxing Formation (limestone) but in different facies. The Lower Triassic consists of three formations: Yinkeng Formation, Helongshan Formation and Nanlinghu Formation. The Yinkeng and Helongshan formations are dominated by mudrocks while the Nanlinghu Formation is mostly carbonate rocks. However, in the Pingdingshan Hill the Nanlinghu Formation is in the core of the syncline so that only the lower part occurs here.

At the Permian-Triassic boundary a stratigraphic set comparable with that in the Meishan section (Figure 1 and Picture 1) was observed and discussed. Though no *Hindeodus parvus* has been found in the Chaohu sections so far, other fossils around the boundary roughly confirm the position of the boundary. The rich Permian brachiopod *Waagenites* spp. and ammonoid *Pseudotirolites* sp. and *Hunnanoceras* sp. occur immediately below the lower claybed while the Triassic bivalve *Claraia* spp. and ammonoid *Ophiceras* sp. are collected right above the upper claybed. However, it is observed at the North Pingdingshan section that a few cherty beds at the top of the Dalong Formation seem to be cut off beneath the overlying claybed. Therefore, there was a suggestion that an unconformity might exist between the Dalong and Yinkeng formations. According to the regional paleogeography and the depositional and paleoecologic changes across the boundary, it is believed that there is no significant gap at the boundary and the disconnected beds might be caused by the post-diagenetic tectonic movement.

The Induan-Olenekian boundary caught particular attention and discussion. The lower part of the Lower Triassic is quite rich in bivalve and ammonoid fossils at the viewed sections. Some index ammonoids were collected in the sections, e.g. *Ophiceras* spp., *Lytophiceras* sp., *Prionolobus* sp., *Dineroceras* sp., *Flemingites* spp., *Euflemingites* sp., *Anasibirites* sp., *Meekoceras* sp., *Subcolumbites* sp., *Xenodiscoides* sp. and others. All are the typical Tethyan forms, entirely different from the Boreal elements in the Siberia; unfortunately, no basal Smithian *Hedenstroemia* are seen here. Conodonts do occur in these sections and the Induan-Olenekian boundary is marked by both *Neospathodus waageni* and *Flemingites*. The FAD of *N. waageni* is about 42m above

Picture 2 The Stratigraphic sequence around the Induan-Olenekian boundary (and sequence surface) at Stop 2 (North Pingdingshan Section)

the Permian-Triassic boundary. The Induan, as defined by the conodonts, is composed of multiple cycles of mudrock and limestone (or marl) with a dominance of mudrocks. It is regarded as condensed due to its much thinner development than the overlying Olenekian, which is about 200m thick. In terms of sequence stratigraphy, the Induan-Olenekian boundary is located close to a sequence boundary with a considerable increase of limestones (Picture 2 and 3), comparable with that observed in the North America.

The lower part of the Olenekian is the interval of the richest fossils in the sections, including bivalves, ammonoids as well as conodonts, and even fishes and trace fossils. It consists of the apparent cycles of thin- to medium-bedded mudrocks and limestones, including the upper Yinkeng Formation and Helongshan Formation in lithostratigraphy. It is well exposed in the Pingdingshan Hill but the complete Olenekian sequence is situated in the Majiashan Hill, where Stop 4 and Stop 5 were scheduled.

In the Majiashan sections (Stop 4 and Stop 5) the Helongshan and Nanlinghu formations were closely examined on the roadsides and quarries. The Helongshan Formation has more limestone beds, usually forming nodular limestones or zebra limestones with thin-bedded mudrocks, than the Yinking Formation while the Nanlinghu Formation is mainly composed of limestones with some thin intercalated beds of calcareous mudrock. The locality yielding the amphibians such as *Chaohusaurus* spp. was reviewed although, unfortunately, no vertebrate fossils were seen there during the excursion. Fossils are quite rare in the uppermost part of the Triassic sequences as the rocks become dolomitized or dominated by dolomite or evaporites. The Lower and Middle Triassic boundary is commonly placed between the Nanlinghu and Domaanshan formations according to the fossil data from neighboring areas. The boundary between the two lithostratigraphic units is evident as the rocks in the uppermost Nanlinghu Formation are bedded relatively thinner, medium- to thick-bedded, colored darker and chiefly limestones while the strata of the Dongmaanshan Formation are mostly grayish massive dolomites and evaporite-solution breccia.

It is believed that the Lower Triassic of Chaohu is quite suitable as a candidate for the GSSP of the Induan-Olenekian boundary, because: (1) the Lower Triassic sections have a good geographic condition with excellent

Picture 3 The Stratigraphic sequence around the Induan-Olenekian boundaryat Stop 3 (West Pingdingshan Section)

access and good stratigraphic exposure on the roadsides. The sections are in the suburb of the Chaohu City, only 3km from downtown. (2) the Lower Triassic of Chaohu has abundant fossils. Most of the crucial ammonoids and conodonts have been collected so that the boundary could be clearly defined and correlated. In the meantime, the sections yield rich bivalves and some vertebrates and they are important sites producing rare fossils of reptiles. (3) the Lower Triassic sequence of Chaohu is complete. The sedimentary sequences are highly suited to sequence stratigraphic analysis and correlation with those of the North America. The cyclic sediments are also propitious to the high-resolution cyclostratigraphic study.

Further in-depth works are planned for the Chaohu sections, especially in conodont and ammonoid biostratigraphy and magnetostratigraphy. The Chinese colleagues are anxious to have collaborations with world experts in order to present a section as a potential GSSP for the Induan-Olenekian boundary.

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The *Hyperodapedon* Biochron, Late Triassic of Pangea

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Globally, occurrences of the rhynchosaur *Hyperodapedon* define a *Hyperodapedon* biochron of late to latest Carnian (Otischalkian-Adamanian) age for strata in North America, Scotland, India, Zimbabwe, Tanzania, Madagascar, Argentina, and Brazil. The biochronological resolution provided by *Hyperodapedon* occurrences is coarser than that achieved using other taxa, principally phytosaurs and aetosaurs, but helps to correlate basins in which these other taxa are rare or absent.

Introduction

Rhynchosaurs are an order of primitive archosauromorph reptiles with an Upper Triassic fossil record from all modern continents except Antarctica and Australia (Hunt & Lucas, 1991a). Hunt & Lucas (1991a) last reviewed the global record of Late Triassic rhynchosaurs and placed them in a biochronological framework. However, in the decade that has passed since their article, new discoveries and taxonomic revisions have greatly altered our understanding of Late Triassic rhynchosaur distribution and taxonomy. Particularly important is recognition of the wide distribution of *Hyperodapedon* Huxley, based primarily on a revision of some South American and Malagasy rhynchosaurs (Contreras, 1999; Langer & Schultz, 2000; Langer et al., 2000a, b). Furthermore, a rhynchosaur recently documented from the Upper Triassic Popo Agie Formation of Wyoming has been assigned to *Hyperodapedon* (Lucas et al., 2002). Here, we define a Pangean *Hyperodapedon* biochron of Otischalkian-Adamanian (late Carnian) age.

The *Hyperodapedon* Biochron

When Hunt & Lucas (1991a) presented the last review of the distribution of Late Triassic rhynchosaurs, they only recognized two records of *Hyperodapedon*—the type locality in the Lossiemouth Sandstone Formation of Scotland and occurrences in the Maleri Formation of India. The Popo Agie Formation record of *Hyperodapedon* reported by Lucas et al. (2002), a record from Zimbabwe (Raath et al., 1992), and taxonomic revisions (Contreras, 1999; Langer & Schultz, 2000; Langer et al., 2000a, b) have resulted in a much broader geographic distribution of *Hyperodapedon* (Fig. 1). The stratigraphic distribution of *Hyperodapedon* is restricted to rocks of Otischalkian and Adamanian (late Carnian) age, and this establishes a *Hyperodapedon* biochron of that age (Fig. 2). Here, we review the geographic and temporal distribution of *Hyperodapedon*.

Wyoming

Lucas et al. (2002) documented a specimen of *Hyperodapedon* from the lower part of the Popo Agie Formation of the Chinle Group in Natrona County, Wyoming. The Popo Agie Formation is the stratigraphically lowest Upper Triassic unit throughout its outcrop belt in Wyoming, Idaho, Colorado, and Utah (Branson, 1927; Lucas, 1993). The most age-diagnostic fossils from the Popo Agie Formation are the tetrapod assemblage collected near Lander, Wyoming by E.B. Branson and M.G. Mehl (e.g., Mehl, 1913, 1915a,b, 1928; Branson, 1915, Branson & Mehl, 1928, 1929). This assemblage includes the phytosaurs *Paleorhinus* and *Angistorhinus* and the metoposaur *Buettneria* (taxonomy follows Hunt, 1993, 1994; Long and Murry, 1995) as well as rarer rauisuchians, including *Poposaurus gracilis* Mehl and *Heptasuchus clarkei* Dawley et al. (Mehl, 1915b, Dawley et al., 1979; Lucas, 1993, 1994, 1997; Long & Murry, 1995). *Paleorhinus* is an index taxon of the Otischalkian (late Carnian) land-vertebrate faunachron (lvf) and thus demonstrates that the Popo Agie Formation, and this occurrence of *Hyperodapedon*, are of late Carnian (Otischalkian) age.

Nova Scotia

In the Fundy basin of Nova Scotia, the middle part of the Wolfville Formation yields a tetrapod assemblage that was summarized by Baird & Olsen (1983) and Olsen (1988, 1989). Baird (1964), Hopson (1984), Sues (1992) and Hunt (1993) have described some elements of this assemblage, which includes the temnospondyl amphibian *Metoposaurus*, an index taxon of the Otischalkian lvf. The rhynchosaur from this assemblage has been assigned to *Scaphonyx* (Hunt & Lucas, 1991a), and is now referred to *Hyperodapedon* (Langer et al., 2000a; M. Langer, written commun., 2002). The Nova Scotia *Hyperodapedon* is thus part of a tetrapod assemblage of Otischalkian age (Huber et al., 1993).

Scotland

The tetrapod assemblage of the Lossiemouth Sandstone Formation of Grampian (Elgin) Scotland comes from small quarry workings and the coastal section at Lossiemouth. Benton & Spencer (1995, p. 62-72) provided a detailed summary and indicate that all sites come from a narrow stratigraphic range, so we treat the vertebrates as a single biostratigraphic assemblage. This assemblage includes: the procolophonid *Leptopleuron lacertinum*, the sphenodont *Brachyrhinodon taylori*, the rhynchosaur *Hyperodapedon gordoni*, the aetosaur *Stagonolepis robertsoni*, the ornithosuchid *Ornithosuchus longidens* (= *O. woodwardi*: Walker, 1964), the ornithodirans *Erpetosuchus granti* and *Scleromochlus taylori* and the dinosaur *Saltopus elginensis* (Benton & Spencer, 1995 and references cited therein). The pres-

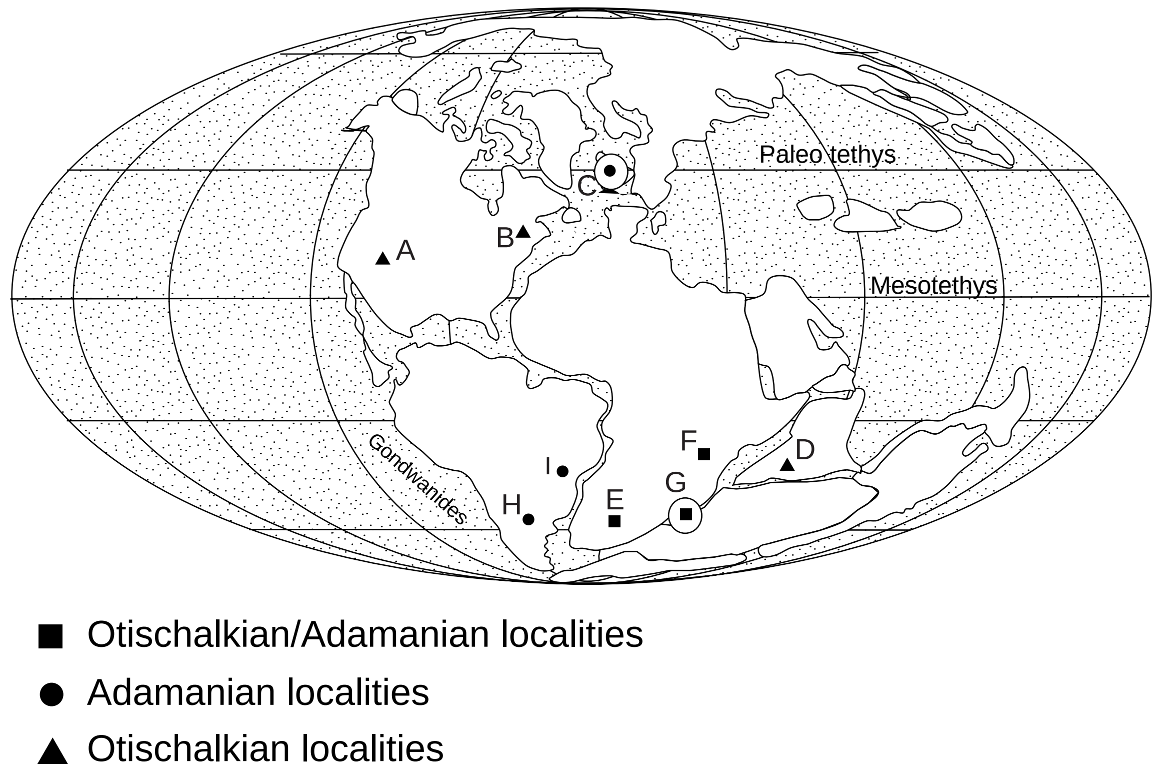

Figure 1: Map of Late Triassic Pangea showing Hyperodapedon localities. A = Popo Agie Formation, Wyoming, U.S.A.; B = Wolfville Formation, Nova Scotia, Canada; C = Lossiemouth Sandstone, Scotland; D = Maleri Formation, India; E = Pebbly Arkose Formation, Zimbabwe; F= un-named strata, Tanzania; G = "Isalo II beds," Madagascar; H = Ischigualasto Formation, Argentina; I = Santa Maria and Caturrita formations, Brazil.

ence of *Stagonolepis* supports correlation of this assemblage to the Chinle Group Adamanian, and therefore it is of late Carnian age.

India

In the Pranhita-Godawari Valley of south-central India, the Maleri Formation is up to 330 m thick and consists mostly of red-bed mudstones, siltstones and sandstones. There are two vertebrate fossil assemblages—lower and upper—in the Maleri Formation (e.g., Kutty & Sengupta, 1987; Kutty et al., 1987).

The lower assemblage is from the basal Maleri and includes the lungfishes *Ceratodus hislopianus* and *C. virapa*, the elasmobranch *Xenacanthus indicus*, a "holostean" fish, the temnospondyl *Buettneria perfecta*, the rhynchosaur *Hyperodapedon huxleyi*, the phytosaur *Paleorhinus* (=*Parasuchus*) *hislopi*, the protorosaur *Malerisaurus*, an aetosaur, the theropod dinosaur *Alwalkeria maleriensis*, a prosauropod ("cf. *Massospondylus*" of Kutty and Sengupta, 1987), a large dicynodont, and the cynodont *Exeraetodon statisticae* (e.g., Miall, 1878; Huene, 1940; Roy Chowdhury, 1965; Chatterjee, 1967, 1974, 1978, 1980b, 1982, 1987; Chatterjee & Roy-Chowdhury, 1974; Chatterjee & Majumdar, 1987; Jain, 1980, 1990; Jain & Roy-Chowdhury, 1987). This is the only well-described assemblage from the Pranhita-Godavari Valley. It includes *Paleorhinus*, an index taxon of late Carnian strata (especially Otischalkian age strata of the Chinle Group) and is securely assigned a late Carnian age.

Zimbabwe

Raath et al. (1992) documented specimens of *Hyperodapedon* from the "Pebbly Arkose Formation" at Dande in the western Cabora Bass basin of the Lower Zambezi Valley. These specimens were associated with fragmentary dinosaur bones and a *Dicroidium* paleoflora, which led Raath et al. (1992) to assign them a Late Triassic age. Raath (1996) considered the Pebbly Arkose Formation a distal facies of, and thus stratigraphically equivalent to, the Molteno Formation. Although many workers interpret the age of the Molteno Formation differently (see Anderson et al., 1998), most lithologic and biostratigraphic evidence supports a late Carnian age for the Molteno Formation (Hancox, 1998; Lucas & Hancox, 2001). Based on the temporal range of *Hyperodapedon* elsewhere, we would assign the Zimbabwe *Hyperodapedon* occurrence a late Carnian (Otischalkian-Adamanian age) (Fig. 2).

Tanzania

Boonstra (1953) named two new species of rhynchosaur,

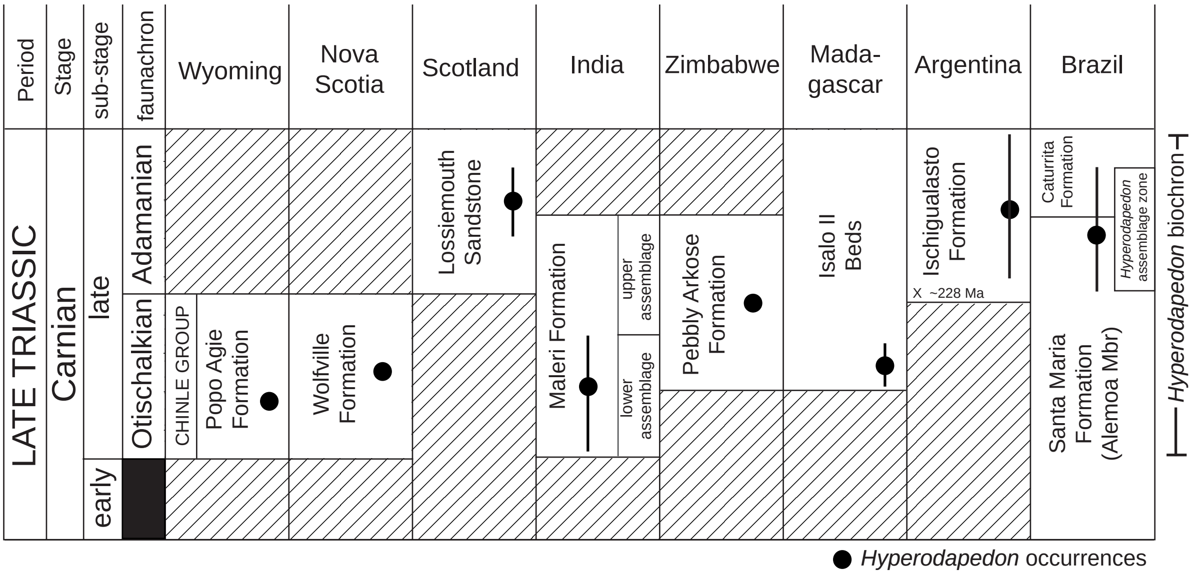

Figure 2: Global correlation of Hyperodapedon localities. The Tanzanian record is not included for lack of stratigraphic data.

Scaphonyx stockleyi and *S. africanus*, from un-named Triassic strata in the Tunduru district of Tanzania. Chatterjee (1980a) erected the genus *Supradapedon* for *S. stockleyi*. However, as Benton (1983) and Hunt & Lucas (1991b) concluded, *Supradapedon* is most likely a large *Hyperodapedon*, though they only referred it to Hyperodapedontinae indeterminate. Langer et al. (2000b), however, assign it to *Hyperodapedon*. Furthermore, *S. africanus*, based on a femur fragment, is best regarded as a *nomen dubium* (Hunt & Lucas, 1991b). The Tanzanian *Hyperodapedon* record is presumably of Otischalkian or Adamanian age, but no stratigraphic data or other vertebrate fossil association is known for this record.

Madagascar

In western Madagascar, Besarie (1930; also see Besarie & Collignon, 1960, 1971) coined the term Isalo Group (“Groupe d l’Isalo”) and divided it into informal units with numerical designations (in ascending order, Isalo I, Isalo II, Isalo III) based on perceived age. The Isalo II strata are as much as 2000 m thick and dominantly red-bed sandstones of fluvial origin (e.g., Besarie & Collignon, 1971; Wescott & Diggens, 1998; Piqué et al., 1999)

“Early” collections from the nonmarine portion of the Isalo II beds consisted of fragmentary Late Triassic vertebrate fossils: osteoderms of phytosaurs (Guth, 1963; Westphal, 1970), metoposaur fragments (Dutuit, 1978), and lungfish toothplates assigned to *Ceratodus acutus* and *C. hislopianus* (Martin, 1981). As noted above, *C. hislopianus* also is known in the upper Carnian Maleri Formation of India (Martin, 1981).

The rhynchosaur *Isalorhynchus genovefae* Buffetaut (Buffetaut, 1983; Hunt & Lucas, 1991a), reassigned to *Hyperodapedon* by Langer et al. (2000a), comes from the base of the Isalo II along the Malio River in the Morondava basin of west-central Madagascar. Subsequently collected Madagascan specimens of *Hyperodapedon* apparently are from the same stratigraphic level along the Malio River (Langer et al., 2000a). These *Hyperodapedon* records thus suggest that the Isalo II base is no older than Otischalkian (late Carnian), which is consistent with palynological age determinations of the unit (Razafimbelo, 1987). Furthermore, it has long been recognized that the Isalo Group is correlative to the Stormberg Group of South Africa: both represent pericratonic deposits that postdate a significant tectonic pulse in the rifting of eastern and southern Africa (e.g., Boast & Nairn, 1982; Wopfner, 1994). The oldest age of the Stormberg Group is late Carnian (e.g., Lucas & Hancox, 2001), so a consistent correlation of tectonic, palynostratigraphic and vertebrate biochronologic data indicates a late Carnian age for the Isalo Group base.

Indeed, Burmeister (2000) has recently described a vertebrate fossil assemblage from stratigraphically high in the Isalo II west of Malaimbandy in the central Morondava basin that includes acrodontid, semionotid and colobodontid fish, the characteristically Otischalkian-Adamanian aetosaur *Desmatosuchus haplocerus*, phytosaur, poposaur, postosuchid and theropod fossils. Although Burmeister (2000) suggested a possible Norian age for this assemblage, the *Desmatosuchus* fossils indicate it is more likely late Carnian.

Flynn et al. (1999, 2000) have reported a vertebrate fossil assemblage from near Sakaraha in the Morondava basin that includes sphenodontids, rhynchosaurs, cynodonts, dicynodonts and prosauropod dinosaurs. This assemblage is near the base of the Isalo II (it is estimated to be about 1200 m lower than the assemblage described by

Burmeister) but is evidently either at the same approximate stratigraphic level or stratigraphically above the *Hyperodapedon* records documented by Buffetaut (1983) and Langer et al. (2000a). Despite this, Flynn et al. (1999, 2000) suggest this assemblage may be as old as Ladinian, though they base this on their ideas about the evolutionary grade of some of the fossils, not on index fossils. Instead, we assign all of the Isalo II tetrapod assemblages a late Carnian (Otischalkian-Adamanian) age and consider that *Hyperodapedon* records in Madagascar place a maximum age of Otischalkian on the Isalo II beds (Fig. 2).

Argentina

In the Ischigualasto-Villa Unión basin, the Ischigualasto Formation is 500 to 900 m thick and consists of drab mudstones, tuffs and sandstones that produce an extensive tetrapod assemblage including: the temnospondyl *Promastodonsaurus*; the chiniquodontid cynodont *Chiniquodon*, the gomphodont cynodonts *Exaraetodon*, *Proexaraetodon*, and *Ischignathus*; the dicynodont *Ischigualastia*, the pseudosuchians *Saurosuchus* and *Proterochampsa*, the rauisuchian *Saurosuchus*, the aetosaur *Stagonolepis* (=*Aetosauroides*), the rhynchosaur *Hyperodapedon* (formerly *Scaphonyx)*; the poposaurid *Sillosuchus* and the dinosaurs *Herrerasaurus* (=*Ischisaurus*, =*Frenguellisaurus*), *Eoraptor*, and *Pisanosaurus* (e.g., Cabrera, 1944; Reig, 1959, 1961, 1963; Casamiquela, 1960, 1962; Cox, 1965; Bonaparte, 1976; Rogers et al., 1993; Sereno et al., 1993; Alcober & Parrish, 1997). The assemblage slightly and mostly overlies the Herr Toba bentonite that yielded an ^{40}Ar/^{39}Ar age of 227.8 ± 0.3 Ma (Rogers et al., 1993).

Romer (1960, 1962a, b) and Reig (1961, 1963) assigned the Ischigualasto tetrapods a Middle Triassic (Ladinian) age. This well fitted the concept—developed and best articulated by Romer—that Middle Triassic tetrapod assemblages had numerous gomphodont cynodonts and an "explosive development" of rhynchosaurs. However, Bonaparte (1966, 1967), noting that rhynchosaurs co-occur with phytosaurs and aetosaurs in the Upper Triassic of Europe and India, assigned a Carnian age to the Ischigualasto vertebrate assemblage.

Subsequent workers have accepted the Carnian age assignment but have correlated the Ischigualasto tetrapods as early or "middle" Carnian, arguing that they predate late Carnian assemblages such as the basal Chinle or lower Maleri. Therefore, according to common practice, the dinosaur fossils from the Ischigualasto Formation are often considered to be the oldest known (e.g., Benton, 1990; Rogers et al., 1993; Novas, 1996).

Hunt & Lucas (1991a, b), Lucas et al. (1992) and Lucas & Hunt (1993) challenged this practice, arguing that the Ischigualasto Formation is of late Carnian age based on: (1) postcrania identified as cf. *Ischigualastia* sp. from Adamanian-aged strata of the Chinle Group, suggesting an Adamanian-Ischigualastian correlation; (2) the presence of *Staurikosaurus*-like dinosaurs in the Adamanian interval of the Chinle Group; and (3) the presence of rhynchosaurs in late Carnian strata of the Chinle Group, Newark Supergroup, Lossiemouth Sandstone Formation and Maleri Formation. Although rhynchosaurs are not abundant in these strata, their presence refutes Romer's assertion that rhynchosaurs indicate a Middle Triassic age.

None of these arguments are incontrovertible evidence for a late Carnian age of the Ischigualasto tetrapods. However, recent revision of the South American aetosaurs by Heckert & Lucas (1996, 2002) indicates that *Aetosauroides* from Argentina (and Brazil) is a subjective junior synonym of the Adamanian index fossil *Stagonolepis*. Furthermore, recognition of *Hyperodapedon* in the Ischigualasto Formation (Contreras, 1999) supports this correlation as well. This secures an Adamanian correlation of the Ischigualasto tetrapods, which are thus clearly of latest Carnian age. We note also that ongoing refinement of the Triassic timescale suggests that 227.8 Ma is a late Carnian age (e.g., Kent et al., 1995), not the early or "middle" Carnian age suggested by the less precise Triassic timescales utilized by Rogers et al. (1993).

Brazil

The Upper Triassic vertebrate assemblage from the upper part of the Alemoa Member of the Santa Maria Formation is mostly from the vicinity of Santa Maria City in Rio Grande do Sul, southern Brazil. This is the Rhynchocephalia Assemblage Zone of Barberena (1977) or the *Scaphonyx* Zone of Barberena et al. (1985). As the rhynchosaurs in this assemblage are dominantly *Hyperodapedon*, not *Scaphonyx* (Langer & Schultz, 2000), Lucas (2002) renamed the zone the *Hyperodapedon* Assemblage Zone.

The *Hyperodapedon* Assemblage Zone in the Alemoa Member includes abundant fossils of the rhynchosaur *Hyperodapedon* (formerly *Scaphonyx*); a few specimens of the aetosaur *Stagonolepis* (formerly *Aetosauroides*); traversodontids and other cynodonts, including *Charrudon*, *Therioherpeton* and *Gomphodontosuchus*; the proterochampsids *Cerritosaurus binsfeldi*, *Rhadinosuchus gracilis*, and *Hoplitosuchus raui*; and the archetypal rauisuchian *Rauisuchus tiradentes.* Alemoa Member dinosaurs are the theropod *Staurikosaurus pricei* Colbert, 1970, the prosauropod *Saturnalia tupiniquim* Langer et al. 1999 (also see Kellner & Campos, 2000), and the theropod *Teyuwasu barberenai* Kischlat, 1999.

In this assemblage zone most, if not all, of the rhynchosaurs, long referred to *Scaphony*x, are now assigned to *Hyperodapedon*, (Hunt & Lucas, 1991a; Langer & Schultz, 2000; Langer et al., 2000b). The aetosaur *Stagonolepis* is also of well documented Adamanian age in the USA and Europe and is abundant in the Ischigualasto Formation in Argentina (Lucas & Heckert, 2001; Heckert & Lucas, 2002). Clearly, the presence of *Hyperodapedon* and *Stagonolepis* supports correlation of the *Hyperodapedon* Assemblage Zone of the Santa Maria Formation with the vertebrates of the Ischigualasto Formation in Argentina, and therefore an Ischigualastian (Adamanian) age assignment (Lucas, 1998; Lucas & Heckert, 2001).

The tetrapod assemblage from the Caturrita Formation, which overlies the Santa Maria Formation, includes a sphenodont skull and postcrania, the proterochampsid *Proterochampsa nodosa*, archosaur teeth, phytosaur teeth and jaw fragments, the cynodonts *Riograndia* and *Exaeretodon*, the rhynchosaur *Hyperodapedon*, the dicynodont *Ischigualastia* (= *Jachaleria candeleriensis* Araújo and Gonzaga) and a supposed *Erythrotherium*-like mammalian mandible fragment (Araújo & Gonzaga, 1980; Barberena et al., 1985; Dornelles, 1990; Ferigolo, 1999; Bonaparte et al., 1999; Faccini et al., 2000; Bonaparte et al., 2001). Caturrita Formation dinosaurs are the theropod? *Guaibasaurus candelarai* Bonaparte et al. 1999 and a new, undescribed prosauropod (Azevedo, 1993; Azevedo et al., 1990, 1999). Lucas & Wild (1995) suggested that the skull assigned to *Jachaleria* belongs to *Ischigualastia*, and we maintain this conclusion, having now studied the Brazilian material firsthand.

The Caturrita assemblage thus shares index taxa with the Ischigualasto Formation of Argentina (*Ischigualastia*, *Exaeretodon* and *Hyperodapedon*), so we also assign it an Ischigualastian age. We therefore reject correlations, such as Bonaparte (1982), Barberena et al. (1985) and Schultz et al. (2000), that indicate that at least part of the Caturrita Formation is younger than the Ischigualastian. All Late Triassic tetrapods known from Brazil are of Ischigualastian (Adamanian) age (Fig. 2).

Certainly, the Caturrita Formation tetrapods are stratigraphically above those from the upper part of the Alemoa Member of the Santa Maria Formation. However, the two assemblages are not, at present, biochronologically separable. Thus, both are of Ischigualastian age, and we include both in the *Hyperodapedon* Assemblage Zone (Fig. 4). More collecting and study of Caturrita Formation tetrapods are needed to provide a basis for recognizing them as a biochronologically distinct assemblage. Using the correlations and biochronology documented here, all Brazilian occurrences of *Hyperodapedon* are of latest Carnian (Adamanian) age.

Conclusions

Clearly, ongoing work has greatly increased our knowledge of Upper Triassic rhynchosaurs since Hunt & Lucas (1991a) last reviewed their fossil record. Particularly significant are new occurrences from North America (Lucas et al., 2002), South Africa (Raath et al., 1992) and the taxonomic revisions of Langer & Schultz (2000) and Langer et al. (2000a, b). The result is a much more unified understanding of the distribution of Upper Triassic rhynchosaurs in general and *Hyperodapedon* in particular. Presently, the *Hyperodapedon* biochron delineates a substantial interval of time (Otischalkian-Adamanian), as opposed to the finer resolution achieved with, for example, genera of phytosaurs or aetosaurs, many of which are restricted to a single lvf. Still, the *Hyperodapedon* biochron is exceptionally useful, as *Hyperodapedon* appears to be one of the most widely distributed (Pangean) Upper Triassic tetrapods, and thus facilitates correlations in places where other index taxa, particularly phytosaurs, are absent.

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References

Alcober, O. & Parrish, J. M. 1997. A new poposaurid from the Upper Triassic of Argentina. Journal of Vertebrate Paleontology, 17: 548-556.

Anderson, J. M., Anderson, H. M. & Cruickshank, A. R. I. 1998. Late Triassic ecosystems of the Molteno/Lower Elliot biome of southern Africa. Palaeontology, 41: 387-421.

Araújo, D. C. & T. D. Gonzaga. 1980. Uma nova espécie de *Jachaleria* (Therapsida, Dicynodonta) do Triássico de Brasil. Actas II Congreso de Paleontología y Bioestratigrafía y I Congreso Latinoamericano de Paleontología Buenos Aires, 1: 159-174.

Azevedo, S. A. K. 1993. Os dinossauros Triássicos no sul do Brasil: Dados e perspectivas. Acta Geológica Leopoldensia, 16: 31-40.

Azevedo, S. A., Schultz, C. L. & Barberena, M. C. 1990. Novas evidências bioestratigraficas e paleoecologicas na analise da evolução explosiva dos rincossauros do Triássico. Paula-Coutiana (Porto Alegre), 4: 23-33.

Azevedo, S. A. K. d., Rosa, A. A. S. d., Boelter, R. A. & Leal, L. A. 1999. A prosauropod dinosaur from the Late Triassic of southern Brazil. Paleontologia em Destaque, 14: 59.

Baird, D. 1964. Rhynchosaurs in the Late Triassic of Nova Scotia. Geological Society of America, Special Paper, 73: 107.

Baird, D. & Olsen, P. E. 1983. Late Triassic herpetofauna from the Wolfville Fm. of the Minas basin (Fundy basin) of Nova Scotia, Canada. Geological Society of America, Abstracts with Programs, 15: 122.

Barbarena, M. C. 1977. Bioestratigrafia preliminar da Formação Santa Maria. Pesquisas, Porto Alegre, 7: 111-129.

Barbarena, M. C., Araújo, D. C., & Lavina, E. L. 1985. Late Permian and Triassic tetrapods of southern Brazil. National Geographic Research, 1: 5-20.

Benton, M. J. 1983. The Triassic reptile *Hyperodapedon* from Elgin: Functional morphology and relationships. Philosophical Transactions of the Royal Society of London B, 302: 605-717.

Benton, M. J. 1990. Origin and interrelationships of dinosaurs, *in* Weishampel, D. B., Dodson, P., &

Osmólska, H., eds. The Dinosauria: Berkeley, University of California Press, p. 11-30.

Benton, M. J., & Spencer, J. S. 1995. Fossil Reptiles of Great Britain. London, Chapman and Hall, 386 p.

Besarie, H. 1930. Recherches géologiques à Madagascar. Contribution à l'étude des resources minérales. Bulletin Société Histoire Naturelle Toulouse, 59: 345-616.

Besarie, H. & M. Collignon. 1960. Madagascar (Supplément). Lexique Stratigraphique International Paris, 4(2): 1-190.

Besarie, H. & Collignon, M. 1971. Géologie de Madagascar I. Les terrains sedimentaires: Annales Géologiques de Madagascar, 35: 461.

Boast, J. & Nairn, A. E. M. 1982. An outline of the geology of Madagascar; in Nairn, A. E. M. & Stehli, F. G., eds. The ocean basins and margins. Volume 6. The Indian Ocean: New York, Plenum Press, p. 649-696.

Bonaparte, J. F. 1966. Chronological survey of the tetrapod-bearing Triassic of Argentina. Brevoria, 251: 1-13.

Bonaparte, J. F. 1967. Cronología de algunas formaciones Triásicos de Argentina: Basada en restos de terápodos. Revista de Asociación Geología Argentina, 21: 20-38.

Bonaparte, J. F. 1976. *Pisanosaurus mertii* Casamiquela and the origin of the Ornithischia. Journal of Paleontology, 50: 808-820.

Bonaparte, J. F. 1982. Faunal replacement in the Triassic of South America. Journal of Vertebrate Paleontology, 2: 362-371.

Bonaparte, J. F., Ferigolo, J., & Ribeiro, A. M. 1999. A new early Late Triassic saurischian dinosaur from Rio Grande do Sul; *in* Tomida, Y., Rich, T. H., & Vickers-Rich, P., eds. Proceedings of the Second Gondwanan Dinosaur Symposium. National Science Museum Monographs: Tokyo, National Science Museum, p. 89-109.

Bonaparte, J. F., Ferigolo, J., & Ribeiro, A. M. 2001. A primitive Late Triassic 'ictidosaur' from Rio Grande do Sul, Brazil. Palaeontology, 44: 623-635.

Boonstra, L. D. 1953. A note on some rhynchosaurian remains from Tanganyika Territory. Annals of the South African Museum, 12: 1-4.

Branson, E. B. 1915. Origin of the red beds of Western Wyoming. Bulletin of the Geological Society of America, 26: 217-230.

Branson, E. B. 1927. Triassic-Jurassic "red beds" of the Rocky Mountain region. Bulletin of the Geological Society of America, 35: 607-630.

Branson, E. B., & Mehl, M. G. 1928. Triassic vertebrate fossils from Wyoming. Science, 67: 325-326.

Branson, E. B., & Mehl, M. G. 1929. Triassic amphibians from the Rocky Mountain region. The University of Missouri Studies, 4(2): 154-253.

Buffetaut, E. 1983. *Isalorhynchus genovefae*, n. g. n. sp. (Reptilia, Rhynchocephalia), un noveau rhynchosaure du Trias de Madagascar. Neues Jahrbuch für Geologie und Paläontologie Monatshefte, 1983: 465-480.

Burmeister, K. C. 2000. Paleogeographic and biostratigraphic implications of new early Mesozoic terrestrial vertebrate fossils from the Poamay site, central Morondava basin, Madagascar [M.A. thesis]. Santa Barbara, University of California at Santa Barbara, 109 p.

Cabrera, A. 1944. Sobre un estgocéfalo del Triásico Argentino. Notas Museo de la Plata, 9: 421-429.

Casamiquela, R. M. 1960. Noticia preliminar sobre dos nuevos estagonolepoideos Argentinos. Ameghiniana, 2: 3-9.

Casamiquela, R. M. 1962. Dos nuevos estagonolepoideos Argentinos. Revista Asociación Geológico Argentino, 16: 143-203.

Chatterjee, S. 1967. New discoveries contributing to the stratigraphy of the continental Triassic sediments of the Pranhita Godavari Valley. Bulletin of the Geological Society of India, 4: 37-41.

Chatterjee, S. 1974. A rhynchosaur from the Upper Triassic Maleri Formation of India. Philosophical Transactions of the Royal Society of London B, 267: 209-261.

Chatterjee, S. 1978. A primitive parasuchid (phytosaur) reptile from the Upper Triassic Maleri Formation of India. Palaeontology, 21: 83-127.

Chatterjee, S. 1980a. The evolution of rhynchosaurs. Mémoires de la Société Géologique de France, 139: 57-65.

Chatterjee, S. 1980b. *Malerisaurus*, a new eosuchian reptile from the Late Triassic of India. Philosophical Transactions of the Royal Society of London B, 291: 163-200.

Chatterjee, S. 1982. A new cynodont reptile from the Triassic of India. Journal of Paleontology, 56: 203-214.

Chatterjee, S. 1987. A new theropod dinosaur from India with remarks on the Gondwana-Laurasia connection in the Late Triassic, *in* McKenzie, G. D., ed., Gondwana Six: Stratigraphy, Sedimentology and Paleontology. Washington D.C., American Geophysical Union, p. 183-189.

Chatterjee, S., & Majumdar, P. K. 1987. *Tikisuchus romeri*, a new rauisuchid reptile from the Late Triassic of India. Journal of Paleontology, 61: 787-793.

Chatterjee, S., & Roy-Chowdhury, T. 1974. Triassic Gondwana vertebrates from India. Indian Journal of Earth Sciences, 1: 96-112.

Colbert, E. H. 1970. A saurischian dinosaur from the Triassic of Brazil. American Museum Novitates, 2405: 1-39.

