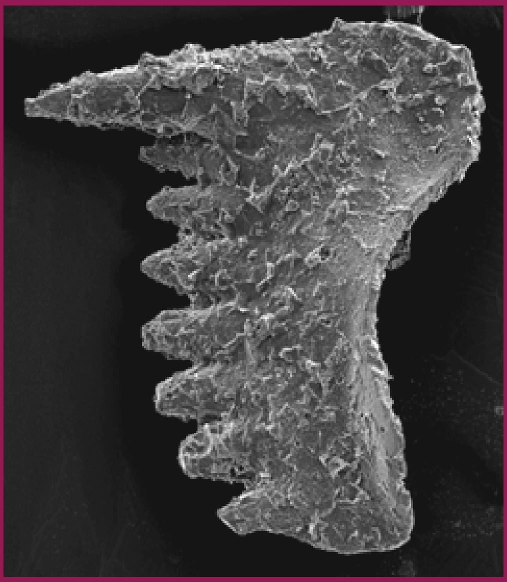
ALBERTIANA



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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.

Cover: Hindeodus parvus (Kozur and Pjatakova 1976). Specimen number GSC 101761, from the basal Triassic Otoceras woodwardi beds of Lalung, Spiti.

Executive Notes

From the Chair

On the occasion of this, my first report to the STS membership, I would like to take the opportunity to thank our past-Chairman, Maurizio Gaetani, our retiring vice-chair, Hans Rieber, and the past-editor of Albertiana, Hans Kerp, for their service to the Subcommision. As the new Chair and Editor take up their positions, we should see some changes in both the composition of the STS, and the dissemination of information via the web. As far as the membership is concerned, as you should all be aware, I have spent the winter soliciting members for their current research interests and seeking renewal of the voting slate and a broader geographic and specialist representation amongst the corresponding membership. I hope this will lead to both greater participation and opportunities for voting member turnaround. This exercise is largely complete and I plan to publish the new STS membership and their research interests in the next Albertiana. At this stage, I would like to thank those titular members who volunteered to step down and allow this first phase of renewal to proceed smoothly.

The business of boundary definition is moving along. The basal Triassic GSSP drawn at the appearance of the conodont Hindeodus parvus at Meishan in China is now ratified by the IUGS. Yin Hongfu led the working group that finally agreed on this definition and he is to be congratulated for providing us with our first formal stadial definition. Yuri Zacharov is active in leading deliberations on the Induan-Olenekian boundary, which now has three prospects, the Abrek Bay and the Tri Kamnya Cape - Orel sections in Russia, and a soon to be described section in South China; Himalayan sections may also provide a further candidate. The working groups on boundaries of the Middle Triassic, which Maurizio Gaetani continues to lead, are more advanced. The Olenekian-Anisian and Anisian-Ladinian boundaries, with candidates in Romania, Italy and Hungary, have been the focus of intense study in recent years and we must soon come to a final decision on them. The Ladinian-Carnian boundary has a formal candidate in Italy, but new data is anticipated from the Himalaya and North America. I have recently begun work on gathering data for Carnian-Norian boundary candidates, with prospects identified in both Europe and North America. The Norian-Rhaetian boundary has as yet no formal working group. I urge all members to contribute data and opinion about all of these boundaries, ideally through the medium of Albertiana, so that we may soon accomplish some standardization of our scientific language.

Mike Orchard

From the Secretary

Know Your Neighbours

STS members working around the upper and lower boundaries of the Triassic should note the following changes in the IUGS subcommissions for the Jurassic and the Permian.

Triassic-Jurassic Boundary Working Group

The STS Secretary was also the Secretary of the Triassic-Jurassic Boundary Working Group (TJBWG) of the IUGS International Subcommission on Jurassic Stratigraphy (ISJS), the body charged with the selection of a candidate GSSP for the base of the Hettangian Stage and, inter alia, the top of the Triassic System. He was recently asked to become Convenor of the TJBWG and a Voting Member of the ISJS; the new Secretary of the TJBWG is:

Dr G. Bloos
Staatliches Museum für Naturkunde, Rosenstein 1, D-70191 Stuttgart, Germany, Phone +49 (0)711 8936 143, Fax: +49 (0)711 8936 100, E-mail: bloos@gmx.de

The ISJS publishes a newsletter; for further information contact the Secretary of the ISJS:

Professor P. L. Smith
Department of Earth & Ocean Sciences, University of British Columbia, 6339 Stores Road, Vancouver, British Columbia V6T 1Z4, Canada, Phone: 1 604 822 6456, Fax: 1 604 822 6088

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Subcommission on Permian Stratigraphy

The IUGS Subcommission on Permian Stratigraphy (SPS) now has a new Secretary:

Dr C. Henderson Department of Geology & Geophysics, University of Calgary, Calgary, Alberta T2N1N4, Canada, E-mail: henderson@geo.calgary.ca

The SPS publishes a newsletter (Permophiles); for further information contact the Secretary of the SPS.

G. Warrington

From the Editor

This is for me the first time serving you, STS members, as the editor of ALBERTIANA and I would like to take the opportunity to thank you and particularly the former editor, Hans Kerp, for your confidence passing this task into my hands. It is a great pleasure for me to present you the new issue of ALBERTIANA in a new layout. Please note that I have written NEW guidlines for the submission of manuscripts at the end of this volume. These are the times of electronic publishing and the internet. It opens not only the possibility of faster distribution of information but also gives way to for more sophisticated data presentations with coloured figures / photographic pictures and computer animations. Thus, Albertiana has not only received a new outfit but is from now on also available as PDF file on our www-server (www.bio.uu.nl/~palaeo). Manuscripts should be submitted as email attachments. Alternatively, you may also transfer your contributions that exceed the email attachment size limit to our ftp server. Our address is ftp://131.211.28.160, userID “alb” and the password “alb”. Finally, electronic distribution may help us also to reduce the high production and mailing costs. Therefore I would like to ask you to let me know whether or not you prefer to receive ALBERTIANA in future only electronically.

Gückauf!

Wolfram M. Kürschner

Reports

Tetrapod-Based Correlation of the Nonmarine Upper Triassic of Southern Africa

S. G. Lucas & P. J. Hancox

Tetrapod fossils suggest the Molteno Formation in southern Africa is no older than late Carnian, whereas the overlying lower Elliot Formation is most likely Norian in age. However, these are not strong correlations, and additional data are needed to confirm correlation of the southern African Upper Triassic strata.

Introduction

The classic nonmarine Triassic section in the Karoo basin of southern Africa yields tetrapod fossils of the *Lystrosaurus* and *Cynognathus* assemblage zones of the Lower-Middle Triassic. These assemblage zones are the standard by which other tetrapod-bearing units of the Lower Triassic are correlated (Ochev & Shishkin, 1989; Hancox & Rubidge, 1997; Lucas, 1998). More problematic for correlation are the younger Triassic nonmarine strata in southern Africa assigned to the Molteno and Elliot formations (of the now defunct "Stormberg Group"). Here, we review tetrapod-based age assignments of the Molteno and Elliot formations.

Molteno Formation

The lowest formation of the Stormberg Group is the Molteno Formation, which rests unconformably on the Permo-Triassic Beaufort Group (Fig. 1). The youngest strata of the Beaufort Group beneath this unconformity belong to the Burgersdorp Formation, which yields a tetrapod assemblage near its top that includes the Perovkan (early Anisian) index taxon *Shansiodon* (Hancox & Rubidge, 1997; Hancox, 1998, 2000). The Molteno Formation in the Karoo basin attains a maximum thickness of around 600-650 m in the Cape Province, and gradually thins northward to less than 30 m across Lesotho into Natal and the Free State; it is mostly fluvial/alluvial plain deposits with minor coal beds (Turner, 1984; Hancox, 1998).

Whereas fossil plants, insects and conchostracans are locally abundant in the Molteno Formation (Cairncross et al., 1995), vertebrate body fossils are scarce, and represented only by specimens of semionotid fishes (Jubb, 1973). Based on the composition of palynomorph and megafossil plant assemblages ("*Dicroidium* flora"), Anderson and Anderson (1993; Anderson et al., 1998) regarded the Molteno to be of Carnian (undivided) age. Hancox (2000) also concluded that at least the lower half of the Molteno Formation is Carnian.

The only tetrapod fossils from the Molteno Formation are footprints. Raath et al. (1990) and Raath (1996) documented small theropod dinosaur tracks (ichnogenus *Grallator*) from the upper part of the formation. The oldest records of dinosaur fossils are Otischalkian (late Carnian: Lucas, 1998), so the Molteno dinosaur tracks suggest late Carnian as a maximum age for the upper part of the formation. Of course, a younger, Norian age cannot be excluded based on the footprint evidence.

Elliot Formation

The Molteno Formation is disconformably overlain by mudrock-dominated facies of the lower Elliot Formation (Fig. 1). Earlier claims of a lateral equivalence of the upper Molteno and Lower Elliot are not supported by field evidence (Hancox, 1998). Indeed, the change in fossil representation and the major facies change at the top of the Molteno Formation argue against its lateral equivalence to the Lower Elliot.

The Elliot Formation approaches a maximum thickness of around 500 m in the southern area of the Karoo basin, and thins to less than 200 m north of Lesotho, following the generalized isopach trend of the underlying Molteno Formation (Visser, 1984; Hancox, 1998, 2000). The lower Elliot contains a tetrapod fossil assemblage (Fig. 1) dominated by prosauropod dinosaurs (common *Euskelosaurus*, rare *Melorosaurus* and *Blikinasaurus*). The assemblage also includes a dinosaur incertae sedis (*Aliwalia*), rare temnospondyls (a large chigutisaurid), a traversodontid (*Scalenodontoides*) and the possible rauisuchian *Basutodon* (Haughton, 1924; Heerden, 1979; Hopson, 1984; Kitching & Raath, 1984; Crompton & Ellenberger, 1957; Galton, 1985a, b; Galton & Heerden, 1985, 1998; Gow & Hancox, 1993; Heerden & Galton, 1997). The lower Elliot also contains a tetrapod ichnofauna (Ellenberger, 1970) that, according to Olsen & Galton's (1984) revision, includes *Brachychirotherium* ("thecodont"), *Tetrasauropus* (prosauropod dinosaur), *Grallator* (theropod dinosaur) and a form of uncertain affinity, *Pentasauropus*. Note that although *Pentasauropus* is only toe imprints, and Ellenberger originally condsidered it prosauroropd, Olsen & Galton (1984) identified it as a dicynodont footprint, a conclusion generally followed by later workers (e.g., Anderson et al., 1998).