Contreras, V. H. 1999. Rhynchosaurs from the Ischigualasto Formation (Upper Triassic, late Carnian), San Juan, Argentina. VII International Symposium on Mesozoic Terrestrial Ecosystems, Buenos Aires, Argentina, Abstracts, p. 19.

Cox, C. B. 1965. New Triassic dicynodonts from South America, their origins and relationships. Philosophical Transactions of the Royal Society of London B, 248: 457-516.

Dawley, R. M., Zawiskie, J. M., & Cosgriff, J. W. 1979. A rauisuchid thecodont from the Upper Triassic Popo Agie Formation of Wyoming. Journal of Paleontology, 53: 1428-1431.

Dornelles, J. E. F. 1990. Registro sobre a ocorrência de dentes de um arcossaurio para a Formação Caturrita, Triássico Superior do Rio Grande do Sul, Brasil. Ciência e Natura, Santa Maria, 12: 99-101.

Dutuit, J. M. 1978. Description de quelques fragments osseux provenant de la région de Folakara (Trias supérieur Malgache). Bulletin Museum Histoire Naturelle, 516(3): 69, 79-89.

Faccini, U. F., Lavina, E. L., Lopes, R. da C., Schultz, C. L. & Dutra, G. 2000. Gondwana sequences (Early Permian to Early Cretaceous) in southern border of Paraná basin—stratigraphy and paleontology (Rio Grande do Sul, southern Brazil). 31 International Geological Congress, Pre-Congress Field Trip-Bft 02, Guidebook, 37 p.

Ferigolo, J. 1999. South American first record of a Sphenodontia (Lepidosauria, Rhynchocephalia) from Late Triassic-Early Jurassic of Rio Grande do Sul State, Brazil. VII International Symposium on Mesozoic Terrestrial Ecosystems, Buenos Aires, Argentina, Abstracts, p. 25.

Flynn, J. J., Parrish, J. M., Rakotosamimanana, B., Ranivoharimanana, L, Simpson, W. F. & Wyss, A. R. 2000. New traversodontids (Synapsida: Eucynodontia) from the Triassic of Madagascar. Journal of Vertebrate Paleontology, 20: 422-427.

Flynn, J. J., Parrish, J. M., Rakotosamimanana, B., Simpson, W. F., Whatley, R. L. & Wyss, A. R. 1999. A Triassic fauna from Madagascar, including early dinosaurs. Science, 286: 763-765.

Guth, C. 1963. Au sujets de restes de reptiles de Madagascar. Compte Rendus de l'Academie des Sciences, 256: 2661-2663.

Hancox, P. J. 1998. A stratigraphic, sedimentological and paleoenvironmental synthesis of the Beaufort-Molteno contact in the Karoo basin [Ph.D. dissertation]. Johannesburg, University of the Witwatersrand, 520 p.

Heckert, A. B., & Lucas, S. G. 1996. Revision of the South American aetosaur (Archosauria:Pseudosuchia) record with implications for the absolute age of the Late Triassic Chinle Group, USA. Geological Society of Americas Abstracts with Programs, 28(7): 365.

Heckert, A. B., & Lucas, S. G. 2002. South American occurrences of the Adamanian (Late Triassic: latest Carnian) index taxon *Stagonolepis* (Archosauria:Aetosauria) and their biochronological significance. Journal of Paleontology, 76: in press.

Hopson, J. A. 1984. Late Triassic traversodont cynodonts from Nova Scotia and southern Africa. Palaeontologia Africana, 25: 181-201.

Huber, P., Lucas, S. G. & Hunt, A. P. 1993. Vertebrate biochronology of the Newark Supergroup Triassic, eastern North America: New Mexico Museum of Natural History and Science. Bulletin 3, p. 179-186.

Huene, F. V. 1940. The tetrapod fauna of the Upper Triassic Maleri Beds. Memoirs of the Geological Survey of India, 32: 1-42.

Hunt, A. P. 1993. Revision of the Metoposauridae (Amphibia: Temnospondyli) and description of a new genus from western North America. Museum of Northern Arizona Bulletin, 59: 67-97.

Hunt, A. P. 1994. Vertebrate paleontology and biostratigraphy of the Bull Canyon Formation (Chinle Group, Upper Triassic), east-central New Mexico with revisions of the families Metoposauridae (Amphibia: Temnospondyli) and Parasuchidae (Reptilia: Archosauria) [Ph.D. dissertation]. Albuquerque, University of New Mexico, 404 p.

Hunt, A. P., & Lucas, S. G. 1991a. A new rhyncosaur from West Texas (USA) and the biochronology of Late Triassic rhynchosaurs. Palaeontology, 34: 191-198.

Hunt, A. P., & Lucas, S. G. 1991b. The *Paleorhinus* biochron and the correlation of the non-marine Upper Triassic of Pangaea. Palaeontology, 34: 487-501.

Jain, S. L. 1980. Freshwater xenacanthid (=pleuracanth) shark fossils from the Upper Triassic Maleri Formation, India. Geological Society of India Journal, 21: 39-47.

Jain, S. L. 1990. An Upper Triassic vertebrate assemblage from Central India. Bulletin of the Indian Geologists' Association, 23(2): 67-84.

Jain, S. L., & Row-Chowdhury, T. 1987. Fossil vertebrates from the Pranhita-Goadvari Valley (India) and their stratigraphic correlation; *in* McKenzie, G. D., ed., Gondwana Six: Stratigraphy, Sedimentology and Paleontology. Washington D.C., American Geophysical Union, p. 219-228.

Kellner, A. W. A., & Campos, D. A. 2000. Brief review of dinosaur studies and perspectives in Brazil. Annales Academie Brasilia Ciências, 72(4): 511-538.

Kent, D. V., Olsen, P. E., & Witte, W. K. 1995. Late Triassic-earliest Jurassic geomagnetic polarity sequence and paleolatitudes from drill cores in the Newark rift basin, eastern North America. Journal of Geophysical Research, 100(B8): 14,965-14,998.

Kischlat, E. E. 1999. A new dinosaurian "rescued" from the Brazilian Triassic: *Teyuwasu barberenai*, new taxon. Paleontologia em Destaque, 14(26): 58.

Kutty, T. S., & Sengupta, D. P. 1987. The Late Triassic formations of the Prahnita-Goadavari Valley and their vertebrate fauna succession—A reappraisal. Indian Journal of Earth Sciences, 16: 189-206.

Kutty, T. S., Jain, S. L., & Roy Chowdhury, T. 1987. Gondwana sequence of the northern Pranhita-Godavari Valley: its stratigraphy and vertebrate faunas. The Palaeobotanist, 36: 214-229.

Langer, M. C., & Schultz, C. L. 2000. A new species of the Late Triassic rhynchosaur *Hyperodapedon* from the Santa Maria Formation of south Brazil. Palaeontology, 43(4): 633-652.

Langer, M. C., Abdala, F., Richter, M. & Benton. 1999. A sauropodomorph dinosaur from the Upper Triassic (Carnian) of southern Brazil. Compte Rendus Academie Science Paris, 329: 511-517.

Langer, M., Boniface, M., Cuny, G., & Barbieri, L. 2000a. The phylogenetic position of *Isalorhynchus genovefae*, a Late Triassic rhynchosaur from Madagascar. Annales de Paléontologie, 86(2): 101-127.

Langer, M. C., Ferigolo, J., & Schultz, C. L. 2000b. Heterochrony and tooth evolution in hyperodapedontine rhynchosaurs (Reptila, Diapsida). Lethaia, 33: 119-128.

Long, R. A., & P. A. Murry. 1995. Late Triassic (Carnian-Norian) tetrapods from the southwestern United States. New Mexico Museum of Natural History and Science, 4: 1-254.

Lucas, S. G. 1993. The Chinle Group: Revised stratigraphy and biochronology of Upper Triassic strata in the western United States. Museum of Northern Arizona, Bulletin, 59: 27-50.

Lucas, S. G. 1994. The beginning of the age of dinosaurs in Wyoming. Wyoming Geological Association Guidebook, 44: 105-113.

Lucas, S. G. 1997. The Upper Triassic Chinle Group, western United States, nonmarine standard for Late Triassic time, *in* Dickins, J. M., Yang, Z., Yin, H., Lucas, S. G., & Acharyya, S. K., eds. Permo-Triassic of the circum-Pacific. Cambridge, Cambridge University Press, p. 200-228.

Lucas, S. G. 1998. Global Triassic tetrapod biostratigraphy and biochronology. Palaeogeography, Palaeoclimatology, Palaeoecology, 143: 347-384.

Lucas, S. G. 2002. Age and correlation of Triassic tetrapod assemblages from Brazil. Albertiana, 26: 11-18.

Lucas, S. G., &Hancox, P. J. 2001. Tetrapod-based correlation of the nonmarine Upper Triassic of southern Africa. Albertiana, 25: 5-9.

Lucas, S. G., & Heckert, A. B. 2001. The aetosaur *Stagonolepis* from the Upper Triassic of Brazil and its biochronological significance. Neues Jahrbuch für Geologie und Paläontologie Monatsheft, 2001: 719-732.

Lucas, S. G. & Hunt, A. P. 1993. A dicynodont from the Upper Triassic of New Mexico and its biochronological significance. New Mexico Museum of Natural History and Science, 3: 321-325.

Lucas, S. G., & Wild, R. 1995. A Middle Triassic dicynodont from Germany and the biochronology of Triassic dicynodonts. Stuttgarter Beiträge zur Naturkunde Serie B (Geologie und Paläontologie), 220: 1-16.

Lucas, S. G., Heckert, A. B. & Hotton, N. III. 2002. The rhynchosaur *Hyperodapedon* from the Upper Triassic of Wyoming and its biochronological significance. New Mexico Museum of Natural History and Science, 21: in press.

Lucas, S. G., Hunt, A. P., & Long, R. A. 1992. The oldest dinosaurs. Naturwissenschaften, 79: 171-172.

Martin, M. 1981. Les Dipneustes mésozoïques malgaches, leurs affinités et leur intérêt paléobiogéographique. Bulletin Societe Géologique de France, 23: 579-585.

Mehl, M. G. 1913. *Angistorhinus*, a new genus of Phytosauria from the Trias of Wyoming. Journal of Geology, 21: 186-191.

Mehl, M. G. 1915a. The Phytosauria of the Triassic. Journal of Geology, 23: 129-165.

Mehl, M. G. 1915b. *Poposaurus gracilis*, a new reptile from the Triassic of Wyoming. Journal of Geology, 23: 516-522.

Mehl, M. G. 1928. The Phytosauria of the Wyoming Triassic. Denison University Bulletin, Journal of the Scientific Laboratories, 23: 141-172.

Miall, L. C. 1878. On the genus *Ceratodus* with special reference to the fossil teeth at Medi, central India. Memoir Geological Society India Series 4, 1(2): 8-17.

Novas, F. E. 1996. Dinosaur monophyly. Journal of Vertebrate Paleontology, 16: 723-741.

Olsen, P. E. 1988. Paleontology and paleoecology of the Newark Supergroup (early Mesozoic, eastern North America); in Manspeizer, W., ed. Triassic-Jurassic rifting, continental breakup and the origin of the Atlantic Ocean and passive margins. New York, Elsevier, p. 186-230.

Olsen, P. E. 1989. Stop 10.1: Tennycape; in Olsen, P. E., Schilsche, R. W. & Gore, P. J. W., eds. Tectonic, depositional and paleoecologic history of early Mesozoic rift basins, eastern North America. Washington, D. C., American Geophysical Union, p. 139.

Piqué, A., Laville, E., Bignot, G., Rabarimanana, M. & Thouin, C. 1999. L'ouverture et le développement du bassin de Morondava (Madagascar) du Carbonifère supérieur au Jurassique moyen. Donées stratigraphiques, sédimentaires, paléontologiques et structurales. Journal of African Earth Sciences, 28: 931-948.

Raath, M. A. 1996. Earliest evidence of dinosaurs from central Gondwana. Memoirs of the Queensland Museum, 39: 703-709.

Raath, M. A., Oesterlen, P. M., & Kitching, J. W. 1992. First record of Triassic Rhynchosauria (Reptilia: Diapsida) from the lower Zambezi Valley, Zimbabwe. Palaentologia Africana, 29: 1-10.

Razafimbelo, M. E. 1987. Le bassin de Morondava (Madagascar) synthèse géologique et structurale [Ph.D. dissertation]. Strasbourg, Université Lous-Pasteur, 219 p.

Reig, O. A. 1959. Primeros datos descriptivos sobre nuevos réptiles arcosaurios del Triásico de Ischigualasto (San Juan, Argentina). Revista Asociación Geológica de Argentina, 13: 257-270.

Reig, O. A. 1961. Acerca de la posición sistemática de la familia Rauisuchidae y del género Saurosuchus (Reptilia, Thecodontia). Publicaciones de la Museo Ciencia Naturales Mar del Plata, 1: 73-114.

Reig, O. A. 1963. La presencia de dinosaurios saurisquios en los "Estratos de Ischigualasto" (Mesotriásico superior) de las provincias de San Juan y La Rioja (República Argentina). Ameghiniana, 3: 3-20.

Rogers, R. R., Swisher, C. C. I., Sereno, P. C., Monetta, A. M., Forster, C. A., & Martínez, R. N. 1993. The Ischigualasto tetrapod assemblage (Late Triassic, Argentina) and 40Ar/39Ar dating of dinosaur origins. Science, 260: 794-797.

Romer, A. S. 1960. Vertebrate-bearing continental Triassic strata in Mendoza Region, Argentina. Geological Society of America Bulletin, 71: 1279-1294.

Romer, A. S. 1962a. The fossiliferous Triassic deposits of Ischigualasto, Argentina. Breviora, 156: 1-7.

Romer, A. S. 1962b. La evolución expolosiva de los rhynchosaurios del Triásico. Revista Museo Argentino Ciencia Natural Ciencia Zoología, 8(1): 1-14.

Roy Chowdhury, T. 1965. A new metoposaurid amphibian from the Triassic Maleri Formation, central India. Philosophical Transactions of the Royal Society of London B, 250: 1-52.

Schultz, C. L., Scherer, C. M. & Barberena, M. C. 2000. Bioestratigraphy of southern Brazilian Middle-Upper Triassic. Revista Brasileira de Geociências, 30: 491-494.

Sereno, P. C., Forster, C. A., Rogers, R. R. & Monette, A. M. 1993. Primitive dinosaur skeleton from Argentina and the early evolution of Dinosauria. Nature, 361: 64-66.

Sues, H. D. 1992. A remarkable new armored archosaur from the Triassic of Virginia. Journal of Vertebrate Paleontology, 12: 142-149.

Walker, A. D. 1964. Triassic reptiles from the Elgin area: *Ornithosuchus* and the origin of carnosaurs. Philosophical Transactions of the Royal Society of London. Series B, 248: 53-134.

Wescott, W. A. & Diggens, J. N. 1998. Depositional history and stratigraphical evolution of the Sakamena Group (Middle Karoo Supergroup) in the southern Morondava basin, Madagascar. Journal of African earth Sciences, 27: 461-479.

Westphal, F. 1970. Phytosaurier-Hautplatten aus der Trias von Madagaskar-ein Beitrag zur Gondwana-Paläogeographie. Neues Jahrbuch für Geologie und Paläontologie Monatshefte, 1970: 632-638.

Wopfner, H. 1994. The Malagasy rift, a chasm in the Tethyan margin of Gondwana. Journal of Southeast Asian Earth Sciences, 9: 451-461.

The need to describe and illustrate all elements in conodont collections – a rationale with special reference to Permian- Triassic conodonts

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Introduction

For over 100 years since Pander (1856) first described Ordovician fish teeth-like fossils and established the taxon of conodont, workers studying these microscopic fossils used the concept of form taxonomy as a basis for the description of conodont collections i.e. each individual element type was treated as a separate biological entity and was given a unique binomen to reflect that perceived individuality. Although Hinde (1879) proposed the multielement species *Polygnathus dubius* based on the discovery of a Devonian conodont assemblage consisting of various forms of conodonts from the Genesee Shale in New York, it wasn't until the years after1966, stimulated by the work of Bergström and Sweet (1966) and Webers (1966), that conodont workers began to believe that many different elements constituted the presumed feeding apparatus of a then unknown marine animal, which became known as the conodont animal. As more and more bedding plane assemblages came to light from different localities and geological periods, palaeontologists gradually accepted the multielement nature of the conodont animal apparatus. The final confirmation came in the 1980's with the discovery of conodont animal body fossils from Scotland (Briggs *et al*. 1983) containing a suite of elements in the head region.

For many decades, Permian –Triassic (P/T) conodonts have been the subject of intense research, especially those found around the P/T boundary. This was because this junction constituted the Palaeozoic – Mesozoic boundary, and also marked the biggest mass extinction in the geological record. However, P/T conodont apparatuses are still poorly understood compared with that of other geological periods. Based on logical inference, historical and micromorphological and statistical methods (e.g. Clark, 1972; Dzik, 1980; Sweet, 1988; von Bitter and Merrill, 1983; Zhang Shunxin, 1991; Orchard and Rieber, 1999), there are about 35 P/T conodont genera that have been reconstructed by means of multiement taxonomy during past years (this paper does not deal with the validity of these genera). Unfortunately, the basis of many of these reconstructions is unsatisfactory and unsafe, so that P/T conodont workers still have not reached a common understanding of some of these genera or species. For example, the important P/T 'gondolellid' conodonts (*Gondolella*, *Neogondolella*, *Mesogondolella* etc.), are thought by some authors to have unimemberate apparatuses, while others believe that they are multielement in constitution. Few 'gondolellid' taxa have broadly accepted reconstructions.

The problems of Permian-Triassic conodont multielement taxonomy

First of all, the multielement taxonomy of P/T conodonts is rarely emphasized in the literature. Since 2001, the authors have been gathering together published papers related to P-T conodonts for the purpose of documenting conodont evolution over the mid-Permian – mid-Triassic interval. According to our P/T conodont library, there are just 65 papers out of approximately 450 published since 1966 which deal with conodont collections in a multielement sense, complete with illustrations of all elements recovered. Even some major contributors to P/T conodont research are inconsistent in their approach, alternatively employing multielement methodology and then perhaps only considering pectiniform (platform) elements alone.

Secondly, another major problem with P/T multiement taxonomy is that only two natural assemblages have been found to date. Rieber (1980) reported a natural assemblage of *Neogondolella* from the Middle Triassic, which played a very important role in establishing *Neogondolella* as a multielement conodont genus (Orchard *et al*., 1999). Ritter and Baesemann (1991) published a natural assemblage of *Sweetognathus* cf *S. inornatus* from the Early Permian which established the multilelement nature of the apparatus of *Sweetognathus* and demonstrated that it possessed elements which were homologous with those of coeval genera such as *Hindeodus*, *Adetognathus*, *Streptognathodus* and *Neostreptognathodus*. However, most P/T conodont genera have no natural apparatus templates on which to base reconstructions, although some data is available from published clusters of elements.

Thirdly, the practice of figuring ramiform elements has declined greatly since the use of multielement taxonomy became universally accepted. This is especially evident in P/T conodont studies, wherein many authors make reference only to pectiniform elements. Where the intention is simply to use conodonts biostratigraphically, this is perhaps understandable. However, the failure to discuss or illustrate ramiform elements is apparent even in many papers which deal with P/T conodont faunas, evolution and taxonomy. Neglecting ramiform elements inevitably leads to the loss of potentially important information about the biological relationship between pectiniform elements and ramiforms, which hinders meaningful reconstructions.

Approaches to the treatment of ramiform elements in publications

Like many P/T conodont workers, the authors have faced difficulties in dealing with ramiform elements whose affinities are uncertain. In these cases, the principles of multielement taxonomy are attempted first, but for several reasons it is often not known where to allocate the ramiform elements. Firstly, the apparatuses of some P/T conodont genera are unreliably reconstructed, thus researchers do not know which group of ramiform elements belong to these genera. Secondly, certain morphotypes of ramiform elements maybe belong to several different established taxa i.e. there are vicarious. When these different genera or species occur at the same level or in the same bed, it is difficult to assign such ramiform elements to the correct taxa. In these cases, a easy way out is to illustrate all the platform elements, but only those ramiform elements whose affinites are certain. This results in neglect of the remaining ramiform elements, with the loss of much data which could prove of use to researchers attempting sensible reconstructions elsewhere.

Considering these difficulties, we would like to suggest the following approaches:

1. Where the affinity of ramiform elements is in no doubt, it should always be the case that the multielement (i.e. true biological) species is stated and the apparatus position recorded. For example, the form species "*Apatognathus*" *longidentatus* Tatge belongs in the multielement species *Neogondolella mombergensis* (Tatge) (Orchard and Rieber, 1999), so it should always be referred to as *Neogondolella mombergensis* Sb1 element.

2. Some ramiforms only belong to a single multielement genus. Thus, when a single species of this genus occurs at a certain level associated with these ramiforms, we can use the multielement species name and apparatus position for these ramiforms (see above). If we find more than two species of this multielement genus at the same level associated with the ramiforms, in this case we need just indicate the generic name and apparatus position for the ramiform elements. For example, the form genus *Enantiognathus* is the Sb1 element of the multielement genus *Neogondolella*, thus when more than two species of *Neogondolella* occur at the same level (which is quite common in the Permian and Triassic), the ramiform element previously named *Enantiognathus* should be described as *Neogondolella* Sb1 element.

3. For ramiform elements which have a form genus name, but whose multilelment affinities are unknown, it is suggested that the form genus name is used and is followed by the term "form element". For example, in the case where a ramiform element of the form species *Hindeodella* occurs at a certain horizon, but the multielement genus is unknown, it is suggested that the term "*Hindeodella* form element" is used. If more than one type of the form genus occurs, they can be distinguished as *Hindeodella* form element 1, *Hindeodella* form element 2, etc.

4. For new ramiform elements, where multielement affinites are unknown, it is very desirable that an illustration should be given, captioned with Gen et sp. indet. 1, Gen et sp. indet. 2, etc., or other sensible description.

5. As a general principle in publications, it is urged that wherever possible, all ramiform element types in a collection are illustrated and a distribution table included. Such data are invaluable to other workers attempting reconstructions.

Conclusions

Multielement taxonomy should be applied in all publications dealing with conodonts. The universal adoption of this principle is particularly urged for studies focussing on the P/T interval. More natural assemblages and clusters should be sought. All ramiform element types should be figured wherever practicable and distribution/occurrence tables included. The implementation of these suggestions will advance reconstructive studies immeasurably.

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References

Bergström, S. M. and Sweet, W. C. 1966. Conodonts from the Lexington Limestone (Middle Ordovician) of Kentucky and its lateral equivalents in Ohio and Indiana. Bulletins of American Paleontology, 50: 271-441.

Briggs, D. E. G., Clarkson, E. N. and Aldridge, R. J. 1983. The conodont animal. Lethaia, 16, 1-14.

Clark, D. L., 1972. Early Permian crisis and its bearing on Permo-Triassic conodont taxonomy. Geologica et Palaeontologica, SB1: 147-158.

Dzik, J. and Trammer, J. 1980. Gradual evolution of conodontophorids in the Polish Triassic. Acta Palaeontologica Polonica, 25: 55-89.

Hinde, G. J. 1879. On conodonts from the Chazy and Cincinnati groups of the Cambro-Silurian and from the Hamilton and Genesse shale division of the Devonian in Canada and the United States. Quarterly Journal of the Geological Society, London, 35: 351-369.

Orchard, M. J. and Rieber, H. 1999. Multielement *Neogondolella* (Conodonta, upper Permian-middle Triassic). Bollettino della Paleontologica Italiana, 37: 475-488.

Pander, C. H. 1856. Monographie der fossilen Fische des siurischen Systems der Russisch-Baltischen Gouvernements. Akademie der Wissenschaften, St. Petersburg: 1-91.

Rieber, H. 1980. Ein conodonten-cluster aus der Grenzbitumenzone (Mittlere Trias) des Monte San Giorgio (Kt. Tessin/Schweiz). Naturhistorisches Museum in Wien, Annalen, 83: 265-274.

Ritter, S. M. and Baesemann, J. F. 1991. Early Permian conodont assemblages from the Wolfcamp shale, Midland basin,West Texas. Journal of Paleontology, 65:

670-677.

Sweet, W. C. 1988. The Conodonta: Morphology, taxonomy, paleoecology, and evolutionary history of a long-extinct animal phylum. Oxford Monographs on Geology and Geophysics No. 10, 212 pp. Clarendon Press, Oxford.

Von Bitter, P. H. and Merrill, G.. K. 1983. Late Palaeozoic species of *Ellisonia* (Conodontophorida). Evolutionary and palaeoecological significance. Life Sciences Contributions, Royal Ontario Museum, 136: 1-56.

Zhang, S. X. and Yang, Z. Y. 1993. Application of R-mode cluster analysis to multielement taxonomy of Early Triassic conodonts. Journal of China University of Geosciences, 4: 14-22

Webers, G.. F. 1966. The Middle and Upper Ordovician conodont faunas of Minnesota. Minnesota Geological Survey Special Publication, 4: 1-123.

Triassic Ammonoid Succession In South Primorye: 1 Lower Olenekian *Hedenstroemia Bosphorensis* And *Anasibirites Nevolini* Zones

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Abstract

A review of a new data on the Lower Triassic (*Hedenstroemia bosphorensis* and *Anasibirites nevolini* Zones) biostratigraphy of South Primorye is given. The exact position of the Induan- Olenekian boundary and *Hedenstroemia bosphorensis* - *Anasibirites nevolini* Zones bondary in the basic sections of South Primorye may be recognized only using data on distribution both ammonoids and conodonts.

Introduction

Hedenstroemia bosphorensis and *Anasibirites nevolini* subdivisions were firstly offered as subzones of the lower Olenekian *Owenites koeneni Zone* (Zakharov, 1968). The type sections of the first one and the second one were arov, 1968, 1978; Burij et al., 1972), correspondingly. Now these subdivisions seem to be the lower zones of the Ayaxian Substage of the Olenekian Stage (Table 1) (Zakharov, 1978, 1997; Zakharov and Rybalka, 1987).

This paper presents the new data on distribution of ammonoids in the lower part of the Olenekian (Ayaxian Substage) of South Primorye.

Early Olenekian ammonoid distribution

Ayax Bay in Russian Island

The Ayax Bay section is located at the north-eastern part of Russian Island (Fig. 1, 2 and 3). The top of the Induan, exposed on the sooth coast (locality 6), contains pure preserved ammonoids (*Gyronites?* sp.) (Zakharov, 1996) and conodonts *Neospathodus pakistanensis* Sweet (Buryi, 1979). In the lower part of the *Hedenstroemia bosphorensis* Zone ammonoids very rare and are represented by *Proharpoceras* and *Juvenites* (Fig. 4) ; its middle part (localities 9, 10-12) is characterized by abundant ammonoid association , but representatives of *Hedenstroemia bosphorensis* Zakharov are very rare here. The *Anasibirites nevolini Zone* is characterized by *Arctoceras labogense* (Zharnikova), *Preflorianites* sp. 1, *Hemiprionites* sp. indet, *Gurleyites* sp. and some other ammonoids, but zonal key-index has not been discovered there. Conodonts *Furnishius triserratus* were met in both the *Hedenstroemia bosphorensis* Zone and the *Anasibirites nevolini* Zone.

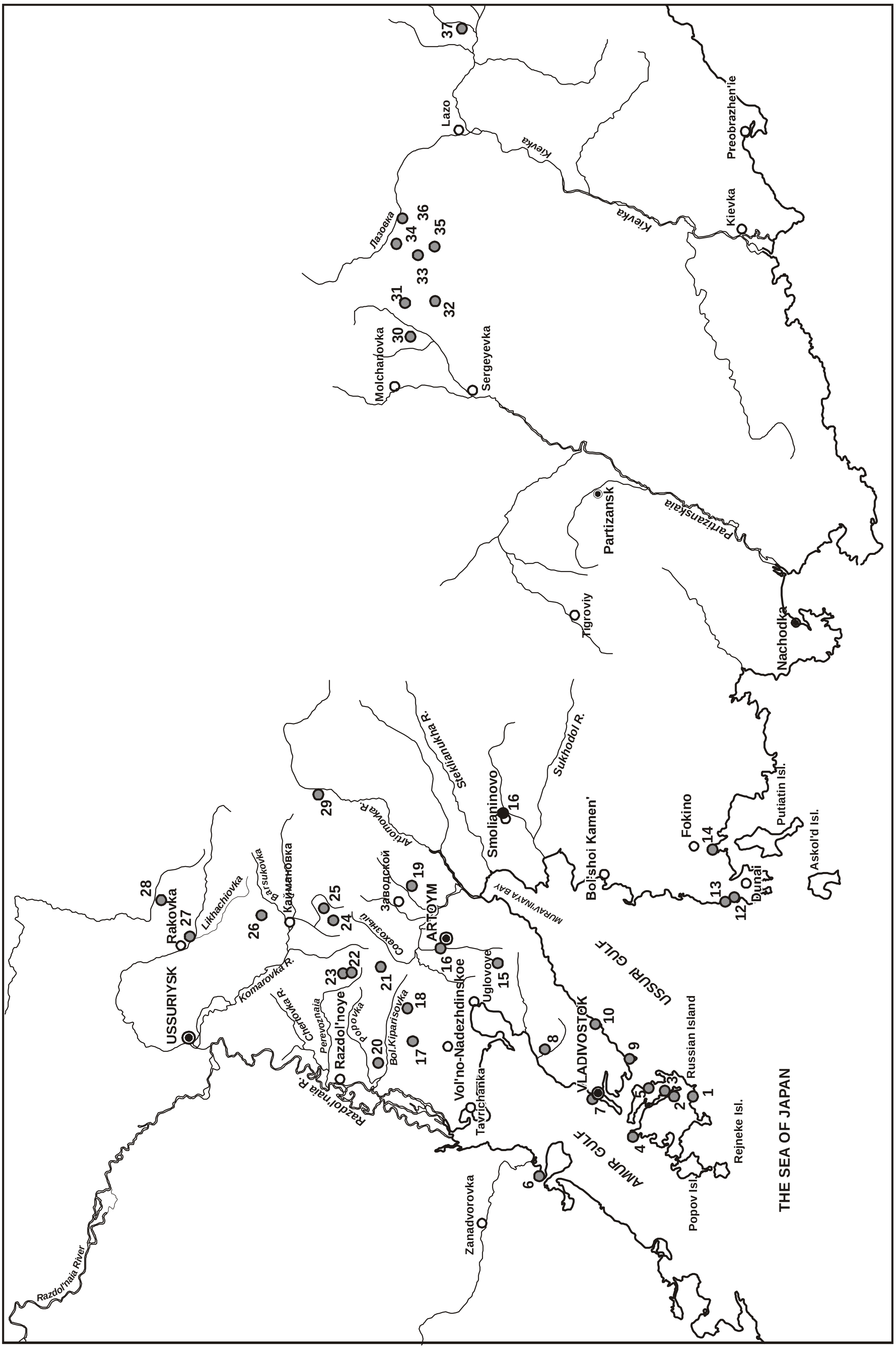
Tobizin Cape in Russian Island

The Tobizin Cape section is located at the south-eastern part of Russian Island (Fig. 5). In the lower part of the *Hedenstroemia bosphorensis* Zone conodonts *Neospathodus pakistanensis* associate with early Olenekian ammonoids (*Ussuria*, *Arctoceras*, *Dieneroceras* and *Meekoceras*). In the overlying zone ammonoid *Anasibirites*, *Hemiprionites*, *Wasatchites*, *Arctoceras*, *Meekoceras*, *Juvenites?*, *Koninkites* and *Prosphingitoides* associate with conodonts *Furnishius triserratus* (Fig. 6).

Novik Bay in Russian Island (Fig. 7)

The uppermost part of the Induan is characterized by rare ammonoids *Gyronites subdharmus* Kiparisova. Ammonoids *Dieneroceras,*

Fig. 1 (page 39): Lower and Middle Triassic (marine and terrestrial) sections in South Primorye. Black circles – localities and their numbers: 1 - Novyj Dzhigit Cape– Vyatlin Cape), 2 – Polonsky Cape, *3 – Melkovodnaya Cape – Konechnyj Cape, 4 –* Staritskij Cape; *5* - Ayax Bay - Akhlestyshev Cape, *6 – Atlasov - Ugolnyj Capes*; *7 – Vladivostok, Kirov Street*; *8 – Bogataya River*, *9* – Basargin Cape, *10* - Lazurnaya (Shamora) Bay – Tri Kamnya Cape; *11* – Village of Smolyaninovo, quarry, *12 - Golyj (Kom-Pikho-Sakho) Cape*, *13 – Village of Yuzhnorechensk (Shimeuza), removal, 14 – Abrek Bay, 15 –* upper Peschanka River, right bank (Rogaty and Zybunnyj Creeks watershed)), *16 – Artyom town, SMID quarry*, *17 - Ammonitovyj Creek, Bolshaya Kiparisovka River basin*, *18* – Dlinnyj Creek, right tributary of the Knevichanka River), *19* – left bank of the Surazhevka River, Artyomovka River basin, *20* **–** ðó÷. Òðàêòîðíûé (Tractornyj Creek), *21* **–** left tributaries of the Mramornyj Creek watershed, Knevichanka River basin, *22* – country between Smolnyj Klyuch Creek – Perevoznaya River), *23* **–** Pad' Pryamaya Creek, left bank, and Perevoznaya River, left bank, *24* **–** Pryamaya Volkha River – Pad' Partizanskaya Creek watershed, Komarovka River basin, *25* – Pad' Partizanskaya – Pikhtovyj Creeks watershed, Komarovka River basin, *26* **–** Komarovka River basin*, 27* **–** Rakovka River, *28* – Solontsovaya Pad' Creek area, right watershed, Osinovka Rier basin, 29 – Artyomovka River, *30* – Sergeevka River, left bank, upstream from the mouth of the Klyuch Starikov Creek, *31* – Klyuch Starikov Creek, right bank, 4 km upstream from its mouth, *32* – Tekhnicheskij Creek, 2 km upstream from its mouth, Pad' Povorotnaya River basin, *33* – Perevalnyj Creek, left tributary of the Malaya Lazovka River, *34* – Tikhij Creek, left tributary of the Malaya Lazovka River, *35* – Malaya Lazovka River watershed, *36* **–** Lazovka River, right bank, *37* – Zverolovnaya River, left tributary of the Kievka River.



Hedenstroemia, *Owenites*, *Prosphingitoides*, *Juvenites*, *Meekoceras* and *Arctoceras* were discovered. in the *Hedenstroemia bosphorensis* Zone (Fig. 8). From the *Anasibirites nevolini* Zone, only *Meekoceras subcristatum* Kiparisova and *Arctoceras labogense* (Zharnikova) are known for certain.

Tri Kamnya Cape on the western coast of Ussuri Gulf

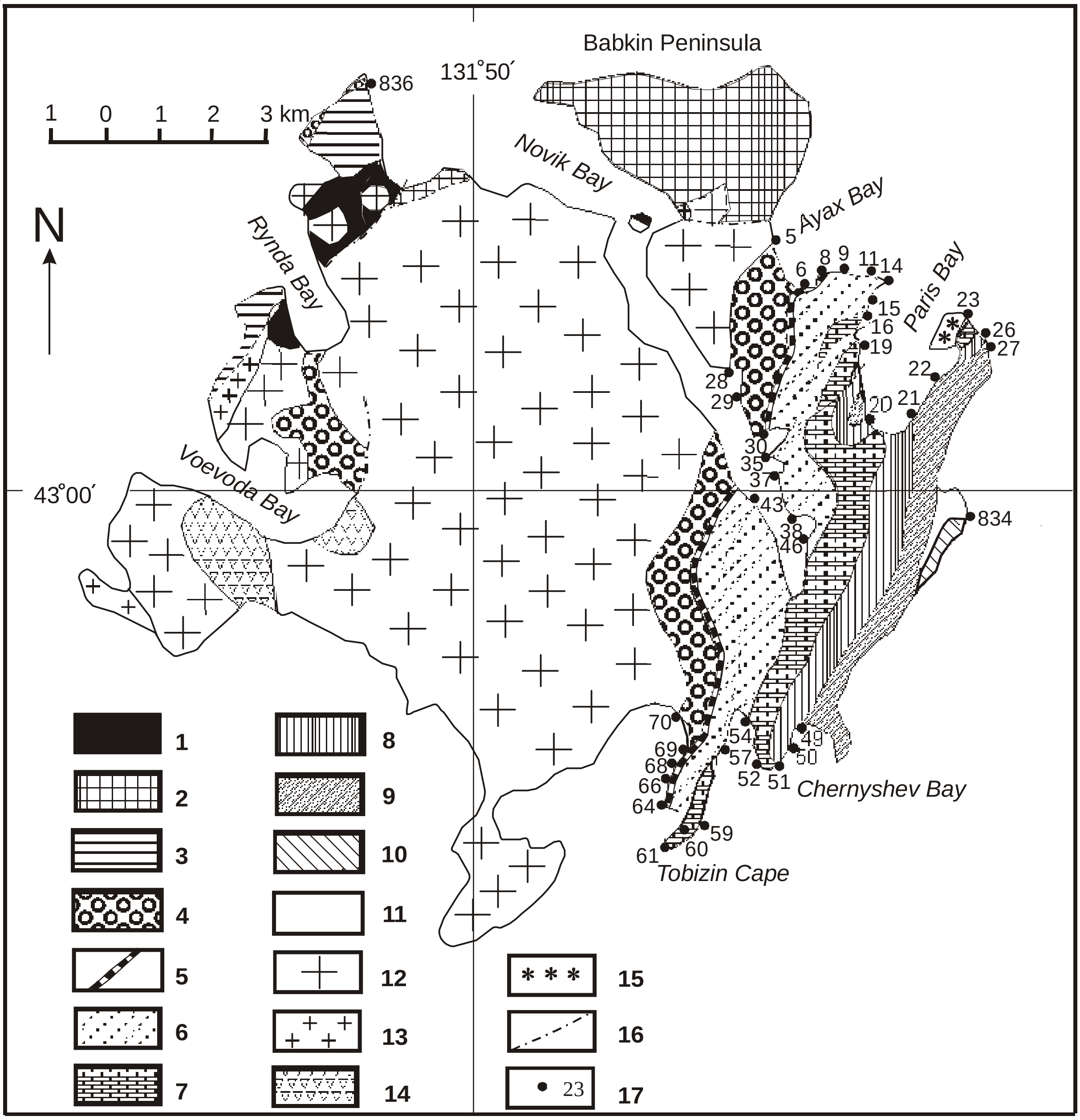


Fig. 2. Geological map of the Russian Island, with locality numbers). 1-9 – suites (formations) and their age: 1 – pre-Cambrian? Putyatin Suite, 2 –Kungurian-Roadian Pospelov Suite, 3 – Wordian lower Vladivostok Suite, 4 – Induan lower Lazurnaya Suite, 5 – upper Lazurnaya Suite (Olenekian basal beds), 6 - lower Ayaxian Tobizin Suite, 7 –upper Ayaxian Schmidt Suite, 8 – Russian Zhitkov Suite, 9 – Anisian Karazin Suite, 10 - Upper Ladinian Akhlestyshev Suite, 11 –Quaternary sediments, 12 - early Paleozoic? granitoids, 13 – late Permian granite porphyry, 14 – late Permian andesite, 15 – Cretaceous felsite porphyry, 16 – tectonic boundary, 17 locality number.

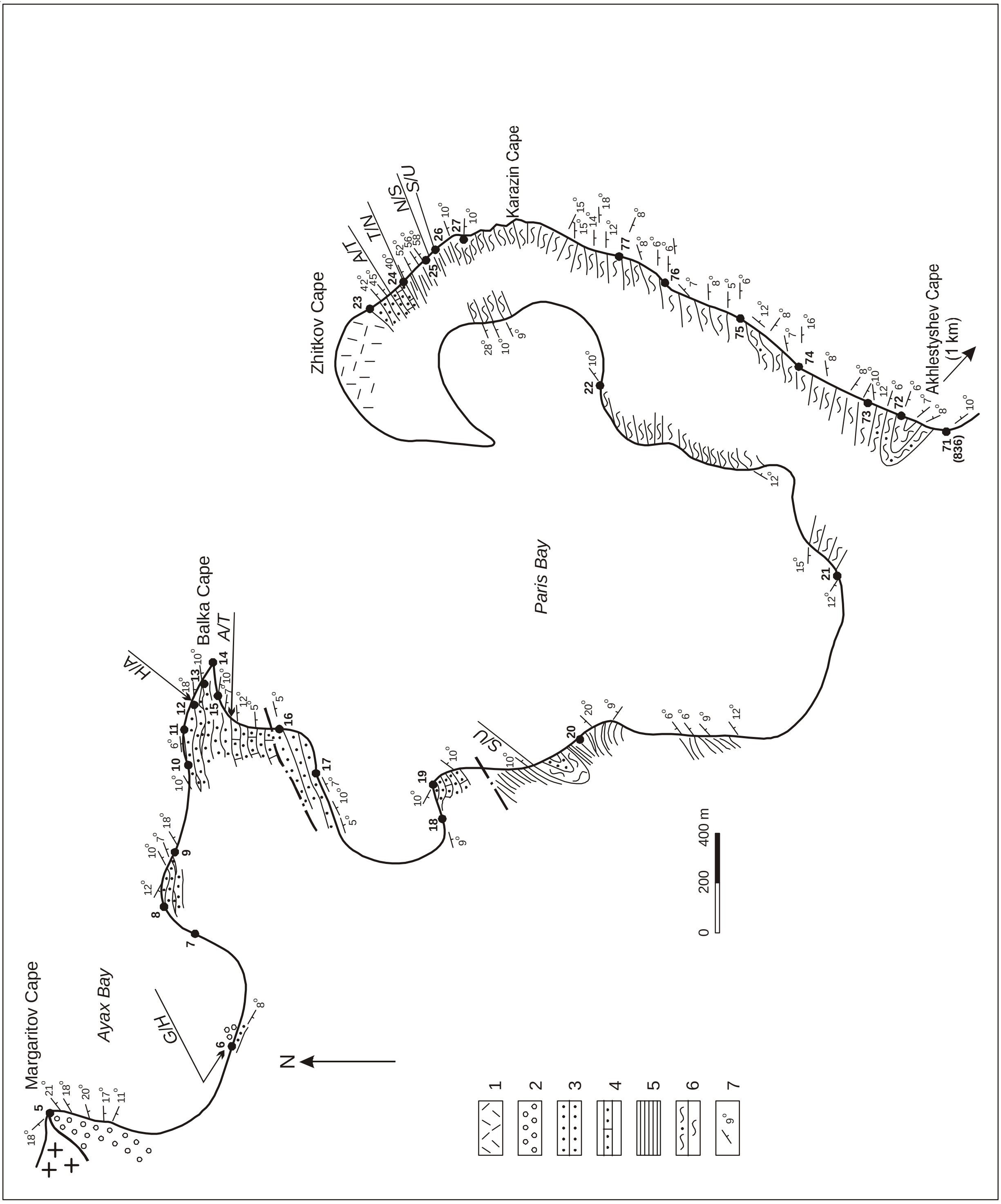


*Fig. 3. Sketch map locating the Ayax Bay - Akhlestyshev Cape section (Fig. 1., section 5; Fig. 2). Designation**:** 1 - Cretaceous felsite porphyry, 2 – conglomerate, 3 –fine grained sandstone, 4 –sandy limestone-coquina, 5 – sltstone and mudstone, 6 – spotted sandy siltstone and mudstone, **7** – bed elements. Zone boundary: G/H – Gyronites subdharmus - Hedenstroemia bosphorensis), H/A - Hedenstroemia bosphorensis - Anasibirites nevolini, A/T - Anasibirites nevolini - Tirolites-Amphistephanites parisensis, T/N - Tirolites-Amphistephanites parisensis - Neocolumbites insignis, N/S - Neocolumbites insignis - Subcolumbites multiformis**,** S/U - Subcolumbites multiformis - Ussuriphyllites amurensis**.** Other designition as in Fig. 2.*

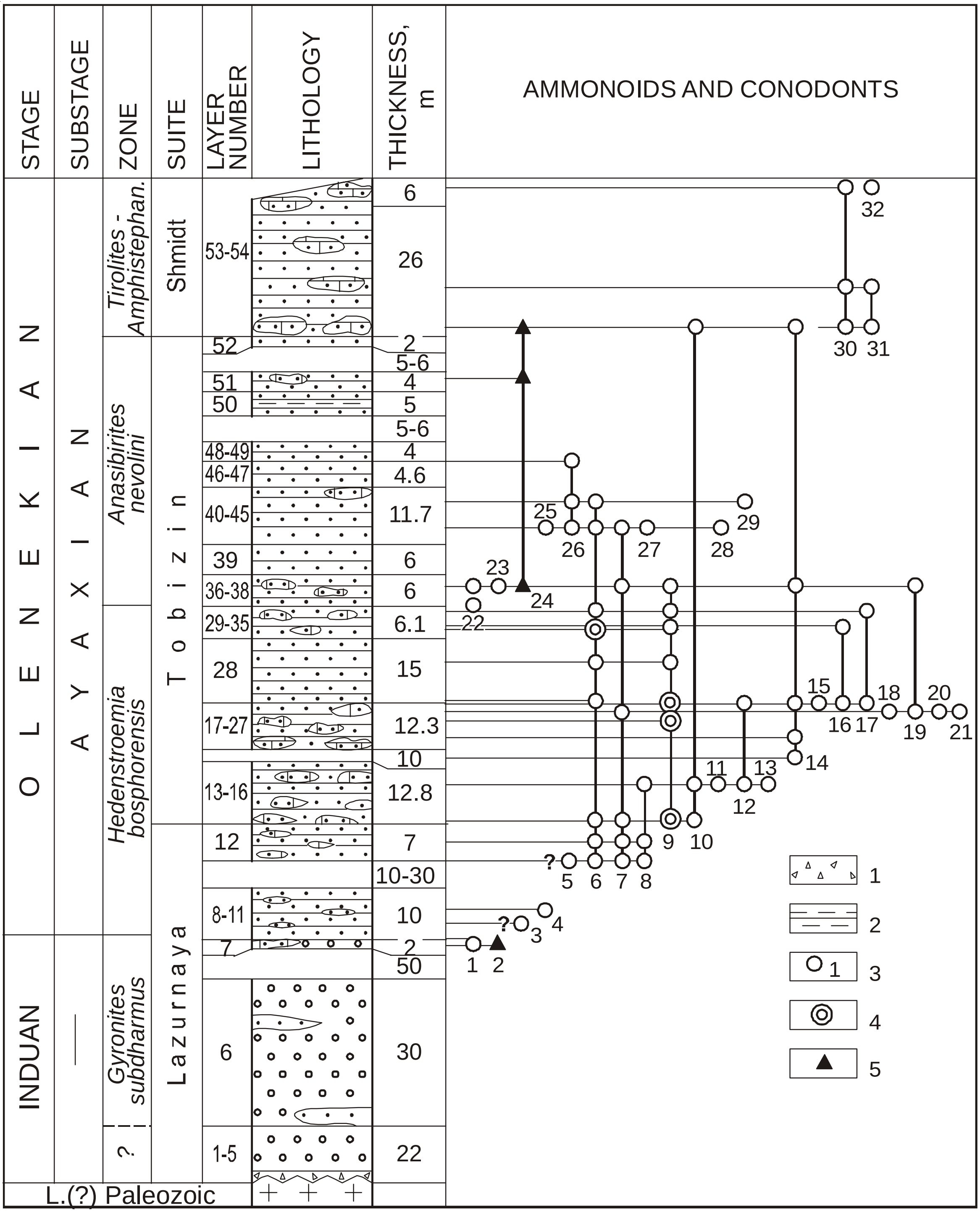


Fig. 4. Lithostratigraphical column of Triassic sediments exposed between Margaritov and Balka (Fig. 1, section 5, Fig. 2 and 3), localities 5-17). : 1 – grussstone, 2 – siltstone, 3 – mollusc species and its number, 4 –dominant mollusc species and its number, 5 – *âèä êîíîäîíòà è åãî íîìåð (conodont species and its number). Other designition as in Fig. 2 and 3).*

Species: 1 – *Gyronites* sp., 2 – *Neospathodus pakistanenis*, 3 – *Proharpoceras carinatitabulatum,* 4 – *Juvenites* cf. *simplex*, 5 – *Gyronites* aff. *planissimus,* 6 – *Arctoceras septentrionale,* 7 – *Juvenites* sp., 8 – *Dieneroceras chaoi,* 9 – *Meekoceras subcristatum,* 10 – *Pseudosageceras* sp., 11 – *Epihedenstroemia ajaxensis,* 12 – *Hedenstoemia bosphorensis,* 13 – *Ussuria iwanowi,* 14 – *Arctoceras* sp., 15 – *Owenites koeneni*, 16 - *Pseudosageceras longilobatum,*– 17 - *Prosphingitoides hxexagonalis*, 18 – *Preflorianites* sp., 19 – *Meekoceras boreale,* 20 – *Anaxenaspis orientalis,* 22 – *Inyoites spicini*, 23 - *Arctoceras labogense*, 24 – *Furnishius triserratus*, 25 – *Meekoceras* sp., 26 – *Preflorianites* sp. 1, 27 – *Hemiprionites* sp. indet., 28 – *Gurleyites* sp., 29 – *Ambites* cf. *discus,* 30 – *Tchernyschevites costatus*, 31 – *Bandoites elegans,* 32 – *Amphistephanites parisensis.*

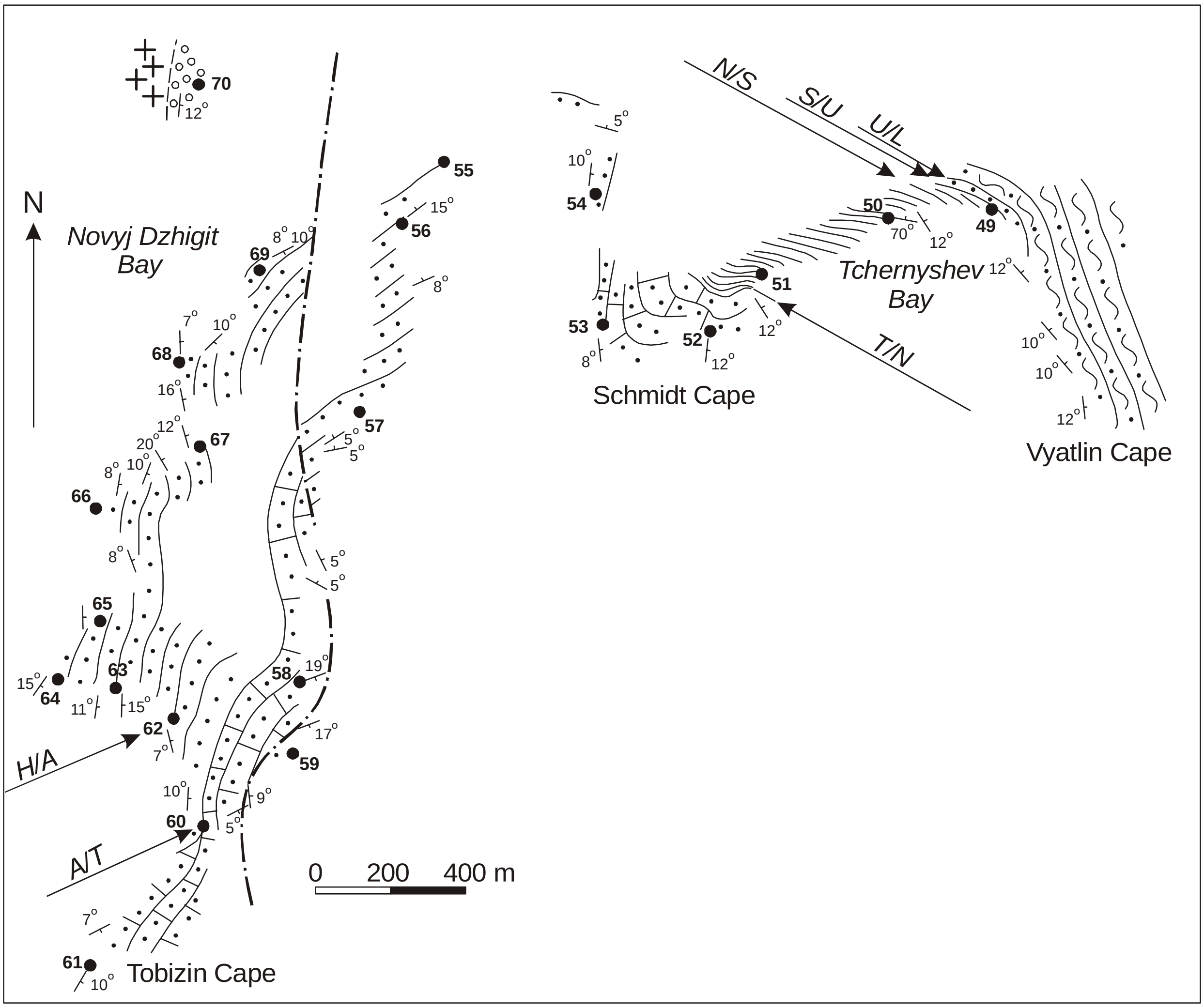


Fig. 5. Sketch map locating the Ayax Bay - Akhlestyshev Cape section (Fig. 1, section 1 and Fig. 2). Designation as in Fig. 3.

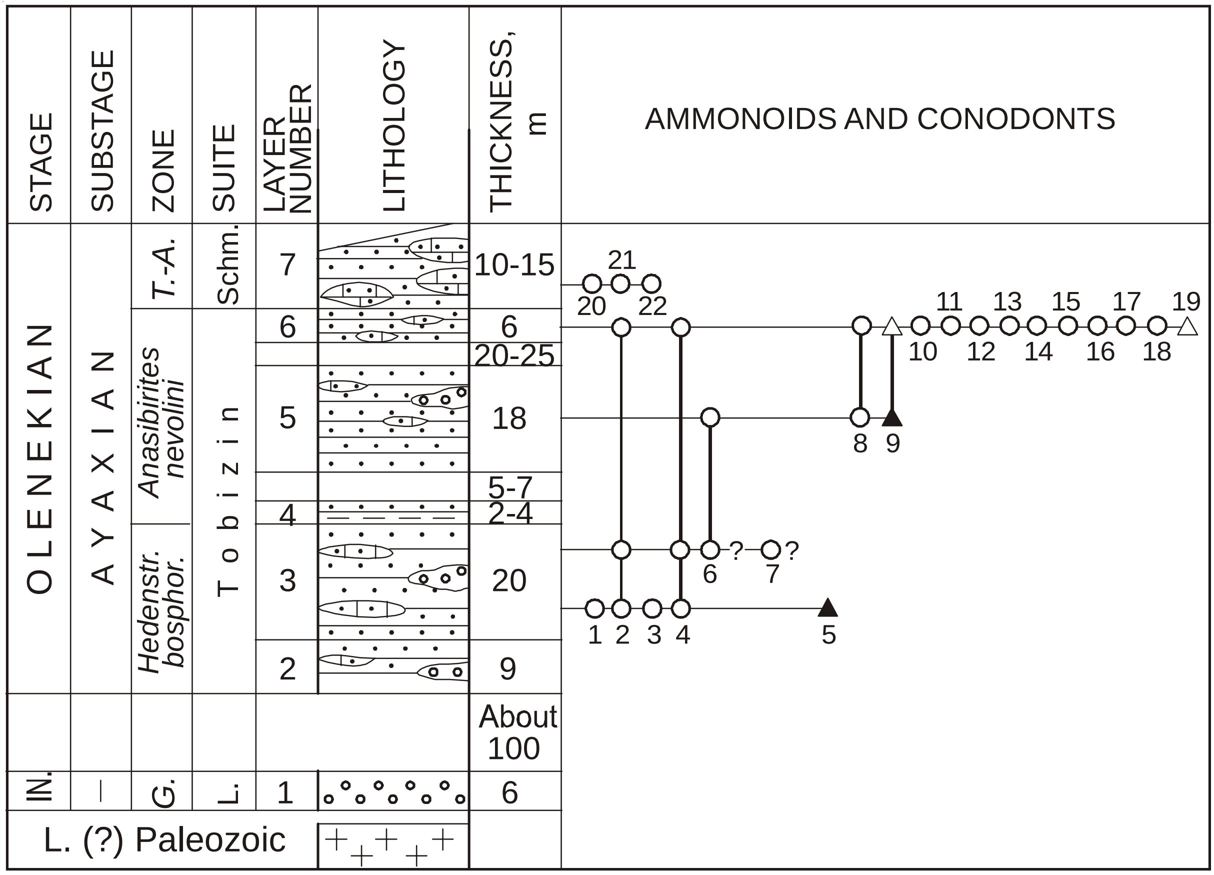


Fig. 6. Lithostratigraphical column of Triassic sediments exposed at the Tobizin Cape (Fig. 1, section 1, Fig. 2 and 8), localities 59-70). Abbraviation: G. – Gyronites subdharmus, Hedenstr. bosphor. – Hedenstroemia bosphorensis, T. A. - Tirolites-Amphistephanites, IN. – èíäñêèé (Induan), L. –Lazurnaya, Shm. –Schmidt. Other designition as in Fig. 2-4).

Species: 1 - *Ussuria* aff. *iwanowi*, 2 – *Arctoceras septentrionale*, 3 – *Dieneroceras* sp., 4 – *Meekoceras subcristatum*, 5 – *Neospathosdus pakistanensis,* 6 – *Meekoceras* cf. *boreale,* 7 – *M. varaha,* 8 – *Owenites koeneni,* 9 – *Furnishius triserratus,* 10 – *Parahedenstroemia conspicienda,* 11 – *Anasibirites* sp., 12 – *Hemiprionites* sp., 13 –*Wasatchites sikhotealinensis,* 14 – *Arctoceras labogense,* 15 – *Meekoceras* aff. *gracilitatis,* 16 – *Juvenites?* sp., 17 – *Koninckites timorensis*, 18 – *Prosphingitoides ovalis,* 19 – *Neospathodus* aff. *hommeri,* 20 – *Amphistephanites parisensis,* 21 – *Bandoites tobisinensis,* 22 – *“Flemingites” tobisinensis.*

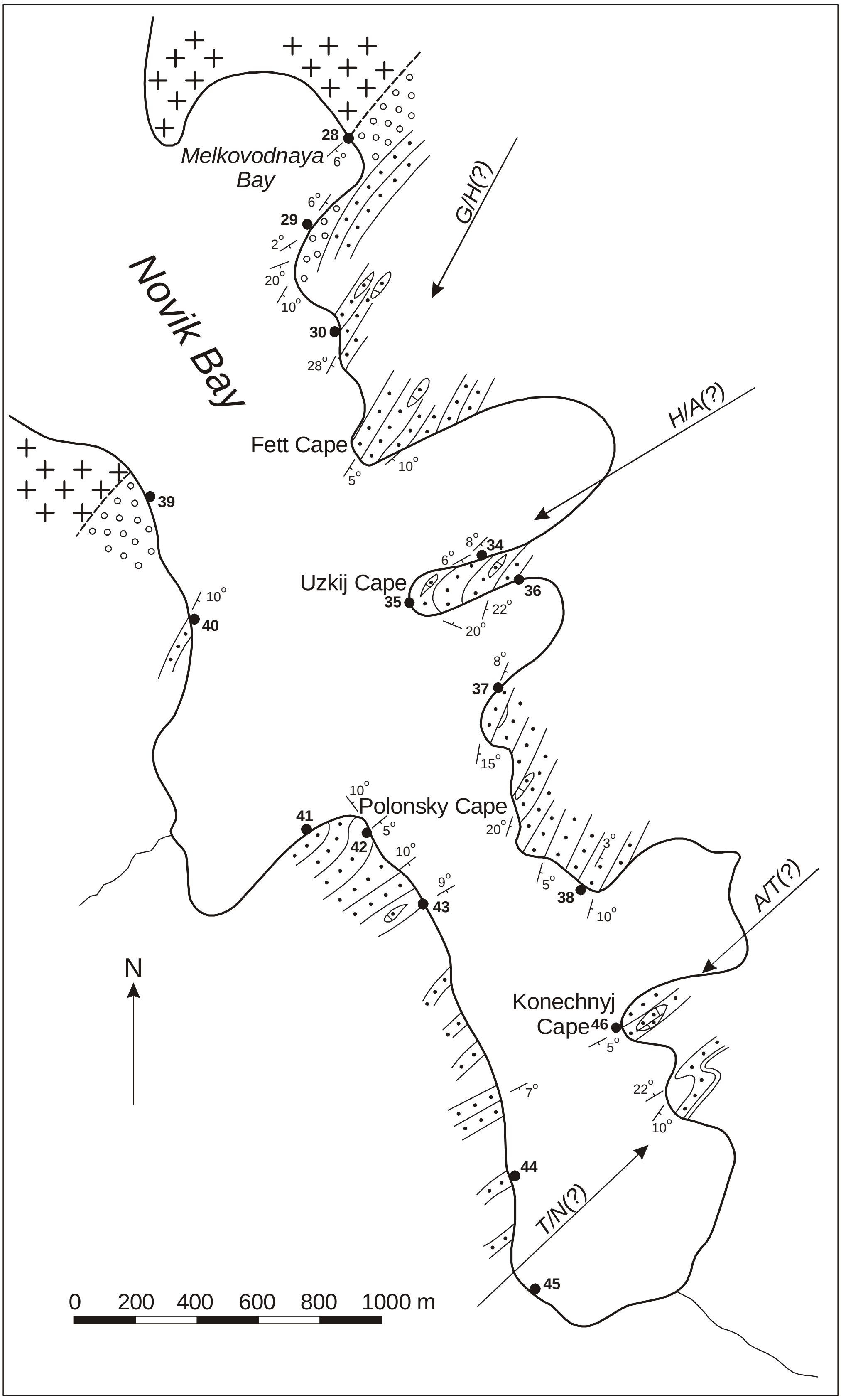


Fig. 7. Sketch map locating the points of geological investigation at Novik (Fig. 1, section 2-4 and Fig. 2). Designition as in Fig. 2 and 3).

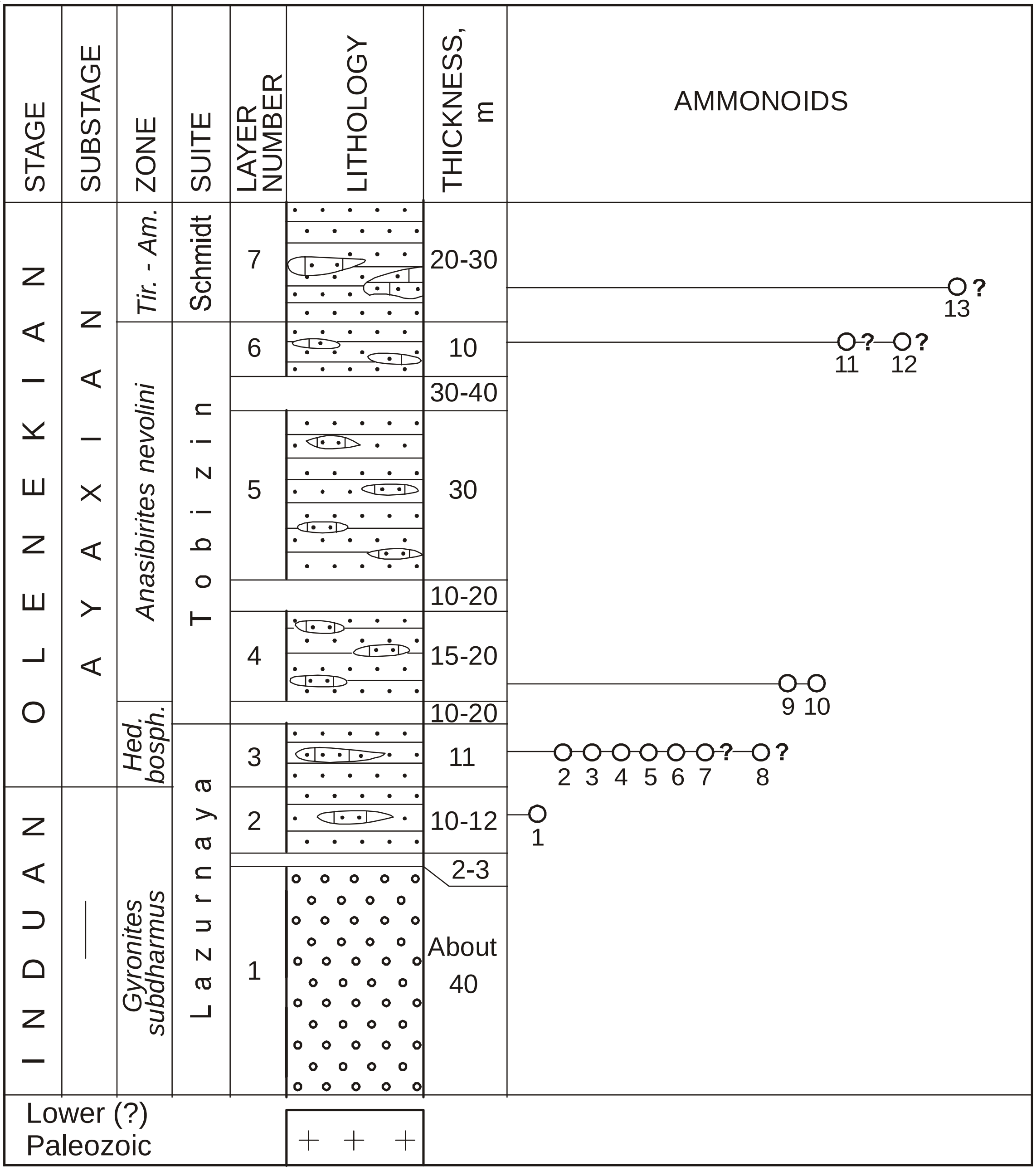


Fig. 8. Lithostratigraphical column of Triassic sediments exposed between the Melkovodnaya Bay and Konechnyj Cape (Fig. 1, section 3, Fig. 2 and 11), localities 28-38 and 46). Abbraviation: Hed. bosph. – Hedenstroemia bosphorensis, Tir.-Am. – Tirolites-Amphistephanites.
Ï ð î÷èå îáîçíà÷åíèÿ íà ðèñ. 3-5 (other designition as in Fig. 3-5).

Species: 1 - *Gyronites subdharmus*, 2 – *Dieneroceras chaoi*, 3 – *Hedenstroemia bosphorensis*, 4 – *Owenites sp. indet.*, 5 – *Prosphingitoides sp. indet.*, 6 – *Juvenites novikensis*, 7 – *Meekoceras boreale*, 8 – *Arctoceras sp.*, 9 – *Meekoceras subcristatum*, 10 – *Arctoceras labogense*, 11 – *A. robinsoni*, 12 – *A. septentrionale*, 13 – *Tchernyschevites costatus*.

This section is located at the western coast of the Ussuri Gulf (Fig. 9 and 10). I/ O boundary was investigated at locality 97. In the upper part of the Induan pure preserved Gyronites subdharmus were discovered (Fig. 11). Just at the base of the *Hedenstroemia bosphorensis* together with species-index *Parahedenstroemia* sp., *Gyronites separatus* Kiparisova, *Gyronites* aff. *planissimus* Spath and *Ambites* sp. are known (Zakharov, 1996; Zakharov et al., 2000). The most representative ammonoid assemblage (*Parahedenstroemia, Ussuria, Arctoceras, Prosphingitoides, Parananites, Ambites, Koninckites, Meekoceras, Anakashmirites, Flemingites, and Euflemingites)* was found stratigraphically somewhat higher, in association with the conodont *Neospathodus dieneri (Flemingites* beds in Kiparisova's (1961) sense). The beds containing *Palaeokazakhstanites* and

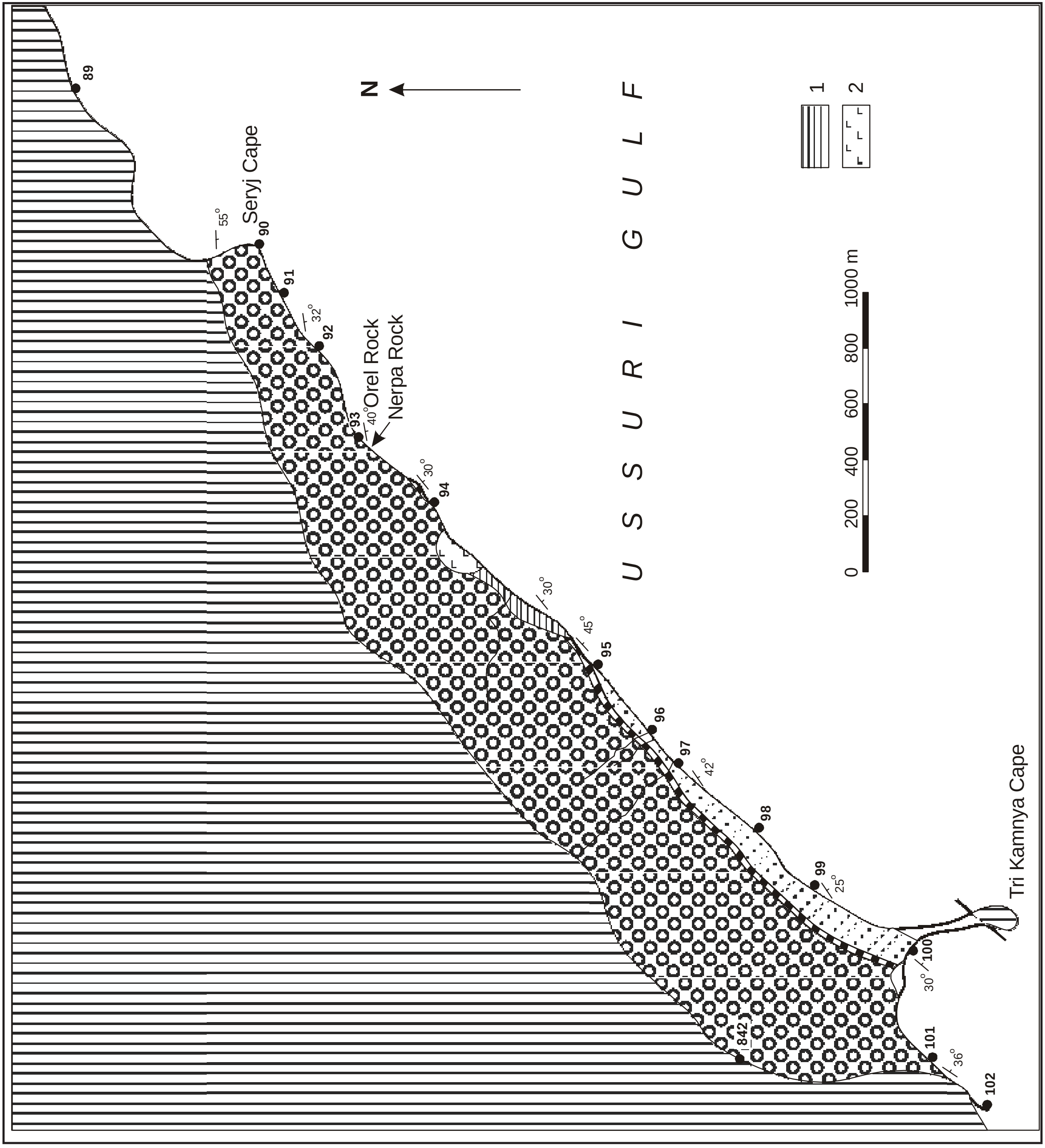


Fig. 9. Sketch map locating the Seryj –Tri Kamnya Capes section at the western Ussuri Gulf (Fig. 1, section 10). Designation: 1 – Lower Cretaceous Ussuri Suite, 2 – Late Cretaceous diorite). Other designition as in Fig. 2.

Prionolobus could belong to the *Anasibirites nevolini* Zone.

Orel Cliff on the western coast of Ussuri Gulf

Orel Cliff is located 1.6 km NE from locality 97 of the Tri Kamnya Cape section (Fig. 12). The upper layers of the Induan is characterized by the occurrence of *Gyronites subdharmus* Kiparisova, associating with conodont *Neogondolella* cf. *carinata.* I/O boundary was determined by the first appearance of *Meekoceras* cf. *subcristatum* Kiparisova and *Gyronites separatus* Kiparisova there (they were met together with conodonts *Neospathodus* sp. indet., *Diplododella* sp. indet. and *Lonchodina* cf. *triassica).*

Artyom town, "SMID" quarry (Fig. 13)

Rare Late Induan ammonoids *Gyronites subdharmus* Kiparisovawere discovered in the neighbour quarry (about 0.8 km E). No any Induan fossils were found at "SMID" quarry. *Metussuria, Dieneroceras, Arctoceras, Prosphingitoides, Owenites, Flemingites, Meekoceras,* and *Anaxenaspis* are presented in the *Hedenstroemia bosphorensis* Zone (Fig. 14). *Anasibirites nevolini* (Burij

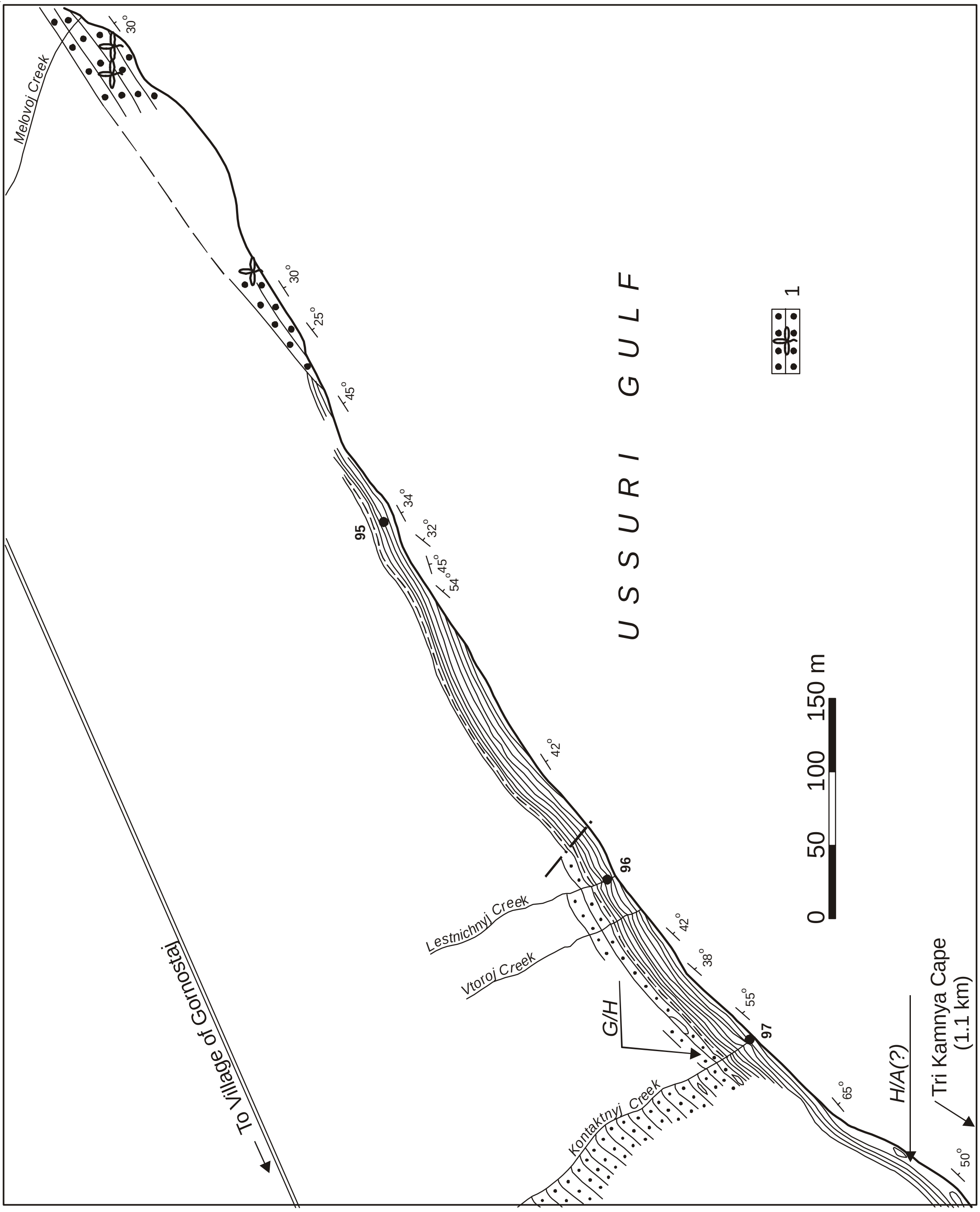


Fig. 10. Sketch map locating the Tri Kamny Cape area, western Ussuri Gulf between Kontaktnyj and Melovoj Creeks (Fig. 1, section 10, Fig. 15), localities 95-97). Designation: 1 –coarse grained sandstone with plant fossils. Other designition as in Fig. 3 and 4.

Species in Fig. 11: 1 – *Glyptophiceras ussuriense,* 2 – *Gyronites subdharmus,* 3 – *Proptychites?* sp., 4 – *Lytophiceras eusakuntala,* 5 – *Proptychites hiemalis,* 6 – *Koninckites* sp., 7 – *K. varaha,* 8 – *Neogondolella carinata*, 9 – *Preflorianites?* sp., 10 – *Promyalina shamarae,* 11 – *Meekoceras subcristatum,* 12 – *Gyronites separatus,* 13 – *Hedenstroemia bosphorensis,* 14 – *Parahedenstroemia* sp., 15 – *Gyronites* aff. *planissimus,* 16 – *Ambites* sp. indet., 17 – *Promyalina putiatinensis,* 18 – *Meekoceras* sp. nov., 19 – *Koninckites* cf. *timorensis*, 20 – *Parahedenstroemia conspicienda*,

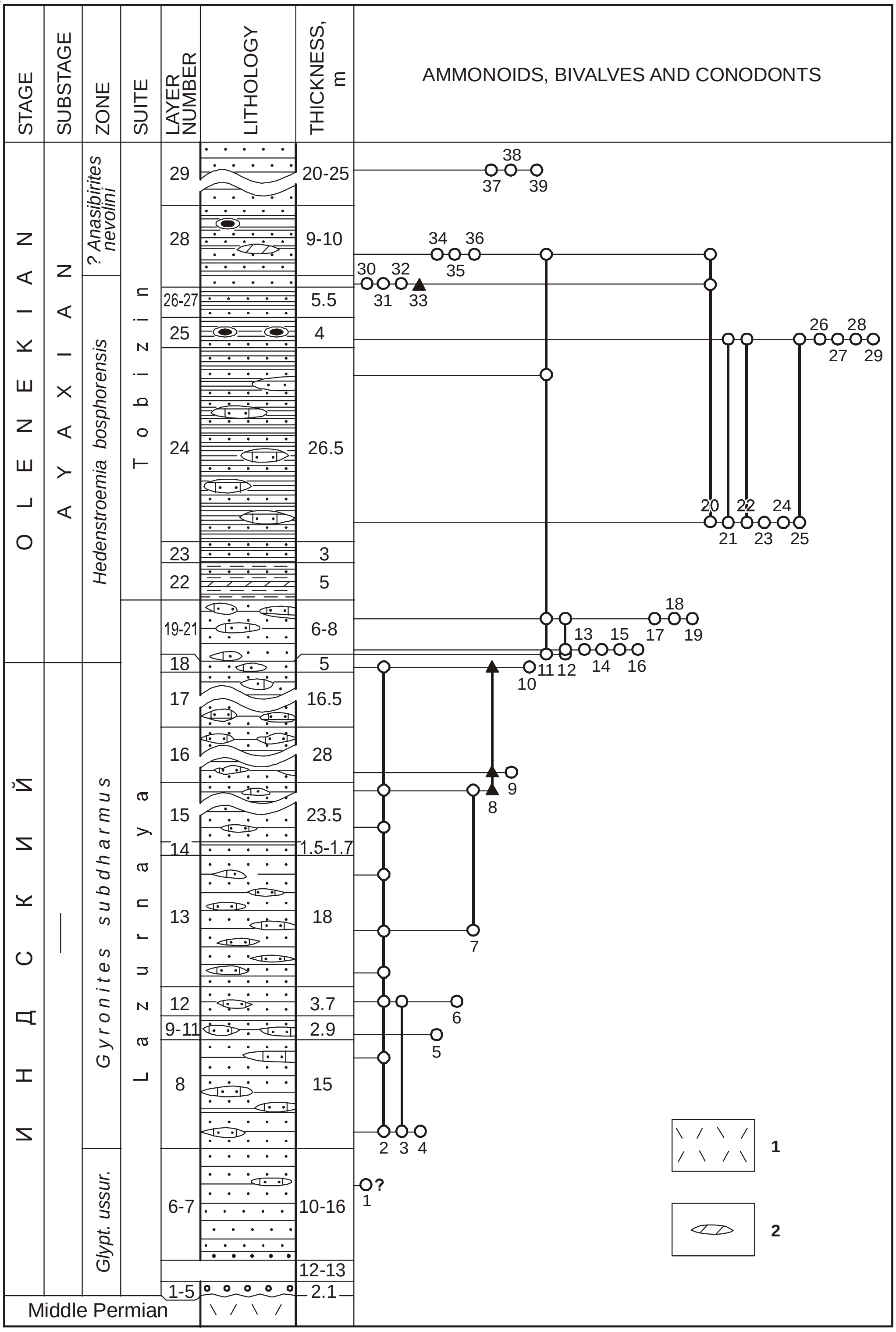


Fig. 11. Lithostratigraphical column of Triassic sediments exposed between the Seryj and Tri Kamnya Capes (Fig. 1, section 10, Fig. 15, 16 and 17), localities 90-99). Designation: 1 –andesite, 2 –marl.