The lower Elliot assemblage ("*Euskelosaurus* range

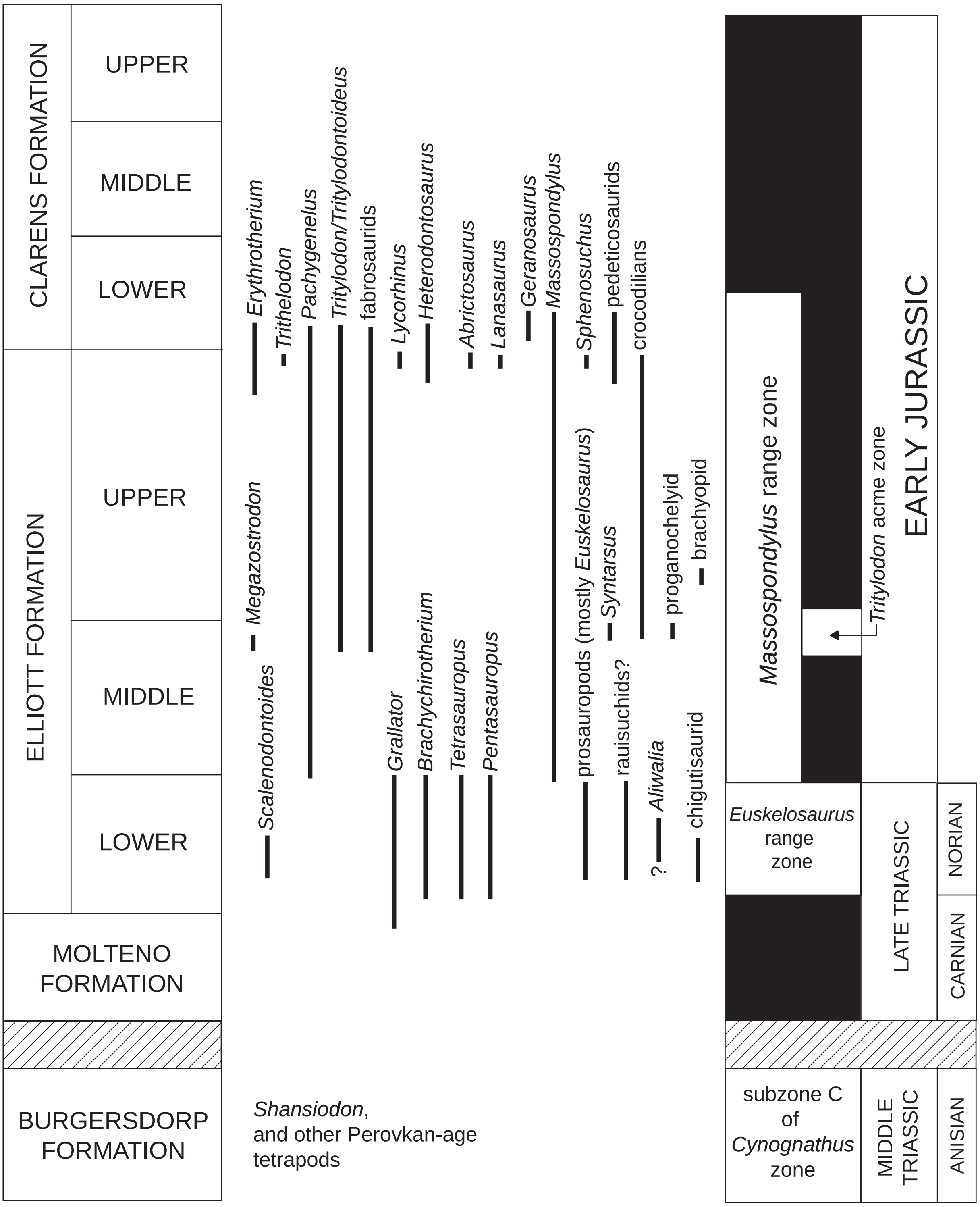

Figure 1: Stratigraphic distribution of tetrapod taxa in the Stormberg Group of southern Africa (based on Kitching & Raath, 1984 and other sources cited in the text) and age assignments based on these taxa.

zone" of Kitching & Raath, 1984) has either been assigned a Carnian or a Norian age (see review by Hancox, 1998, 2000). Cooper (1982) assigned it to the late Norian, based largely on correlating *Euskelosaurus* and the German late Norian prosauropod *Plateosaurus*. Olsen & Galton (1984) reviewed previous ideas about the correlation of the Stormberg Group and concluded that the lower Elliot Formation is of Carnian-Norian age, and that the middle-upper Elliot Formation is Early Jurassic.

However, Gauffre (1993) assigned the lower Elliot a Carnian age simply because it contains a traversodontid. Thus, Gauffre (1993:148) incorrectly believed "that traversodontids are unknown above beds dated as Carnian." Gauffre (1993:148) further argued for "a lower Carnian age for the Ischigualasto, Santa Maria and Lower Elliot Formation with their traversodonts-rauisuchians-rhynchosaurs assemblage." There are clearly three problems here: (1) traversodontids are known through the Rhaetian (Hahn et al., 1988; Lucas & Hunt, 1994; Godefroit & Battail, 1997); (2) the Ischigualasto and upper Santa Maria assemblages are late Carnian (Lucas, 1998); and (3) no taxa are shared between Ischigualasto-Santa Maria and the lower Elliot, so their correlation lacks any basis.

Warren & Damiani (1999) assigned a Carnian age to the lower Elliot Formation, following some of the earlier workers. Galton & Heerden (1998) simply accepted the correlation of Gauffre (1993) that the lower Elliot Formation is Carnian, possibly early Carnian. They concluded, therefore, that it includes the oldest record of articulated prosauropods and the first evidence of the diversification of the group.

The *Euskelosaurus* range zone of the lower Elliot must be Triassic as it includes fossils of rauisuchians and traversodontids, taxa not known from post-Triassic beds. The fauna is dominated by prosauropod dinosaurs and thus resembles two other Late Triassic prosauropod-dominated faunas of Norian age—that of the German Knollenmergel and that of the Los Colorados Formation in Argentina. Furthermore, the tetrapod footprint ichnofauna of the lower Elliot Formation is very similar to the footprint ichnofauna of the Rock Point sequence of the Chinle Group, strata of Norian-Rhaetian? age (Lockley & Hunt, 1995).

Furthermore, note that if the Lower Elliot is assigned a Carnian age, then there must be a substantial unconformity representing a hiatus of at least 20 million years between it and overlying Lower Jurassic strata of the Middle Elliot. However, field evidence does not indicate such an unconformity.

We thus assign the lower Elliot Formation a Norian age because: (1) the only other prosauropod-dominate Late Triassic faunas are Norian; (2) *Euskelosaurus* may be an ecological vicar of *Plateosaurus*, as Cooper argued; (3) its footprint ichnofauna is closest to Norian ichnofaunas; and (4) Lower Jurassic strata directly overlie the lower Elliot. However, none of these arguments is incontrovertible.

The middle and upper Elliot contains a more diverse tetrapod assemblage that Kitching & Raath (1984) defined as the "*Massospondylus* range zone." The combined assemblage is dominated by the tritylodontid *Tritlyodon*, which occurs with rare brachyopid amphibian remains, a proganochelyid turtle (Gaffney & Kitching, 1994), sphenosuchian archosaurs

(*Sphenosuchus* and "pedeticosaurids"), a variety of dinosaurs (the prosauropod *Massospondylus*, a coelurosaur referred to cf. *Syntarsus*, and several ornithischians), other cynodonts including *Pachygenelus* and *Tritheledon*, and the mammals *Megazostrodon* and *Erythrotherium* (Kitching & Raath, 1984). The *Tritylodon* acme zone is interpreted as a reworked paleosol (Smith & Kitching, 1996, 1997), and is widely, and we believe correctly, assigned an Early Jurassic age. The age of the *Massospondylus* range zone between the *Euskelosaurus* range zone and the *Tritylodon* acme zone is unclear and we conservatively assign it an Early Jurassic age (Fig. 1).

The overlying Clarens Formation contains a limited fauna that includes taxa of mostly ornithischian dinosaurs and cynodonts common to the underlying upper Elliot assemblage and also is of Early Jurassic age. Olsen & Galton (1984) described the upper Stormberg footprint fauna to include *Batrachopus* (crocodylomorph), theropod tracks referable to *Grallator* (*Anchisauripus*) and *Grallator* (*Eubrontes*), *Anomoepus* sp. (Ornithschia), *Ameghinichnus* sp. (tritylodontid?), and the enigmatic *Episcopopus ventrosus* Ellenberger.

References

Anderson, J. M. & Anderson, H. M. 1993. Terrestrial flora and fauna of the Gondwanan Triassic. Part 1., occurrences. New Mexico Museum of Natural History Science Bulletin, 3:3-12.

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

Cairncross, B., Anderson, J. M. & Anderson, H. M. 1995. Palaeoecology of the Triassic Molteno Formation, Karoo basin, South Africa—sedimentological and paleontological evidence. S. Afr. J. Geol., 98: 452-478.

Cooper, M. R. 1982. A mid-Permian to earliest Jurassic tetrapod biostratigraphy and its significance. Arnoldia Zimbabwe, 9:77-104.

Crompton, A. W. & Ellenberger, F. 1957. On a new cynodont from the Molteno beds and the origin of the tritylodontids. Ann. South Afr. Mus., 44:1-14.

Ellenberger, P. 1970. Les niveaux paléontologiques de première apparition des mammifères primordiaux en Afrique du Sud et leur ichnologie: Establissement de zones stratigraphiques detaillées dans le Stormberg du Lesotho, (Afrique du Sud) (Triassique supérieur à Jurassique; in Haughton, S. H. (ed.), International Union of Geological Sciences, Second Symposium on Gondwana Stratigraphy and Paleontology. Pretoria,