Species in Fig. 11 (continued): 21 – *Arctoceras septentrionale,* 22 - *Koninckites timorensis,* 23 – *Meekoceras gracilitatis,* 24 – *Anakashmirites shamarensis,* 25 – *Euflemingites prynadai,* 26 – *Ussuria iwanowi*, 27 – *Prosphingitoides* sp., 28 – *Pseudosageceras* cf. *multilobatum*, 29 – *Flemingites radiatus*, 30 –*Ambites* cf. *discus,* 31 – *Euflemingites* sp., 32 – *Anakashmirites latiplicatus*, 33 – *Neospathodus dieneri,* 34 – *Palaeokazachstanites ussuriensis*, 35 – *Prionolobus subevolutus,* 36 – *Anakashmirites?* sp., 37 – *Arctoceras* sp. indet., 38 – *Dieneroceras* sp., 39 – *Prosphingitoides ovalis*

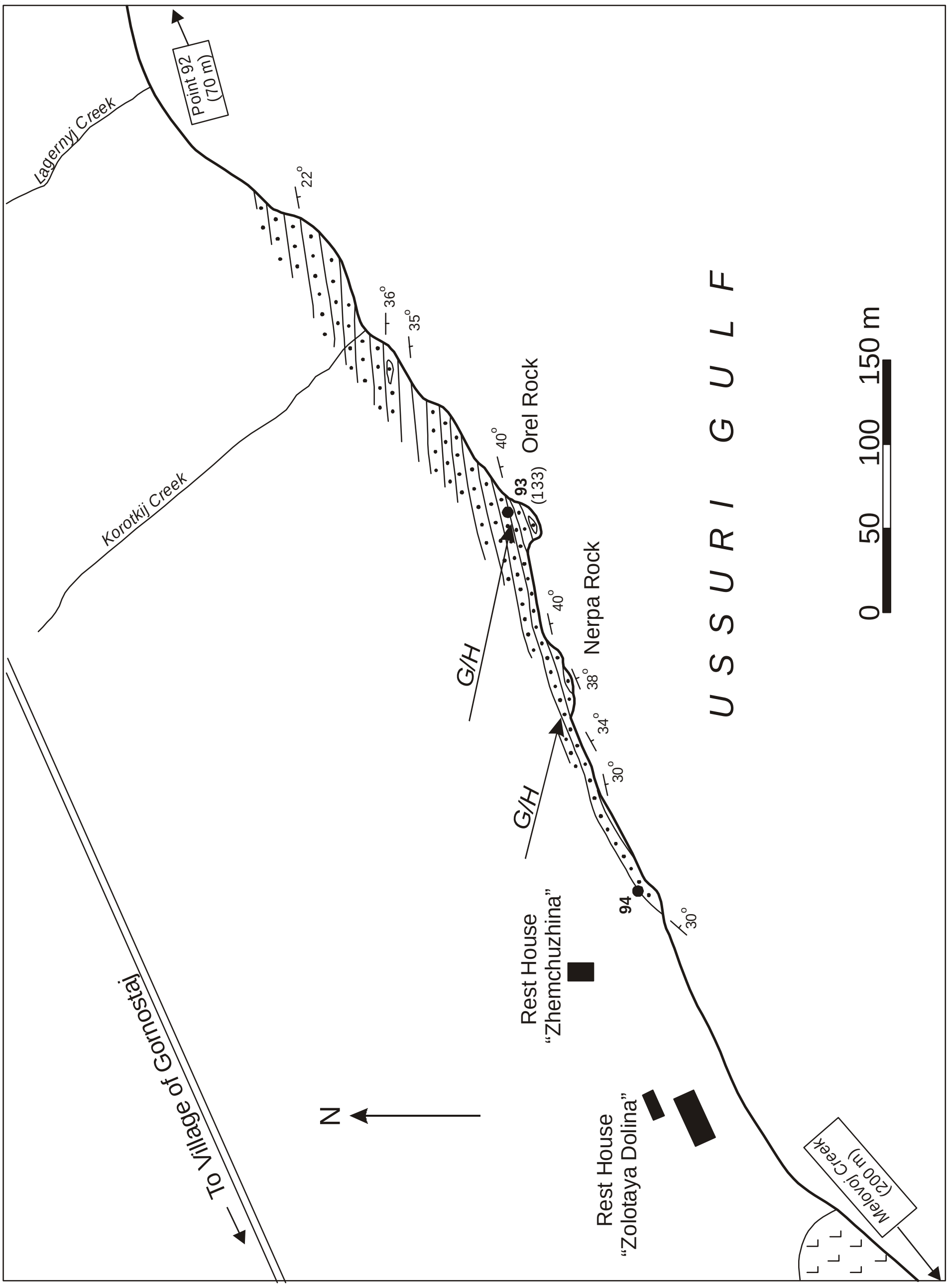


Fig. 12. Sketch map locating the Orel and Nerpa Rocks at the western Ussuri Gulf (Fig. 1, section 10, Fig. 15), localities 93-94). Designation as in Fig. 3 and 15.

et Zharnikova), *Arctoceras labogense* (Zharnikova), *Wasatchites* sp., *Kashmirites?* sp. and *Churkites* sp. nov. seem to be typical elements of the *Anasibirites nevolini* Zone.

Artyomovka River

The *Hedenstroemia bosphorensis* Zone in the Artyomovka River section yields *Metussuria bella* Zakh., *Dieneroceras chaoi* Kiparisova, *Hedenstroemia* cf. *bosphorensis* (Zakharov), *Arctoceras septentrionale* (Diener), *Prosphingitoides ovalis* (Kiparisova), *Juvenites simplex* (Chao), *Owenites koeneni* Hyatt et Smith, *Meekoceras subcristatum* Kiparisova, *Eophyllites ascoldiensis* Zakharova, *Hemiprionites dunajensis* Zakharov.

нНж *Anasibirites nevolini* the type section is characterized by *Parahedenstroemia nevolini* Burij et Zharnikova, *Arctoprionites maritimus* Burij et Zharnikova , *Arctoprionites ovalis* Burij et Zharnikova, *Parahedenstroemia nevolini* Burij et Zharnikova, *Hemiprionites contortus* Burij et Zharnikova, *Anasibirites nevolini* Burij et Zharnikova, *Wasatchites vlasovi* Burij et Zharnikova., *Gurleyites maichensis* Burij et Zharnikova., *Burijites skorochodi* (Burij et Zharnikova), *Arctoceras* sp., *Paranannites minor Parahedenstroemia nevolini* Burij et Zharnikova, *Owenites koeneni* Hyatt et Smith, *Hemiprionites contortus* Burij et Zharnikova, *Preflorianites?* sp.2, *Subalbanites mirabilis* Zakharov

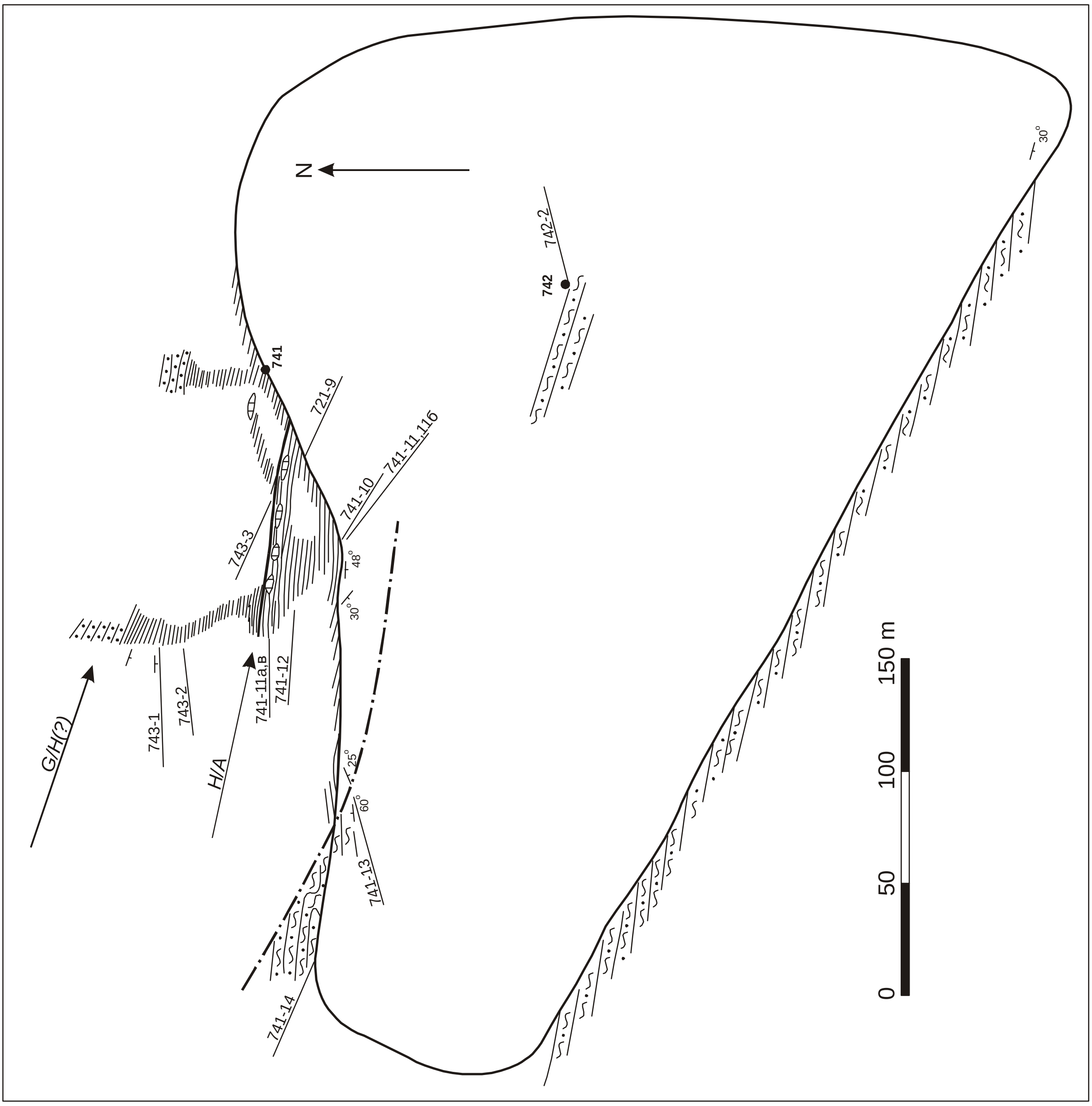


Fig. 13. Sketch map locating the “SMID” quarry at the Artyom environs (Fig. 1, section 16), localities 741 and 742. Designationas in Fig. 3.

(Burij et al., 1972; Zakharov, 1978). Typical conodonts of the *Anasibirites nevolini* are *Neogondolella milleri, Neospathodus waageni, N. discreta, Furnishius triserratus, Hindeodella nevadensis, H. budurovi, H. raridenticulata, Hadrodontina adunca, H. symmetrica, H. subsymmetrica, Parachirognathus symmetrica, H. subsymmetrica, Parachirognathus symmetrica, Lonchodina triassica* (Buryj, 1979).

Village of Smolyninovo quarry

The finding of gigantic shells of *Churkites sp. nov.* (Zakharov, 2002) in the *Anasibirites nevolini* Zone is a main result of our investigation of the Smolyaninovo section. Genus *Churkites* was firstly described by Okuneva (1990) on the base of material from the Lower Olenekian beds of Khabarovsk area characterized by conodonts Neogondolella milleri.

Golyj (Kom-Pikho-Sakho) Cape on the eastern coast of Ussuri Gulf

Golyj Cape section is located at the eastern coast of the Ussuri Gulf (Fig. 15). Very rare *Gyronites subdharmus* Kiparisova are known from the uppermost Induan (Fig. 16). *Hedenstroemia, Parussuria, Metussuria, Arctoceras, Prosphingitoides, Juvenites, Owenites, Prionolobus, Inyoites, Hemiprionites, Gurleyites?, Bandoites, Euflemingites* were met in the upper part of the *Hedenstroemia bosphorensis* Zone, in association with conodonts *Neospathodus zharnikovae* and *Furnishius*

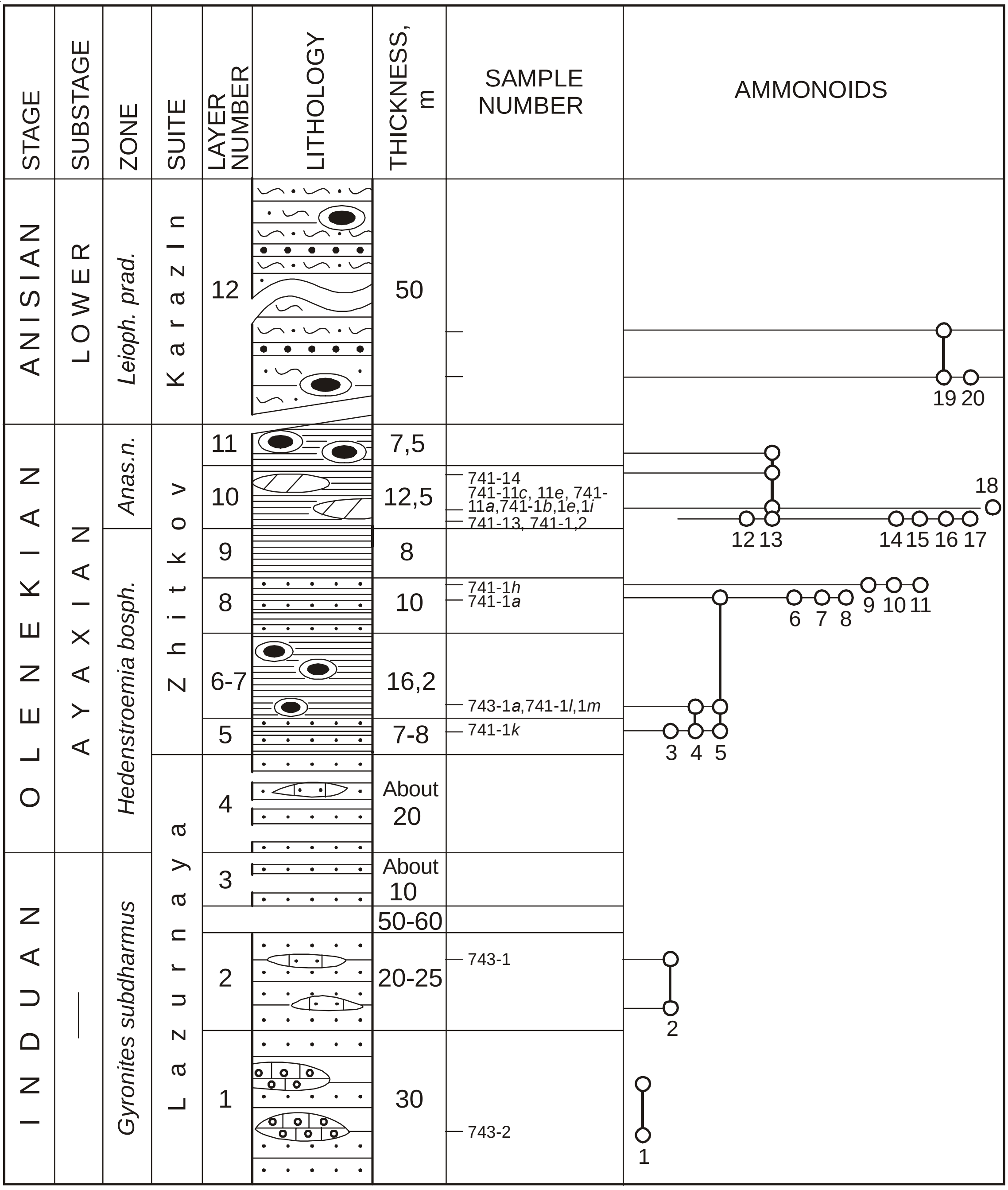


Fig. 14. Lithostratigraphical column of Triassic sediments exposed at the “SMID” quarry and neighbour quarry at the Artyom environs (Fig. 1, section 16, Fig. 19), localities 741-743.

Species: 1 – *Promyalina shamarae*, 2 – *Gyronites subdharmus,* 3 –*Metussuria* sp., 4 - *Dieneroceras* sp., 5 – *Arctoceras septentrionale,* 6 – *Prosphingitoides* sp*.,* 7 –*Dieneroceras chaoi*, 8 – *Owenites koeneni,* 9 –*Flemingites* sp., 10 – *Meekoceras* sp. nov., 11 – *Anaxenaspis sp.,* 12 - *Anasibirites nevolini,* 13 – *Arctoceras labogense,* 14 – *Wasatchites* sp., 15 – *Pseudosageceras* sp., 16 –*Posidonia ussurica,* 17 – *Kashmirites?* sp., 18 – *Churkites syaskoi,* 19 – *Leiophyllites* sp., 20 – *Hollandites?* sp.

triserratus. Hedenstroemia bosphorensis - *Anasibirites nevolini* Zones boundary is not determined there (the beds containing *Arctoceras labogense* and *Preflorianites* cf. *radians* could belong to the lower part of the *Anasibirites nevolini* Zone).

Yuzhnorechensk (Shimeuza) area

This section is located about 1-1.2 km E from the Golyj Cape section. No Induan ammonoid were discovered there (Fig. 17). At the base of the *Hedenstroemia bosphorensis* Zone, *Meekoceras gracilitatis* White, *Hemiprionites dunajensis* Zakharov and *Koninckites* sp. were recently found. In its upper part, *Dieneroceras, Arctoceras, Metussuria, Hedenstroemia, Koninckites, Parakymatites, Anaxenaspis, Owenites, Euflemingites, Lanceolites* are

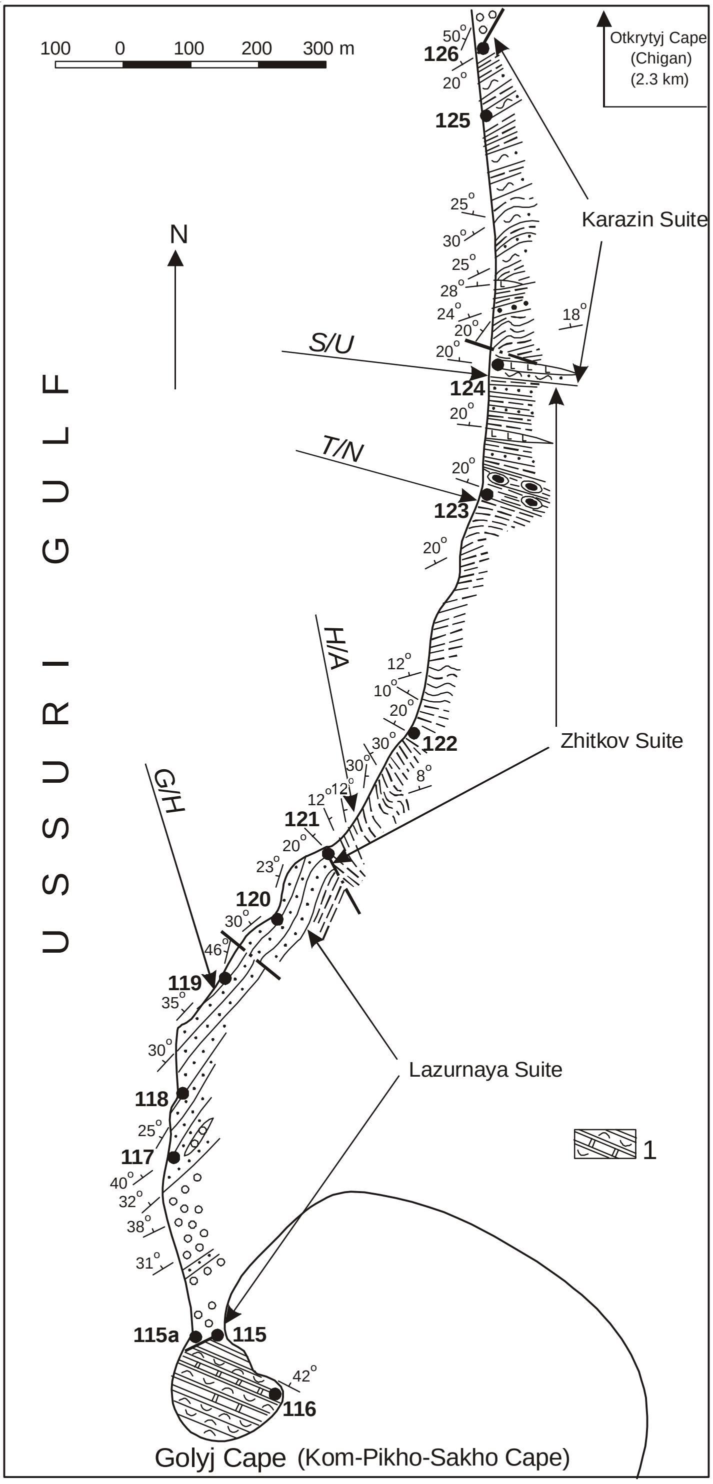


Fig. 15. Sketch map locating the Golyj (Kom-Pikho-Sakho) Cape section at the eastern Ussuri Gulf (Fig. 1, section 12). Designation: 1**-** Lower Permian? tufogenous and siliceous rock. Other designition as in Fig. 3 and 5.

present in association with conodonts *Neospathodus zharnikovae* and *Furnishius triserratus*. Just above a single shells of *Anasibirites* were found in association with *Gurleyites, Anakashmirites, Kashmirites, Anakashmirites, Prionolobus, Subalbanites, Preflorianites?, Eophyllites, Ussuria* and Melagaticeratidae. (*Anasibirites nevolini* Zone).

Abrek Bay, Strait of Strelok

This section is located at the Strelok Strait (Fig. 18). Rare Induan ammonoids were determined as *Gyronites subdharmus* Kiparisova, *Lytophiceras* cf. *eusacuntala* Zakharov and *Koninkites* sp. indet. (Fig. 19). The base of the *Hedenstroemia bosphorensis* (member 7) is marked by rare shells of *Meekoceras boreale* Diener associated with *Ambites* sp. and *Neogondolella carinata*. The latter

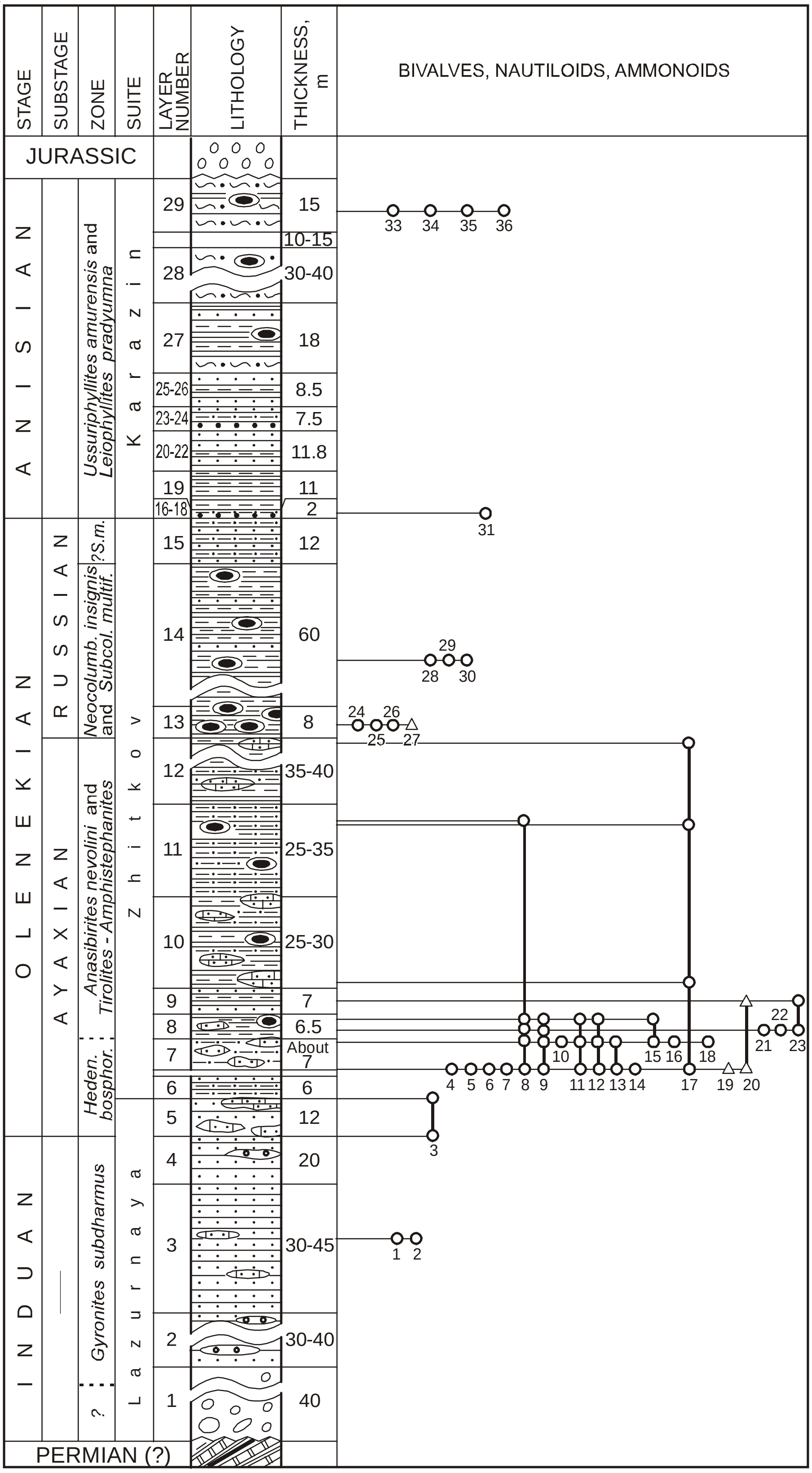


Fig. 16. Lithostratigraphical column of Triassic sediments exposed at the Golyj Cape area (Fig. 1, section 12, Fig. 20), localities 116-126 Abbraviation: Hed. bosph. – Hedenstroemia bosphorensis, Neocolumb. Insign .– Neocolumbites insignis, ?S. m. - ?Subcolumbites multiformis. Other designition as in Fig. 3, 5 and 2.

.

Âèäû (species): 1- *Promyalina putiatinensis*, 2 – *Gyronites subdharmus,* 3 – *Meekoceras* sp., 4 – *Hedenstroemia* sp., 5 – *Parussuria semenovi,* 6 – *Metussuria* cf. *bella,* 7 – *Tellerites?* sp., 8 – *Arctoceras septentrionale,* 9 – *Prosphingitoides ovalis,* 10 – *P. hexagonalis,* 11 – *Juvenites simplex*,

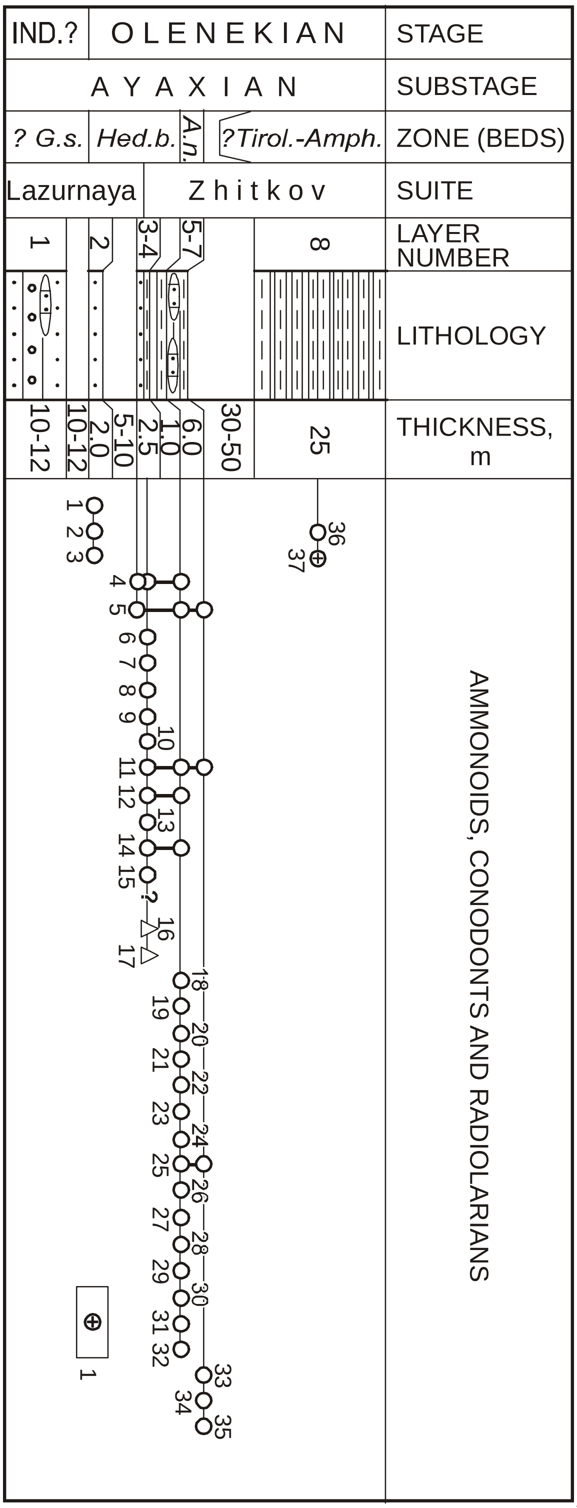


Fig. 17. Lithostratigraphical column of Triassic sediments exposed at the Yuzhnorechensk area (Fig. 1, section 13). Abbraviation: ?G.s. – Glyptophiceras ussuriense, Hed.b. – Hedenstroemia bosphorensis, A.n. – Anasibirites nevolini, Tirol.-Amph. – Tirolites-Amphistephanites. Designation: 1 – radiolarians. Other designition as in Fig. 3 and 4).

Species: 1 – Meekoceras gracilitatis, 2 – Hemiprionites dunaijensis, 3 – Koninckites sp., 4 – Dieneroceras chaoi, 5 – Arctoceras septentrionale, 6 – Metussuria sp. nov., 7 – Hedenstroemia bosphorensis, 8 – Koninckites timorensis, 9 – Parakymatites sp. nov., 10 – Anaxenaspis orientalis, 11 – Owenites koeneni, 12 – Prosphingitoides ovalis, 13 – Arctoceras sp., 14 – Euflemingites prynadai, 15 – Lanceolites sp. nov., 16 – Neospathodus zharnikovae, 17 – Furnishius triserratus, 18 – Anasibirites sp., 19 – Gurleyites armatus, 20 – Pseudosageceras longilobatum, 21 – Ussuria sp. nov., 22 – Arctoceras cf. labogense, 23 – Anaxenaspis orientalis, 24 – Juvenites simplex, 25 – Prosphingitoides hexagonalis, 26 Anasibirites nevolini, 27 – Anakashmirites sp. nov., 28 - Kashmirite sp. indet, 29 – Prionolobus subevolvens, 30 – Subalbanites mirabilis, 31 – Preflorianites? sp., 32 – Eophyllites ascoldiensis, 33 – Pseudosageceras sp., 34 – Ussuria iwanowi, 35 – Melagaticeratidae gen. et sp. nov., 36 – Bandoites sp., 37 – Radiolaria.

Species in Fig. 16 (continued):12 – *Owenites koeneni,* 13 – *Prionolobus subevolvens,* 14 – *Inyoites spicini,* 15 – *Hemiprionites dunajensis*, 16 – *Gurleyites?* sp., 17 – *Bandoites elegans,* 18 – *Euflemingites prynadai,* 19 – *Neospathodus zharnikovae,* 20 – *Furnishius triserratus*, 21 – *Pseudosageceras* sp. indet., 22 – *Arctoceras labogense,* 23 – *Preflorianites* cf. *radians,* 24 – *Neocolumbites* sp*.,* 25 – *Columbites ussuriensis,* 26 – *Columbites* sp*.,* 27 – *Neospathodus triangularis,* 28 – *Khvalinites unicus,* 29 – *Hellenites?* sp., 30 – *Olenekoceras?* sp., 31 - *Hollandites?* sp., 32 – *Leiophyllites?* sp., 33 – *Tropigastrites sublahontanus,* 34 – *Tropigastrites* sp., 35 - *Leiophyllites* cf. *pradiumna,* 36 – *Hollandites tozeri.*

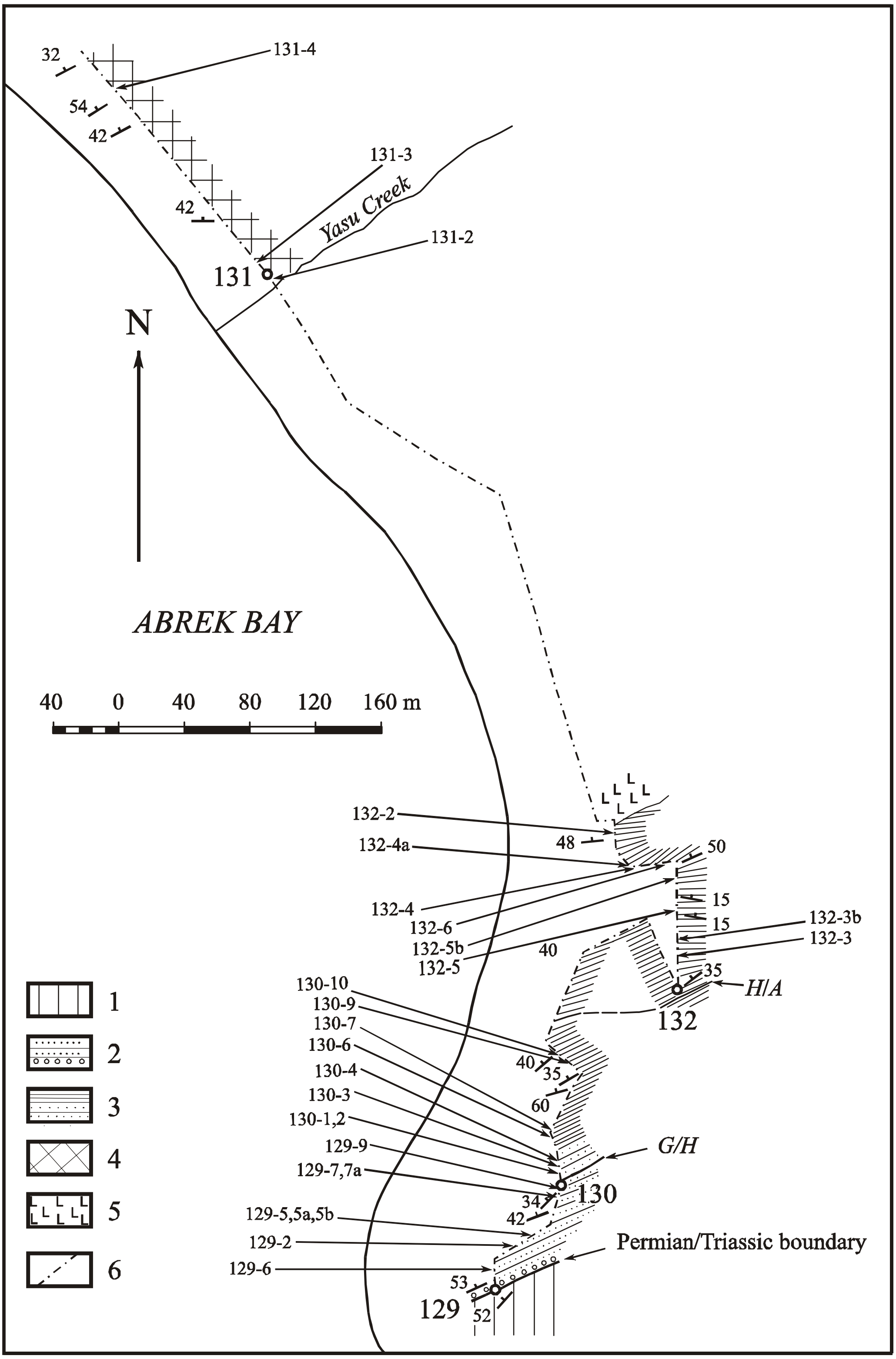


Fig. 18. Sketch map locating the Abrek Bay section at the Strelok Strait (Fig. 1, section 14). Designation: 1- Wordian Abrek suite, 2 – Lazurnaya suite (Induan and basal beds of the Olenekian), 3 – lower Zitkov suite (Lower Ayaxian), 4 – Anisian Karazin suite, 5 – dykes of porphyrite, 5 –geological route. Other designition as in Fig. 3.

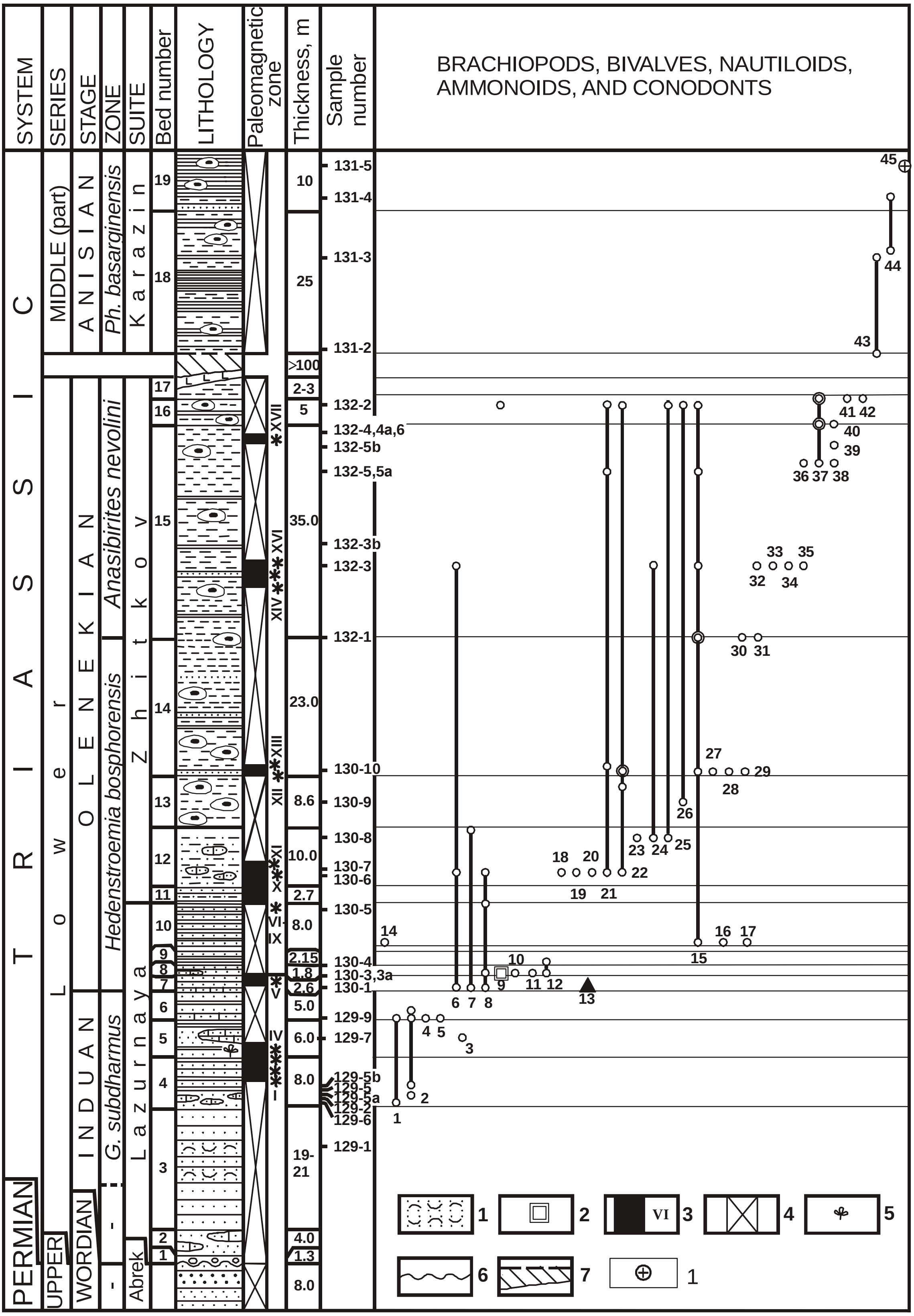


Fig. 19. Lithostratigraphical column of Triassic sediments exposed at Abrek Bay (Fig. 1, section 14), localities 129-132). Abbraviation: G. subddharmus - Gyronites subddharmus, Ph. basarginensis **-** Phyllocladiscites basarginensis. Designation**):** 1 – sandstone with fragments of mollusk valves, 2 – brachiopods – dominant, 3 **–** paleomagnetic zone (interval of normal polarity), 4 –uninspected interval, 5 – plant remains, 6 – erosion, 7 **–** tuf-interval. Other desigmition as in Fig. 3, 5, 23 and 24.

Species: 1 - *Gyronites subdharmus,* 2 – *Promyalina putiatinensis,* 3 – *Lytophiceras* cf. *eusacuntala,*

.

is a single conodont species recently determined by G.I. Buryj in this section. Rare ammonoids *Arctoceras?* and Melagathiceratidae occur 2.6 m upper. 5-9 m above the base of the Olenekian (member 10), *Meekoceras boreale* Diener was found again. *Hedenstroemia* sp. indet . (Kiparisova, 1961) and *Gyronites* cf. *subdharmus* Kiparisova (Y. Shigeta's finding) seem to be found in this level. Ammonoids are extremely abundant and varied in the member 12 (*Parahedenstroemia, Inyoites, Arctoceras, Pseudoprosphingites, Ambites, Koninckites, Meekoceras, Dieneroceras* and *Preflorianites)*, member 14 (Gyronitidae?, *Koninckites, Flemingites,* and *Anaxenaspis*). A single small shell of *Anasibirites nevolini* Burij et Zharnikova was found in the member 15, in association with *Arctoceras labogense* (Zharnikova), *Arctoceras subhydaspis* (Kiparisova), *Arctoceras septentrionale* (Diener), *Pseudoprosphingites magnumbilicatum* (Kiparisova), *Owenites koeneni* Hyatt et Smith, Gyronitidae gen et sp. nov., *Koninckites timorensis* Wanner, *Gurleyites* sp., *Palaeokazakhstanites ussuriensis* (Zakharov), *Euflemingites prynadai* (Kiparisova) and *Eophyllites* sp. (*Anasibirites nevolini* Zone). The upper part of this zone contains *Arctoceras, Pseudoproshingites, Koninckites, Parakymatites, Meekoceras,, Hemiprionites* and *Preflorianites.*

The finding ammonoids similar with *Gyronites subdharmus* in the member 10 somewhat disturb well-composed picture of the Abrek Bay section painted early (Zakharov et al., 2000). Y. Shigeta considers that I/O boundary is lockated at the base of member 10, 5-9 m above the base of the Olenekian offered early (Zakharov et al., 2000). In Y. Zakharov's opinion, the position of the I/O boundary in the Abrek Bay section must be check up by the data on conodont distribution taking into account the relative rarity and not so good preservation of some ammonoids just at the I/O boundary transition and also the fact that some Induan and Olenekian ammonoids (*Gyronites*) differ at least only on species level.

Concluding remark

Mainly based on data on lower Olenekian ammonoids from South Primorye we arrive at a conclusion that the comprehensive approach, including the investigation of both ammonoid and conodont assemblages, is an indispensable condition of successful correlation of Lower Triassic sediments of Tethys (Table 2) and the Boreal realm.

Acknowledgements

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References

Buryi, G.I. 1979. Lower Triassic conodonts of South Primorye, 143 pp., pls. 1-21. Moskva, Nauka (in Russian).

Burij, I.V., Zakharov, Y.D., Zharnikova, N.K. & Nevolin, L.A. 1972. On the finding of *Anasibirites* fauna in South Primorye and its stratigraphical significanse. *In.* Y. Ustinovsky (ed.), Osadochnye i vulkanogenno-osadochnye formatsii Dalnego Vostoka, p. 79-81, Vladivostok (in Russian).

Kiparisova, L.D. 1961. Paleontological basis of Triassic stratigraphy of Primorye region. 1. Cephalopods. Trudy VSEGEI, n. ser., 48:1-278 (in Russian).

Okuneva, T.M. 1990. Triassic biostratigraphy of southern regions of the East USSR (without the Primorye territory). *In* Y.D. Zakharov (ed.), Novye dannye po biostratigraphii paleozoya i mezozoya yuga Dalnego Vostoka, p. 125-136, pls. 14. Vladivostok, DVO AN SSSR (in Russian).

Zakharov, Y.D. 1968. Biostratigraphiya i ammonoidei nizhnego triasa Yuzhnogo Primorya (Lower Triassic biostratigraphy and ammonoids of South Primorye), 175 pp., pls 1-31. Moskva, Nauka (in Russian).

Zakharov, Y.D. 1978. Rannetriasovye ammonoidei Vostoka SSSR (Early Triassic ammonoids of the East USSR), 224 pp., pls. 1-19, Moskva, Nauka (in Russian).

Zakharov, Y.D.1996. The Induan-Olenekian boundary in the Tethys and Boreal realm.Ann. Mus. civ. Roveto. Sez.: Arch., St., Sc. nat., 11: 133-156.

Zakharov, Y.D., Shigeta, Y., Popov, A.M., Sokarev, A.N., Buryi, G.I., Golozubov, V.V., Panasenko, E.S.& Dorukhovskaya, E.A. The candidates of global stratotype of the boundary of the Induan and Olenekian stages of the Lower Triassic in Southern Primorye. Albertiana, 2000, 24: 12-26.

Zakharov, Y.D. 1997. Ammonoid evolution and the problem of the stage and substage division of the Lower

Species in Fig. 19 (continued): 4 – *Promyalina schamarae,* 5 – *Koninckites* sp. indet., 6 – *Promyalina* sp., 7 – *Ambites* sp., 8 – *Meekoceras boreale,* 9 – *Abrekia sulcata,* 10 – *Hedenstroemia* sp. indet., 11- *Arctoceras?* sp. indet., 12 – Melagathiceratidae gen et sp. nov., 13 – *Neogondolella carinata,* 14 – *Gyronites* cf. *subdharmus,* 15 – *Koninckites timorensis,* 16 – *Gyronautilus praevolutum,* 17 – *Syringonautilus* sp., 18 – *Inyoites spicini,* 19 - aff. *timorensis,* 20 – *Dieneroceras chaoi,* 21 – *Pseudoprosphingites magnumbilicatum,* 22 –*Koninckites varaha,* 23 –*Parahedenstroemia conspicienda,* 24 – *Arctoceras septentrionale,* 25 – *Preflorianites* cf. *radiatus,* 26 – *Meekoceras* sp. nov., 27 – Gyronitidae?, 28 – *Flemingites radiatus,* 29 – *Anaxenaspis* cf. orientalis, 30 – *Gurleyites* sp., 31 – *Anasibirites nevolini,* 32 – *Owenites koeneni,* 33 – Gyronitidae gen. Et sp. indet., 34 – *Palaeokazakhstanites ussuriensis,* 35 – *Eophyllites* sp., 36 – *Pseudosageceras* sp., 37 – *Arctoceras labogense,* 38 – *Euflemingites prynadai,* 39 – *Arctoceras subhydaspis,*40 – *Pseudosageceras longilobatum,* 41 – *Parakymatites* sp. nov., 42 – *Hemiprionites dunajensis,* 43 – *Leiophyllites* sp., 44 – *Cuccoceras* sp., 45 – *Spumellaria* sp.

Triassic. Mém. Géologie (Lausanne), 30: 121-136.

Zakharov, Y.D. & Rybalka, S.V. 1987. A standard for the Permian-Triassic in the Tethys. *In* Y.D. Zakharov & Y.I Onoprienko (eds.), Problem of Permian and Triassic biostratigraphy of the East USSR, p. 6-48, pls. 1-5. Vladivostok, DVNC AN SSSR (in Russian).

Zakharov, Y.D., Shigeta, Y., Popov, A.M., Sokarev, A.N., Buryi, G.I., Golozubov, V.V., Panasenko, E.S.& Dorukhovskaya, E.A. 2000. The candidates of global stratotype of the boundary of the Induan and Olenekian stages of the Lower Triassic in Southern Primorye. Albertiana, 24: 12-26.

Table 1. Lower and Middle Triassic sequence in South Primorye.

<table>
<tr><th rowspan="2">SYSTEM</th><th rowspan="2">SERIES</th><th rowspan="2">STAGE</th><th rowspan="2">SUBSTAGE</th><th rowspan="2" colspan="2">ZONE
(BEDS)</th><th rowspan="2">Horizon
(Burij, 1997)</th><th colspan="2">SUITE</th></tr>
<tr><th>Western group of sections</th><th>Eastern group of sections</th></tr>
<tr><td rowspan="15">TRIASSIC</td><td rowspan="7">MIDDLE</td><td rowspan="2">LADINIAN</td><td>UPPER</td><td><i>Atractites-?Ptychites</i> beds</td><td rowspan="2"><i>Daonella</i> beds</td><td>Chers.</td><td>Akhlestyshev
(Zakharov et al., this work)</td><td>Traktornyj
(Shorokhova, this work)</td></tr>
<tr><td>LOWER</td><td>Monophyllites - <i>Protrachyceras</i> beds</td><td>—</td><td>Sputnik
(Burij, 1959)</td><td>——</td></tr>
<tr><td rowspan="5">ANISIAN</td><td rowspan="2">UPPER</td><td colspan="2"><i>Gymnotoceras medvedevi</i> beds</td><td rowspan="5">Karazin</td><td rowspan="5" colspan="2">Karazin
(Zakharov, 1997)</td></tr>
<tr><td colspan="2"><i>Paraceratites - Ptychites oppeli</i> beds</td></tr>
<tr><td>MIDDLE</td><td colspan="2"><i>Acrochordiceras kiparisovae</i>
(=<i>Phyllocladiscites basarginensis</i>)</td></tr>
<tr><td rowspan="2">LOWER</td><td colspan="2"><i>Leiophyllites pradyumna</i></td></tr>
<tr><td colspan="2"><i>Ussuriphyllites amurensis</i></td></tr>
<tr><td rowspan="8">LOWER</td><td rowspan="6">OLENEKIAN</td><td rowspan="2">RUSSIAN</td><td colspan="2"><i>Subcolumbites multiformis</i></td><td rowspan="4">Chernyshev</td><td rowspan="2">Zhitkov
(Zakharov, 1997)</td><td rowspan="6">Zhitkov
(Zakharov et.al., 2000)</td></tr>
<tr><td colspan="2"><i>Neocolumbites insignis</i></td></tr>
<tr><td rowspan="4">AYAXIAN</td><td rowspan="2"><i>Tirolites - Amphystephanites</i></td><td><i>Tirolites ussuriensis</i> beds</td><td rowspan="2">Shmidt
(Zakharov, 1997)</td></tr>
<tr><td><i>Bajarunia dagysi</i> beds</td></tr>
<tr><td colspan="2"><i>Anasibirites nevolini</i></td><td rowspan="2">Tobizin</td><td rowspan="2">Tobizin
(Zakharov, 1997)</td></tr>
<tr><td colspan="2"><i>Hedenstroemia bosphorensis</i></td></tr>
<tr><td rowspan="2">INDUAN</td><td rowspan="2">—</td><td colspan="2"><i>Gyronites subdharmus</i></td><td rowspan="2">Lazurnaya</td><td rowspan="2" colspan="2">Lazurnaya (Zakharov, 1997)</td></tr>
<tr><td colspan="2">Слои с <i>Glyptophiceras ussuriense</i></td></tr>
</table>

Table 2. Correlation of the upper Induan and lower Olenekian ammonoid and conodont zones at the Tethys and Boreal realm.

TRIASSIC				SYSTEM	
LOWER				SERIES	
INDUAN (upper part)	OLENEKIAN (lower part)			STAGE	
	AYAXIAN			SUBSTAGE	
Gyronites subdharmus (upper part)	*Hedenstroemia bosphorensis*	*Anasibirites nevolini*	*Tirolites-Amphistephanites* *Tirolites ussuriensis* *Bajarunia dagysi*	Zakharov, 1997	SOUTHERN PRIMORYE
Neogondolella carinata (upper part) *Neospathodus pakistanensis*	? *Neospathodus waageni* *Parachirognathus-Furnishius*	*Neogondolella milleri*	*Icriospathodus collinsoni*	Buryj, 1979 (altered)	
Prionolobus rotundatus (upper part)	*Flemingites flemingianus*	*Anasibirites pluriformis*	*Tirolites-Columbites* (lower part)	Waagen, 1895; Guex, 1978 (altered)	SALT RANGE
Neospathodus cristagalli *Neospathodus pakistanensis*	*Neospathodus waageni*		*Neogondolella jubata* (lower part)	Sweet, 1970a	
Vavilovites sverdrupi *Tompoprotychites turgidus* ?	*Hedenstroemia hedenstroemi* *Lepiskites kolymensis*	*Anawasatchites tardus*	*Bajarunia euomphala* *Northophiceras contrarium*	Dagys, Ermakova, 1993 (altered)	NORTHEASTERN ASIA
? *Neogondolella nepalensis*	*Neospathodus waageni* *Neogondolella moscheri*	*Neogonlella milleri*	*Neogondolella jubata* (lower part)	Dagys, 1984	
Vavilovites sverdrupi	*Hedenstroemia hedenstroemi* *Euflemingites romunderi*	*Anawasatchites tardus*	?	Orchard, Tozer, 1997	CANADA
Neospathodus cristagalli	? *Neospathodus pakistanensis* *Gladigondolella meeki*	*Neogondolella milleri*	*Neogondolella aff. sweeti*		

Preliminary data on Triassic palaeomagnetism of South Primorye

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Introduction

In practice of palaeomagnetic investigation of Phanerozoic sections located in folded belts we have many negative results (McElhinny & Opdyke, 1973; Dobson & Heller, 1992; Wang & Van der Voo, 1993). As was shown early (Vlasov & Popova, 1964; Zakharov & Sokarev, 1991a,b; Bazhenov et al., 1999), the material from many series of the Permian-Triassic sections in South Primorye contains secondary or unstable magnetization components only, particularly the Triassic. Therefore we have some problems to choose the global stratotype and point of the Induan-Olenekian boundary in Primorye region on this reason, in spite of abundance of good preserved ammonoids at the base of the Olenekian in many sections of the region (Zakharov, 1996; Zakharov et al., 2000).

Palaeomagnetic sampling and measurements

The aim of the present paper is to estimate the fundamental possibility to use Triassic rocks of South Primorye for palaeomagnetic investigation, we made an additional at-

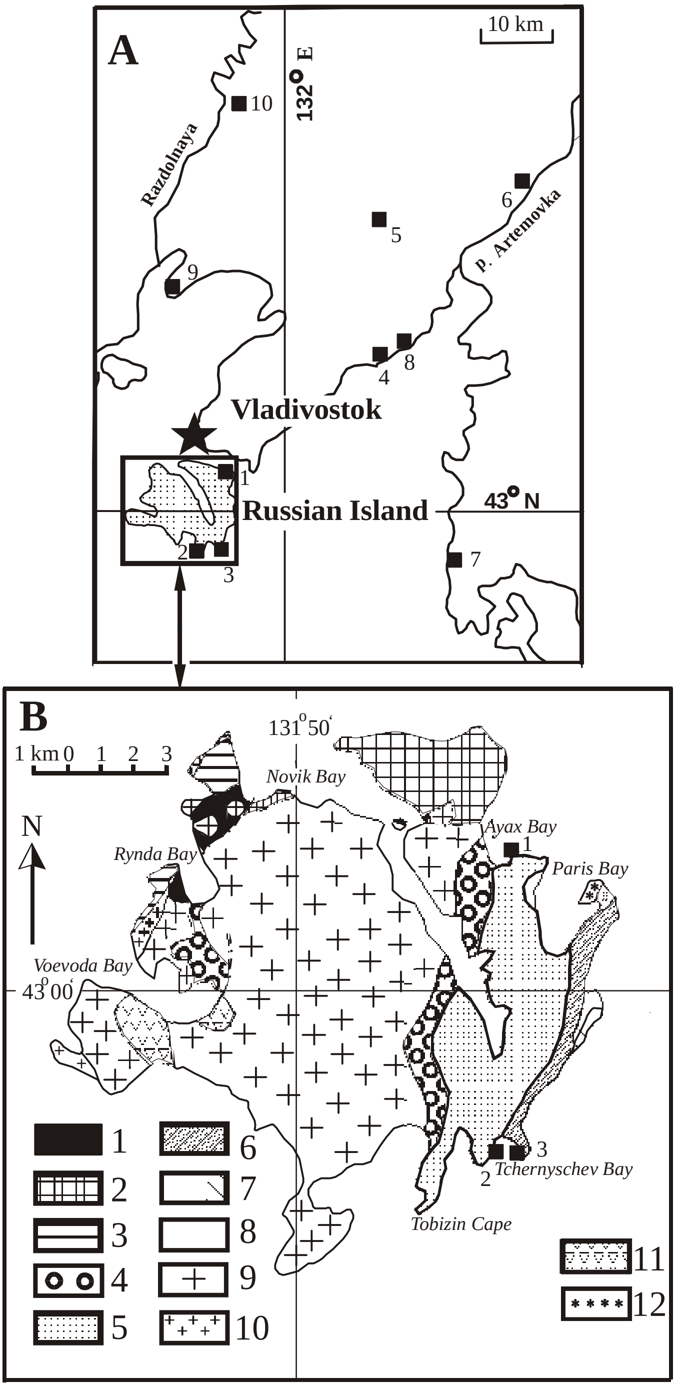

Figure 1: Maps showing location of palaeomagnetic samples in the Triassic of South Primorye (A) including Russian Island (B). Sections: 1 – Ayax Bay (Lower Olenekian), 2 – western Tchernyschev Bay (Upper Olenekian), 3 – eastern Tchernyschev Bay (middle Lower Anisian), 4 – Tri Kamnya Cape (Lower Olenekian), 5 – Artyom (quarry SMID) (Lower Olenekian and lower Lower Anisian), 6 – village of Mnogoudobnoye (Upper Triassic), 7 – village of Podyampolskoye (Middle Triassic) (Bazhenov et al., 1999), 8 – Zhemchuzhina Hotel area (Lower Triassic) (Bazhenov et al., 1999), 9 – village of Tavrichanka (Upper Triassic) (Bazhenov et al., 1999), 10 – village of Razdolnoye (Upper Triassic) (Bazhenov et al., 1999). Rocks in Russian Island: 1 –large xenolith (Precambrian? Putyatin Fm.) in early Palaeozoic granitoids, 2 – Kungurian-Roadian (Pospelov Fm.), 3 – Wordian (Vladivostok Fm.), 4 – Induan (Lazurnaya Fm.), 5 – Olenekian (Tobisin, Schmidt and Zhitkov Fms.), 6 – Anisian (Karasin Fm.), 7 –Ladinian? (Akhlestyshev Fm.), 8 - Quaternary, 9 – early Palaeozoic granitoids, 10 – late Permian granite porphyry , 11 – late Permian andesite, 12 – Cretaceous felsite porphyry.

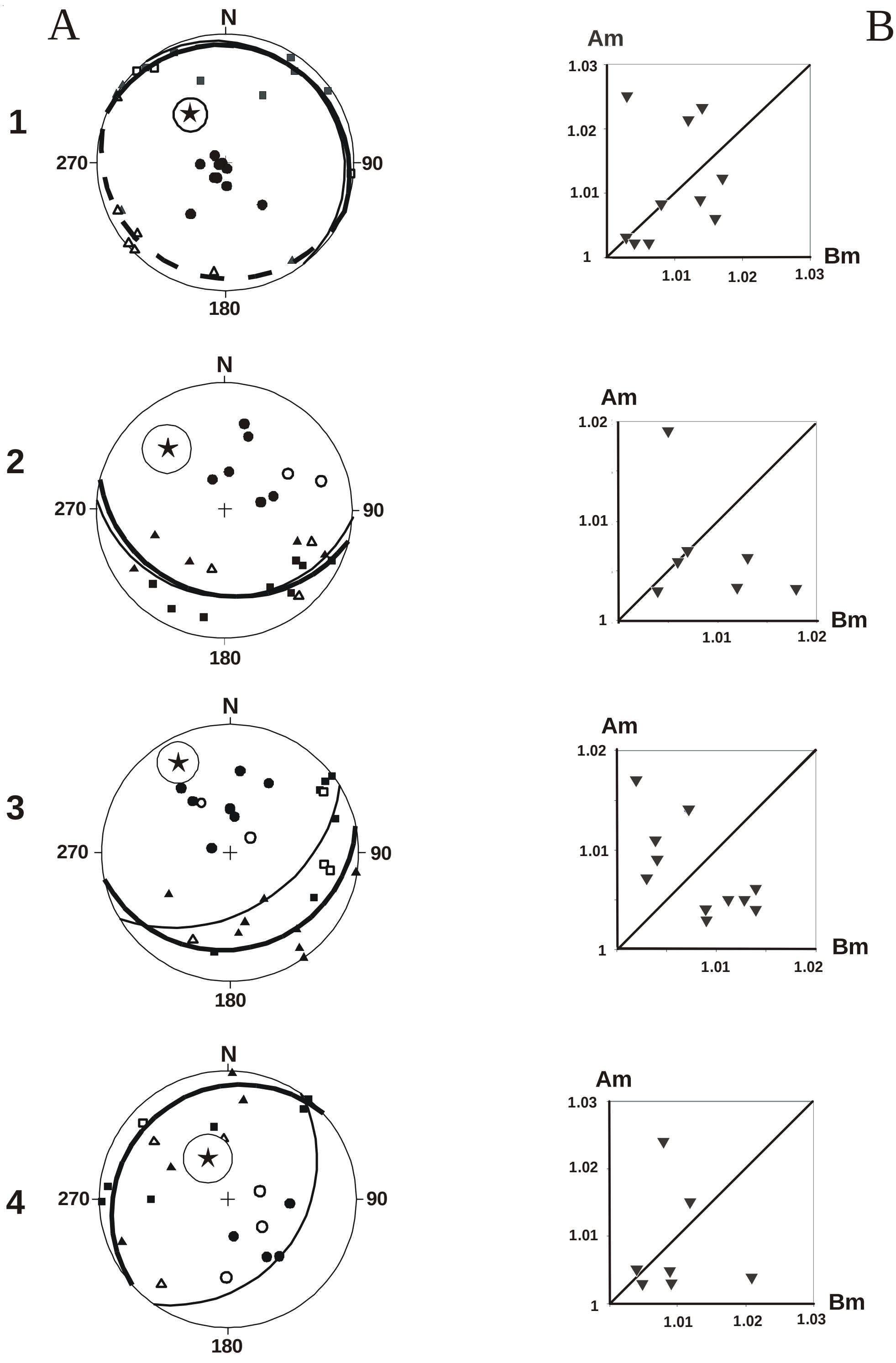

Figure 2: Anisotropy of magnetic sensitivity of Triassic rocks (in Bretstein & Klimova's interpretation). A – distribution of direction projections for main axes of the ellipsoid AMS on the scope and average direction for the magnetization vector I_n. Closed (open) squares, triangles and circles denote projections of the large, intermediate and small axes of the ellipsoid on the lower (upper) Hemisphere. The star in the circle denotes direction of the vector I_n and the oval of confidence, 95% probability level. Thin lines denote projections of flats for bed declining on the lower Hemisphere. Reinforced lines denote the projection of magnetic anisotropy flats (tensor distribution of large and intermediate axes of the ellipsoid AMS) on the lower and upper Hemispheres, correspondingly. Double circles mean the initial position of the vectors I_n. B – Flinn's diagrams (distribution of scalar values of parameters AMS). Sections: 1 – Rusasian Island, 2 – Artyom (SMID), 3 –Mnogoudobnoye, 4 – Tri Kamnya.

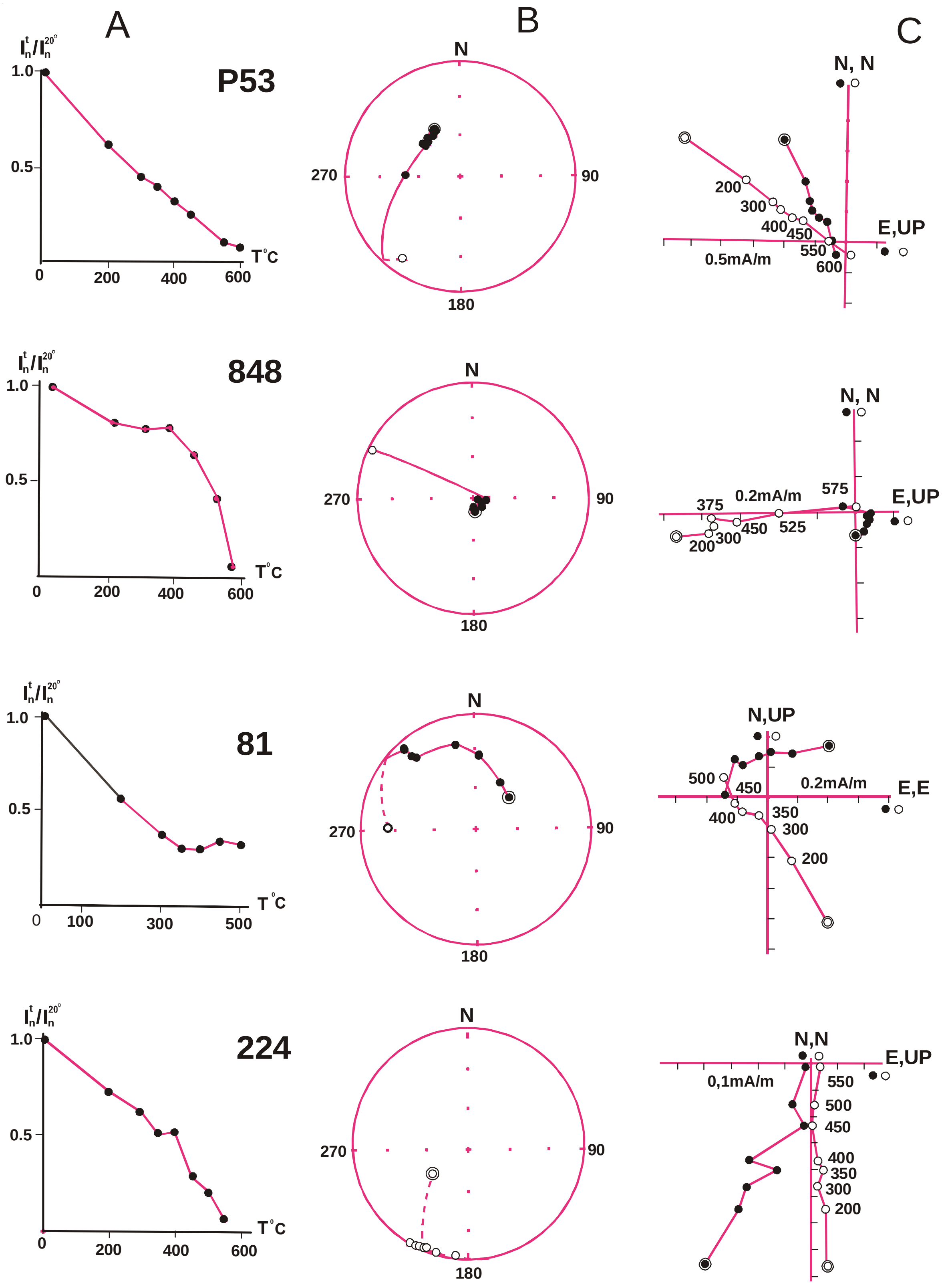

Figure 3: Results of step-like thermal demagnetization of rocks (demagnetization curves in Bretstein & Klimova's interpretation).
A – key graphic charts of $I_{n.}$
B - stereograms of distribution of vectors I_n on the basis of step-like thermal demagnetization of samples.
C – Zijderveld's diagrams. Closed (open) circles denote projections of vectors $I_{n.}$ on the horizontal (vertical) flats, correspondingly. Double circles mean initial position of the vectors I_n. 224 - number of the sample.

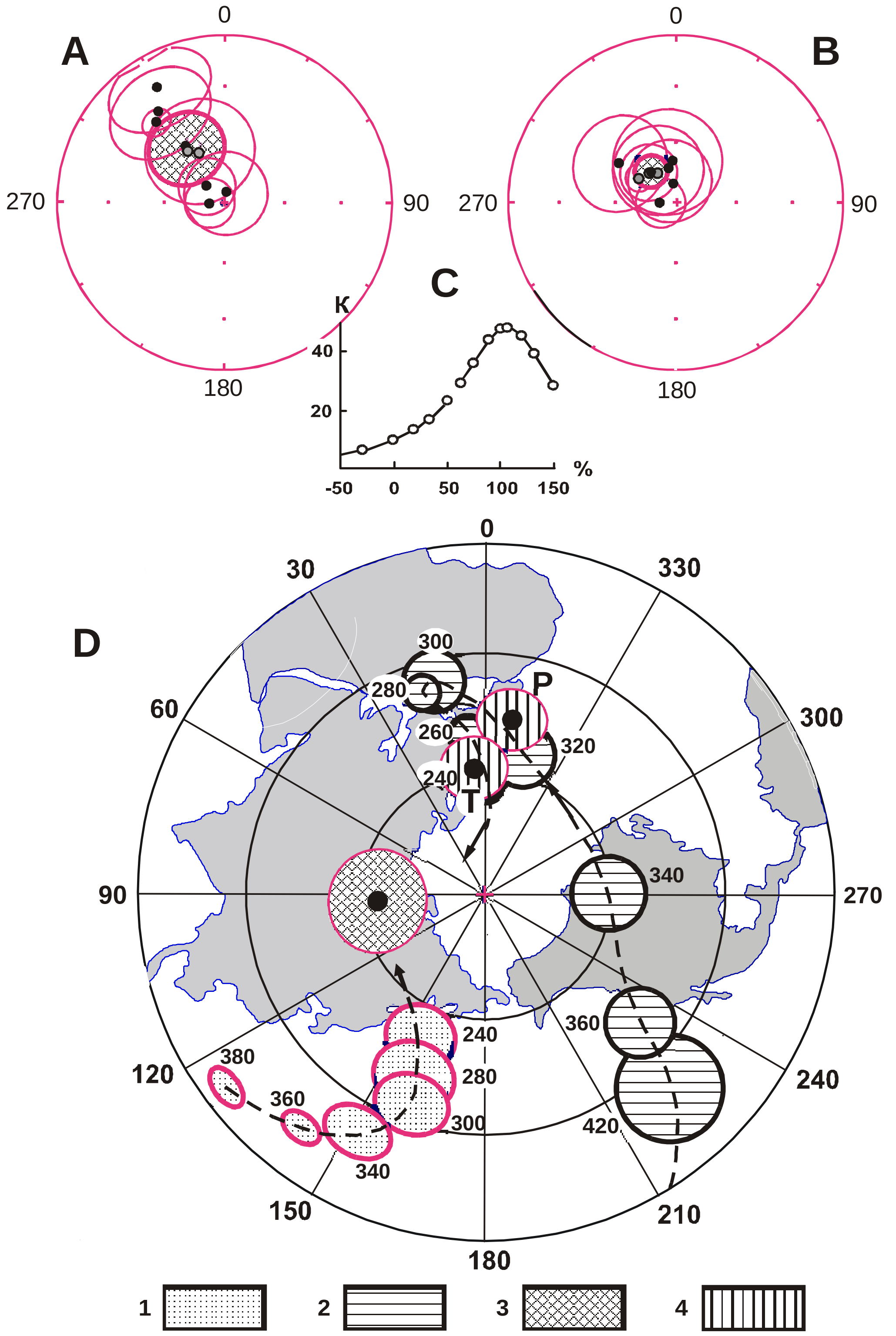

Figure 4: Palaeomagnetic property of Triassic rocks of South Primorye (in Bretstein & Klimova's interpretation).
Distribution of average I_n. direction in investigated sections:
A (B) – recent (ancient) coordinate systems; point inside of circles mean the oval of confidence, reinforced ovals denote the average for eight groups (shaded).
C - graphic chart of change in concentration of palaeomagnetic directions during step-like proportional straightening of the beds.
D – palaeopole position and seeming trend lines of North pole migration for Siberia (1) and North China (2) Platforms (Pechersky and Didenko, 1995); 3 – palaeopole position for some sections of South Primorye; 4 – palaeopole position for the Permian (P) and Triassic (Zhao et al., 1996).

Table 1. Summary of palaeomagnetic data from the Triassic in South Primorye

Section (geographical co-ordinates)	N_1	N_2	Recent coordinate system				Ancient coordinate system				Coordinate system (after using of methods of proportional erection)				%
			D, deg.	I, deg.	K	α_{95}, deg.	D, deg.	I, deg.	K	α_{95}, deg.	D, deg.	I, deg.	K	α_{95}, deg.	
Russian Island (Ayax and Tchernyschev) (43.0; 131.9)	14	13	325.6	55.5	10.6	13.4	324.8	58.0	10.9	13.1	325.8	57.3	12.8	12.0	50
Tri Kamnya (43.2; 132.1)	12	10	333.9	60.8	4.1	27.2	37.4	73.8	3.9	28.2	348.9	68.9	4.3	26.7	40
Artyom (SMID) (43.3; 132,2)	10	9	316.2	34.9	4.6	26.9	297.1	53.9	5.4	24.5	297.1	53.9	5.4	24.5	100
Mnogoudobnoye (43.5; 132.5)	13	13	329.9	20.2	4.3	22.8	331.7	71.5	4.4	22.4	331.7	71.5	4.4	22.4	100
Razdolnoye (43.5; 131.9)	8	6	4.9	85.2	12.0	20.6	344.8	78.8	12.0	20.6	344.8	78.8	-	20.6	0
Tavrichanka (43.3; 131.8)	10	7	269.6	82.4	25.0	2.3	219.0	77.0	22.0	13.2	269.4	82.4	-	2.3	100
Zhemchuzhina (43;132.2)	10	9	319.5	36.1	71.0	6.2	299.2	71.7	54.0	7.1	304.8	68.1	-	6.9	34
Podyampolskoye (42.9; 132.3)	9	8	312.2	77.9	17.0	13.8	321.7	54.5	16.0	14.5	318.1	69.8	-	14.1	88
Average (43.2; 132.1)		8	324.6	57.0	10.1	18.4	318.1	71.4	22.2	12.0	318.6	70.1	43.4	8.5	-

N_1 – number of investigated specimens; N_2 - number of specimens used for calculation; D and I mean declination and inclination of site; K – estimate of Fisher's precision parameter; α_{95} - radius of cone of confidence, 95% probability level.

tempt to make something on this topic, using the modern cryogenic magnetometer o the California University (USA) for investigation of restricted material from some sections of South Primorye: (1) Ayax Bay (Lower Olenekian, *Hedenstroemia bosphorensis* Zone), (2) Tchernyshev Bay (Upper Olenekian, *Neocolumbites insignis* Zone; middle Lower Anisian (*Acrochordiceras kiparisovae* Zone), (3) Tri Kamnya Cape (Lower Olenekian, *Hedenstroemia bosphorensis* Zone), (4) Artyom, quarry SMID (Lower Olenekian, *Anasibirites nevolini* Zone; lower Lower Anisian, *Leiophyllites pradiumna* Zone), and (5) village of Mnogoudobnoye (Upper Triassic) (Figure 1). It was made after cleaning in thermal demagnetization (with 6-12 stages of cleaning within 150-690^{o}C interval). All investigated rocks except sandstone of the Tri Kamnya Cape section are characterized by presence of the anisotropy levels confined to the lamination levels. Russian Island rocks seem to be significantly not deformed because tensorial distributing of axes in them is observed, besides, they are usually characterized by slightly sloping inclination of their beds.

We have used also recently published results on some other Triassic sections (the village of Razdolnoye (Upper Triassic), village of Tavrichanka (Upper Triassic), village of Podyampolskoye (Middle Triassic), Hotel Zhemchuzhina area (Lower Triassic) (Bazhenov et al., 1999) for comparative purpose. Our main results and mentioned published data are placed in the Table 1 and Figures 2-4. Released high-temperature component believes to be mainly before folded but it must confirmed on the basis of more representative material in feature.

Preliminary results on pole position for South Primorye in Triassic time

According our preliminary interpretation next data on North pole position for South Primorye during Triassic time were obtained: $l = 54.1^{o}$; $f = 61.1^{o}$; $j_{m} = 54.1^{o}$; $dp = 12.6^{o}$; $dm = 14.6^{o}$. The calculated pole situates in direction of crossing of seeming trend lines of North pole migration for North China and Siberia (Figure 4). It well agree with palaeobiogeographical data (Zakharov & Sokarev, 1991b), according which Triassic marine and terrestrial organisms found in South Primorye and Kitakami (Japan) inhabited in condition of temperate climate closed to subtropical one.

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References

Bazhenov, M.L., Gurariy, G.Z., Krezhovskikh, O.A., & Fein, A.G. 1999. Palaeomagnetic investigation of the Permian and Mesozoic of South Primorye. Teoretichskiye i regionalnyye problemy geodinamiki (Theoretical and regional problems of geodynamics). Nauka, Moscow, p. 181-195 (in Russian).

Dobson, J. & Heller, F. 1992. Remagnetization in southeast China and collision and suturing of the Huanan and Yangtze Block. Earth and Planetary Science Letters 111: 11-21.

McElhinny, M. & Opdyke, N. 1973. Remagnetization hypothesis discounted: a paleomagnetic study of the Trenton limestone, New York State. Geol. Soc. Amer. Bull. 103: 163-169.

Pechersky, D.M. & Didenko,A.N. 1995. Paleoaziatskiy okean (Palaeo-Asian ocean). OIFZ, Russian Acad. of Sci., Moscow, 298 p. (in Russian).

Vlasov, A.Y. & Popova, A.V. 1964. About position of thr Northern magnetic pole during Late Palaeozoic and Mesozoic based on data from palaeomagnetic investigation in Primorye region. Geolog. Geoph. 1: 159-162 (in Russian).

Wang, Z. & Van der Voo, R. 1993. Pervasive remagnetization of Paleozoic rocks acquired at the time of Mesozoic folding in the South China Block. J. Geoph. Res. 98 (B2): 1729-1741.

Zakharov, Y.D. 1996. The Induan-Olenekian boundary in the Tethys and Boreal realm. Ann. Mus. civ. Rovereto. Sec.: Arch., Sc. nat. 11:133-156.