Council for Scientific and Industrial Research, p. 347-370.
Gaffney, E. S. & Kitching, J. W. 1994. The most ancient African turtle. Nature, 369: 55-58.
Galton, P. M. 1985a. Notes on the Melanorosauridae, a family of large prosauropod dinosaurs (Saurischia: Sauropodomorpha). Geobios, 18: 671-676.
Galton, P. M. 1985b. The poposaurid thecodontian *Teratosaurus suevicus* v. Meyer, plus referred specimens mostly based on prosauropod dinosaurs, from the Middle Stubensandstein (Upper Triassic) of Nordwurttemberg. Stuttgart. Beitr. Naturk. B, 116: 1-29.
Galton, P. M. & Heerden, J. van. 1985. Partial hindlimb of *Blikanasaurus cromptoni* n. gen. and n. sp., representing a new family of prosauropod dinosaurs from the Upper Triassic of South Africa. Geobios, 18: 509-516.
Galton, P. M. & Heerden, J. van. 1998. Anatomy of the prosauropod dinosaur *Blikanosaurus cromptoni* (Upper Triassic, South Africa), with notes on the other tetrapods from the Lower Elliot Formation. Paläont. Zeitschr., 72: 163-177.
Gauffre, F. -X. 1993. Biochronostratigraphy of the lower Elliot Formation (southern Africa) and preliminary results on the Maphutseng dinosaur (Saurischia: Prosauropoda) from the same formation of Lesotho. New Mex. Mus. Nat. Hist. Sci. Bull., 3:147-149.
Godefroit, P. & Battail, B. 1997. Late Triassic cynodonts from Saint-Nicolas-de-Port (north-eastern France). Geodiversitas, 19:567-631.
Gow, C. E. & Hancox, P. J. 1993. First complete skull of the Late Triassic Scalenodontoides (Reptilia, Cynodontia) from southern Africa. New Mex. Mus. Nat. Hist. Sci. Bull., 3: 161-168.
Hahn, G., Lepage, J. C. & Wouters, G. 1988. Traversodonten-Zahne (Cynodontia) aus der Ober-Trias von Gaume (Sud-Belgien). Bull. Inst. Roy. Sci. Nat. Belg. Sci. Terre, 58:177-186.
Hancox, P. J. 1998. A stratigraphic, sedimentological and paleoenvironmental synthesis of the Beaufort-Molteno contact in the Karoo basin. Unpublished Ph.D. dissertation, University of the Witwatersrand, Johannesburg, 520 p.
Hancox, P. J. 2000. The continental Triassic of South Africa. Zbl. Geol. Paläont. Teil I, 11-12:1285-1324.
Hancox, P. J. & Rubidge, B. A. 1997. The role of fossils in interpreting the development of the Karoo basin. Palaeont. Afr., 33: 41-54.
Haughton, S. H. 1924. The fauna and stratigraphy of the Stormberg Series. Ann. South Afr. Mus., 12:323-497.
Heerden, J. van 1979. The morphology and taxonomy of *Euskelosaurus* (Reptilia: Saurischia; Late Triassic) from South Africa. Navors. Nas. Mus., 4: 21-84.
Heerden, J. van & Galton, P. M. 1997. The affinities of *Melanorosaurus*, a Late Triassic prosauropod dinosaur fromn South Africa. N. Jb. Geol. Paläont. Abh., 1997:39-55.
Hopson, J. A. 1984. Late Triassic traversodont cynodonts from Nova Scotia and southern Africa. Palaeont. Afr., 25:181-201.
Jubb, R. A. 1973. Brief synthesis of present information on the geographical and stratigraphical distribution of fossil fishes within the Stormberg Series, South Africa. Palaeont. Afr., 16:17-23.
Kitching, J. W. & Raath, M. A. 1984. Fossils from the Elliot and Clarens formations (Karoo sequence) of the northeastern Cape, Orange Free State and Lesotho, and a suggested biozonation based on tetrapods. Palaeont. Afr., 25: 111-125.
Lockley, M. G. & Hunt, A. P. 1995. Dinosaur tracks and other fossil footprints of the western United States. New York, Columbia University Press, 338 p.
Lucas, S. G. 1998. Global Triassic tetrapod biostratigraphy and biochronology. Palaeogeog., Palaeoclimat., Palaeoecol., 143: 347-384.
Lucas, S. G. & Hunt, A. P. 1994. The chronology and paleogeography of mammalian origins; in Fraser, N. C. & Sues, H.-D. (eds.), In the shadow of the dinosaurs. Cambridge, Cambridge University Press, p. 335-351.
Ochev, V. G. & Shishkin, M. A. 1989. On the principles of the global correlation of the continental Triassic on the tetrapods. Acta Palaeont. Pol., 34: 149-173.
Olsen, P. E. & Galton, P. M. 1984. A review of the reptile and amphibian assemblages from the Stormberg of South Africa, with special emphasis on the footprints and the age of the Stormberg. Palaeont. Afr., 25: 87-110.
Raath, M. A. 1996. Earliest evidence of dinosaurs from central Godwana. Mem. Queensland Mus., 39:703-709.
Raath, M. A., Kitching, J. W., Shone, R. W. & Rossow, G. J. 1990. Dinosaur tracks in Triassic Molteno sediments: The earliest evidence of dinosaurs in South Africa. Palaeont. Afr., 27: 89-95.
Smith, R. & Kitching, J. 1996. Sedimentology and vertebrate taphonomy of the *Tritylodon* acme zone: A reworked palaeosol in the Lower Jurassic Elliot Formation, Karoo Supergroup, South Africa. Mus. North. Ariz. Bull., 60: 531-532.
Smith, R. & Kitching, J. 1997. Sedimentology and vertebrate taphonomy of the *Tritylodon* acme zone: A reworked palaeosol in the Lower Jurassic Elliot Formation, Karoo Supergroup, South Africa. Palaeogeog., Palaeoclimat., Palaeoecol., 117: 81-104.

Turner, B. R. 1984. Paleogeographic implications of braid bar deposition in the Triassic Molteno Formation in the eastern Karoo basin, South Africa. Palaeont. Afr., 25: 29-38.

Visser, J. N. J. 1984. A review of the Stormberg Group and Drakensberg volcanics in southern Africa. Palaeont. Afr., 25: 5-26.

Warren, A. & Damiani, R. 1999. Stereospondyl amphibians from the Elliot Formation of South Africa. Palaeont. Afr., 35: 45-54.

Fossil succession and sequence stratigraphy of the Upper Triassic of Black Bear Ridge, northeast British Columbia, a GSSP prospect for the Carnian-Norian boundary.

M.J. Orchard, J.P. Zonneveld, M.J. Johns, C.A. McRoberts, M.R. Sandy, E.T. Tozer & G. G. Carrelli

Black Bear Ridge on Williston Lake is one of several important North American reference sections for intercalibrating the ranges of Upper Triassic ammonoids, conodonts, bivalves, ichthyoliths, and brachiopods. The section, largely comprising the Ludington and Pardonet formations, consists of four sequences (BB-I through IV) spanning the uppermost Carnian through Hettangian of the Lower Jurassic. These sequences record deposition on the distal slope and adjacent abyssal plain, west (seaward) of the Pangaean continental shelf. Fossil fauna and sequence stratigraphy serve to identify significant biological and sedimentary events in the history of the Late Triassic. Each of the four sequences consists of a comparably coarse- grained lowstand succession which grades up through a thick transgressive succession marked by peak abundances of the conodont *Norigondolella* and ichthyolith *Birgeria*. Highstand systems tracts within the study interval are thin, consisting of condensed intervals with few fossiliferous limestone beds. The Carnian-Norian boundary interval lies within sequence BB-1 and the transitional beds between the Ludington and Pardonet Formations, wherein a lineage of several *Metapolygnathus* conodont species provide two potential datums for boundary definition: the base of the Communisti and Primitius zones. Within the same interval, several ammonoids and bivalves occur, and there are several changes in the ichthyolith fauna.

Introduction

This article summarizes the biostratigraphy of one of several important Triassic outcrops on the shores of Williston Lake in northeast British Columbia. This region has produced much of the data on which North American Upper Triassic biochronology is based (e.g. see Tozer, 1967, 1994; Orchard, 1983, 1991b; Orchard and Tozer, 1997). Considerable progress has been possible since the Peace River was dammed in 1967 and its valley was flooded to form Williston Lake. New Triassic outcrops along the perimeter of the lake were first noted by Tozer in 1979, and in subsequent years (chiefly 1980-1983) Tozer and Orchard examined most of these and made large collections of ammonoids and conodonts. This work continued sporadically through the 1990s and was supplemented by stratigraphic studies by Gibson (e.g. Gibson and Edwards, 1992; 1995) and Zonneveld (e.g. Zonneveld and Gingras, 2000; Zonneveld et al., 1997a, b), and paleontological work by M.J. Johns (ichthyoliths, Johns et al., 1997), C. McRoberts (bivalves), and M. Sandy (brachiopods). G. Muttoni also undertook a magnetostratigraphic study but found the Triassic polarity overprinted (Muttoni et al., in press).

The Black Bear Ridge section lies on the north shore of Williston Lake (Fig. 1), 4 km northeast of the mouth of Nabesche River (NTS Map 94 B/3; zone 10, UTM 497670E, 6215500N). The section begins within the Upper Carnian Ludington Formation, extends through the largely Norian Pardonet Formation, and ends in the Lower Jurassic Fernie Formation. The entire Pardonet Formation is exposed with the exception of a small covered interval. The steeply dipping beds are locally disturbed but there is no major structural complexity.

Of the several chronostratigraphic boundaries recognized in this section, the Carnian-Norian boundary interval offers the most continuous and fossiliferous succession, particularly for conodonts. As such, it is presented as a potential GSSP candidate section (see also Orchard et al., 2000). In the following text, responsibility of individual authors is indicated in parentheses.

Stratigraphy (JPZ/GGC/MJO)

The Black Bear Ridge section has been described in a number of field guides (e.g. Gibson and Edwards, 1992; 1995; Zonneveld et al., 1997; Zonneveld and Gingras, 2000), not all of which have been published; the following stratigraphic summary draws freely on these guides.

The Ludington Formation at Black Bear Ridge consists of approximately 40 meters of interlaminated siltstone, dolostone and minor limestone. These strata are generally laminated to ribbon-bedded, although convolute bedding and slumping also occur. A large olistolith and numerous smaller intraclasts occur at the base of the outcrop. The Ludington is characterized by a comparably clean outcrop gamma profile. Calcite, chert and quartz-lined vugs, many of which are filled with pyrobitumen are also common. The Ludington Formation was deposited on the western Pangea slope, far offshore of the continental coastline (Gibson and Edwards, 1995; Zonneveld and Gingras, 2000). Individual beds and

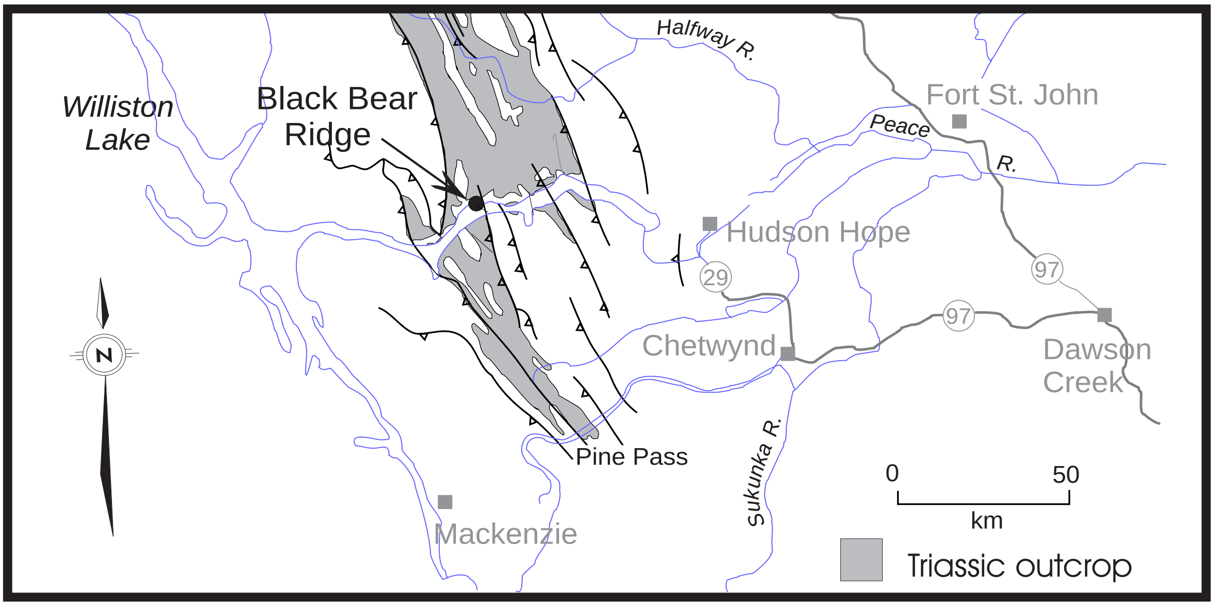

Figure 1: Location of the Blackbear Ridge section on Williston Lake in northeaast British Columbia.

bed-sets represent deposition by various submarine mass transport mechanisms including slumping, debris flows and turbidity currents. These deposits represent thanatocoenoses in which individual taxa from shallower settings are brought together in a more distal setting by sedimentary processes. The Ludington Formation represents the deep water equivalent of the primarily shallow water Baldonnel Formation and the primarily marginal marine Charlie Lake Formation.

At Black Bear Ridge, the Ludington Formation is overlain by the Pardonet Formation. Gibson and Edwards (1995) drew the base of the Pardonet Formation between his units 3 and 4 (Fig. 2), where dominantly dolostone beds grade into bioclastic, brachiopod grainstone/packstone layers containing rare ammonoids, halobiids, and the calcite spheres or “pseudo-oolites” that characterize the Pardonet Formation elsewhere on Williston Lake. This study recognizes a transitional zone, approximately 28 meters thick, where clean, silty dolostone is intercalated with dark grey, carbonaceous limestone (Gibson units 4 and 5, Fig. 2). Prior to revision of Upper Triassic lithostratigraphy, these strata had been incorporated into the Baldonnel Formation, subjacent to the base of the Pardonet Formation (Gibson and Edwards, 1992). Outcrop gamma measurements support the transitional nature of this interval between the Ludington and Pardonet Formations (Fig. 2). Deposition within this transitional interval is also dominated by submarine mass transport mechanisms, primarily turbidity currents. Numerous sharp-based bioclastic grainstone/packstone beds in this interval likely represent individual calcareous turbidites. Like those discussed above, bioclastic accumulations in this interval are thanatocoenoses rather than biocoenoses transported basinward from a variety of settings on the shelf and proximal slope. The monotypic brachiopod packstone beds that characterize this interval may represent a series of events sourced from brachiopod banks on the shelf, similar to those described from the Middle Triassic (Ladinian) Liard Formation (Zonneveld et al., 1997; Zonneveld, in press).

The Pardonet Formation consists of carbonaceous silty limestone, calcareous and dolomitic siltstone and shale, and densely packed bioclastic grainstone beds composed primarily of whole and unabraded bivalve shells. Limestone concretions are common throughout the Pardonet Formation and often contain ammonoids and scattered ichthyosaur bones. The Pardonet Formation is rich in organic carbonaceous matter and has a strong fetid sulphurous odour. Radioactive uranium bound within this organic material has resulted in the jagged, relatively high, gamma ray profile (Figs. 2, 3).

Limestone beds and concretions rich in ammonoids and belemnoids (including *Aulacoceras*) associated with abundant ichthyosaur bones and horizons rich in pseudo-oolites occur approximately 10-20 m above the ‘Pardonet gash’, a 30 cm thick shale bed characterized by high gamma radiation that occurs near the top of the transitional zone (Fig. 2). These fossil beds are recrystallized and macrofossil extraction is difficult. Overlying beds are silty and sparsely fossiliferous. Richly fossiliferous limestone beds do not occur again until just below (east of) a covered beach interval at 162 metres (Fig. 3).

West of the beach, stratigraphically higher strata contain many rich fossil horizons yielding excellent

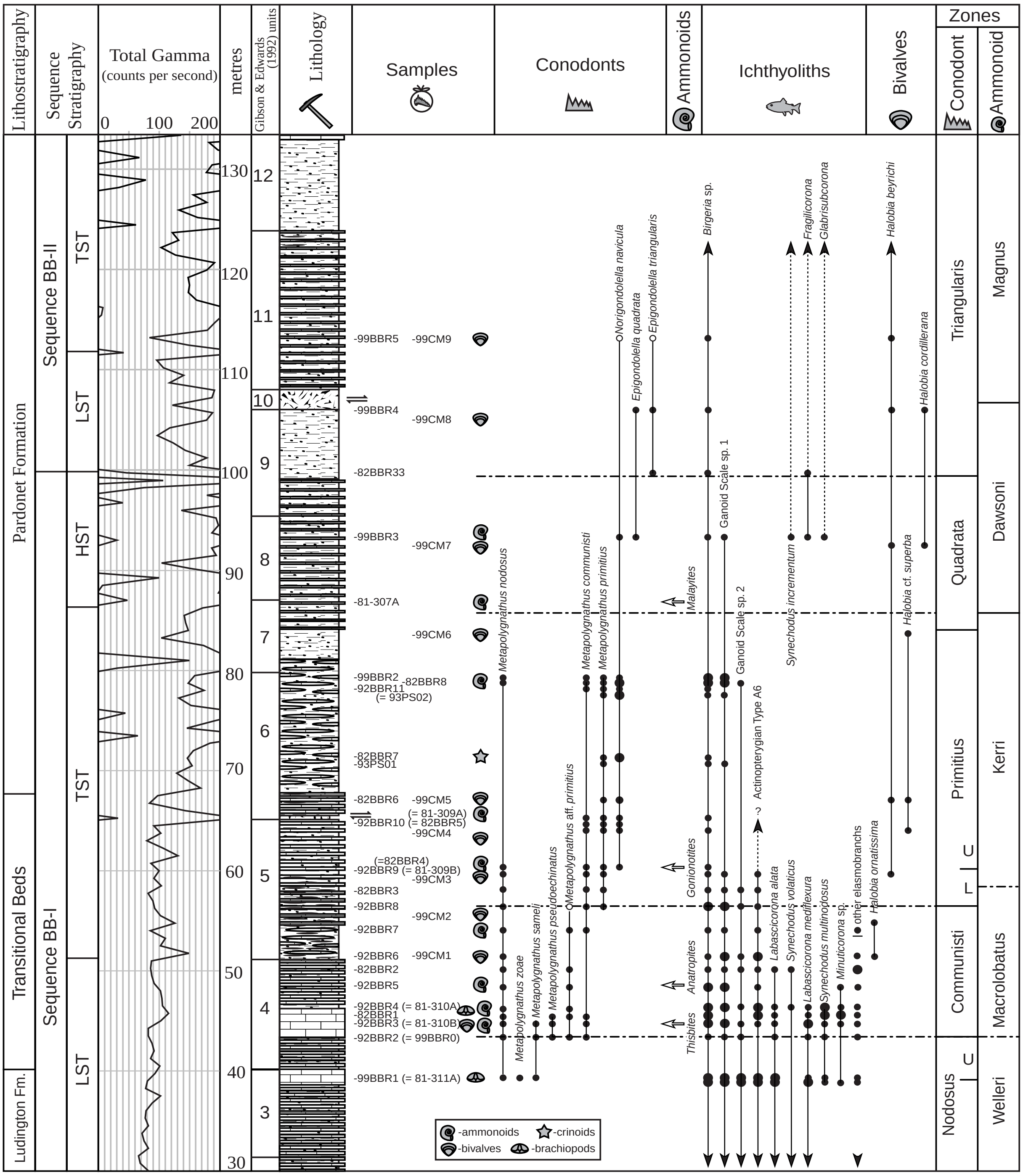

Figure 2: Schematic section of the Upper Carnian-Lower Norian part of the Black Bear Ridge section showing occurrence and distribution of conodonts, ammonoids, ichthyoliths, bivalves, and brachiopods within the Ludington and lower Pardonet formations. The larger dots show the position of abundant specimens of the named taxon. Also shown are units differentiated by Gibson and Edwards (1992). On the left are shown lithostratigraphic and sequence stratigraphic units within the study interval as well as general lithology and outcrop gamma patterns measured with a Scintrex BGS-4 hand-held gamma ray scintillometer. Numbered samples which were taken for conodonts and/or ammonoids, and bivalves (CM) are shown to the right of the lithology column. Ichytholith fauna was recovered from the former. See text for lithological descriptions.

ammonoid faunas and a succession of wavy, crenulated, bivalve grainstone beds (Fig. 3). Although much of the upper Pardonet is fossiliferous, the best preservation occurs in rare limestone concretions. The distinctive *Monotis* beds comprise much of the upper 30 m of the Triassic section. They are extremely rich in organic residue, contain a monotypic assemblage of *Monotis subcircularis* and are variably dolomitic, calcareous, silty and shaly.

The Pardonet Formation at Black Bear Ridge was

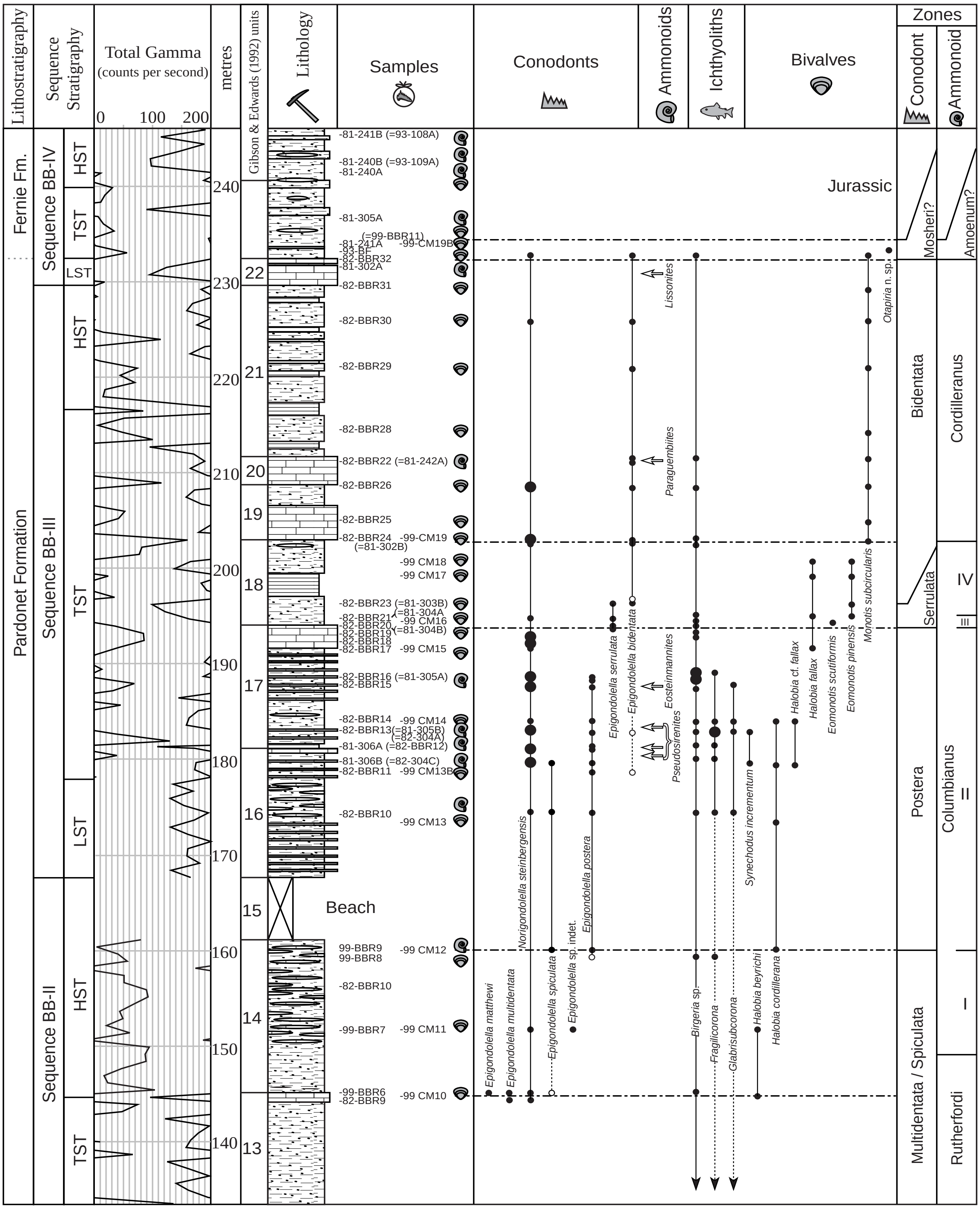

Figure 3: Schematic section of the Middle-Upper Norian and younger part of the Black Bear Ridge section showing occurrence and distribution of conodonts, ammonoids, ichthyoliths, and bivalves within the upper Pardonet and lowest Fernie formations. Other features as in Figure 2.

deposited in a deep water setting, likely on the distal slope or abyssal plain, well offshore of the west Pangaea coastline. Its deposition followed a major transgression and represents the deepest water deposition in the Upper Triassic of western Canada. Lithological and faunal attributes are consistent with a deep water, restricted anoxic basin environment well below storm wave-base.