Zakharov, Y.D., Shigeta, Y., Popov, A.M., Sokarev, A.N., Buryi, G.I., Golozubov, V.V., Panasenko, E.S., & Dorukhovskaya, E.A. 2000. Albertiana 24: 12-26.

Zakharov, Y.D. & Sokarev, A.N. 1991a. Permian-Triassic paleomagnetism of Eurasia. Saito Ho-on Kai Spec. Pub. 3 (Proceeding of Shallow Tethys 3, Sendai, 1990: 313-323.

Zakharov, Y.D. & Sokarev, A.N. 1991b. Biostratigraphiya i paleomagnetizm permi i triasa Evrazii (Biostratigraphy and palaeomagnetism of the Permian and Triassic of Eurasia). Nauka, Moscow, 135 p. (in Russian).

Zhao, X., Coe, R.S., Gilder, S.A., & Frost, G.M. 1996. Palaeomagnetic constraints on the palaeogeography of China: implications for Gondwanaland. Australian J. Earth Sci. 43: 645-672.

NEW TRIASSIC LITERATURE

G. Warrington, Kerp, H., Kürschner, W. M. and Lucas, S. G.

Abdala, F., Ribeiro, A. M. & Schultz, C. L. 2001. A rich cynodont fauna of Santa Cruz do Sul, Santa Maria Formation (Middle-Late Triassic), southern Brazil. Neues Jahrbuch für Geologie und Paläontologie, Monatshefte, 2001 (11): 669-687.

Abdala, F., Barberena, M.C. & Dornelles, J. 2002. New species of the traversodontid cynodont *Exaeretodon* from the Santa Maria Formation (Middle/Late Triassic) of southern Brazil. Journal of Vertebrate Paleontology, 22: 313-325.

Adams, C. J., Barley, M. E., Maas, R. & Doyle, M. G. 2002. Provenance of Permian-Triassic volcaniclastic sedimentary terranes in New Zealand: evidence from their radiogenic isotope characteristics and detrital mineral age patterns. New Zealand Journal of Geology and Geophysics, 45: 221-242.

Afonin, S. A., Barinova, S. S. & Krassilov, V. A. 2001. A bloom of *Tympanicysta* Balme (green algae of zygnematalean affinities) at the Permian-Triassic boundary. Geodiversitas, 23 (4): 481-487.

Ahlberg, A., Arndorff, L. & Guy-Ohlson, D., 2002. Onshore climate change during the Late Triassic marine inundation of the Central European Basin. Terra Nova, 14: 241-248.

Ainsworth, N. R. & Boomer, I. 2001. Upper Triassic and Lower Jurassic stratigraphy from exploration well L134/5-1, offshore Inner Hebrides, west Scotland. Journal of Micropalaeontology, 20 (2): 155-168.

Ait-Ouali, R. & Nedjari, A. 2002. Apport de l'analyse de la subsidence dans la definition des phases de rifting au cours du Trias au Sahara. Documents des Laboratoires de Géologie Lyon, 156: 18

Aitkenhead, N., Barclay, W. J., Brandon, A., Chadwick, R. A., Chisholm, J. I., Cooper, A. H. & Johnson, E. W. 2002. *British regional geology: the Pennines and adjacent areas* (Fourth edition). British Geological Survey, Nottingham, x+206pp.

Aldiss, D. T. 2002. Geology of the Chichester and Bognor district. *Sheet description of the British Geological Survey*, 1:50 000 Series Sheet 317 and 332 (England and Wales). Keyworth, Nottingham: British Geological Survey, vi+87pp.

Alonso-Zarza, A. M., Sanchez-Moya, Y., Bustillo, M. A., Sopeña, A. & Delgado, A., 2002. Silicification and dolomitization of anhydrite nodules in argillaceous terrestrial deposits: an example of meteoric-dominated diagenesis from the Triassic of central Spain. Sedimentology, 49: 303-317.

Al-Riyami, K. K., Danelian, T. & Robertson, A. H. F. 2002. Radiolarian biochronology of Mesozoic deep-water successions in NW Syria and Cyprus: implications for south-Tethyan evolution. Terra Nova, 14: 271-280.

Ambrose, K. 2001. The lithostratigraphy of the Blue Lias Formation (Late Rhaetian-Early Sinemurian) in the southern part of the English Midlands. Proceedings of the Geologists' Association, 112: 97-110.

Andrew, T. & Robertson, A. H. F., 2002. The Beysehir-Hoyran-Hadim Nappes: genesis and emplacement of Mesozoic marginal and oceanic units of the northern Neotethys in southern Turkey. Journal of the Geological Society London, 159: 529-543.

Angielczyk, K. D. 2001. Preliminary phylogenetic analysis and stratigraphic congruence of the dicynodont anomodonts (Synapsida: Therapsida). Palaeontologia Africana, 37: 53-79.

Ash, S. R. 2001. New cycadophytes from the Upper Triassic Chinle Formation of the southwestern United States. PaleoBios, 21: 15-28.

Ausich, W. I. & Kammer, T. W. 2001. The study of crinoids during the 20th century and the challenges of the 21st century. Journal of Paleontology, 75 (6): 1161-1173.

Avanzini, M. 2002. Dinosauromorph tracks from the Middle Triassic (Anisian) of the Southern Alps (Valle di Non – Italy). Bolletino della Societa Paleontologica Italiana, 41 (1): 37-40.

Avanzini, M., Ferretti, P., Seppi, R. & Tomasoni, R. 2001. Un grande esemplare di orma "dinosauride" *Parachirotherium* Kuhn 1958 sp. dall'Anisico superiore (Illirico) del Sudalpino (Italia). Studi Trentini di Scienze Naturali - Acta Geologica, 76 (1999): 201-204.

Avanzini, M. & Leonardi, G., 2002. *Isochirotherium inferni* ichnosp. n. in the Illyrian (Late Anisian, Middle Triassic) of Adige Valley (Bolzano – Italy). Bolletino della Societa Paleontologica Italiana, 41 (1): 41-50.

Avanzini, M. & Renesto, S. 2002. A review of *Rhynchosauroides tirolicus* Abel, 1926 ichnospecies (Middle Triassic: Anisian-Ladinian) and some inferences on *Rhynchosauroides* trackmaker. Rivista Italiana di Paleontologia e Stratigrafia, 108 (1): 51-66.

Bachmann, G.H., 2002. A lamellibranch-stromatolite bioherm in the lower Leuper (Ladinian, Middle Triassic), South Germany. Facies: 46: 83-88.

Bai Yun-Shan, Li Li, Niu Zhi-Jun, Wie Jun-Qi & Bu Jian-Jun. 2001. Characteristics and diagenetic tectonic setting of the Late Triassic volcanic rocks in the source region (Geladandong) of the Yangtze River. Geology and Mineral Resources of South China, 2001 (3): 9-13.

Bandyopadhyay, D. N. & Shah, B. A. 2000. Facies distribution and depositional pattern across Permo-Triassic boundary: a case study from Nuniya Nala, Raniganj coalfield, West Bengal. Indian Journal of Geology, 72 (4): 257-271.

Bandyopadhyay, D. N., Roychowdhury, T. K. & Sengupta, D. P. 2002. Taphonomy of some Gondawana vertebrate assemblages of India. Sedimentary Geology, 147

(1-2): 219-245.

Barde, J-.P., Gralla, P., Harwijanto, J. & Marsky, J. 2002. Exploration at the eastern edge of the Precaspian basin: impact of data integration on Upper Permian and Triassic prospectivity. AAPG Bulletin, 86 (3): 399-415.

Barde, J-.P., Chamberlain, P., Galavazi, M., Gralla, P., Harwijanto, J., Marsky, J. & Van Den Belt, F. 2002. Sedimentation during halokinesis: Permo-Triassic reservoirs of the Saigak Field, Precaspian Basin, Kazakhstan. Petroleum Geoscience, 8: 177-187.

Barton, C. M., Strange, P. J., Royse, K. R. & Farrant, A. R. 2002. Geology of the Bristol district – a brief explanation of the geological map. *Sheet Explanation of the British Geological Survey*. 1:50 000 Sheet 264 Bristol (England and Wales). Keyworth, Nottingham: British Geological Survey, ii+30pp.

Beauchamp, B. & Baud, A. 2002. Growth and demise of Permian biogenic chert along northwest Pangea: evidence for end-Permian collapse of thermohaline circulation. Palaeogeography, Palaeoclimatology, Palaeoecology, 184 (1-2): 37-63.

Beerling, D. J. & Royer, D. L., 2002. Fossil plants as indicators of the phanerozoic global carbon cycle. Annual Review of Earth and Planetary Sciences, 30: 527-556.

Bechtel, A., Gratzer, R. & Rantitsch, G. 2001. Upper Triassic (Rhaetian) mudstones (Kössen Formation) within the central Gailtal Alps (eastern Alps, Austria) as potential hydrocarbon source rocks. Neues Jahrbuch für Geologie und Paläontologie Abhandlungen, 222 (3): 427-451.

Berner, R. A., 2002. Examination of hypotheses for the Permo-Triassic boundary extinction by carbon cycle modeling. Proceedings of the National Academy of Sciences of the United States of America, 99: 4172-4177.

Berra, F. & Rettori, R. 2001. Paleoenvironmental control on the foraminiferal and microfossil distribution in the Norian succession of the Quattervals Nappe (Austroalpine, Lombardy, Italy). Atti Ticinensi di Scienze della Terra, 42: 63-74.

Berra, F. & Jadoul, F. 2002. Evidence of a "Mid-Carnian" transgression in the western Southern Alps (Lombardy, Italy): stratigraphic and paleogeographic implications. Rivista Italiana di Paleontologia e Stratigrafia, 108 (1): 119-131.

Blodgett, R. B. & Frýda, J. 2001. On the occurrence of *Spinidelphinulopsis whaleni* (Gastropoda) in the Late Triassic (early Norian) Cornwallis Limestone, Kuiu Island, southeastern Alaska (Alexander terrane) and its paleobiogeographic significance. Bulletin of the Czech Geological Survey, 76 (4): 235-242.

Bonaparte, J. F. & Barberena, M. C. 2001. On two advanced carnivorous cynodonts from the Late Triassic of southern Brazil. Bulletin of the Museum of Comparative Zoology, 156 (1): 59-80.

Bonaparte, J. F., Ferigolo, J. & Ribeiro, A. M. 2001. A primitive Late Triassic 'Ictidosaur' from Rio Grande do Sul, Brazil. Palaeontology, 44: 623-635.

Bordy, E. M. & Catuneanu, O. 2001. Sedimentology of the upper Karoo fluvial strata in the Tuli Basin, South Africa. Journal of African Earth Sciences, 33 (3-4): 605-629.

Borsuk-Bialynicka, M. & Evans, S. E. 2002. The scapulocoracoid of an Early Triassic stem-frog from Poland. Acta Palaeontologica Polonica, 47 (1): 79-96.

Bourquin, S., Robin, C., Guillocheau, F. & Gaulier, J. M., 2002. Three-dimensional accommodation analysis of the Keuper of the Paris Basin: discrimination between tectonics, eustasy and sediment supply in the stratigraphic record. Marine and Petroleum Geology, 19: (4): 469-498.

Boven, A., Pasteels, P., Punzalan, L. E., Liu, J., Luo, X., Zhang, W., Guo, Z. & Hertogen, J. 2002. ^{40}Ar/^{39}Ar geochronological constraints on the age and evolution of the Permo-Triassic Emeishan Volcanic Province, southwest China. Journal of Asian Earth Sciences, 20: 157-175.

Boy, J. A., Schoch, R. R. & Lucas, S. G. 2001. The Moenkopi Formation in east-central New Mexico: Stratigraphy and vertebrate fauna; in Lucas, S. G. and Ulmer-Scholle, D. S., eds., Geology of the Llano Estacado: New Mexico Geological Society Guidebook 52, p. 103-109.

Brack, P., Muttoni, G. & Rieber, H. 2001. Comment on: 'Magnetostratigraphy and biostratigraphy of the Middle Triassic Margon section (Southern Alps, Italy)' by P. R. Gialanella, F. Heller, P. Mietto, A. Incoronato, V. De Zanche, P. Gianolla, C. Roghi [Earth Planet. Sci. Lett. 187 (2001) 17-25]. Earth and Planetary Science Letters, 193: 253-255.

Brochu, C. A. 2001. Progress and future directions in archosaur phylogenetics. Journal of Paleontology, 75 (6): 1185-1201.

Bucur, I. I. & Enos, P. 2001. Middle Triassic dasyclad algae from Guizhou, China. Micropaleontology, 47 (4): 317-338.

Bugge, T., Ringås, J. E., Leith, D. A., Mangerud, G., Weiss, H. M. & Leith, T. L. 2002. Upper Permian as a new play model on the mid-Norwegian continental shelf: investigated by shallow continental drilling. AAPG Bulletin, 86 (1): 107-127.

Bugge, T., Elvebakk, G., Fanavoll, S., Mangerud, G., Smelror, M., Weiss, H. M., Gjelberg, J., Kristensen, S. E. & Nilsen, K. 2002. Shallow stratigraphic drilling applied in hydrocarbon exploration of the Nordkapp Basin, Barents Sea. Marine and Petroleum Geology, 19: 13-37.

Buratti, N. & Carrillat, A. 2002. Palynostratigraphy of the Mufara Formation (Middle-Upper Triassic, Sicily). Rivista Italiana di Paleontologia e Stratigrafia, 108 (1): 101-117.

Burger, K., Zhou, Y. & Ren, Y. 2002. Petrography and geochemistry of tonsteins from the 4th Member of the Upper Triassic Xujiahe formation in southern Sichuan Province, China. International Journal of Coal Geology, 49: 1-17.

Bugge, T., Elvebakk, G., Fanavoll, S., Mangerud, G., Smelror, M., Weiss, H. M., Gjelberg, J., Kristensen, S. E. & Nilsen, K., 2002. Shallow stratigraphic drilling applied in hydrocarbon exploration of the Nordkapp Basin, Barents Sea. Marine and Petroleum Geology, 19: 13-37.

Cao, C. Q., Wang, W. & Jin, Y. G., 2002. Carbon isotope excursions across the Permian-Triassic boundary in the Meishan section, Zhejiang Province, China. Chinese Science Bulletin, 47: 1125-1129.

Caselli, A. T., Mariscano, C. A. & Arucci, A. B. 2001. Sedimentología y paleontología de la Formación Los Colorados, Triásico superior (provincias de La Rioja y San Juan, Argentina. Revista de la Asociación Geológica Argentina, 56 (2): 173-188.

Cawood, P. A., Landis, C. A., Nemchin, A. A. & Hada, S. 2002. Permian fragmentation, accretion and subsequent translation of a low-latitude Tethyan seamount to the high-latitude east Gondwana margin: evidence from detrital zircon age data. Geological Magazine, 139: 131-144.

Cecca, F., Critelli, S., De Capoa, P., Di Staso, A., Giardino, S., Messina, A. & Perrone, V. 2002. New dating and interpretation of the sedimentary succession of Fiumara Sant'Angelo (Peloritani Mountains; southern Italy) : consequences for the Mesozoic palaeogeography of the central Mediterranean. Bulletin de la Societé géologique de France, 173: 171-184.

Celâl Sengör, A. M. & Natal'in, B. A. 2001. Rifts of the world. Geological Society of America Special Paper 352: 389-482.

Chang, B. S. W., Jonsson, K., Kazmi, M. A., Donoghue, M. J. & Sakmar, T. P. 2002. Recreating a functional ancestral archosaur visual pigment. Molecular Biology and Evolution, 19: 1483-1489.

Chen Jin-Hua, Cao Mei-Zhen & Stiller, F. 2001. Preliminary palaeosynecological analyses of the upper Anisian (Middle Triassic) Qingyan fauna. Acta Palaeontologica Sinica, 40 (2): 262-268.

Chen, Z. Q., Shi, G. R. & Kaiho, K. 2002. A new genus of rhynchonellid brachiopod from the Lower Triassic of South China and implications for timing the recovery of Brachiopoda after the end-Permian mass extinction. Palaeontology, 45 (1): 149-164.

Ching-Hua Lo, Sun-Lin Chung, Tung-Ye Lee & Genyao Wu. 2002. Age of the Emeishan flood magmatism and relations to Permian-Triassic boundary events. Earth and Planetary Science Letters, 198: 449-458.

Chonglakmani, C., Feng Qinglai, Meischner, D., Ingavat-Helmcke, R. & Helmcke, D. 2001. Correlation of tectono-stratigraphic units in northern Thailand with those of western Yunnan (China). Journal of China University of Geosciences, 12 (3): 207-213.

Cohen, A. S. & Coe, A. L. 2002. New geochemical evidence for the onset of volcanism in the Central Atlantic magmatic province and environmental change at the Triassic-Jurassic boundary. Geology, 30 (3): 267-270.

Colacicchici, R., Parisi, G. & Zamparelli, V. (Eds.) 1999. Bioevents and integrated stratigraphy of the Triassic and the Jurassic in Italy. Palaeopelagos Spec. Pub., 3. 71pp.

Colbert, E. H. & Olsen, P. E. 2001. A new and unusual aquatic reptile from the Lockatong Formation of New Jersey (Late Triassic, Newark Supergroup). American Museum Novitates, 3334: 1-24.

Coombs, D. 2001. OBITUARY: John Douglas Campbell, 14.4.1927-27.7.01. Geological Society of New Zealand, Newsletter 126: 45-48.

Corazzato, C., Groppelli, G., Natoli, E. & Pasquare, G. 2001. The Montecampione Group: stratigraphy of the subvolcanic bodies between Val Camonica and Val Trompia (Southern Alps, Lombardy, Italy). Atti Ticinensi di Scienze della Terra, 42: 141-152.

Cortés, A. L., Díaz-Martínez, E., González-Casado, J. M., Aurell, M. & Casas-Sainz, A. M. 2002. Cratered cobbles in Triassic Buntsandstein conglomerates in northeastern Spain: an indicator of shock deformation in the vicinity of large impacts: Comment and Reply. Geology, 30 (1): 91-92

Costamanga, L. G. & Barca, S. 2002. The "Germanic" Triassic of Sardinia (Italy): a stratigraphic, depositional and palaeogeographic review. Rivista Italiana di Paleontologia e Stratigrafia, 108 (1): 67-100.

Courtinat, B., Rio, M. & Malartre, F. 2002. Palynofaciès des depots marins proximaux: le Rhétien de la bordure orientale du Massif Central (France). Revue de Micropaléontologie, 45 (1): 47-55.

Crasquin-Soleau, S., Richoz, S., Marcoux, J., Angiolini, L., Nicora, A. & Baud, A., 2002. The events of the Permian-Trias boundary: last survivors and/or first colonisers among the ostracods of the Thurides (south-western Turkey). Comptes Rendus Geoscience, 334: 489-495.

Crostella, A. 2001. Geology and petroleum potential of the Abrolhos sub-basin, Western Australia. Western Australia Geological Survey, Report 75: iv+57pp.

Cuny, G., Rieppel, O. & Sander, P. M. 2001. The shark fauna from the Middle Triassic (Anisian) of north-western Nevada. Zoological Journal of the Linnaean Society, 133: 285-301.

Curtis, M. L. 2002. Palaeozoic to Mesozoic polyphase deformation of the Patuxent Range, Pensacola Mountains, Antarctica. Antarctic Science, 14 (2): 175-183.

Dagys, A. S. 2001. The ammonoid family Arctohungaritidae from the Boreal lower-middle Anisian (Triassic) of Arctic Asia. Revue de Paléobiologie, 20: 543-641.

Dalla Vecchia F.M., Wild, R., Hopf, H. & Reitner, J. 2002. A crested rhamphorhynchoid pterosaur from the Late Triassic of Austria. Journal of Vertebrate Paleontology, 22: 196-199.

Damiani, R. J. 2001. Cranial anatomy of the giant Middle Triassic temnospondyl *Cherninia megarhina* and a review of feeding in mastodonsaurids. Palaeontologia Africana, 37: 41-52.

Damiani, R. J. 2001. A systematic revision and phylogenetic analysis of Triassic mastodonsauroids (Temnospondyli: Stereospondyli). Zoological Journal of the Linnaean Society, 133: 379-482.

Damiani, R. J. 2002. *Parotosuchus* (Amphibia, Temnospondyli) from the *Cynognathus* assemblage zone (Early Triassic) of South Africa: Cranial morphology and relationships. Alcheringa, 25: 351-379.

Damyanov, Z. & Vassileva, M. 2001. Authigenic phyllosilicates in the Middle Triassic Kremikovtsi sedimentary exhalative siderite iron formation, western Balkan, Bulgaria. Clays and Clay Minerals, 49 (6): 559-585.

Damiani, R. J. & Welman, J. 2001. A long-snouted trematosaurid amphibian from the Early Triassic of South Africa. South African Journal of Science, 97: 318-320.

Davis, G. A., Zheng Yadong, Wang Cong, Darby, B. J., Zhang Changou & Gehrels, G. 2001. Mesozoic tectonic evolution of the Yanshan fold and thrust belt, with emphasis on Hebei and Liaoning provinces, northern China. Geological Society of America Memoir 194: 171-197.

De Bono, A., Martini, R., Zaninetti, L., Hirsch, F., Stampfli, G. M. & Vavassis, I. 2001. Permo-Triassic stratigraphy of the pelagonian zone in central Evia island (Greece). Eclogae Geologicae Helvetiae, 94: 289-311.

De Wever, P., Dumitrica, P., Caulet, J.P., Nigrini, C. & Caridroit, M. 2001. *Radiolarians in the sedimentary record*. Amsterdam, Overseas Publishers Association N.V., for Gordon and Breach Science Publishers, xxi+533pp.

De Wit, M. J., Ghosh, J. G., De Villiers, S., Rakotosolofo, N., Alexander, J., Tripathi, A. & Looy, C. 2002. Multiple organic carbon isotope reversals across the Permo-Triassic boundary of terrestrial Gondwana sequences: clues to extinction patterns and delayed ecosystem recovery. The Journal of Geology, 110: 227-240.

Diedrich, C. 2001. Vertebrate track bed stratigraphy of the Röt and basal Lower Muschelkalk (Anisian) of Winterswijk (East Netherlands). Geologie en Mijnbouw, 80 (2): 31-39.

Diedrich, C. 2002. Wirbeltierfährten aus dem Unteren Muschelkalk (Mitteltrias) von Thüringen (SE-Deutschland). Neues Jahrbuch für Geologie und Paläontologie Monatshefte, 2002 (2): 75-91.

Diedrich, C. 2002. Die Wirbeltierfährenfundstelle Borgholzhausen (Teutoburger Wald, NW-Deutschland) aus der Oolith-Zone (Unterer Muschelkalk, Mitteltrias). Paläontologische Zeitschrift, 76 (1): 35-56.

Diedrich, C. 2002. Vertebrate track bed stratigraphy at new megatrack sites in the Upper Wellenkalk Member and *orbicularis* Member (Muschelkalk, Middle Trias) in carbonate tidal flat environments of the western Germanic Basin. Palaeogeography, Palaeoclimatology, Palaeoecology, 183 (3-4): 185-208.

Diez, J.B., Broutin, J. & Ferrer, J. 2000. Premières données sur une palynoflore triasique découverte dans la localité de Fombuena (Zaragoza; Espagne). Monografias de la Academia de Ciencias Exactas, Físicas, Qu

Dobruskina, I. A., Jurkovšek, B. & Kolar-Jurkovšek, T. 2001. Upper Triassic flora from "Raibl beds" of Julian Alps (Italy) and Karavanke Mts. (Slovenia). Geologija, 44 (2): 263-290.

Dolenec, M. & Ogorelec, B. 2001. Organic carbon isotope variability across the P/Tr boundary in the Idrijca Valley section (Slovenia): a high resolution study. Geologija, 44 (2): 331-340.

Duffin, C. J. 2001. Synopsis of the selachian genus *Lissodus* BROUGH, 1935. Neues Jahrbuch für Geologie und Paläontologie Abhandlungen, 221 (2): 145-218.

Dunford, G. M., Dancer, P. N. & Long, K. D. 2001. Hydrocarbon potential of the Kish Bank Basin: integration within a regional model for the Greater Irish Sea Basin. Geological Society, London, Special Publications, 188: 135-154.

Durand, J. F. 2001. The oldest juvenile dinosaurs from Africa. Journal of African Earth Sciences, 33 (3-4): 597-603.

Echarfaoui, H., Hafid, M., Salem, A. A. & Abderrahmane, A. F., 2002. Seismo-stratigraphic analysis of the Abda Basin (West Morocco): a case of reverse structures during the Atlantic rifting. Comptes Rendus Geoscience, 334: 371-377.

Embry, A.F., Krajewski, K.P., Mørk, A., 2002. A Triassic upwelling zone: The Shublik Formation, Arctic Alaska, USA - Discussion. Journal of Sedimentary Research, 72 (5): 740-741.

Erlström, M. & Sivhed, U. 2001. Intra-cratonic dextral transtension and inversion of the southern Kattegat on the southwest margin of Baltica - seismostratigraphy and structural development. Geological Survey of Sweden, Research Paper C 832, 33pp.

Ermakova, S.P., 2002. Evolutionary history of Late Olenekian ammonoids in the east of the Boreal realm. Paleontologicheskii Zhurnal, 2002(4): 23-29.

Ernst, R. E. & Buchan, K. L. 2001. The use of mafic dike swarms in identifying and locating mantle plumes. Geological Society of America Special Paper 352: 247-265.

Ernst, R. E. & Buchan, K. L. 2001. Large mafic magmatic events through time and links to mantle-plume heads. Geological Society of America Special Paper 352: 483-575.

Esaulova, N. K., Burov, B. V. & Gubareva, V. I. 2001. Upper Permian type sections of the East European Platform and their correlation. Annali di Museo Civico di Scienze Naturali di Brescia, Monografia 25: 295-300.

Fara, E. & Hungerbühler, A. 2000. A *Paleorhinus magnoculus* from the Upper Triassic of Morocco: a juvenile primitive phytosaur (Archosauria). Comptes Rendus de l'Académie des Sciences, Série II, Fascicule A, 331 (12): 831-836.

Farrant, A. 2002. Geology of the Arlesford district – a brief explanation of the geological map. *Sheet Explanation of the British Geological Survey*. 1:50 000 Sheet 300 Arlesford (England and Wales). Keyworth, Nottingham: British Geological Survey, ii+30pp.

Feldman, H. R. 2002. A new species of *Coenothyris* (Brachiopoda) from the Triassic (Upper Anisian-Ladinian) of Israel. Journal of Paleontology, 76 (1): 34-42.

Feng Qing-Lai, Gu Song-Zhu & Ding Mei-Hua. 2001. Early Triassic radiolarians from Sangzhi, Hunan. Acta Micropalaeontologica Sinica, 18 (3): 249-253.

Floodpage, J., Newman, P. & White, J. 2001. Hydrocarbon prospectivity in the Irish Sea area: insights from recent exploration of the Central Irish Sea, Peel and Solway basins. Geological Society, London, Special Publications, 188: 107-134.

Frakes, L.A., Barron, E.J., 2002. Phanerozoic general circulation model results and quantitative climate data for Australia. Australian Journal of Earth Sciences, 48: 643-655.

Fritsche, H.G., Becker, F. & Heggemann, H. 2001. Die Tiefbohrung Rotenburg HKZ 1001 – Geologie des Deckgebirges und hydrogeologische Ergebnisse. Geologisches Jahrbuch Hessen, 128: 5-17.

Frolov, B. M., Ainemer, A. I. & Shenkman, A. L. 2002. Oil habitats in the northeastern Negev: on the evaluation of Triassic hydrocarbon potential in Israel. Israel Journal of Earth Sciences, 51 (1):35-53.

Gallois, R. W. 2001. The lithostratigraphy of the Mercia Mudstone Group (Mid to Late Triassic) of the south Devon coast. Geoscience in south-west England, 10 (2): 195-204.

Galton, P. M. 2001. Prosauropod dinosaur *Sellosaurus gracilis* (Upper Triassic, Germany): Third sacral vertebra as either a dorsosacral or a caudosacral. Neues Jahrbuch für Geologie und Paläontologie, Monatshefte, 2001 (11): 688-704.

Garzanti, E. & Gaetani, M. 2002. Unroofing history of Late Paleozoic magmatic arcs within the "Turan Plate" (Tuarkyr, Turkmenistan). Sedimentary Geology, 151: 67-87.

Gatesby, S. M. 2001. Skin impressions of Triassic theropods as records of foot movement. Bulletin of the Museum of Comparative Zoology, 156 (1): 137-149.

Gehrmann, O. & Aigner, T. 2002. Der Schilfsandstein (Obere Trias) bei Heilbronn (SW-Deutschland): Hinweise auf tidale Einflüsse. Neues Jahrbuch für Geologie und Paläontologie Abhandlungen, 223 (3): 377-403.

Ghosh, S. C. 2002. The Raniganj Coal Basin: an example of an Indian Gondwana rift. Sedimentary Geology, 147 (1-2): 155-176.

Ghosh, P., Bhattacharya, S. K., Shukla, A. D., Shukla, P. N., Bhandari, N., Parthasarathy, G. & Kunwar, A. C. 2002. Negative $^{\sim 13}$C excursion and anoxia at the Permo-Triassic boundary in the Tethys Sea. Current Science, 83: 498-502.

Girard, M. 2001. Metamorphism and tectonics of the transition between non metamorphic Tethyan Himalaya sediments and the North Himalayan Crystalline Zone (Rupshu area, Ladakh, NW India). Mémoires de Géologie (Lausanne), No.35, iv+100pp.

Gong, Yi-Ming. 2001**.** Trace fossils from the flysch sequences of the Silurian, Carboniferous and Triassic of the Tianshan and Kunlun-Qinling orogenic belts of northwestern China. Acta Palaeontologica Sinica, 40 (2): 177-188.

Götz, A. E., Feist-Burkhardt, S. & Dittrich, D. 2001. Lithostratigraphie und palynofazies des Unteren Muschelkalk (Mitteltrias, Anis) der Forschungsbohrung Onsdorf (Saargau). Mainzer geowissenschaftliche Mitteilungen, 30: 43-66.

Gower, D.J., 2002. Braincase evolution in suchian archosaurs (Reptilia : Diapsida): evidence from the rauisuchian *Batrachotomus kupferzellensis*. Zoological Journal of the Linnean Society, 136: 49-76.

Gower, D. J. & Walker, A. D., 2002. New data on the braincase of the aetosaurian archosaur (Reptilia : Diapsida) *Stagonolepis robertsoni* Agassiz. Zoological Journal of the Linnean Society, 136: 1-7.

Greene, T. J., Carroll, A. R., Hendrix, M. S., Graham, S. A., Wartes, M. A. & Abbink, O. A. 2001. Sedimentary record of Mesozoic deformation and inception of the Turpan-Hami basin, northwest China. Geological Society of America Memoir 194: 317-340.

Grimaldi, D. 2001. Insect evolutionary history from Handlirsch to Hennig, and beyond. Journal of Paleontology, 75 (6): 1152-1160.

Gröcke, D. R., 2002. The carbon isotope composition of ancient CO_2 based on higher-plant organic matter. Philosophical Transactions of the Royal Society of London, Series A, Mathematical Physical and Engineering Sciences, 360 (1793): 633-658.

Guex, J. 2001. Environmental stress and atavism in ammonoid evolution. Eclogae Geologicae Helvetiae, 94: 321-328.

Güngör, T. & Erdogan, B. 2002. Tectonic significance of mafic volcanic rocks in a Mesozoic sequence of the Menderes Massif, west Turkey. International Journal of Earth Sciences, 91 (3): 386-397.

Gürgey, K. 2002. An attempt to recognise oil populations and potential source rock types in Paleozoic sub- and Mesozoic-Cenozoic supra-salt strata in the southern margin of the Pre-Caspian Basin, Kazakhstan Republic. Organic Geochemistry, 33: 723-741.

Haas, J., 2002. Origin and evolution of late triassic backplatform and intraplatform basins in the Transdanubian Range, Hungary. Geologica Carpathica, 53: 159-178.

Haas, J., Budai, T., Hips, K., Konrád, G & Török, Á. 2002. Sequence stratigraphy of Triassic facies areas in Hungary. Földtani Közlöny, 132 (1): 17-43.

Haas, J. & Demény, A. 2002. Early dolomitisation of Late Triassic platform carbonates in the Transdanubian Range (Hungary). Sedimentary Geology, 151 (3-4): 225-242.

Halamic, J., Marchig, V. & Gorican, S. 2001. Geochemistry of Triassic radiolarian cherts in north-western Croatia. Geologica Carpathica, 52 (6): 327-342.

Hallam, A., 2002. How catastrophic was the end-Triassic mass extinction? Lethaia, 35: 147-157.

Hancox, P. J. & Rubidge, B. S. 2001. Breakthroughs in the biodiversity, biogeography, biostratigraphy and basin analysis of the Beaufort group. Journal of African Earth Sciences, 33 (3-4): 563-577.

Hauser, M., Martini, R., Matter, A., Krystyn, L., Peters, T., Stampfli, G. & Zaninetti, L. 2002. The break-up of East Gondwana along the northeast coast of Oman: evidence from the Batain basin. Geological Magazine, 139 (2): 145-157.

Hautmann, M. 2001. Die Muschelfauna der Nayband-Formation (Obertrias, Nor - Rhät) des östlichen Zentraliran. Beringeria, 29: 1-181.

Harris, J. D. & Downs, A. 2002. A drepanosaurid pectoral girdle from the Ghost Ranch (Whitaker) *Coelophysis* quarry (Chinle Group, Rock Point Formation, Rhaetian), New Mexico. Journal of Vertebrate Paleontology, 22: 70-75.

Heckert, A. B., Lucas, S. G., Kahle, R. & Zeigler, K. 2001.New occurrence of *Trilophosaurus* (Repitilia: Archosauromorpha) from the Upper Triassic of West Texas and its biochronological significance; in Lucas, S. G. and Ulmer-Scholle, D. S., eds., Geology of the Llano Estacado: New Mexico Geological Society Guidebook 52, p. 115-122.

Heckert, A. B., Lucas, S. G., Hunt, A. P. & Harris, J. D. 2001. A giant phytosaur (Reptilia: Archosauria) skull from the Redonda Formation (Upper Triassic: Apachean) of east-central New Mexico; in Lucas, S. G. and Ulmer-Scholle, D. S., eds., Geology of the Llano Estacado: New Mexico Geological Society Guidebook 52, p. 169-176.

Heckert, A. B. & Lucas, S. G., 2002. South American occurrences of the Adamanian (Late Triassic: latest Carnian) index taxon *Stagonolepis* (Archosauria: Aetosauria) and their biochronological significance. Journal of Paleontology, 76: 852-863.

Heitele, H. 2001. Geologischer Aufbau und Grundwasserfliessvorgänge im Nordwestteil der Pfälzer Triasmulde (Sickinger Höhe und Westpfälische Moorniederung im Bereich der TK 25, Blatt 6610 Homburg). Mainzer geowissenschaftliche Mitteilungen, 30: 227-270.

Helmcke, D., Ingavat-Helmcke, R., Feng Qinglai, Wagner, B. & Heppe, K. 2001. On geodynamic evolution of Simao region (southwestern Yunnan, China) during Late Paleozoic and Triassic. Journal of China University of Geosciences, 12 (3): 195-200.

Hendrix, M. S., Beck, M. A., Badarch, G. & Graham, S. A. 2001. Triassic synorogenic sedimentation in southern Mongolia: early effects of intracontinental deformation. Geological Society of America Memoir 194: 389-412.

Herzog, A. 2001. *Peltoperleidus obristi* sp. nov., ein neuer, kleiner Strahlenflosser (Actinopterygii, Perleidiformes) aus der Prosanto-Formation (Mitteltrias) von Graubünden (Schweiz). Eclogae Geologicae Helvetiae, 94: 495-507.

Hervé, F. & Fanning, C. M. 2001. Late Triassic detrital zircons in meta-turbidites of the Chonos Metamorphic Complex, southern Chile. Revista Geológica de Chile, 28 (1): 91-104.

Hester, P. M. & Lucas, S. G. 2001. Lacustrine depositional environments of the Upper Triassic Redonda Formation, east-central New Mexico; in Lucas, S. G. and Ulmer-Scholle, D. S., eds., Geology of the Llano Estacado: New Mexico Geological Society Guidebook 52, p. 153-168.

Hips, K. 2001. The structural setting of Lower Triassic formations in the Aggtelek-Rudabánya Mountains (northeastern Hungary) as revealed by geological mapping. Geologica Carpathica, 52 (5): 287-299.

Hirsch, F. & Ishida, K. 2002. The Izanami Plateau: pre-accretionary origin of Japan's low latitude Triassic pelagic carbonates. Eclogae Geologicae Helvetiae, **95** (1): 43-55.

Holliday, D. W., Warrington, G., Brookfield, M. E., Mcmillan, A. A. & Holloway, S. 2001. Permo-Triassic rocks in boreholes in the Annan-Canonbie area, Dumfries and Galloway, southern Scotland. Scottish Journal of Geology, 37 (2): 97-113.

Holloway, M., 2002. Trees of the Triassic. Scientific American, 286: 96-98.

Hopson, J. A. & Kitching, J. W. 2001. A probainognathian cynodont from South Africa and the phylogeny of nonmammalian cynodonts. Bulletin of the Museum of Comparative Zoology, 156 (1): 5-35.

Hornung, J. & Aigner, T. 2002. Reservoir architecture in a terminal alluvial plain: an outcrop analogue study (Upper Triassic, southern Germany) Part 1: sedimentology and petrophysics. Journal of Petroleum Geology, 25 (1): 3-30.

Hornung, J. & Aigner, T. 2002. Reservoir architecture in a terminal alluvial plain: an outcrop analogue study (Upper Triassic, southern Germany) Part II: cyclicity, controls and models. Journal of Petroleum Geology, 25 (2): 151-178.

Huang, D. H., Duan, Y. C., Li, B., Yao, L.Q., Zhang, H., Zhang, F., Wang, J. H., Guo, H. & Yin, H.F., 2002. Middle Yangtze sea-basin over Paleozoic-Mesozoic transition - Sedimental continuity and environmental catastrophe. Science in China Series D - Earth Sciences, 45: 730-740.

Hunt, A. P. & Lucas, S. G. 2001. The Frio uplift: A Paleozoic-Mesozoic control on sedimentation patterns in east-central New Mexico; in Lucas, S. G. and Ulmer-Scholle, D. S., eds., Geology of the Llano Estacado: New Mexico Geological Society Guidebook 52, p. 21-22.

Hunt, A. P. & Lucas, S. G. 2001. The first vertebrate track (*Brachychirotherium*) from the upper Carnian Garita Creek Formation, east-central New Mexico; in Lucas, S. G. and Ulmer-Scholle, D. S., eds., Geology of the Llano Estacado: New Mexico Geological Society Guidebook 52, p. 51-52.

Hunt, A. P., Lucas, S. G. & Heckert, A. B. 2001. Paleocurrents in the Trujillo Formation (Chinle Group; Upper Triassic), east-central New Mexico, and the myth of the Dockum lake; in Lucas, S. G. and Ulmer-

Scholle, D. S., eds., Geology of the Llano Estacado: New Mexico Geological Society Guidebook 52, p. 22-23.

Iannace, A. & Zamparelli, V. 2002. Upper Triassic platform margin biofacies and the paleogeography of Southern Apennines. Palaeogeography, Palaeoclimatology, Palaeoecology, 179: 1-18.

Ibouh, H., Saidi, A., Bouabdelli, M., Youbi, N., Boummane, Kh., Aït Chayeb, E. H. & Bougadir, B. 2002. Les roches volcaniques triaso-liasiques du Maroc: example de la ride de Tasraft (Haut Atlas Central); données pétrologiques, géochimiques et implications géodynamiques. Africa Geoscience Review, 9 (1): 75-92.

Il Lee, Y., 2002. Provenance derived from the geochemistry of late Paleozoic-early Mesozoic mudrocks of the Pyeongan Supergroup, Korea. Sedimentary Geology, 149: 219-235.