Few, if any, of the bioclastic beds in the Pardonet represent in situ communities. Bioclastic material in most of these beds consists of a mix of whole and fragmentary material which is oriented primarily parallel to bedding. In rare cases, the bioclasts (ammonoids and bivalves alike) exhibit crude imbrication. Many of these beds are sharp based and are ungraded to normally graded. These beds are interpreted as calcareous turbidites deposited on the distal slope and abyssal plain below the Pangaean continental shelf (Zonneveld and Gingras, 2000). The absence of coarse (sand-sized or larger) clastic material reflects deposition during a period of sediment starvation on the shelf and slope. The origin of the dense *Monotis* beds is interpreted to result from similar processes. Although the Monotis shells are primarily whole and unabraded, they occur primarily in a convex-up orientation (>80% of valves), implicating current processes in the development of these deposits.

Triassic strata in the Western Canada Sedimentary Basin (WCSB) have been subdivided into three "facies assemblages" reflecting large scale cycles in regional sea level; I) Early Triassic (Griesbachian through Spathian), II) Middle Triassic (Anisian through early Carnian) and III) Late Triassic (Carnian through Rhaetian) (Gibson and Barclay, 1989). The study interval comprises the upper portion of the last of these large scale cycles. It comprises an overall aggradational succession of four third-order sequences (BB-I, BB-II, BB-III, and BB-IV) based on lithologic criteria, outcrop gamma characteristics and correlation with other outcrop sections (Figs. 2 and 3). Fluctuations in sea-level responsible for these sequences and their bounding surfaces were likely driven by both eustatic and regional tectonic influences. Each of the four sequences identified here has been separated into lowstand, transgressive and highstand systems tracts (Figs. 2 and 3). Evidence of subaerial exposure was not noted at any of the sequence boundaries. These surfaces are interpreted to represent the basal, conformable equivalents to subaerial unconformities landward (east) of the study area.

In general, lowstand systems tracts in the study interval consist of aggradational successions of calcareous turbidites and (in the case of sequence BB-I) by debris flows and slumping. These intervals generally include the coarsest sediment in the study interval and are characterized by relatively clean (low) outcrop gamma patterns (Figs. 2 and 3).

Transgressive systems tracts within the study interval are characterized by outcrop gamma profiles that are increasingly spiky upwards (Figs. 2 and 3). These intervals represent periods of relative sediment starvation in the basin. Although bioclastic turbidites do occur, these intervals are dominated primarily by suspension deposition and may be considered to be condensed intervals. Increasing water depth in these intervals is supported by spikes in the quantity of *Norigondolella* and *Birgeria* elements (Figs. 2 and 3). Highstand systems tracts in the study interval occur as relative sea-level reached a maximum and sedimentation in the basin gradually began to outpace the increase in accommodation space. These intervals are generally much thinner than subjacent transgressive systems tracts. The contact between highstand and overlying lowstand systems tracts are picked where the proportion and thickness of coarser bioclastic beds shows a sharp increase.

Embry (1997) identified four globally correlatable sequences and sequence boundaries in the study interval: 1) near Carnian-Norian boundary; 2) mid-Norian boundary; 3) near Norian-Rhaetian boundary; and 4) near Triassic-Jurassic (Rhaetian-Hettangian) boundary. The base of sequence BB-I occurs beneath the study interval, within the upper Carnian and may be equivalent to the global near Carnian-Norian sequence boundary. Two mid-Norian sequence boundaries (BB-I\BB-II and BB-II\BB-III) are interpreted to occur within the Black Bear Ridge section. Additional work is needed to ascertain which, if either, is correlative to the globally recognized sequence boundary.

The upper surface of the top *Monotis* bed contains small, discontinuous patches of phosphatic granules. This surface has previously been interpreted as an erosional unconformity and interpreted as both the Fernie-Pardonet lithostratigraphic contact and the Triassic-Jurassic contact (Gibson and Edwards, 1992). However, evidence of an erosional unconformity at this boundary is not evident and the presence of conodonts and possible Rhaetian bivalves in dolomitic siltstone beds immediately above this surface demonstrates a Triassic age for some of these strata. The Triassic-Jurassic contact occurs somewhere within the dolomitic siltstone interval between 233 and 236 meters (Fig. 3), the level of the lowest reported Hettangian ammonoids (see Tozer, 1982). The surface at the top of the abundant *Monotis* beds is here interpreted as a transgressive surface, below wave base and may represent sediment starvation in a deep water setting. The boundary between sequence BB-III and sequence BB-IV apparently occurs near the Rhaetian-Norian boundary and may be coeval with the global boundary discussed in Embry (1997). A sequence boundary equivalent to the Triassic-Jurassic boundary has not been observed within the study area.

Gibson and Edwards (1992; 1995) measured a total of about 212 m for the Black Bear Ridge section, with the Pardonet Formation attaining a thickness of about 182 m and the Ludington about 30 m. Cumulative thicknesses in Figures 2 and 3 were compiled over several visits, most recently May, 2000. The zero datum used here has been chosen a few meters below a large olistolith within the Ludington Formation, 40 meters below the base of the Ludington-Pardonet transitional facies. The total outcrop thickness as presented here is 245 meters (Ludington, 40 meters; transitional zone, 28 meters; Pardonet, 180 meters). Discrepancies between this and earlier studies are the result of shifting beach outcrops between successive visits, inclusion here of lower Jurassic strata into the Pardonet Formation, and the transitional nature of the Ludington-Pardonet lithostratigraphic contact. Reliable datums include the main brachiopod bed near the base of the section (~39 meters), the radioactive 'gash' within the lower section (~66 meters, Fig. 2), and the base and top of the *Monotis* beds in the upper part of the section (~203 and ~232 respectively, Fig 3).

Conodonts (MJO)

Conodont faunas have been collected from throughout the Black Bear Ridge section and provide a rather complete framework for Late Carnian through Late Norian time. The lowest conodont faunas come from the turbiditic shell beds of the 'transitional facies'. The lowest fauna (Fig. 2, 92BBR-1) contains predominantly unornamented to weakly nodose metapolygnathids assigned to the *Metapolygnathus* ex gr. *nodosus* Hayashi. More ornate forms correspond to *Metapolygnathus samueli* Orchard and rarely *M. zoae* Orchard. This association identifies the Upper Nodosus Zone of Orchard (1991a). Several samples taken across 1 m of shell beds containing brachiopods and rare halobiids and ammonoids reveal a major diversification of the conodont fauna characterized as the base of the Communisti Zone (Fig. 2, 92BBR-2). *Metapolygnathus communisti* Hayashi appears concurrently with a variety of *M. pseudoechinatus* Kozur morphotypes, regarded as a proxy for the Communisti Zone in western Canada. Both *Metapolygnathus* ex gr. *nodosus* and *M. samueli* occur at this level but amongst the former considerable variety leads to the recognition of several morphotypes, one of which is here called *M. aff. primitius* (Mosher). Unlike the index of the succeeding zone, this distinctly nodose form lacks the consistent node differentiation and low posterior platform of *M. primitius* as shown by Orchard (1991a, Pl. 3, F) but the trend toward that species is clear.

Above the brachiopod beds (Fig. 2, 92BBR-5, 6, 7), the sharp-noded species disappear, and most collections are dominated by *Metapolygnathus* ex gr. *nodosus* through to near the top of the siliceous facies (lower Unit 5 sensu Gibson). At this level (92BBR-8), a major faunal shift is evident and M. primitius becomes the dominant metapolygnathid. A little higher (92BBR-9), within the typical concretionary facies of the Pardonet Formation, *Norigondolella navicula* (Mosher) appears. This datum marks the base of the "Upper" Primitius Zone in the Williston Lake exposures (Orchard, 1983), but the taxon is rare at first and occurs sporadically through the Primitius Zone, as it does elsewhere (Carter and Orchard, 2000; Orchard et al., 2000). Peak abundance of *Norigondolella navicula* occurs only in higher collections from the *Aulacoceras*-bearing pseudo-oolite beds collections near the top of the Primitius Zone (Fig. 2). Overlying strata is characterized by siltier and less fossiliferous beds but single conodont collections nevertheless document the succeeding Lower Norian Quadrata and Triangularis zones (99BBR-3, 4).

Richly fossiliferous limestone beds re-appear in the Middle Norian (Fig. 3). The Multidentata Zone is succeeded by the Spiculata, Postera, and Serrulata zones in succession (Orchard, 1991b). The first two imply levels corresponding to the Rutherfordi and Columbianus I ammonoid zones although neither macrofauna is certainly identified at Black Bear Ridge. The Postera Zone, which occurs through 10+ m of section with ammonoids of Columbianus Subzone II, is characterized by abundant specimens of *Norigondolella steinbergensis* (Mosher), the second such 'flood' of the genus in the Black Bear Ridge section. Conodonts of the Serrulata Zone are associated with the overlying species of *Eomonotis* bivalves.

Upper Norian *Monotis* coquina and associated strata extend through about 30 m of section at Black Bear Ridge (Fig. 3). The Bidentata Zone fauna occurs both with Monotis bivalves and more abundantly in limestone concretions with the ammonoid *Paraguembilites*. Variation in the conodont faunas are noted: abundant Norigondolella steinbergensis occurs in the lower part of the *Monotis* coquina, but indices of *Epigondolella* dominate the limier ammonoid beds. The stratigraphically highest conodonts occur in a small limestone concretion sitting directly above the youngest bedding surface of *Monotis*. These are examples of *Epigondolella* ex gr. *bidentata* Mosher, including a few large elements resembling the younger *E. mosheri* Kozur and Mostler (Orchard, 1994). This species is known overlying *Monotis* strata at a single locality elsewhere on Williston Lake (Ne Parle Pas Point), that is in the "*Rhacophyllites* beds" assigned to the Rhaetian Amoenum Zone. The data is sparse but provides an indication of Rhaetian strata.

Ammonoids (ETT)

Well preserved and locally abundant ammonoids occur in the Middle and Upper Norian, and in the overlying Lower Jurassic strata at the Black Bear Ridge section. Ammonoids also occur in Upper Carnian and Lower Norian but they are less common and difficult to separate from the matrix. Many of these ammonoid faunas are reported by Tozer (1994, p. 344-5, indicated below as * ; see also Tozer, 1982). The notable features of the ammonoid succession are the several levels of the Columbianus Subzone II fauna, and the superimposition of two *Eomonotis* faunas and two subzones of the Upper Norian Cordilleranus Zone. The Lower Jurassic (Hettangian) succession is also unique (currently under study by R. Hall, U. of Calgary). Available data are summarized in ascending stratigraphic order below with both field numbers (see Fig. 1) and GSC locality numbers indicated. These data enable the other faunal elements to be calibrated with the standard Triassic ammonoid biochronology.

99-BBR0 = GSC loc. C-304377. Ammonoid indet.

81-310A = GSC loc. 98555. Ammonoids indet.

82-BBR1 = GSC loc. C-101002. *Thisbites* sp. indet.

92-BBR5 = GSC loc. C-201931. *Anatropites* sp. indet.

81-309B = GSC loc. 98554. *Gonionotites* sp. indet.

81-307A = GSC loc. 98553. cf. *Malayites dawsoni* McLearn. Approximates 82-305B = 98872.

81-306B = *GSC loc. 98552. *Pseudosirenites pardoneti* (McLearn), *Mesohimavatites columbianus* (McLearn), *Distichites canadensis* McLearn, *Leiodistichites ursidens* Tozer, *Helicites decorus* McLearn. Repeated as 82-304C = 98770.

81-306A = *GSC loc. 98551. *Pseudosirenites pardoneti* (McLearn), *Himavatites multiauritus* McLearn, *Distichites canadensis* McLearn, *Helicites decorus* McLearn, *Episculites teres* (McLearn).

81-305B = *GSC loc. 98550. *Pseudosirenites pardoneti* (McLearn), *P. pressus* (McLearn), *Distichites canadensis* McLearn, *Leiodistichites ursidens* Tozer, *Helicites decorus* McLearn. Repeated as 82-304A = 98868.

81-305A = *GSC loc. 98549. *Eosteinmannites orientalis* Tozer, *Himavatites appinatus* Tozer, *Helicites decorus* McLearn, *Parajuvavites canadensis* Tozer. Repeated as 82-303A = 98867.

81-304B = GSC loc. 98548. *Eomonotis scutiformis* (Teller)

81-304A = GSC loc. 98547. *Eomonotis pinensis* (Westermann)

81-303B = GSC loc. 98546. *Eomonotis pinensis* (Westermann)

81-242A = *GSC loc. 98534. *Paraguembilites ludingtoni* Tozer, *Monotis* sp. Repeated as 82-301A = 98865.

81-302A = *GSC loc. 98545. *Lissonites* sp. indet., *Monotis* sp.

81-305A = GSC loc. 98871. *Primapsiloceras*? sp.

81-240A = GSC loc. 98531. *Psiloceras calliphyllum* (Neumayr), *phylloceratids* (Tozer, 1982).

81-240B = GSC loc. 98532; 93-109A = GSC loc. C-209258. *Curviceras* sp.

81-241B = GSC loc. 98533; 93-108A = GSC loc. C-209257. *Caloceras* sp.

82-316F = GSC loc. 98894. *Schlotheimia* sp.

82-316G = GSC loc. 98895. *Pseudaetomoceras* sp.

In addition to these levels, Tozer collected faunas of both the *Juvavites magnus* Subzone 2 and Columbianus 3 from talus on the west slope of Black Bear Ridge prior to dam construction and flooding. These are respectively:

64-137D = *GSC loc. 64636. *Dimorphotoceras caurinum* (McLearn), *D. ursinum* Tozer, *Juvavites concretus* McLearn.

64-138C = *GSC loc. 64638. *Paragymnites symmetricus* (Mojsisovics), *Steinmannites* sp. indet.

McLearn (1960) also collected several rich examples of the Columbianus Subzone 2 fauna (*GSC locs. 9741, 9744, 9745; see Tozer, 1994, p. 295-6).

Bivalves (CAM)

The continuous sequence of the Pardonet Formation and its transitional facies at Black Bear Ridge provides documentation of a *Halobia* and *Monotis* succession unparalleled throughout the North American Cordillera. Biostratigraphic resolution is best in the lower and uppermost parts of the Pardonet Formation in which diagnostic halobiid and monotid species occur. In particular the succession of *Halobia ornatissima* Smith overlain by *H. beyrichi* (Mojsisovics) indicates the traditional Carnian/Norian stage boundary which, based on *Halobia* species, lies between beds 99CM-2 and -3 (Fig. 2). *Halobia beyrichi* (*H. alaskana* Smith is considered a junior synonym) is known to occur throughout the Cordilleran terranes from Alaska to Nevada. It is well represented from Vancouver Island and the Queen Charlotte Islands of British Columbia (Tozer, 1967; Carter et al., 1989; and undescribed GSC collections), southeast Alaska (Muffler, 1967), as well as from the Wallowa Terrane Oregon (McRoberts, 1993), and the Shoshone Mountains of Nevada where it occurs with the ammonoid *Stikinoceras kerri* (Silberling, 1959; and Silberling and Tozer, 1968, Kristan-Tollmann and Tollmann, 1983). In the Tethys realm and the western Pacific regions the place of *H. beyrichi* is replaced by *H. styriaca* (Mojsisovics), a key zonal fossil of the earliest Norian which is conspicuously absent from North America (e.g. Gruber, 1976).

In the higher parts of the Pardonet Formation, *H. cordillerana* Smith together with *H. beyrichi* indicates the probable occurrence of the Dawsoni and Magnus zones. *Halobia cordillerana* is known from throughout the Cordillera with significant occurrences in Nevada (H. hochstetteri Mojsisovics listed by Kristan-Tollmann and Tollmann (1983) from the Luning Formation is here treated as a synonym for H. cordillerana), California, possibly northeast Oregon, and southern, eastern, and arctic Alaska (see McRoberts, 1997). In British Columbia, this species was known as *Halobia pacalis* McLearn, which is now considered a junior synonym.

The bivalve succession in the Middle Norian Columbianus Zone and the Upper Norian Cordilleranus Zone is demonstrated in the succession of *Eomonotis* and *Monotis* species. *Eomonotis pinensis* (Westermann) is the more common Middle Norian species (Fig. 3, 99CM-17, -18), but earlier collections made by E.T. Tozer (see above) also included a lower horizon with *E. scutiformis* (Teller) (Fig. 3, 81-304B); both species apparently occur within the upper range of *Halobia fallax* Mojsisovics. *Eomonotis* is well known from numerous middle Norian localities elsewhere in northeastern British Columbia (e.g. Westermann, 1962) as well as in several allochthonous terranes such as the Nixon Fork and Alexander terranes of central and southern Alaska (see Silberling et al., 1997). In all of these localities it occurs in the upper part of the Middle Norian Columbianus Zone where is often associated with the ammonoid *Himavatites* (see for example Tozer, 1979; Silberling et al., 1997).

At Black Bear Ridge, the *Eomontis pinensis* beds are overlain by beds dominated by Upper Norian *Monotis subcircularis* Gabb, perhaps one of the most abundant of monotids in the North American Cordillera and eastern Asia (see for example Tozer, 1982; Silberling et al., 1997). The first appearance of *Monotis subcircularis* is taken as the base of the Cordilleranus Zone. Overlying the uppermost *Monotis subcircularis* bed occur a probably new and undescribed species of *Otapiria*. While several species of *Otapiria* are well known from the Norian and Rhaetian of the circum-Pacific (e.g. New Zealand, Japan, and Russia) and Tethys (e.g. Austria) they become increasingly common in Lower Jurassic strata. The specimens recovered from Black Bear Ridge are Rhaetian or Hettangian.

The transitional beds from the Pardonet Formation to the Jurassic Fernie Formation contain abundant specimens belonging to at least two pectinacean genera, *Entolium* and *Agerchlamys*. Similar pectinacean specimens occur from approximately the same stratigraphic horizon elsewhere in northeastern British Columbia (e.g. Ne Parle Pas Point, Pine Pass; Tozer, 1982), where some appear to be Triassic. A complete taxonomic assessment of these “Pecten Beds” awaits further study.

Ichthyoliths (MJJ)

The study of ichthyolith distributions in the Upper Triassic strata of northeastern British Columbia (Johns et al., 1997) suggest that ichthyoliths are longer ranging in deeper water facies (e.g. outer shelf to slope Pardonet Fm.) but far more variable and abundant in the shallower and thicker Baldonnel Formation and its equivalents (Johns et al, 1999, 2000a,b, 2001). The section at Black Bear Ridge provides an excellent opportunity to compare what appear to be more distal ichthyolith assemblages in the sub-Pardonet transitional beds (Fig. 2) to more proximal assemblages to the north and east.

Ichthyoliths recovered from the transitional beds between the Ludington and Pardonet formations (Nodosus and Communisti conodont zones) at Black Bear Ridge are abundant and diverse. The lowest level, corresponding to the Upper Nodosus conodont Zone (Fig. 2, 81-311A & 99BBR-1), contains abundant actinopterygian (bony fish) teeth and ganoid scales in addition to abundant *Labascicorona mediflexura* Johns and a variety of other elasmobranch (shark) scales and teeth (Johns et al., 1997). The next ichthyolith-rich and distinct level occurs in the Communisti Zone (Fig. 2, 81-310B, 82BBR-1, 92BBR-2, 3 & 4). It is marked by a peak abundance of the elasmobranch tooth *Synechodus multinodosus* Johns, *Minuticorona* scales, actinopterygian teeth and scales, and other ichthyoliths; this interval represents the type locality for the *S. multinodosus* concurrent-range ichthyolith Zone (Johns et al., 1997). Just above this level (Fig. 2; 92BBR-5) there is a change in the distribution of ichthyoliths. *Birgeria* sp., Type A6, and ganoid scale sp. 1 are abundant and there are only a few small elasmobranch scales. These beds show a shallower water *S. multinodosus* assemblage followed by a deeper water Birgeria-abundant assemblage.

Sample 82BBR-2 contains an odd diversity and abundance of ichthyoliths including: 1) elasmobranch scales commonly observed from shallow water and older rocks in the region that do not occur in the Nodosus and Communisti zones (see Johns et al., 1997, p. 112 and compare to p. 100-107); 2) other actinopterygian and elasmobranch ichthyoliths that are commonly found in the Communisti Zone (Fig. 2); and 3) an absence of diagnostic taxa of the *S. multinodosus* ichthyolith Zone (including *S. multinodosum*, *Minuticorona*, and *Labascicorona alata*). Just above this level (Fig. 2; 92BBR-6), no elasmobranch teeth or scales were recovered and actinopterygian scales and teeth were common to abundant in the sample. The mixing of shallower water ichthyoliths presumably arose from downslope transport in turbidites during the system lowstand and deeper water ichthyoliths (92BBR-6) returned during the transgressive system tract. Above, in sample 92BBR-7, a new ichthyolith assemblage occurs: it includes the last examples of the elasmobranchs present in older units, and is correlative to the uppermost Baldonnel Formation at other locations.

Ichthyoliths in the Pardonet Formation throughout northeastern British Columbia predominantly contain Birgeria. However, in at least three levels at Black Bear Ridge, the *Synechodus incrementum* assemblage (from shallower water than the *Birgeria* assemblage) occurs, that is within the Quadrata, Multidentata/Spiculata and Postera conodont zones. In sample 92BBR-8 (Fig. 2), *Birgeria* and ganoid scale sp. 1 are very abundant. For about 30 additional metres of strata, fish diversity remains low (Fig. 2). Near the top of the Upper Primitius Zone (Fig. 2, 82BBR-8) there is another peak abundance of *Birgeria* sp. and ganoid scale sp. 1 in addition to a rare occurrence of ganoid scale sp. 2 (Fig. 2). Higher strata in the Pardonet Formation (Fig. 2, 99BBR-3, 82BBR-33) contain the first new elasmobranchs typical of the Norian (Johns et al., 1997), including *Synechodus incrementum* Johns, and form species of *Fragilicorona*, and *Glabrisubcorona*. The *S. incrementum* assemblage repeats in 99-BBR-8, and in the set of samples 82BBR-10, 82-BBR-12, 81-306A, -306B, -305B, and 82-BBR-14 and 15 (Fig. 3) in the Postera conodont zone. The remaining Upper Norian strata at Black Bear Ridge mainly contain Birgeria ichthyoliths. Some new ichthyoliths were found in the ?Rhaetian (Fig. 3; 93-BF).