Irnstorfer, O., 2002. Trias-Ammoniten aus den Hallstätter Kalken (4. Teil). Fossilien 2002(5): 277-282.

Isaksen, G. H., Patience, R., van Graas G. & Jenssen, A. I., 2002. Hydrocarbon system analysis in a rift basin with mixed marine and nonmarine source rocks: The South Viking Graben, North Sea. AAPG Bulletin, 86: 557-591.

Ishida, K. & Hirsch, F. 2001. Taxonomy and faunal affinity of late Carnian - Rhaetian conodonts in the southern Chichibu Belt, Shikoku, SW Japan. Rivista Italiana di Paleontologia e Stratigrafia, 107 (2): 227-250.

Izatt, C. Maingarm, S. & Racey, A. 2001. Fault distribution and timing in the Central Irish Sea Basin. Geological Society, London, Special Publications, 188: 155-169.

Jablonski, D., 2002. Survival without recovery after mass extinctions. Proceedings of the National Academy of Sciences of the United States Of America, 99: 8139-8144.

Jeans, C. J. V., Mitchell, J. G., Fisher, M. J., Wray, D. S. & Hall, I. R. 2001. Age, origin and climatic signal of English Mesozoic clays based on K/Ar signatures. Clay minerals, 36: 515-539.

Jenchen, U. 2001. Fazies und geochemie in kontinentalen Trias-Becken im westlichen Argentinien und in Patagonien (30°-50°S). Münstersche Forschungen zur Geologie und Paläontologie, Heft 91: 441pp.

Jenkins, F. A. Jr., Shubin, N. H., Gatesby, S. M. & Padian, K. 2001. A diminutive pterosaur (Pterosauria: Eudimorphodontidae) from the Greenlandic Triassic. Bulletin of the Museum of Comparative Zoology, 156 (1): 151-170.

Jiang Fen-Hu, Yang Jin & Liu Chang-Fan. 2001. Middle Triassic charophytes from Hole Tanggu-5 and the subdivision and correlation of the Lower-Middle Triassic red beds in Lingqing Depression, Bohai Sea coast. Acta Micropalaeontologica Sinica, 18 (4): 406-411.

Johnston, S. Doré, A. & Spencer, A. M. 2001. The Mesozoic evolution of the southern North Atlantic region and its relationship to basin development in the south Porcupine Basin, offshore Ireland. Geological Society, London, Special Publications, 188: 237-263.

Juez-Larre, J. & Andriessen, P.A.M., 2002. Post Late Paleozoic tectonism in the southern Catalan Coastal Ranges (NE Spain), assessed by apatite fission track analysis. Tectonophysics, 349: 113-129.

Junghans, W.-D., Rösler, W., Aigner, T. & Appel, E. 2002. Magnetostratigraphie an der Perm/Trias-Grenze der Bohrung Kraichgau 1002 (SW-Deutschland). Neues Jahrbuch für Geologie und Paläontologie Monatshefte, 2002 (2): 92-106.

Kamata, Y., Sashida, K., Ueno, K., Hisada, K., Nakornsri, N. & Charusiri, P. 2002. Triassic radiolarian faunas from the Mae Sariang area, northern Thailand and their palaeogeographic significance. Journal of Asian Earth Sciences, 20: 491-506.

Kammerer, T. 2001. Palynologische Untersuchungen im Grenzbereich Unterer Gipskeuper/Schilfsandstein (Trias, Mittlerer Keuper) des Erfurter Stadtgebietes. Geowissenschaftliche Mitteilungen Thüringen, 9: 125-131.

Karl, H.-V. & Tichy, G. 2000. *Murrhardtia staeschei* n. gen. n. sp. – eine neue Schildkroete aus der Oberen Trias von Süddeutschland. Joannea Geol. Palaeont. 2: 57-72.

Kassim, A., Carmignani, L., Conti, P., Fantozzi, P.L., 2001. Geology of the Mesozoic-Tertiary sedimentary basins in southwestern Somalia. Journal of African Earth Sciences, 34: 3-20.

Kato, Y., Nakao, K. & Isozaki, Y. 2002. Geochemistry of Late Permian to Early Triassic pelagic cherts from southwest Japan: implications for an oceanic redox change. Chemical Geology, 182: 15-34.

Kawakami, G. & Kawamura, M. 2002. Sediment flow and deformation (SFD) layers: evidence for intrastratal flow in laminated muddy sediments of the Triassic Osawa Formation, northeast Japan. Journal of Sedimentary Research, 72 (1): 171-181.

Keim, L. & Brandner, R. 2001. Facies interfingering and synsedimentary tectonics on late Ladinian-early Carnian carbonate platforms (Dolomites, Italy). International Journal of Earth Sciences, 90 (4): 813-830.

Keim, L. & Brandner, R. 2002. Erratum: Facies interfingering and synsedimentary tectonics on late Ladinian-early Carnian carbonate platforms (Dolomites, Italy). International Journal of Earth Sciences, 91 (3): 555-556.

Kerr, R. A. 2001. Paring down the Big Five Mass Extinctions. Science, 294: 2072-2073.

Kerr, R. A. 2002. Did an impact trigger the dinosaur’s rise? Science, 296: 1215-1216.

Kilani, F., Mehdi, D., Kamoun, F. & Peybernès, B. 2002. Associations palynologiques et micropaléontologiques dans le Trias du sud et du centre de la Tunisie. Documents des Laboratoires de Géologie Lyon, 156: 140-141.

Kirkham, A. 2002. Triassic microtektite pseudomorphs of the Bristol area, England. Geoscientist, 13 (7): 17-18.

Klavins, S. D., Taylor, T. N. & Taylor, E. L. 2002. Anatomy of *Umkomasia* (Corystospermales) from the Triassic of Antarctica. American Journal of Botany, 89: 664-676.

Kleiman, L. E. & Salvarredi, J. A. 2001. Petrología, geoquímica e implicancias tectónicas del volcanismo triásico (Formación Puesto Viejo), Bloque de San Rafael, Mendoza. Revista de la Asociación Geológica Argentina, 56 (4): 559-570.

Kloprogge, T. J., Ruan, H., Duong, L. V. & Frost, R. L. 2001. FT-IR and Raman microscopic study at 293 K and 77 K of celestine $SrSO_4$, from the middle triassic limestone (Muschelkalk) in Winterswijk, The Netherlands. Geologie en Mijnbouw, 80 (2): 41-47.

Knaust, D. 2002. Pinch- and swell structures at the Middle/ Upper Muschelkalk boundary (Triassic): evidence of earthquake effects (seismites) in the Germanic Basin. International Journal of Earth Sciences, 91 (2): 291-303.

Knaust, D., 2002. *Ichnogenus pholeus* Fiege, 1944, revisited. Journal of Paleontology, 76: 882-891.

Kordikova, E. G. 2002. Comparative morphology of the palate dentition in *Proganochelys quenstedti* Baur 1887 from the Upper Triassic of Germany and Chelonian Ancestry. Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen, 225: 195-249.

Korngreen, D. & Benjamini, C. 2001. Upper Triassic reef facies in the Asher-Atlit-1 Borehole, northern Israel: microfacies, cement stratigraphy and paleogeographic implications. Facies, 45: 1-24.

Koukharsky, M., Tassinari, C., De Brodtkorb, M. K. & Leal, P. 2001. Basaltos del Neopaleozoico-Triásico temprano? en las sierras Norte de Córdoba y de Ambargasta, Sierras Pampeanas Orientales: petrografía y edades K/Ar. Revista de la Asociación Geológica Argentina, 56 (3): 400-403.

Kovalevych, V., Peryt, T. M., Beer, W., Geluk, M. & Halas, S. 2002. Geochemistry of Early Triassic seawater as indicated by study of the Röt halite in the Netherlands, Germany, and Poland. Chemical Geology, 182: 549-563.

Kozur, H. W., Aydin, M., Demir, O., Yakar, H., Göncüoglu, M. C. & Kuru, F. 2000. New stratigraphic and palaeogeographic results from the Palaeozoic and Early Mesozoic of the Middle Pontides (northern Turkey) in the Azdavay, Devrekani, Küre and Inebolu areas: implications for the Carboniferous-Early Cretaceous geodynamic evolution and some related remarks on the Karakaya Oceanic Rift Basin. Geologia Croatica, 53 (2): 209-268.

Kruczyk, J., Kadzialko-Hofmokl, M., Jelenska, M., Túnyi, I., Gazdacko, L. & Grabowski, J. 2002. Paleomagnetism of metamorphic rocks from the Germerides (western Carpathians). Geologica Carpathica, 53 (1): 15-25.

Kumar, P. & Kumar, P. 2001. Phthirapteran insect and larval acanthocephala from the Late Triassic sediments of the Satpura Basin, India. Journal of the Palaeontological Society of India, 46: 141-146.

Krzeminski, W. & Krzeminska, E. 2002. Rhaetaniidae, a new family of the Diptera from the Upper Triassic of Great Britain (Diptera : Nematocera). Annales Zoologici, 52: 211-213.

Labudía, C. H. & Bjerg, E. A. 2001. El Grupo Los Menucos: redefinición estratigráfica del Triásico superior del Macizo Nordpatagónico. Revista de la Asociación Geológica Argentina, 56 (3): 404-407.

Langer, M., Ferigolo, J. & Schultz, C. L. 2000. Heterochrony and tooth evolution in hyperodontine rhynchosaurs (Reptilia, Diapsida). Lethaia, 33 (2): 119-128.

Latimer, E. M., Hancox, P.J., Rubidge, B. S., Shishkin, M. A, & Kitching, J. W. 2002. The temnospondyl amphibian *Uranocentrodon*, another victim of the end-Permian extinction event. South African Journal of Science, 98: 191-193.

Lekkas, E., Danamos, G., Skourtsos, E. & Sakellariou, D. 2002. Position of the Middle Triassic Tyros Beds in the Gavrovo-Tripolis unit (Rhodes Island, Dodecanese, Greece). Geologica Carpathica, 53 (1): 37-44.

Li, C., Rieppel, O., 2002. A new cyamodontoid placodont from Triassic of Guizhou, China. Chinese Science Bulletin, 47: 403-412.

Li Xiang-Hui, Wang Cheng-Shan & Wu Rui-Zhong. 2002. Recognition and correlation of supersequences in Lhasa Block, southern Tibet. Acta Sedimentologica Sinica, 20 (2): 179-187.

Lindsay, G. & Herbert, C., 2002. Coal and conglomerate in the Newcastle Coal Measures - coeval facies or temporally unrelated? International Journal of Coal Geology, 51: 169-184.

Lindstrom, S., 2002. *Lunnomidinium scaniense* Lindstrom, gen. et sp nov., a new suessiacean dinoflagellate cyst from the Rhaetian of Scania, southern Sweden. Review of Palaeobotany and Palynology, 120: 247-261.

Liu Guan-Bang, Feng Hong-Zhen, Wang Ju-Xian, Wu Tie-Min & Zhai Zhong-Hua. 2001. Early Triassic fishes from Jurong, Jiangsu. Acta Palaeontologica Sinica, 41 (1): 27-52.

Liu Zhao-Sheng. 2001. Sporopollen assemblage of the Huangshanjie Formation from the northern margin of the Tuha Basin of Xinjiang, NW China. Acta Micropalaeontologica Sinica, 18 (2): 163-172.

Lo, C. H., Chung, S. L., Lee, T. Y., Wu & G. Y. 2002. Age of the Emeishan flood magmatism and relations to Permian-Triassic boundary events. Earth and Planetary Science Letters, 198: 449-458.

Löser, H., Bach, F. & Müller, A., 2002. Die Sammlung mesozoischer und känozoischer Korallen von Johannes Felix am Geologisch-Paläontologischen Institut der Universität Leipzig. Leipziger Geowissenschaften, 14: 1-70.

Lockley, M. G., Wright, J. L., Hunt, A. P. & Lucas, S. G. 2001. The Late Triassic sauropod track record comes into focus: Old legacies and new paradigms; in Lucas, S. G. and Ulmer-Scholle, D. S., eds., Geology of the Llano Estacado: New Mexico Geological Society Guidebook 52, p. 181-190.

Lombardo, C. 2001. Actinopterygians from the Middle Triassic of Northern Italy and Canton Ticino (Switzerland): anatomical descriptions and nomenclatural problems. Rivista Italiana di Paleontologia e Stratigrafia, 107 (3): 345-369.

Lozovsky, V. R., Krassilov, V. A., Afonin, S. A., Burov, B. V. & Yaroshenko, O. P. 2001. Transitional Permian-Triassic deposits in European Russia, and non-marine correlations. Natura Bresciana, Monografi 25: 301-310.

Lucas, S. G. 2001. Abandon the term Dockum!; in Lucas, S. G. and Ulmer-Scholle, D. S., eds., Geology of the Llano Estacado: New Mexico Geological Society Guidebook 52, p. 12-13.

Lucas, S. G. 2001. The bennettitalean leaf "*Zamites*" *powellii* from the Middle Triassic Moenkopi Formation, east-central New Mexico; in Lucas, S. G. and Ulmer-Scholle, D. S., eds., Geology of the Llano Estacado: New Mexico Geological Society Guidebook 52, p. 111-114.

Lucas, S. G. 2001. Restoration of Late Triassic landscapes at the Petrified Forest National Park, Arizona; in Santucci, V. L. and McClelland, L., eds., Proceedings of the 6th Fossil Resource Conference: National Park Service Technical Report NPS/NRGRD/GRDTR-01/01, p. 52-54.

Lucas, S. G. 2001. Chinese fossil vertebrates. New York, Columbia University Press, 375 p.

Lucas, S. G. & Heckert, A. B. 2001. The aetosaur *Stagonolepis* from the Upper Triassic of Brazil and its biochronological significance: Neues Jahrbuch für Geologie und Paläontologie Monatshefte, v. 2001, p. 719-732.

Lucas, S. G. & Ulmer-Scholle, D. S., eds. 2001.Geology of the Llano Estacado: New Mexico Geological Society, 52nd Annual Field Conference Guidebook: Socorro, New Mexico Geological Society, 340 pp.

Lucas, S. G., Heckert, A. B. & Hunt, A. P. 2001. Triassic stratigraphy, biostratigraphy and correlation in east-central New Mexico; in Lucas, S. G. and Ulmer-Scholle, D. S., eds., Geology of the Llano Estacado: New Mexico Geological Society Guidebook 52, p. 85-102.

Lucas, S. G., Hunt, A. P. & Lockley, M. G. 2001. Tetrapod footprint ichnofauna of the Upper Triassic Redonda Formation, Chinle Group, Quay County, New Mexico; in Lucas, S. G. and Ulmer-Scholle, D. S., eds., Geology of the Llano Estacado: New Mexico Geological Society Guidebook 52, p. 177-180.

Lucas, S. G. & Heckert, A. B. 2001.The aetosaur *Stagonolepis* from the upper Triassic of Brazil and its biochronological significance. Neues Jahrbuch für Geologie und Paläontologie Monatshefte, 12: 719-832.

Lucas, S. G. & Schoch, R. R. 2002. Triassic temnospondyl biostratigraphy, biochronology and correlation of the German Buntsandstein and North American Moenkopi Formation. Lethaia, 35: 97-106.

Lugli, S., Morteani, G. & Blamart, D. 2002. Petrographic, REE, fluid inclusion and stable isotope study of magnesite from the Upper Triassic Burano Evaporites (Secchia Valley, northern Apennines): contributions from sedimentary, hydrothermal and metasomatic sources. Mineralium Deposita, 37: 480-494.

Luo Jinglan, Ketzer, J. M., Li Wenhou, Yan Shike, Wu Fuli & Li Yuhong. 2001. Sequence stratigraphy and source-reservoir-cap assemblages of Jurassic-Upper Triassic in Yanchang oil province. Oil & Gas Geology, 22 (4): 337-401.

Luo, J. L., Morad, S., Zhang, X. L., Yan, S. K., Wu, F. L., Li, Y. H. & Xue, J. M. 2002. Reconstruction of the diagenesis of the fluvial-lacustrine-deltaic sandstones and its influence on the reservoir quality evolution - Evidence from Jurassic and Triassic sandstones, Yanchang Oil Field, Ordos Basin. Science in China Series D, Earth Sciences, 45: 616-634.

Maisch, M. W., 2002. A new basal lystrosaurid dicynodont from the upper Permian of South Africa. Palaeontology, 45: 343-359.

Maisch, M. W. & Matzke, A. T. 2000. The Ichthyosauria. Stuttgarter Beiträge zur Naturkunde, Serie B, Nr.298: 159pp.

Maisch, M. W. & Matzke, A. T. 2001. The cranial osteology of the Middle Triassic ichthyosaur *Contectopalatus* from Germany. Palaeontology, 44 (6): 1127-1156.

Maisch, M. W. & Lehmann, J., 2002. A new basal omphalosaurid from the Middle Triassic of Germany. Neues Jahrbuch für Geologie und Paläontologie, Monatshefte, 2002(9): 513-525.

Maisch, M. W. & Matzke, A. T. 2002. The skull of a larger Lower Triassic ichthyosaur from Spitzbergen and its implications for the origin of the Ichthyosauria. Lethaia, 35: 250-256.

Malartre, F., Palain, C., Michels, R. & Courtinat, B. 2002. Stratigrapie intégrée dun complexe fluviatile: la formation du "Grès à Roseaux" (Trias supérieur, NE France). Signature locale d'un événement global? Documents des Laboratoires de Géologie Lyon, 156: 150-151.

Mantovani, N. 2002. The genus *Tetractinella* Bittner, 1890: morphology, ultrastructure, and 3D reconstruction. Rivista Italiana di Paleontologia e Stratigrafia, 108 (1): 37-50.

McGowan. A. J. 2002. The macroevolution of Triassic ammonoids. The Palaeontological Association, Newsletter 49: 48-51.

McManus, H. A., Taylor, E. L., Taylor, T. N. & Collinson, J. W. 2002. A petrified Glossopteris flora from Collinson Ridge, central Transantarctic Mountains: Late Permian or Early Triassic? Review of Palaeobotany and Palynology, 120: 233-246.

Melchor, R. N., De Valais, S. & Genise, J. F. 2002. Bird-like fossil footprints from the Late Triassic. Nature, 417: 936-938.

Merz, G., 2001. Geologische und hydrogeologische Verhältnisse am Westhang des Tannrodaer Sattels im Verbreitungsgebiet des Muschelkalks. Geowissenschaftliche Mitteilungen Thüringen, 9: 29-36.

Metcalfe, I., Nicoll, R. S., Mundil, R., Foster, C., Glen, J., Lyons, J., Wang Xiaofeng, Wang Cheng-Yuan, Renne, P. R., Black, L. Qu Xun & Mao Xiaodong. 2001. The Permian-Triassic boundary & mass extinction in China. Episodes, 24 (4): 239-244.

Michael, K. & Bachu, S. 2002. Origin, chemistry and flow of formation waters in the Mississippiam-Jurassic sedimentary succession in the west-central part of the Alberta Basin, Canada. Marine and Petroleum Geology, 19 (3): 289-306.

Michaelsen, P. 2002. Mass extinction of peat-forming plants and the effect on fluvial styles across the Permian-Triassic boundary, northern Bowen Basin, Australia. Palaeogeography, Palaeoclimatology, Palaeoecology, 179 (3-4): 173-188.

Michelsen, O. & Clausen, O. R., 2002. Detailed stratigraphic subdivision and regional correlation of the southern Danish Triassic succession. Marine and Petroleum Geology, 19: 563-587.

Millar, I. L., Pankhurst, R. J. & Fanning, C.M. 2002. Basement chronology of the Antarctic Peninsula: recurrent magmatism and anatexis in the Palaeozoic Gondwana Margin. Journal of the Geological Society, 159: 145-157.

Miller, M. F., Mcdowell, T., Smail, S. E., Shyr, Y. & Kemp, N. R. 2002. Hardly used habitats: dearth and distribution of burrowing in Paleozoic and Mesozoic stream and lake deposits. Geology, 30 (6): 527-530.

Milodowski, A. E., Styles, M. T., Horstwood, M. S. A. & Kemp. S. J. 2002. Alteration of uraniferous and native copper concretions in the Permian mudrocks of south Devon, United Kingdom. Swedish Nuclear Fuel and Waste Management Co. Technical Report TR-02-09, 121pp.

Mitrovic-Petrovic, J. 2000. Mesozoic Echinodermata of Stara Planina, eastern Serbia. Annales Géologiques de la Péninsule Balkanique, 63: 71-89.

Modesto, S., Sues, H-D. & Damiani, R. 2001. A new Triassic procolophonoid reptile and its implications for procolophonoid survivorship during the Permo-Triassic extinction event. Proceedings Royal Society of London B, 268: 2047-2052.

Morales, M. & Shishkin, M. A., 2002. A re-assessment of *Parotosuchus africanus* (Broom), a capitosauroid temnospondyl amphibian from the Triassic of South Africa. Journal Of Vertebrate Paleontology, 22: 1-11.

Mountney, N. P. & Thompson, D.B. 2002. Stratigraphic evolution and preservation of aeolian dune and damp/wet interdune strata: an example from the Triassic Helsby Sandstone Formation, Cheshire Basin, UK. Sedimentology, 49: 805-833.

Myo Min, Khin Khin Lin, Feng Qinglai, Chonglakmani, C., Meischner, D., Ingavat-Helmcke, R. & Helmcke, D. 2001. Tracing disrupted outer margin of paleoeurasian continent through Union of Myanmar. Journal of China University of Geosciences, 12 (3): 201-206.

Nagy, E. A., Maluski, H., Lepvrier, C., Schärer, U., Phan Tuong Thi, Leyreloup, A. & Vu Van Thich. 2001. Geodynamic significance of the Kontum Massif in central Vietnam: composite ^{40}Ar/^{39}Ar and U-Pb ages from Paleozoic to Triassic. The Journal of Geology, 109: 755-770.

Nagy, Z. R. & Csillag, G. 2002. Correlation of Upper Julian to Lower Tuvalian (Carnian) depositional cycles from the Balatonhenye - Barnag area, Balaton Highland, Hungary. Acta Geologica Hungarica, 45 (1): 45-62.

Nedjari, A. & Ait-Ouali, R. 2002. Les phases passives du Trias saharien: alterations et altérites. Documents des Laboratoires de Géologie Lyon, 156: 177.

Nel, A., Bethoux, O., Bechly, G., Martinez-Delclos, X. & Papier, F. 2001. The Permo-Triassic odonatoptera of the “protodonate” grade (Insecta: Odonatoptera). Annales de la Societé Entomologique de France, 37: 501-525.

Nicoll, R. S., Metcalfe, I., Wang, C. Y. & 2002. New species of the conodont Genus *Hindeodus* and the conodont biostratigraphy of the Permian-Triassic boundary interval. Journal of Asian Erath Sciences, 20: 609-631.

Nikishin, A. M., Ziegler, P. A., Abbott, D., Brunet, M. F. & Cloetingh, S., 2002. Permo-Triassic intraplate magmatism and rifting in Eurasia: implications for mantle plumes and mantle dynamics. Tectonophysics, 351: 3-39.

Nilsen, O., Hagen, E. & Dypvik, H., 2001. Sediment provenance and Karoo rift basin evolution in the Kilombero Rift Valley, Tanzania. South African Journal of Geology, 104: 137-150.

Novak, M. 2001. Scythian beds in the Toško elo area (Slovenia). Geologija, 44 (2): 295-303.

Novokshonov, V. G. 2002. Scorpionflies of the family Liassophilidae from the Triassic of Ukraine. Paleontologicheskii Zhurnal, 2002(4): 57-59.

Noyan, Ö. F. & Vrielynck, B. 2002. New data on the stratigraphical range of Triassic conodonts from the Ammonitico-rosso and associated deposits near Epidaure, Greece. Neues Jahrbuch für Geologie und Paläontologie, Monatshefte, 2002 (5): 310-320.

Nützel, A. 2002. The Late Triassic species *Cryptaulax*? *bittneri* (Mollusca: Gastropoda: Procerithiidae) and remarks on early aspects of the Mesozoic marine revolution. Paläontologische Zeitschrift, 76 (1): 57-63.

Nützel, A. & Erwin, D. H. 2002. *Battenizyga*, a new Early Triassic gastropod genus with a discussion of the caenogastropod evolution at the Permian/Triassic boundary. Paläontologische Zeitschrift, 76 (1): 21-27.

Oblak, K. 2001. Carnian foraminifera from the Kucler quarry at Lesno Brdo (Slovenia). Geologija, 44 (2): 305-316.

Olsen, P. E., Kent, D. V., Sues, H.-D., Koeberl, C., Huber, H., Montanari, A., Rainforth, E. C., Fowell, S. J., Szajna, M. J. & Hartline, B. W. 2002. Ascent of dinosaurs linked to an iridium anomaly at the Triassic-Jurassic boundary. Science, 296: 1305-1307.

Othman, R. & Ward, C. R. 2002. Thermal maturation pattern in the southern Bowen, northern Gunnedah and

Surat basins, northern New South Wales, Australia. International Journal of Coal Geology, 51: 145-167.

Pálfy, J., Demény, A., Haas, J., Hetényi, M., Orchard, M. J. & Vetö, I. 2001. Carbon isotope anomaly and other geochemical changes at the Triassic-Jurassic boundary from a marine section in Hungary. Geology, 29 (11): 1047-1050.

Pamic, J., Jurkovic, I., 2002. Paleozoic tectonostratigraphic units of the northwest and central Dinarides and the adjoining South Tisia. International Journal of Earth Sciences, 91: 538-554.

Parrish, J. T., Droser, M. L. & Bottjer, D. J. 2002. A Triassic upwelling zone: The Shublik Formation, Arctic Alaska, USA - Reply. Journal of Sedimentary Research, Journal of Sedimentary Research, 72: 742-743.

Peng Yuanqiao, Tong Jinnan, Shi, G. R. & Hansen, H. J. 2001. The Permian-Triassic Boundary Stratigraphic Set: characteristics and correlation. Newsletters on Stratigraphy, 39 (1): 55-71.

Péréz-López, A. 2001. Significance of pot and gutter casts in a Middle Triassic carbonate platform, Betic Cordillera, southern Spain. Sedimentology, 48: 1371-1388.

Piros, O. 2002. Anisian to Carnian carbonate platform facies and dasycladacean biostratigraphy of the Aggtelek Mts, northeastern Hungary. Acta Geologica Hungarica, 45 (2): 119-151.

Pöppelreiter, M. 2002. Facies, cyclicity and reservoir properties of the Lower Muschelkalk (Middle Triassic) in the NE Netherlands. Facies, 46: 119-132.

Poller, U., Uher, P., Broska, I., Plasienka, D. & Janák, M. 2002. First Permian-Early Triassic zircon ages for tin-bearing granites from the Gemeric unit (western Carpathians, Slovakia): connection to the post-collisional extension of the Variscan orogen and S-type granite magmatism. Terra Nova, 14: 41-48.

Preston, J., Hartley, A., Mange-Rajetsky, M., Hole, M., May, G., Buck, S. & Vaughan, L. 2002. The provenance of Triassic continental sandstones from the Beryl Field, northern North Sea: mineralogical, geochemical, and sedimentological constraints. Journal of Sedimentary Research, 72 (1): 18-29.

Preto, N., Hinnov, L. A., Hardie, L. A. & De Zanche, V. 2001. Middle Triassic orbital signature recorded in the shallow-marine Latemar carbonate buildup (Dolomites, Italy). Geology, 29 (12): 1123-1126.

Prudden, H. C. 2001. Geology and Landscape of Taunton Deane. Taunton, Taunton Deane Borough Council, 141pp.

Qinglai Feng, Zhenfang Zhang & Mei Ye. 2001. Middle Triassic radiolarian fauna from southwest Yunnan, China. Micropaleontology, 47 (3): 173-204.

Querol, X., Alastuey, A., Xinguo Zhuang, Hower, J. C., Lopez-Soler, A., Plana, F. & Rongsu Zeng. 2001. Petrology, mineralogy and geochemistry of the Permian and Triassic coals of the Leping area, Jiangxi Province, southeast China. International Journal of Coal Geology, 48: 23-45.

Radley, J. D. & Swift, A. 2002. Sedimentology of the Triassic-Jurassic boundary beds in Pinhay Bay (Devon, SW England)' by P. B. Wignall: comment. Proceedings of the Geologists Association, 113: 271-272.

Rainbird, R. H. & Ernst, R. E. 2001. The sedimentary record of mantle-plume uplift. Geological Society of America Special Paper 352: 227-245.

Ramovš, A. 2001. Erste Brachiopoden Fundstelle in den obersten Tuval-kalken (Oberkarn) in der nordalpinen Hallstätter Ausbildung in den Julischen Alpen. Geologija, 44 (2): 291-294.

Ray, S., Chinsamy, A., 2002. A theropod tooth from the Late Triassic of southern Africa. Journal of Biosciences, 27: 295-298.

Rees, J. & Underwood, C. J. 2002. The status of the shark genus *Lissodus* Brough, 1935, and the position of nominal Lissodus species within the Hybodontoidea (Selachii). Journal of Vertebrate Paleontology, 22: 471-479.

Rees, P.M., 2002. Land-plant diversity and the end-Permian mass extinction. Geology, 30: 827-830.

Reichow, M. K., Saunders, A. D., White, R. V., Pringle, M. S., Al'mukhamedov, A. I., Medvedev, A. I. & Kirda, N. P. 2002. ^{40}Ar/^{39}Ar dates from the West Siberian Basin: Siberian flood basalt province doubled. Science, 296: 1846-1849.

Reisz, R. R. & Scott, D. 2002. *Owenetta kitchingorum*, sp nov, a small parareptile (Procolophonia : Owenettidae) from the Lower Triassic of South Africa. Journal of Vertebrate Paleontology, 22: 244-256.

Renaut, A. J. & Hancox, P. J. 2001. Cranial description and taxonomic re-evaluation of *Kannemeyeria argentinensis* (Therapsida: Dicynodontia). Palaeontologia Africana, 37: 81-91.

Renesto, S. & Avanzini, M. 2002. Skin remains in a juvenile Macrocnemus bassanii NOPCSA (Reptilia, Prolacertiformes) from the Middle Triassic of northern Italy. Neues Jahrbuch für Geologie und Paläontologie Abhandlungen, 224 (1): 31-48.

Renesto, S., Dalla Vecchia, F. M. & Peters, D. 2002. Morphological evidence for bipedalism in the Late Triassic prolacertiform reptile *Langobardisaurus*. Senkenbergiana lethaea, 82 (1): 95-106.

Renne, P. R. 2002. Flood basalts - bigger and badder. Science, 296: 1812-1813.

Renne, P. R., Sharp, W. D., Montañez, I. P., Becker, T. A. & Zierenberg, R. A. 2001. ^{40}Ar/^{39}Ar dating of Late Permian evaporites, southeastern New Mexico, USA. Earth and Planetary Science Letters, 193: 539-547.

Retallack, G. J. 2002. Carbon dioxide and climate over the past 300 Myr. Philosophical Transactions of the Royal Society of London, Series A, Mathematical Physical and Engineering Sciences, 360 (1793): 659-673.

Rogers, R. R., Arcucci, A. B., Abdala, F., Sereno, P. C., Forster, C. A. & May, C. L. 2001. Paleoenvironment and taphonomy of the Chañares Formation tetrapod assemblage (Middle Triassic), northwestern Argentina: spectacular preservation in volcanogenic concretions. Palaios, 16: 461-481.

Roniewicz, E. & Michalik, J. 2002. Carnian corals from the Male Karpaty Mountains, Western Carpathians, Slovakia. Geologica Carpathica, 53: 149-157.

Rothwell, G. W., Taylor, E. L. & Taylor, T. N. 2002. *Ashicaulis woolfei* n. sp.: Additional evidence for the antiquity of osmundaceous ferns from the Triassic of Antarctica. American Journal of Botany, 89: 352-361.

Sankaran, A. V., 2002. Search for the elusive end-Permian bolide impact: Exotic carbon - fullerene, as a potential tracer. Current Science, 83: 363-365.

Schatz, W. 2001. Taxonomic significance of biometric characters and the consequences for classification and biostratigraphy, exemplified through moussoneliform daonellas (*Daonella*, Bivalvia; Triassic). Paläontologische Zeitschrift, 75 (1): 51-70.

Schatz, W. 2001. Revision der Untergattung *Daonella (Pichlerella)* (Bivalvia, Ladin). Eclogae Geologicae Helvetiae, 94: 389-398.

Schlagintweit, F., Mandl, G.W. & Ebli, O. 2001. *Slpingoporella austriaca* n.sp., a new dasycladale (calcareous alaga) from the lower Norian Dachstein Limestone of Mount Dachstein (Northern Calcareous Alps, Austria). Revue de Paléobiologie, 20: 359-365.

Schlirf, M., Uchman, A. & Kümmel, M. 2001. Upper Triassic (Keuper) non-marine trace fossils from the Hassberge area (Franconia, south-eastern Germany). Paläontologische Zeitschrift, 75 (1): 71-96.

Schuster, R., Scharbert, S., Abart, R. & Frank, W. 2001. Permo-Triassic extension and related HT/LP metamorphism in the Austroalpine - Southalpine realm. Mitteilungen der Gesellschaft der Geologie und Bergbaustudenten in Österreich, 45: 111-141.

Sha, J. G. 2002. Hispanic Corridor formed as early as Hettangian: On the basis of bivalve fossils. Chinese Science Bulletin, 47: 414-417.

Shang Qing-Hua, Caridroit, M. & Wang Yu-Ping. 2001. Radiolarians from the uppermost Permian Changhsingian of southern Guangxi. Acta Micropalaeontologica Sinica, 18 (3): 229-240.

Shapiro, M. D. & Jenkins, F. A. Jr. 2001. A cynodont from the Upper Triassic of East Greenland: tooth replacement and double-rootedness. Bulletin of the Museum of Comparative Zoology, 156 (1): 49-58.

Siblík, M. 2001. On the find of Triassic brachiopopd fauna in the variegated micrites on the Dachstein Plateau. Slovak Geological Magazine, 7 (1): 91-94.

Siblík, M. 2001. New genus (Superbirhyncha gen. n.) for rhynchonellid (Brachiopoda) from the Alpine Upper Triassic. Slovak Geological Magazin, 8 (1): 101-103.

Siblík, M. 2001. Brachiopoda mesozoica. In Piller, W. E. & Flügel, H. W. (Eds.): Catalogus Fossilum Austriae. Heft Vc 2 (a), pp. 1-45.

Small, B. J. 2002. Cranial anatomy of *Desmatosuchus haplocerus* (Reptilia : Archosauria : Stagonolepididae). Zoological Journal of the Linnean Society, 136: 97-111.

Smith, R. M. H. & Ward, P. D. 2001. Pattern of vertebrate extinctions across an event bed at the Permian-Triassic boundary in the Karoo Basin of South Africa. Geology, 29 (12): 1147-1150.

Smith, R. M. H. & Swart, R. 2002. Changing fluvial environments and vertebrate taphonomy in response to climatic drying in a Mid-Triassic rift valley fill: the Omingonde Formation (Karoo Supergroup) of central Namibia. Palaios, 17: 249-267.

Smuc, A. & Car, J. 2002. Upper Ladinian to Lower Carnian sedimentary evolution in the Idrija-Cerkno region, Western Slovenia. Facies, 46: 205-216.

Souto, P. R. F. 2001. Tetrapod coprolites from the Middle Triassic of southern Brazil. Gaia, 16: 51-57.

Spalletti, L. A. 2001. Modelo de sedimentación fluvial y lacustre en el margen pasivo de un hemigraben: el Triásico de la Precordillera occidental de San Juan, República Argentina. Revista de la Asociación Geológica Argentina, 56 (2): 189-210.

Spenceley, A. P. 2002. Grooves and striations on the Stanthorpe Adamellite: evidence for a possible late Middle-Late Triassic age glaciation. Australian Journal of Earth Sciences, 48: 777-784.

Spencer, A. M. & Mactiernan, B. 2001. Petroleum systems offshore western Ireland in and Atlantic margin context. Geological Society, London, Special Publications, 188: 9-29.

Stampfli, G. M. (Ed.). 2001. Geology of the western Swiss Alps. A guide book. Mémoires de Géologie (Lausanne), No.36, ix+195pp.

Stampfli, G. M., Borel, G. D., Cavazza, W., Mosar, J. & Ziegler, P. A. 2001. Palaeotectonic and palaeogeographic evolution of the western Tethys and PeriTethyan domain (IGCP Project 369). Episodes, 24 (4): 222-228.

Stampfli, G. M. & Borel, G. D. 2002. A plate tectonic model for the Paleozoic and Mesozoic constrained by dynamic plate boundaries and restored synthetic oceanic isochrons. Earth and Planetary Science Letters, 196: 17-33.

Stanistreet, I. G. & Stollhofen, H. 2002. Hoanib River flood deposits of Namib Desert interdunes asanalogues for thin permeability barrier mudstone layers inaeolianite reservoirs. Sedimentology, 49: 719-736.

Stemmerik, L., Bendix-Almgreen, S. E. & Piasecki, S. 2001. The Permian-Triassic boundary in central East Greenland: past and present views. Bulletin of the Geological Society of Denmark, 48 (2): 159-167.

Steyer, J. S. 2002. The first articulated trematosaur ‘amphibian’ from the Lower Triassic of Madagascar: implications for the phylogeny of the group. Palaeontology, 45 (4): 771-793.

Stiller, F. 2001. Scaphopods from the Upper Anisian (Middle Triassic) of Qingyan, south-western China. Neues Jahrbuch für Geologie und Paläontologie Monatshefte, 2001 (10): 617-632.

Stiller, F. 2001. Fossilvergellschaftungen, Paläoökologie und paläosynökologische Entwicklung im Oberen Anisium (Mittlere Trias) von Qingyan, insbesondere Bangtoupo, Provinz Guizhou, Südwestchina. Münstersche Forschungen zur Geologie und Paläontologie, 92: 523pp.

Streetly, H. R., Hamilton, A. C. L., Betts, C., Tellam, J. H.

& Herbert, A. W. 2002. Reconnaissance tracer tests in the Triassic sandstone aquifer north of Liverpool. Quarterly Journal of Engineering Geology and Hydrogeology, 35: 167-178.

Sulej, T., 2001. Species discrimination of the Late Triassic temnospondyl amphibian *Metoposaurus diagnosticus*. Acta Palaeontologica Polonica, 47: 535-546.

Sues, H.-D. 2001. On *Microconodon*, a Late Triassic cynodont from the Newark Supergroup of eastern North America. Bulletin of the Museum of Comparative Zoology, 156 (1): 37-48.

Sun, W. D., Li, S. G., Chen, Y. D. & Li, Y. J. 2002. Timing of synorogenic granitoids in the South Qinling, central China: Constraints on the evolution of the Qinling-Dabie orogenic belt. Journal of Geology, 110: 457-468.

Suo Shutian, Zhong Zengqiu, Zhou Hanwen & You Zhendong. 2002. Triassic collisional structures and post-collisional deformation of Bixiling UHP rock stack: insights for tectonic evolution of UHP metamorphic belt in Dabie Massif, central China. Journal of China University of Geosciences, 13 (1): 1-13.

Surono & Bachri, S. 2002. Stratigraphy, sedimentation and palaeogeographic significance of the Triassic Meluhu Formation, southeast arm of Sulawesi, Eastern Indonesia. Journal of Asian Earth Sciences, 20: 177-192.

Svendsen, J. B. & Hartley, N.R. 2002. Synthetic heavy mineral stratigraphy: applications and limitations. Marine and Petroleum Geology, 19: 389-405.

Sweet, W. C. & Donoghue, P. C. J. 2001. Conodonts: past, present, future. Journal of Paleontology, 75 (6): 1174-1184.

Tatarinov, L. P. 2002. Gomphodont cynodonts (Reptilia, Theriodontia) from the Middle Triassic of the Orenburg Region. Paleontologicheskii Zhurnal, 2002(2): 58-61.

Tatarinov, L. P. 2002. Monophyly and polyphyly in the origin of mammals: Current state of the question. Paleontologicheskii Zhurnal , 2002(3): 66-74.