Brachiopods (MRS)

Low diversity brachiopod faunas are known from a number of localities on Williston Lake, and the Upper Carnian fauna at Black Bear Ridge has counterparts at the nearby Brown Hill and Pardonet Hill. The brachiopods are generally very well preserved in carbonates, often “popping out” of the sediment; only the high level of induration of some of the carbonate layers prevents their easy removal from matrix for study. The Black Bear Ridge brachiopod fauna is concentrated in several layers within a 60 cm bed and is composed of monotypic rhynchonellids referred to *Piarorhynchia winnemae* (Smith).

Although the brachiopods have yet to be subjected to detailed taxonomic investigation, the species has been interpreted as quite varied morphologically. Other authors have considered that varieties or subspecies may be present. Ager and Westermann (1963) recorded two species, *P. winnemae* and *P. hamiltonensis*, from the Carnian of Caribou Ridge in the Mount Laurier area of northeastern British Columbia; these are thought to be probable synonyms. Their material was composed of smaller specimens compared with that of Smith (1927), who first recorded the species from the Hosselkus Limestone of Brock Mountain in Shasta County, California. The material from the rhynchonellid horizons at Williston Lake show both small and larger forms, and some of these resemble other species that Smith identified; it seems likely that these are also synonyms of *P. winnemae*. There have been no other records of the taxa in North America to date.

Although first described from the Jurassic, *Piarorhynchia* is known to range into the Triassic. The genus has been identified from the latest Triassic of southern Europe, and Dagys (1974) recorded the range as Carnian - Rhaetian. Ager and Westermann (1963) regarded the British Columbian occurrences of *Piarorhynchia winnemae* as Lower Carnian although this was not substantiated. The occurrences at Black Bear Ridge and elsewhere on Williston Lake are high in the Carnian.

Intercalibration and Summary

An integrated bio- and sequence-stratigraphic summary of the Black Bear Ridge section is summarized below in point form emphasizing the essential features of the succession.

1. The base of the section occurs within the upper Ludington Formation. A relatively low diversity association of Upper Nodosus Zone conodonts occurs at the top of the Ludington Formation (Fig. 2). Ichthyoliths are both diverse and abundant and in-

clude the elasmobranch *Synechodus multinodosus* and a peak abundance of ganoid scale sp. 2.

2. The upper Ludington Formation and the base of the Ludington-Pardonet transitional interval is interpreted as a lowstand succession characterized by event beds deposited by a variety of submarine mass transport mechanisms including turbidity currents, slumps and debris flows. Monotypic, brachiopod-bearing, bioclastic limestone beds within this succession likely represent faunas transported basinward by turbidity currents.

3. The study interval represents deposition on the slope and abyssal plain west of the Pangaean continental shelf. It has been subdivided into four sequences (BB-I, BB-II, BB-III and BB-IV, Figs. 2 and 3), bound by the basinward conformable equivalents to subaerial unconformities. Although, with the exception of bioclastic material, the entire succession is fine-grained, sequence boundaries can be identified by an increase in the proportion of sharp-based bioclastic beds (calcareous turbidites). These surfaces are readily identified on outcrop gamma profiles by an abrupt decrease in gamma radiation. Transgressive systems tract are characterized by a gradually upward increasing gamma profile and a decrease in the quantity of bioclastic turbidites. Highstand systems tracts are characterized by fine-grained deposits and high gamma radiation.

4. At 43 m, Communisti Zone conodonts appear with rare Macrolobatus Zone ammonoids in bioclastic grainstone beds of *Piarorhynchia winnemae* brachiopods. This level marks the peak abundance of *Synechodus multinodosus* and *Minuticorona* ichthyoliths. *Halobia ornatissima* ranges within the upper part of the Communisti Zone, where several changes in ichthyolith fauna are noted.

5. At ~56 m, Primitius Zone conodonts appear above the commonly cherty beds and at the base of the concretionary beds of the Pardonet Formation. Associated ichthyoliths are abundant, low diversity actinopterytgian teeth and ganoid scales, with most of the older elasmobranch teeth and scales having disappeared. This interval occurs within the early transgressive systems tract of sequence BB-I. A little higher *Halobia beyrichi* appears.

6. From ~70 m - ~80 m, there is a peak abundance of *Norigondolella navicula* within the Primitius Zone. This interval includes rich ammonoid and belemnoid beds that also contain "pseudo-oolites". Extremely abundant actinopterygian ichthyoliths occur at 38 m. Dawsoni Zone ammonoids and *Halobia* cf. *superba* are identified within these strata, which are thought to represent an interval of sediment starvation in the basin during maximum transgression.

7. From ~115 m through ~144 m, monotonous, generally unfossiliferous strata bear uncommon levels of Lower Norian Quadrata and Triangularis Zone conodonts, and the bivalve Halobia cordillerana. New elasmobranchs - *Synechodus incrementum*, *Fragilicorona*, and *Glabrisubcorona* - occur within the Quadrata Zone. Fossiliferous strata become more common in Middle Norian Multidentata and Spiculata zones, which include the last *Halobia beyrichi*. This interval occurs within the late lowstand and early transgressive system tracts of sequence BB-II

8. At ~160 m - ~194 m, diverse ammonoids of Columbianus Subzone 2, Postera Zone conodonts, the bivalves *Halobia cordillerana* and *H.* cf. *fallax*, and abundant ichthyoliths of the *Synechodus incrementum* Zone occur in limestone nodules. From ~178 m through the end of the Postera Zone, a peak abundance of *Norigondolella steinbergensis* is interpreted to represent another interval of sediment starvation in the basin during maximum transgression of sequence BB-III.

9. Between ~194 m and ~202 m, a succession of *Eomonotis scutiformis* followed by *E. pinensis* occurs within the range of *Halobia fallax*. Serrulata Zone conodonts are associated with the lower part of this succession.

10. Above ~203 m, Upper Norian *Monotis* grainstone/ packstone beds and Bidentata Zone conodonts occur together throughout a succession that includes two ammonoid faunas characterized by *Paraguembilites ludingtoni* and *Lissonites* sp. These represent the Cordilleranus subzones 1 and 2. *Norigondolella* is very common in the lower 5 m of the *Monotis* beds, reflecting deposition during continued trasnsgression.

11. Above ~232 m, a very thin Rhaetian succession is tentatively identified on the basis of *Otapiria* sp. and possible Mosheri Zone conodonts that abruptly overlie *Monotis* grainstone/ packstone beds. The upper surface of the top *Monotis* bed is interpreted

as a transgressive surface based on the abrupt change in lithology and the presence of a discontinuous phosphate granule lag. Other bivalves of the overlying “Pecten Beds” include *Entolium* and *Agerchlamys* and may be of latest Triassic or earliest Jurassic age. New ichthyoliths occur at this level.

12. At least six levels of Lower Jurassic ammonites were collected from within the basal Fernie Formation during preliminary investigations. Subsequent work has located 30 separate horizons of ammonites over 22 m of Fernie Formation, and indications are that at least parts of the Lower, Middle, and Upper Hettangian are represented (R.Hall, pers. comm.).

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References

Ager, D.V.& Westermann, G.E.G., 1963. New Mesozoic brachiopods from Canada. J. Paleont., 37: 595-610.

Carter, E.S., Orchard, M.J. & Tozer, E.T., 1989. Integrated ammonoid-conodont-radiolarian biostratigraphy, Late Triassic Kunga Group, Queen Charlotte Islands, British Columbia. Current Research, Part H - Geol. Surv. Canada, Pap. 89-1H: 23-30.

Carter, E.S. & Orchard, M.J., 2000. Intercalibrated conodont-radiolarian biostratigraphy and potential datums for the Carnian/Norian boundary within the Upper Triassic Peril Formation, Queen Charlotte Islands. Current Research 2000-A07 - Geol. Surv. Canada, 11pp. (online: http://www.nrcan.gc.ca/gsc/ bookstore).

Dagys, A.S., 1974. Triasovye brakhiopody (morphologiya, sistema filogeniya, stratigraficheskoe znachenie i biogeografiya). Akad. Nauk SSSR, Sib. Otd., Inst. Geol. Geofiz, Tr., 214: 386pp. (in Russian).

Embry, A.F., 1997. Global sequence boundaries of the Triassic and their identification in the Western Canada Sedimentary Basin. In: T. Moslow & J. Wittenberg (eds), Triassic of Western Canada Basin. Can. Soc. Pet. Geol., Bull. 45: 415-433.

Gibson, D.E. & Barclay, J.E., 1989. Middle Absaroka sequence: the Triassic stable craton. In: B. Ricketts (ed), Western Canada Sedimentary Basin: a case history. Can. Soc. Pet. Geol., p. 219-231.

Gibson, D.W. & Edwards, D.E., 1992. Triassic stratigraphy and sedimentary environments of the Williston Lake area and adjacent subsurface plains, northeastern British Columbia. Field Trip Guidebook, Am. Assoc. Pet. Geol., Convention, 125 p.

Gibson, D.W. & Edwards, D.E., 1995. Triassic stratigraphy and sedimentary environments of the Williston Lake area and adjacent subsurface plains, northeastern British Columbia. Field Trip Guidebook, Can. Soc. Pet. Geol., Convention, 125p.

Gruber, B., 1976. Neue ergebnisse auf dem gebiete der ökologie, stratigraphie und phylogenie der Halobien (Bivalvia). Mitt. Ges. Geol. Bergbaustud. Österr., 23: 181-198.

Johns, M.J., Barnes, C.R. & Orchard, M.J., 1997. Taxonomy and biostratigraphy of Middle and Late Triassic elasmobranch ichthyoliths from northeastern British Columbia. Geol. Surv. Canada, Bull. 502: 235 p.

Johns, M.J., Barnes, C.R. & Orchard, M.J., 1999. Progress on Triassic ichthyolith biostratigraphy and regional thermal-maturation studies, Trutch and Halfway River map areas, northeastern British Columbia. Current Research 1999-A - Geol. Surv. Canada, p. 51-59.

Johns, M.J., Barnes, C.R. & Orchard, M.J., 2000a. Ichthyolith-abundant beds, high gamma ray levels, sequence boundaries, and thermal maturation in Middle and Upper Triassic strata of northeastern British Columbia. GeoCanada 2000 – The Millennium Geoscience Summit, May 29-June 2, Calgary, Alberta, Abs. No. 392.

Johns, M.J., Barnes, C.R. & Orchard, M.J., 2000b. Progress report on Middle and Late Triassic biostratigraphy and regional thermal maturation studies in the Trutch map area of northeastern British

Columbia. In: F. Cook & P. Erdmer (compilers), Slave-Northern Cordillera Lithospheric Evolution (SNORCLE) Transect and Cordilleran Tectonics Workshop Meeting (February 25-27), Univ. Calgary, Lithoprobe Rpt. No. 72: 104-109.