Tanner, L. H., Hubert, J. F., Coffey, B. P. & Mcinerney, D. P. 2001. Stability of atmospheric CO_2 levels across the Triassic/Jurassic boundary. *Nature*, 411: 675-677.

Tatzreiter, F. 2001. *Noetlingites strombecki* (GRIEPENKERL 1860) und die stratigraphische Stellung der Großreiflinger Ammonitenfaunen (Anis, Steiermark/Österreich). Mitteilungen der Gesellschaft der Geologie und Bergbaustudenten in Österreich, 45: 111-141.

Taylor, D. G., Guex, J. & Rakus, M. 2001. Hettangian and Sinemurian ammonoid zonation for the Western Cordillera of North America. *Bulletin de la Société vaudoise des Sciences naturelles*, 87 (4): 381-421 (*Bulletin de Géologie de l'Université de Lausanne*, Nº 350).

Tekin, U. K. 2002. Lower Jurassic (Hettangian-Sinemurian) radiolarians from the Antalya nappes, Central Taurids, southern Turkey. Micropaleontology, 48 (2): 177-205.

Tekin, U. K., Göncüoglu, M. C. & Turhan, N. 2002. First evidence of Late Carnian radiolarians from the Izmir-Ankara suture complex, central Sakarya, Turkey: implications for the opening age of the Izmir-Ankara branch of Neo-Tethys. Geobios, 35: 127-135.

Thomson, A. & Mcwilliam, A. 2001. The structural style and evolution of the Bróna Basin. Geological Society, London, Special Publications, 188: 401-410.

Tingate, P. R. & Duddy, I. R. 2002. The thermal history of the eastern Officer Basin (South Australia): evidence from apatite fission track analysis and organic maturity data. Tectonophysics, 349: 251-275.

Tiwari, R. S. 2000. Theory and praxis of palynological correlation of Gondwana coalseams. Bulletin of the Oil and Natural Gas Corporation Limited, 37 (2): 103-111.

Tiwari, R. S. 2001. Was there a 'mass extinction' of plant life at the PTB of Peninsular India? Geological Survey of India Special Publication, 54: 7-14.

Tong, J. & Erwin, D. H. 2001. Triassic gastropods of the Southern Qinling Mountains, China. Smithsonian Contributions to Paleobiology, 92: v+47pp.

Tripathi, A. 2000. Palynological events during Late Triassic-Early Jurassic time in India. *Palaeobotanist*, 49 (3): 399-408.

Trop, J. M., Ridgway, K. D., Manuszak, J. D. & Layer, P. 2002. Mesozoic sedimentary-basin development on the allochthonous Wrangellia composite terrane, Wrangell Mountains basin, Alaska: a long-term record of terrane migration and arc construction. Bulletin of the Geological Society of America, 114 (6): 693-717.

Turner, P., Pilling, D., Walker, D., Exton, J., Binnie, J. & Sabaou, N. 2001. Sequence stratigraphy and sedimentology of the late Triassic TAG-I (Blocks 401/402, Berkine Basin, Algeria). Marine and Petroleum Geology, 18: 959-981.

Uher, P., Ondrejka, M., Spisiak, J., Broska, I. & Putis, M. 2002. Lower Triassic potassium-rich rhyolites of the Silicic Unit, western Carpathians, Slovakia: geochemistry, mineralogy and genetic aspects. Geologica Carpathica, 53 (1): 27-36.

Unterschutz, J. L. E., Creaser, R. A., Erdmer, P., Thompson, R. I. & Daughtry, K. L. 2002. North American margin origin of Quesnel terrane strata in the southern Canadian Cordillera: inferences from geochemical and Nd isotopic characteristics of Triassic metasedimentary rocks. Geological Society of America Bulletin, 114 (4): 462-475.

Urlichs, M., 2000. *Germanonautilus* (Nautiloidea) aus dem Unterkarnium der Dolomiten (Obertrias, Italien). Stuttgarter Beiträge zur Naturkunde, Serie B (Geologie und Paläontologie), 291: 1-13.

Urlichs, M., 2000. Zur Entwicklungsreihe *Germanonautilus bidorsatus-G. Suevicus* aus dem Germanischen Oberen Muschelkalk (Nautiloidea, Mitteltrias). Stuttgarter Beiträge zur Naturkunde, Serie B (Geologie und Paläontologie), 292: 1-16.

Urlichs, M., 2001. Die Zwergfauna aus der Obertrias von St.Kassian (Dolomiten), in: Weidert, K. (Ed.), Klassische Fundstellen der Paläontologie, Band 4: 76-

86. Goldschneck, Korb.

Urlichs, M., Tichy, G., 2000. Zur Alterstellung der Schlernplateau-Schichten (Mitteltrias) am Schlern (westliche Dolomiten, Italien). Stuttgarter Beiträge zur Naturkunde, Serie B (Geologie und Paläontologie), 297: 1-10.

Vachard, D., Hauser, M., Martini, R., Zaninetti, L., Matter, A., Peters, T., 2002. Middle Permian (Midian) foraminiferal assemblages from the Batian Plain (eastern Oman): their significance to neotethyan paleogeography. Journal of Foraminiferal Research, 32: 155-172.

Van Konijnenburg-Van Cittert, J. H. A. 2002. Ecology of some Late Triassic to Early Cretaceous ferns in Eurasia. Review of Palaeobotany and Palynology, 119: 113-124.

Van Konijnenburg-Van Cittert, J. H. A., Miku•, V. & Pavši , J. 2001. *Pterophyllum* (Cycadopsida) from Carnian beds in Poljane valley (Slovenia). Geologija, 44 (2): 317-323.

Vecsei, A. & Mandau, T. 2002. Redbeds from the Middle Muschelkalk (Middle Triassic) of the SW Germanic Basin: arid environments from Pangea's interior. International Journal of Earth Sciences, 91 (1):111-122.

Velaj, T., 2002. Evaporites in Albania and their impact on the thrusting processes. Carbonates and Evaporites, 17: 68-78.

Verneau, O., Bentz, S., Sinnappah, N.D., du Preez, L., Whittington, I., Combes, C., 2002. A view of early vertebrate evolution inferred from the phylogeny of polystome parasites (Monogenea: Polystomatidae). Proceedings of the Royal Society of London, Series B - Biological Sciences, 269 (1490): 535-543.

Vincent, S. J. & Allen, M. B. 2001. Sedimentary record of Mesozoic intracontinental deformation in the eastern Junggar Basin, northwest China: response to orogeny at the Asian margin. Geological Society of America Memoir 194: 341-360.

Vörös, A., 2001. Middle Triassic (Anisian) nautilid cephalopods from AszófQ (Balaton Highland, Hungary). Fragmenta Palaeontologica Hungarica, 19: 1-14.

Walker, L. J., Wilkinson, B. H. & Ivany, L. C. 2002. Continental drift and Phanerozoic carbonate accumulation in shallow-shelf and deep-marine settings. The Journal of Geology, 110: 75-87.

Wang Liting, Li Jinling, Wang Xinjin, Li Chun, Wu Tianzhuang & Liu Jun. 2001. Biostratigraphy of Triassic marine reptiles in southwest Guizhou and its adjacent area. Acta geologica Sinica, 75 (4): 349-353.

Wang Xing-Zhi, Zhang Fan, Ma Qing, Yang Man-Ping, Wang Yi-Gang, Wen Ying-Chu, Yang Yu & Zhang Jing. 2002. The characteristics of reef and bank and the fluctuation of sea-level in Feixianguan period of Late Permian-Early Triassic, East Sichuan Basin. Acta Sedimentologica Sinica, 20 (2): 249-254.

Wang Yue, Cao Chang-Qun & Jin Yu-Gan. 2001. Analysis of the confidence intervals of marine fossils around the Permian-Triassic boundary in Meishan, Zhejiang. Acta Palaeontologica Sinica, 40 (2): 244-251.

Wappler, T. 2001. Haglidae (Insecta: Orthoptera) aus der obertriassischen Molteno-Formation im südlichen Afrika. Neues Jahrbuch für Geologie und Paläontologie Abhandlungen, 222 (3): 329-352.

Waterhouse, B. 2001. The new GSSP for the Permian-Triassic boundary. Geological Society of New Zealand, Newsletter 126: 21-23.

Wei Lin, Faure, M., Yan Sun, Liangshu Shu & Qingchen Wang. 2001. Compression to extension switch during the Middle Triassic orogeny of Eastern China: the case study of the Jiulingshan massif in the southern foreland of the Dabeishan. Journal of Asian Earth Sciences, 20: 31-43.

Weiler, H. 2001. Beobachtungen zur Hydrogeologie und Tektonik des Buntsandsteingebietes von Oberbettingen (Eifeler Nord-Südzone). Mainzer geowissenschaftliche Mitteilungen, 30: 195-226.

Wen Jiao Xiao, Windley, B. F., Han Lin Chen, Guo Cheng Zhang & Ji Liang Li. 2002. Carboniferous-Triassic subduction and accretion in the western Kunlun, China: implications for the collisional and accretionary tectonics of the northern Tibetan Plateau. Geology, 30 (4): 295-298.

Wilson, J.A., 2002. Sauropod dinosaur phylogeny: critique and cladistic analysis. Zoological Journal of the Linnean Society, 136: 217-276.

Woodcock, D. 2002. The sandstone quarries of Overton Hill, Frodsham: a geological study. Open University Society Journal 23 (1): 6-15.

Wopfner, H., 2001. Tectonic and climatic events controlling deposition in Tanzanian Karoo basins. Journal of African Earth Sciences, 34: 167-177.

Wu, X. & Russell, A. P. 2001. Redescription of *Turfanosuchus dabanensis* (Archosauriformes) and new information on its phylogenetic relationships. Journal of Vertebrate Paleontology, 21: 40-50.

Wu, X., Liu, J. & Li, J. 2001. The anatomy of the first archosauriform (Diapsida) from the terrestrial Upper Triassic of China. Vertebrata PalAsiatica, 39: 251-265.

Wu, Y. S. & Fan, J. S. 2002. Permian-Triassic history of reefal thalamid sponges: evolution and extinction. Acta Palaeontologica Sinica, 41: 163-177.

Xiao, W. J., Windley, B. F., Chen, H. L., Zhang, G. C., Li, J. L. 2002. Carboniferous-Triassic subduction and accretion in the western Kunlun, China: Implications for the collisional and accretionary tectonics of the northern Tibetan Plateau. Geology, 30: 295-298.

Xu, Q. D., Ouyang, J. P., Zhang, B. R. & Kuang, S. P. 2002. Tectonic affinity of Paleozoic stratigraphic slices along the northern margin in Dabie Orogen, central China: evidence from Pb isotope of rocks. Progress in Natural Science, 12: 438-444.

Yates, A. M. & Sengupta, D. P. A lapillopsid temnospondyl from the Early Triassic of India. Alcheringa, 26 (2): 201-208.

Yu Yuan-Jiang, Sun Jing-Min, Zhu Qing-Zhong, Yang Bing, Shen Jun-Shan, Liu Xian-Bin & Han Chun-Ming. 2002. Preliminary research on the Mesozoic lithofacies - palaeogeography in the Chalangla area, Qiangtang Basin, northern Tibet. Acta Sedimentologica Sinica, 20 (2): 249-254.

Zakharov, V. A., Shurygin, B. N., Kurushin, N. I., Meledina, S. V. & Nikitenko, B. L. 2002. A Mesozoic ocean in the Arctic: Paleontological evidence. Geologiya i Geofizika, 43: 155-181.

Zamparelli, V., Cirilli, S., Iannace, A. & Jadoul, F. (Coordinators). 1999. Paleotectonic and paleoceanographic controls on microbial-serpulids communities in the Norian-Rhaetian carbonates of Italy: a synthesis. Pp.7-84 in Colacicchi, R., Parisi, G. & Zamparelli, V. (eds) Bioevents and integrate stratigraphy of the Triassic and the Jurassic in Italy. Palaeopelagos Special Publication 3.

Zeeh, S. & Hagedorn, H. 2002. Aspekte der Taphonomie von Muschelkalk-Cephalopoden. Teil 2: Diagenese (Zementation und Kompaktion). Neues Jahrbuch für Geologie und Paläontologie Abhandlungen, 223 (3): 351-376.

Zhou, M. F., Malpas, J., Song, X. Y., Robinson, P. T., Sun, M., Kennedy, A. K., Lesher, C. M. & Keays, R. R. 2002. A temporal link between the Emeishan large igneous province (SW China) and the end-Guadalupian mass extinction. Earth and Planetary Science Letters, 196: 113-122.

Zi-Qiang Wang & An-Shu Chen. 2001. Traces of arborescent lycopods and dieback of the forest vegetation in relation to the terminal Permian mass extinction in North China. Review of Palaeobotany and Palynology, 117: 217-243.

Zonneveld, J-P. 2001. Middle Triassic biostromes from the Liard Formation, British Columbia, Canada: oldest examples from the Mesozoic of NW Pangea. Sedimentary Geology, 145: 317-341.

G. Warrington contributes with the approval of the Director, British Geological Survey (N.E.R.C.).

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British Triassic Palaeontology: Supplement 27

G. Warrington

Since the completion of the writer's previous supplement (No.26; ALBERTIANA, 26: 57) on British Triassic palaeontology, the following works relating to aspects of that subject have been published or have come to his notice:

Benton, M. J., Cook, E. & Turner, P. 2002. *Permian and Triassic Red Beds and the Penarth Group of Great Britain*. Geological Conservation Review Series, No. 24, Joint Nature Conservation Committee, Peterborough, xvi+337pp.

Benton, M. J., Walker, A. D., 2002. *Erpetosuchus*, a crocodile-like basal archosaur from the Late Triassic of Elgin, Scotland. Zoological Journal of the Linnean Society, 136: 25-47.

Carney, J. N., Ambrose, K., Brandon, A., Cornwell, J. D., Hobbs, P. R. N., Lewis, M. A., Merriman, R. J., Ritchie, M. A. & Royles, C. P. 2001. Geology of the country between Loughborough, Burton and Derby. *Sheet description of the British Geological Survey*, 1:50 000 Series Sheet 141 Loughborough (England and Wales), 92pp. Keyworth, Nottingham, British Geological Survey.

Carney, J. N., Ambrose, K. & Brandon, A. 2002. Geology of the Loughborough district – a brief explanation of the geological map. *Sheet Explanation of the British Geological Survey*. 1:50 000 Sheet 141 Loughborough (England and Wales). Keyworth, Nottingham: British Geological Survey, ii+34pp.

Chadwick, R. A., Jackson, D. I., Barnes, R. P., Kimbell, G. S., Johnson, H., Chiverrell, R. C., Thomas, G. S. P., Jones, N. S., Riley, N. J., Pickett, E. A., Young, B., Holliday, D. W., Ball, D. F., Molyneux, S. G., Long, D., Power, G. M. & Roberts, D. H. 2001. Geology of the Isle of Man and its offshore area. British Geological Survey Research Report, RR/01/06. Keyworth, Nottingham: British Geological Survey, viii+144pp.

Cifelli, R. L. 2001. Early mammalian radiations. Journal of Paleontology, 75 (6): 1214-1226.

Fraser, N. C., Padian, K., Walkden, G. M. & Davis, A. L. M. 2002. Basal dinosauriform remains from Britain and the diagnosis of the Dinosauria. Palaeontology, 45 (1): 79-95.

Hesselbo, S. P., Robinson, S. A., Surlyk, F. & Piasecki, S. 2002. Terrestrial and marine extinction at the Triassic-Jurassic boundary synchronized with major carbon-cycle perturbation: a link to initiation of massive volcanism? Geology, 30 (3): 251-254.

Hopkins, C. 2001. Lives and times of the Hopeman Sandstone. Proceedings of the Westmorland Geological Society, 29: 12-14.

Hungerbühler, A. 2001. The status and phylogenetic relationships of "*Zanclodon*" *arenaceus*: the earliest known phytosaur? Paläontologische Zeitschrift, 75 (1): 97-112.

Hungerbühler, A. 2002. The Late Triassic phytosaur *Mystriosuchus westphali*, with a revision of the genus. Palaeontology, 45: 377-418.

King, M. J. & Thompson, D. B. 2000. A history of the vertebrate footprint discoveries on Hilbre, Wirral, Merseyside, England, 1990-1994. The North West Geologist, 10: 10-38.

Milroy, P. G. & Wright, V. P. 2002. Fabrics, facies control and diagenesis of lacustrine ooids and associated grains from the Upper Triassic, southwest England. Geological Journal, 37: 35-53.

Rieppel, O. 2001. A new species of *Nothosaurus* (Reptilia, Sauropterygia) from the Upper Muschelkalk (Lower Ladinian) of southwestern Germany. Palaeontographica, Abt.A, 263 (1-6): 137-161.

Rieppel, O. 2001. Tooth implantation and replacement in Sauropterygia. Paläontologische Zeitschrift, 75 (2): 207-217.

Rieppel, O. 2001. The cranial anatomy of *Placochelys placodonta* Jaekel, 1902, and a review of the Cyamodontoidea (Reptilia, Placodonta). Fieldiana, Geology New Series, No.45, iv+104pp.

Rieppel, O. & Dall Vecchia, F. M. 2001. Marine reptiles from the Triassic of the Tre Venezie area, northeastern Italy. Fieldiana Geology New Series, 44: 1-25.

Rieppel, O. 2002. The dermal armor of the cyamodontoid placodonts (Reptilia, Sauropterygia): Morphology and systematic value. Fieldiana Geology New Series, 46: 1-41.

Spencer, P. S. & Storrs, G. W. 2002. A re-evaluation of small tetrapods from the Middle Triassic Otter Sandstone Formation of Devon, England. Palaeontology, 45: 447-467.

Rieppel, O., Sander, P. M. & Storrs, G. W. 2002. The skull of the pistosaur *Augustasaurus* from the Middle Triassic of northwestern Nevada. Journal of Vertebrate Paleontology, 22: 577-592.

Wignall, P. B. 2001. Sedimentology of the Triassic-Jurassic boundary beds in Pinhay Bay (Devon, SW England). Proceedings of the Geologists' Association 112 (4): 349-360.

Wood, G. D. & Benson, D. G. 2000. The North American occurrence of the algal coenobium *Plaesiodictyon*: paleogeographic, paleoecologic, and biostratigraphic importance in the Triassic. Palynology, 24: 9-20.

Zhe-Xi Luo, Kielan-Jaworowska, S. & Cifelli, R. L. 2002. In quest for a phylogeny of Mesozoic mammals. Acta Palaeontologica Polonica, 47 (1): 1-78.

New Books

The following new books will be of interest to workers on the Triassic:

Benton, M. J., Cook. E. & Turner, P. 2002. *Permian and Triassic Red Beds and the Penarth Group of Great Britian*. Geological Conservation Review Series, No.24. Joint Nature Conservation Committee, Peterborough, xvi+337pp. A4 format. ISBN 1-86-107-493-X

This is the 24th in a projected series of 42 volumes in the Geological Conservation Review series, and covers 45 sites in England, Scotland and Wales that were selected to represent and illustrate aspects of Triassic successions in Britain.

Price £62 (Sterling), plus handling charges. Available from NHBS Ltd, 2-3 Wills Road, Totnes, Devon TQ9 5XN, UK (www.nhbs.com) (e-mail: nhbs@nhbs.co.uk)

For further information contact the GCR Unit, Joint Nature Conservation Committee, Monkstone House, City Road, Peterborough PE1 1JY, UK (www.jncc.gov.uk) (Phone: +44 (0)1733 562626, FAX: +44 (0)1733 555948)

Weiss, R. H. (ed.). 2002. *Contributions to Geology and Palaeontology of Gondawa in honour of Helmut Wopfner*. Geological Institute, University of Cologne, x+530pp, including 182 black and white figures, 8 colour figures, 39 tables, 27 black and white plates and 2 colour plates. A4 format. ISBN 3-934027-07-5.

This volume comprises 32 papers contributed by 53 geoscientists from 14 countries. It covers the reconstruction of the assembly, evolution, and fragmentation of Gondwana, and the inter-regional stratigraphical correlation of sequences preserved in basins that are now dispersed throughout the southern hemisphere.

Price EUR 64, plus postage and any bank charges. Order forms available from Dr. R. H. Weiss, Universität zu Köln, Geologisches Institut, Zülpicher Strasse 49a, D-50674, Köln, Germany (FAX: +49 2173 960473; e-mail: aro.cologne@t-online.de).

This contribution is published with the approval of the Director, British Geological Survey (N.E.R.C.).

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Future Meetings

First announcement:

Triassic geochronology and cyclostratigraphy -a field symposium

St. Christina, Val Gardena, Dolomites, Italy, Sept. 11 - 15, 2003

The **Seceda Working Group** in conjunction with the **International Commission on Triassic Stratigraphy** (STS) and **IGCP 467** (Triassic Time and trans-Panthalassan Correlations) invite you to an open symposium on geochronology, stratigraphy and sedimentology of the Triassic. Special emphasis will be given to age dating, depositional rhythms and the question of orbital cycles of the Triassic.

The symposium is also the concluding meeting of the Seceda Working Group, an informal assembly of earth scientists from 15 institutions in five countries that studied the Seceda boring, a research bore hole in mid-Triassic basin sediments contributed to the Earth Science Community by the Province of Bolzano/Bozen, Italy.
Both the STS and IGCP 467 are promoting the quest for enhanced Triassic chronologies as a contribution towards time scale definition.

The program consists of:
September, 12+13: oral and poster presentations, discussions
September, 14: field trip to Seceda outcrops and bore hole
September, 15: field trip to Latemar carbonate platform.

The meeting will be organized by Wolfgang Schlager (Free University Amsterdam, Netherlands), Marco Stefani (University of Ferrara, Italy) and Peter Brack (ETH Zürich, Switzerland), in close collaboration with the Geological Survey of Bolzano/Bozen, Italy.

After the symposium, interested participants should be able to reach the 22nd IAS Meeting of sedimentology in Opatija (Croatia), Sept. 17-19, 2003.

Information on Hotels and (reduced) room rates will follow in the next few weeks.

We appreciate early response to the questionnaire because available space will be somewhat limited! **If you are interested** please press the reply button and compile / modify the questionnaire below and return this information by e-mail to:
peter.brack@erdw.ethz.ch
or fax the compiled printed version to: Peter Brack, Department of Earth Sciences, ETH-Zentrum, CH-8042 Zurich, Switzerland; Fax nr.: ++41 1 632 1088.

Preliminary application form see next page:

Triassic geochronology and cyclostratigraphy - a field symposium

St. Christina, Val Gardena, Dolomites, Italy, Sept. 11 - 15, 2003

Last name: ...

First name: ...

Affiliation: ...

Address: ...

City: ...

Country: ...

E-mail: ...

Phone: ...

Fax: ...

I am interested in giving Talk: YES / NO

I am interested in giving Poster: YES / NO

Title of talk or poster: ...

I am interested in the field-trip to Seceda (1 day: Sept. 14): YES / NO

I am interested in the field trip to Latemar (1-2 days: Sept. 15-16): YES / NO

The XVth International Congress on Carboniferous and Permian Stratigraphy (XV ICC-P)

The Netherlands

University Centre De Uithof

The XVth International Congress on Carboniferous and Permian Stratigraphy will be organised by the Netherlands Institute of Applied Geoscience TNO - National Geological Survey (TNO-NITG) and the Faculty of Earth Science of the Utrecht University, in Utrecht, the Netherlands. The congress will take place at the campus of the Utrecht University in the period between 10 - 16 August 2003. The venue is within 5 minutes walking distance from the buildings of the Faculty of Earth Sciences of Utrecht University and TNO-NITG.

Invitation

Geoscientists all over the world with an interest in Carboniferous and Permian geology are invited to meet in Utrecht, the Netherlands from August 10-16, 2003 in order to present and discuss their research. The technical sessions, workshops and fieldtrips of the XVth International Congress on Carboniferous and Permian Stratigraphy include all aspects of Carboniferous and Permian geology.

The deposition and burial of Carboniferous and Permian sediments and organisms provided today's mineral resources. The environment during Carboniferous and Permian was continously changing as continental fragments amalgamated into Pangea. Environmental and climatic changes had their effects on organisms and plants.

A better understanding of the evolution of the earth during the Carboniferous and Permian will not only help to find more mineral resources for future societal needs, but also provide insight into important environmental questions of today's world.

In order to visualise the geology of the Southern North Sea Basin, various field excursions will be organised to several classical exposures in Germany, Belgium and the U.K.

We invite you to come to Utrecht to meet and discuss ideas with university, industry and consulting geoscientists working in different fields of research.

We hope you will be able to attend.

55th Meeting of the International Committee for Coal and Organic Petrology

In the same period and at the same location the International Committee of Coal and Organic Petrology (ICCP) will hold its annual meeting.

For more information on this meeting: http://www.nitg.tno.nl/eng/iccp.shtml

Call for abstracts

Abstracts are invited for oral and poster presentation at the congress. Please submit your abstract for oral presentation or poster before March 1st, 2003.

Instructions

Please **submit abstracts electronically** according to the guidelines below:

- Abstracts should be submitted in English by email or on disk (if email is not possible) in one of the following formats: Microsoft Word 97 (or lower), WordPerfect, as a text attachment or in the body of the mail message.
- Each abstract should include a completed Abstract Submission Form. Fax copies are not acceptable.
- Please indicate if the abstract is for oral or poster presentation.
- Please indicate in which section you would like to give the presentation
- Abstracts should not exceed 3 pages page in length (including tables and figures). Photographs cannot be accepted. Use single line spacing throughout. Make the title as concise as possible.
- Set last name off with a comma followed by the first name or initial, then second initial; follow this, if appropriate, with another comma. If multiple authors from the same institution, list all authors followed by address and the e-mail address of Senior Author. Where multiple authors from differing addresses, insert address following each author. Do not indent second line of authors. Make sure all authors are capitalised. Indicate by (*) presenting author(s).
- Include four keywords.
- All abstracts will be refereed and a criterion of rejection will be lack of originality. A condition of submission is that, if accepted, the paper will be presented at the XVth International Congress on Carboniferous and Permian Stratigraphy by one of the authors.

For more information contact:

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Call for papers

General

The proceedings of the XV ICC-P will be published as a special issue of the Netherlands Journal of Geosciences. A strict time frame is kept to ensure publication of the proceedings within 18 months after the Congress.

Reviews

All papers will be reviewed by two reviewers and a third if there is a conflict.

Length

The contributions will be limited to 10 printed pages per paper, therefore the manuscript should be concisely written and conform to the presentation. Review copies of manuscripts to be submitted double spaced including, title, authors, addresses and references.

Submission Date

August 12th, 2003 preferred (at the beginning of the congress).
Manuscripts will not be accepted after October 31st, 2003.

Instructions to authors

Manuscripts should generally be organized in the following order

1. title;
2. name(s) of the author(s);
3. the author(s) affiliation(s) and e-mail address(es); in the case of more than one author, please, indicate to whom the correspondence should be addressed;
4. abstract;
5. keywords (in alphabetical order);
6. introduction;
7. methods and materials;
8. results and analyses;
9. discussion and conclusions;
10. acknowledgements;
11. references (according to the format detailed below);
12. appendices (if any; their use should be restricted to a minimum);
13. tables;

14. figure and table captions;
15. figures.

The title should be as concise as possible, but leave no doubt as to the contents. Area and age of studied material should if appropriate be mentioned. Abbreviations in the title should be avoided. Names etc. should contain all relevant diacritical symbols required.

The **abstract** should not be descriptive but rather be a concise summary stating the methods used, the main results and the conclusions. It should not exceed 500 words.

Keywords should preferable amount to 3-6. They should preferably be taken from the most recent American Geological Institute GeoRef Thesaurus. A single keyword should not consist of more than three words, but preferably of one.

The running text should be subdivided into chapters and if required sections and subsections. The headings are, respectively, in bold (with a white line underneath), in italics (with a white line underneath), and in italics (without a white line underneath). Chapters, sections and subsections should not be numbered.

All **references** cited in the text are to be listed in the reference list (and vice versa). The manuscript should be carefully checked to ensure that the spellings of authors' names and publication years are exactly the same in the text as in the reference list. Do not type anything in bold or italics. Do not abbreviate journal titles. Refer in the text to the author's name (without initials) and year of publication: 'as suggested earlier (Smith, 1999)' or 'as suggested by Smith (1999) and Johnson & Petersen (2000)'. If reference is made to publications written by more than two authors, the name of the first author should be used, followed by 'et al.'. This indication should, however, never be used in the list of references: all names of authors and all co-authors must be given in full in the list.
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1. publications by the single author, arranged according to publication year;
2. publications of the same author with one co-author, arranged alphabetically per co-author and, if necessary, per co-author according to publication year;
3. publications of the author with more than one co-author, arranged chronologically (per year, if necessary, alphabetically).

The following system should be used for arranging references:

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   Example:
   Louwije, S., De Coninck, J. & Verniers, J., 1999. Dinoflagellate cyst stratigraphy and depositional history of Miocene and Early Pliocene Formations in northern Belgium (southern North Sea Basin). Geologie en Mijnbouw 78: 31-46.
2. Books: names and initials of all authors, year. Title of the book. Publisher (location of publisher): page numbers.
   Example:
   Brodzikowski, K. & Van Loon, A.J., 1991. Glacigenic sediments. Elsevier Science Publishers (Amsterdam): 674 pp.
3. Edited volume papers: names and initials of all authors, year. Title of paper. In: Names and initials of the volume editors: title of the edited volume. Publisher (location of publisher): first and last page numbers of the paper.
   Example:
   De Jong, J.D. & Maarleveld, G.C., 1983. The glacial history of the Netherlands. In: Ehlers, J. (ed.): Glacial deposits in North-West Europe. Balkema (Rotterdam): 353-356.

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Each illustration should be identified on the reverse side on the lower front side by its number and the name of the principle author. Indicate the top of the illustration in cases where doubt may arise.

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Miscellanous

FRIEDRICH VON ALBERTI-STIFTUNG - HOHENLOHER MUSCHELKALKWERKE

Friedrich von Alberti-Preis 2002

Verleihung des Friedrich von Alberti-Preises 2002 an Dr. Léa Grauvogel-Stamm und Prof. Dr. Jean-Claude Gall, Université Louis Pasteur de Strasbourg, Frankreich

Im Jahr 2002 wird der Friedrich von Alberti-Preis wieder geteilt verliehen. Vorstand und Kuratorium der Alberti-Stiftung folgten damit der Empfehlung der Paläontologischen Gesellschaft und bestimmten als Preisträger die Paläontologen Dr. Léa Grauvogel-Stamm und Prof. Dr. Jean-Claude Gall von der Université Louis Pasteur de Strasbourg in Frankreich.

Beide Laureaten haben ihr wissenschaftliches Werk zu einem guten Teil der Erforschung des Voltziensandsteins in den Nordvogesen gewidmet. Dieser rötlichgraue Sandstein wird seit Jahrhunderten in vielen Steinbrüchen als Baustein gewonnen. Seit 1936 sammelte Louis Grauvogel, der Vater von Léa Grauvogel-Stamm, in dünnen Tonsteinlinsen, die zwischen den Werksteinbänken lagern, Tausende von Fossilien. Später hat Jean-Claude Gall, der 1971 mit einer Monographie über Fauna und Entstehung des „Grès à *Voltzia*" promovierte und habilitierte, die Sammlung fortgeführt. Die fossilreichen Tonsteine öffnen ein Fenster in die Zeit der beginnenden Mitteltrias, vor etwas mehr als 240 Millionen Jahren. Während sich weiter östlich schon das Muschelkalkmeer ausdehnte, lagerte sich im Gebiet des heutigen Elsass in einer von Flüssen durchzogenen Küstenebene Sand als Schuttfächer des Vogesengebirges ab. Der feinkörnige Tonschlamm in ausgetrockneten Wasserläufen hat in einmaliger Detailtreue feinste Strukturen von Insektenflügeln, Skorpione, Spinnen, verschiedenartige Krebse, Fische, Amphibien, ja sogar Eigelege von Insekten und hauchdünne Süßwassermedusen überliefert. Léa Grauvogel-Stamm wandte sich in ihrer Doktorarbeit der Pflanzenwelt des Voltziensandsteins zu und bearbeitete die Makro- und Mikrofloren, darunter die Zweige der namengebenden *Voltzia*, eines frühen Nadelbaums, Schachtelhalme und Farne und die zugehörigen Sporen. Seither haben die beiden Preisträger den Grès à *Voltzia* der Vogesen zu einer der besterforschten und bedeutendsten Fossillagerstätten der Triaszeit gemacht, die wie nirgendwo sonst auf der Welt faszinierende Einblicke in die amphibische Welt kleiner periodischer Gewässer der Triaszeit öffnet.

Mit erstmals auf diese Floren angewandten Methoden, der Mazerationstechnik, der Kutikularanalyse und der in-situ-Untersuchung von Fruktifikationen nach Palynomorphen, kam Dr. Léa Grauvogel-Stamm zu grundlegenden Ergebnissen über das Ökosystem des Voltziensandsteins. Ihre Arbeit über das sukkulente Bärlappgewächs *Pleuromeia*, das nach dem weltweiten Aussterbeereignis an der Perm/Trias-Wende als erste Pionierpflanze wieder festländische Biotope besiedelte, weitete sie auf die ganze Welt aus. Außerdem arbeitete sie über die krautige Konifere *Aethophyllum*, neuerdings verstärkt über die Koevolution von Tieren und Pflanzen, wie sie sich an Fraß- und Siedlungsspuren auf Pflanzen zeigt. Frau Grauvogel-Stamm hat ihre Forschungen stets in renommierten internationalen Zeitschriften veröffentlicht und dabei mit Wissenschaftlern aus vielen Ländern kooperiert. Neben ihrer Forschungstätigkeit hat sie für die interessierte Öffentlichjkeit populärwissenschaftlich geschrieben und Besucher aus aller Welt durch das von ihr betreute Museum Grauvogel in Ringendorf geführt.

Die Alberti-Stiftung verleiht den Alberti-Preis des Jahres 2002 an Frau Dr. Léa Grauvogel-Stamm und würdigt damit ihre „Verdienste auf dem Gebiet der Paläobotanik, besonders um die Erforschung der reichen triaszeitlichen Floren im Grès à *Voltzia* und um die Rekonstruktion des Ökosystems im Oberen Buntsandstein der Vogesen, um Mikrofloren und Floren der europäischen Trias und um die Erhaltung und wissenschaftliche Auswertung der Sammlung ihres Vaters Louis Grauvogel".

Ausgehend vom Grès à *Voltzia* untersuchte Jean-Claude Gall auch vergleichbare fossile Ökosysteme der erdgeschichtlichen Vergangenheit in Marokko und den USA, wandte sich Fragen der Diagenese und Geochemie zu, besonders den mikrobiellen Biomatten, und legte seine Forschungen in über 130 Publikationen nieder, darunter sein preisgekröntes Lehrbuch „Sedimentationsräume und Lebensbereiche der Erdgeschichte. Eine Einführung in die Paläoökologie", das vom Französischen ins Deutsche, Englische und Chinesische übertragen wurde. Über sein hochschulpolitisches Engagement um Studiengänge und Administration hinaus hat er mehrere wissenschaftliche Kongresse organisiert. Ganz besondere Verdienste erwarb er sich mit der Gründung der European Palaeontological Association (EPA), einer wissenschaftlichen und wissenschaftspolitischen Nicht-Regierungsorgansation, in der paläontologische Interessen auf höchster Ebene im Europarat vertreten werden. Herr Gall hat die EPA als ihr Gründungspräsident von 1991 bis 1995 an seinem Institut in Straßburg geleitet. Angesichts seiner weitreichenden wissenschaftlichen, populärwissenschaftlichen und wissenschaftspolitischen Erfolge und seines Engagements für die Paläontologie hat er vielfache Ehrungen aus Frankreich und aus anderen Ländern erfahren. Die Paläontologische Gesellschaft ernannte ihn im Jahr 2000 zum Korrespondierenden Mitglied.

Die Alberti-Stiftung verleiht den Alberti-Preis des Jahres 2002 an Jean-Claude Gall für seine „Verdienste um die Erforschung der reichen und exzellent erhaltenen triaszeitlichen Faunen im Grès à Voltzia und um die Rekonstruktion von Genese und Lebewelt des Oberen Buntsandsteins in den Vogesen, um die Paläoökologie vorzeitlicher Biotope und um die Gründung der European Palaeontological Association”.

Mit den beiden Preisträgern des Jahres 2002 geht der Alberti-Preis erstmals über die Landesgrenzen hinaus, freilich in ein Land und an ein Institut, mit dem wir nicht nur durch die Triasgesteine rechts und links des Rheins und durch zwei Jahrhunderte ihrer Erforschung verbunden sind. Dafür stehen Namen wie Elie de Beaumont und Friedrich von Alberti, A. Mougeot und W. P. Schimper, L. Voltz und E. W. Benecke. Der Namenspatron der Stiftung, Friedrich von Alberti, hat seine „Trias-Formation” 1834 mit dem Blick auf beide Seiten des Rheins begründet, und hier wie dort und überall auf der Welt gilt heute sein Begriff, mit dem er die geologischen Formationen des Buntsandsteins, des Muschelkalks und des Keupers zusammengefasst hat. Freilich versteht man heute darunter das erdgeschichtliche System, mit dem vor 250 Millionen Jahren das Erdmittelalter begonnen hat.

Die Laudationes bei der festlichen Preisverleihung am 29. November im württembergischen Ingelfingen (Hohenlohekreis) halten Klaus-Peter Kelber, Paläobotaniker am Institut für Mineralogie der Universität Würzburg, und Prof. Dr. Fritz Steininger, Direktor des Forschungsinstituts Senckenberg Frankfurt am Main. Im Festvortrag führt Prof. Dr. Jean-Claude Gall in die Welt des Voltziensandsteins ein und spricht über:

„Der Buntsandstein der Nordvogesen. Ein Blick in die Lebewelt vor 240 Millionen Jahren”.

Das Muschelkalkmuseum zeigt in den nächsten Monaten in drei Vitrinen Funde aus Sammlung Grauvogel und Gall, die von den Laureaten für die Ausstellung

„Der Sandstein lebt. Funde aus dem Voltziensandstein der Nordvogesen aus Sammlung Grauvogel und Gall”

zur Verfügung gestellt wurden.

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Special attention should be paid to grammar and syntax - linguistic corrections will be minimal. In case of doubt, send your manuscript to a colleague for proof reading. References should be in the format used in the ‘New Triassic Literature’ section in issue 25 of Albertiana. Please write all Journal titles in full length. The use of names of biostratigraphic units should be in accordance with the International Stratigraphic Guide:

The formal name of a biostratigraphic unit should be formed from the names of one, or preferably no more than two, appropriate fossils combined with the appropriate term for the kind of unit in question.”

The writing and printing of fossil names for stratigraphic units should be guided by the rules laid down in the International Code of Zoological Nomenclature and in the International Code of Botanical Nomenclature. The initial letter of generic names should be capitalized; the initial letter of the specific epithets should be in lowercase; taxonomic names of genera and species should be in italics. The initial letter of the unit-term (Biozone, Zone, Assemblage Zone) should be capitalized; for example, Exus albus Assemblage Zone.”

The name of the fossil or fossils chosen to designate a biozone should include the genus name plus the specific epithet and also the subspecies name, if there is one. Thus Exus albus Assemblage Zone is correct. After the first mention, the genus name may be abbreviated to its initial letter if there is no danger of confusion with some other genus beginning with the same letter; for example, Exus albus may be shortened to E. albus. On the other hand, the use of the specific epithet alone, in lowercase or capitalized, in italics or not (albus Assemblage zone, Albus Assemblage zone, albus Assemblage zone, or Albus Assemblage zone), is inadvisable because it can lead to confusion in the case of frequently used species names. However, once the complete name has been cited, and if the use of the specific epithet alone does not cause ambiguous communication, it may be used, in italics and lowercase, in the designation of a biozone; for example, uniformis Zone.”

From: Salvador, A. (ed.), 1994. International Stratigraphic Guide. Second Edition. International Commission on Stratigraphic Classification of IUGS International Commission on Stratigraphy. IUGS/GSA, Boulder, Co, p. 66.

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