Johns, M.J., Barnes, C.R. & Orchard, M.J., 2001. Preliminary report on ichthyolith studies from the Baldonnel and Pardonet formations, Trutch and Halfway River map-areas, northeastern British Columbia. In: F. Cook & P. Erdmer (compilers), LITHOPROBE Slave-Northern Cordillera Lithospheric Evolution (SNORCLE) and Cordilleran Tectonics Workshop, Lithoprobe Rpt. No. 79: 253-255.

Kristan-Tollmann, E. & Tollmann, A., 1983. Tethysfaunenelemente in der Trias der USA. Mitt. Ges. Geol. Bergbaustud. Österr., 76: 213-232.

McLearn, F.H., 1960. Ammonoid faunas of the Upper Triassic Pardonet Formation, Peace River Foothills, British Columbia. Geol. Surv. Canada, Mem. 311: 118pp.

McRoberts, C.A., 1993. Systematics and biostratigraphy of halobiid bivalves from the Martin Bridge Formation (Upper Triassic), northeast Oregon. J. Paleont., 67: 198-210.

McRoberts, C.A., 1997. Late Triassic North American halobiid bivalves: stratigraphic distribution, diversity trends, and their circum-Pacific correlation. In: J.M. Dickins et al. (eds), Late Paleozoic and Early Mesozoic circum-Pacific events. Cambridge Univ. Press, Cambridge, p. 198-208.

Muffler, L.J.P., 1967. Stratigraphy of the Keku Islets and neighboring parts of Kuiu and Kupreanof Islands, southeastern Alaska. U.S. Geol. Surv., Bull. 1241-c: 1-52.

Muttoni, G., Kent, D.V. & Orchard, M.J., in press. Paleomagnetic reconnaissance of Early Mesozoic carbonates from Williston Lake, northeastern British Columbia: evidence for Late Mesozoic remagnetization. Can. J. Earth Sci.

Orchard, M.J., 1983. Epigondolella populations and their phylogeny and zonation in the Norian (Upper Triassic). Fossils Strata, 15: 177-192.

Orchard, M.J., 1991a. Late Triassic conodont biochronology and biostratigraphy of the Kunga Group, Queen Charlotte Islands, British Columbia. In: G.J. Woodsworth (ed), Evolution and hydrocarbon potential of the Queen Charlotte Basin, British Columbia. Geol. Surv. Canada, Pap. 1990-10: 173-193.

Orchard, M.J., 1991b. Upper Triassic conodont biochronology and new index species from the Canadian Cordillera. In: M.J. Orchard & A.D. McCracken (eds), Ordovician to Triassic conodont paleontology of the Canadian Cordillera. Geol. Surv. Canada, Bull. 417: 299-335.

Orchard, M.J., 1994. Late Triassic (Norian) conodonts from Peru. In: G.D. Stanley Jr. (ed), Paleontology and Stratigraphy of Triassic to Jurassic Rocks of the Peruvian Andes. Palaeontogr. Abt. A, 233: 203-208.

Orchard, M.J. & Tozer, E.T., 1997. Triassic conodont biochronology, its calibration with the ammonoid standard, and a biostratigraphic summary for the Western Canada Sedimentary Basin. In: T. Moslow & J. Wittenberg (eds),Triassic of Western Canada Basin. Can. Soc. Pet. Geol., Bull. 45(4): 675-692.

Orchard, M.J., Carter, E.S. &Tozer, E.T., 2000. Fossil data and their bearing on defining a Carnian-Norian (Upper Triassic) boundary in Western Canada. Albertiana, 24: 43-50.

Silberling, N.J., 1959. Pre-Tertiary stratigraphy and Upper Triassic paleontology of the Union District Shoshone Mountains Nevada. U. S. Geol. Surv., Prof. Pap. 322: 1-67.

Silberling, N.J. & Tozer, E.T., 1968. Biostratigraphic classification of the marine Triassic in North America. Geol. Soc. Am., Spec. Pap. 110: 1-63.

Silberling, N.J., Grant-Mackie, J. & Nichols, K.M., 1997. The Late Triassic bivalve Monotis in accreted terranes of Alaska. U. S. Geol. Surv., Bull. 2151: 1-21.

Smith, J.P., 1927. Upper Triassic marine invertebrate faunas of North America. U. S. Geol. Surv., Prof. Pap. 141: 1-262.

Tozer, E.T., 1967. A standard for Triassic Time. Geol. Surv. Canada, Bull. 156: 1-103.

Tozer, E.T., 1979. Late Triassic ammonoid faunas and biochronology, western Canada. Geol. Surv. Canada, Pap. 79-1B: 127-135.

Tozer, E.T., 1982. Late Triassic (Upper Norian) and earliest Jurassic (Hettangian) rocks and ammonoid faunas, Halfway River and Pine Pass map areas, British Columbia. Current Research, Part A - Geol. Surv. Canada, Pap. 82-1A: 385-391.

Tozer, E.T., 1994. Canadian Triassic ammonoid faunas. Geol. Surv. Canada, Bull. 461: 663 p.

Westermann, G.E.G., 1962. Succession and variation of Monotis and the associated fauna in the Norian Pine River Bridge section, British Columbia (Triassic, Pelecypoda). J. Paleont., 36: 745-792.

Zonneveld, J-P., in press. Middle Triassic biostromes from the Liard Formation, British Columbia, Canada: oldest examples from the Mesozoic of NM T.F. & Gingras, M.K., 1997a. Sequence stratigraphy and sedimentary facies of the Lower and Middle Triassic of northeastern British Columbia: progradational shoreface associations in a mixed carbonate siliciclastic system. Field Trip Guide, Sedimentary Events-Hydrocarbon Systems, 1997, Can. Soc. Pet. Geol.-Soc. Sediment. Geol. (SEPM), Joint Convention, Calgary, 118pp.

Zonneveld, J-P., Moslow, T.F. & Henderson, C.M., 1997b. Lithofacies associations and depositional environments in a mixed siliciclastic-carbonate depositional system, upper Liard Formation, Triassic, northeastern British Columbia. In: T. Moslow & J. Wittenberg (eds), Triassic of Western Canada Basin. Can. Soc. Pet. Geol., Bull.

Report on the Lower Triassic of Chaohu, Anhui Province, China

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With the final decision of the Global Stratotype Section and Point (GSSP) of the Permian and Triassic boundary (PTB), the Triassic has its first GSSP and the base defined at last. The next step in the Triassic study is to extend and correlate this GSSP into every parts of the Triassic as well as to establish the other chronostratigraphic GSSPs of the Triassic.

The GSSP of the PTB is located in a protected quarry at Meishan, Changxing County, Zhejiang Province, China, where the uppermost Permian Changhsingian stage was proposed, and the Lower Triassic at Meishan Section can be well traced on the hillside from the boundary up to the top of the hill. The index fossils and some relative forms of six Lower Triassic conodont Zones were found at the section: *Hindeodus parvus* Zone, *Isarcicella isarcia* Zone, *Clarkina carinata* Zone, *Neospathodus kummeli* Zone, *N. cristagalli* Zone and *N. waageni* Zone (Tong and Yang, 1998). This is an excellent section containing the most lower Lower Triassic conodont Zones in South China. The *Neospathodus waageni* is believed to belong to the Olenekian (Sweet et al., 1971). The continuous sequence from the PTB up to the *N. waageni* Zone is quite positive and valuable for the serialized studies, such as magnetostratigraphy, chemostratigraphy, cyclostratigraphy and so on, to define the next chronostratigraphic boundary, that is the Induan and Olenekian boundary in the Triassic. Unfortunately, at Meishan section as well as in its neighboring area the uppermost of the Lower Triassic was eroded off. Moreover, the Lower Triassic in Meishan area is made mostly of carbonate rocks, in which ammonoids and bivalves are rare except for the lowest part, about ten meters, which is predominated by argillaceous rocks, probably condensed (Tong and Yin, 1998), and contains rich specimens of the Ophiceras-Claraia Assemblage.

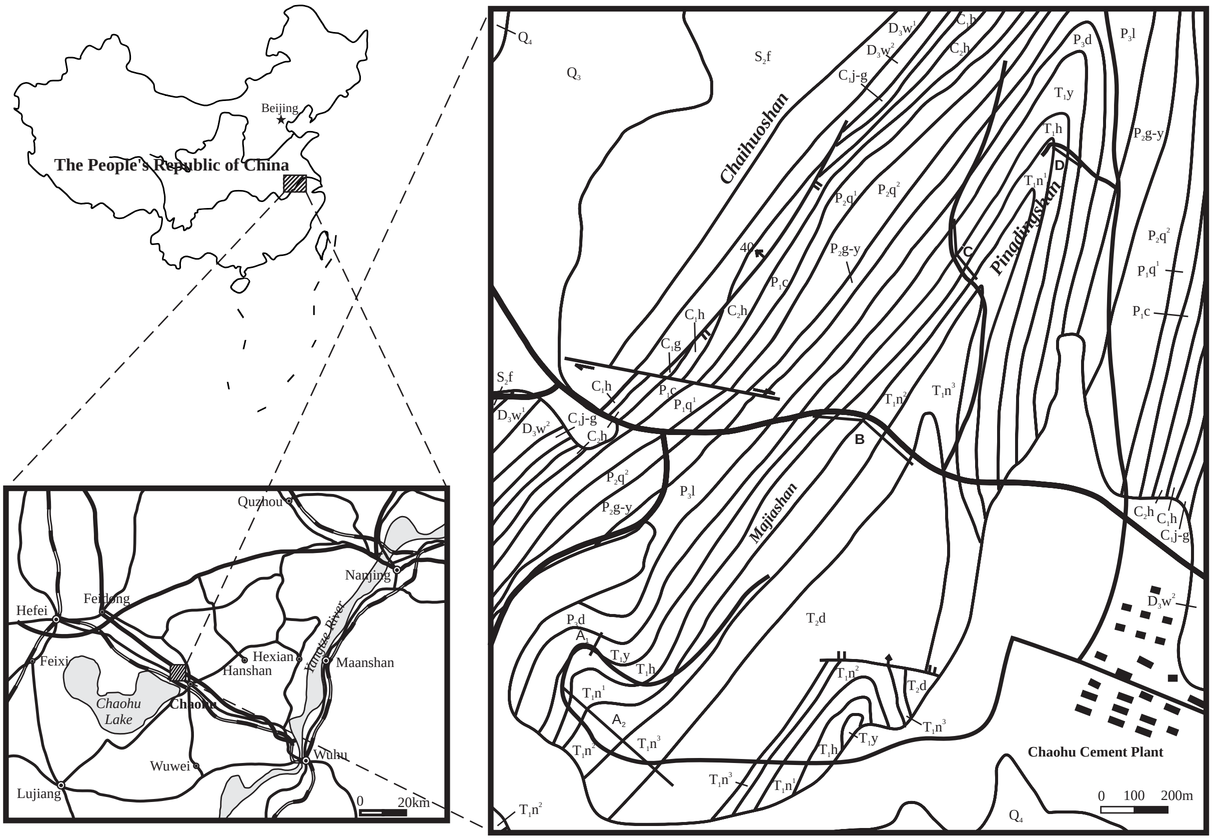

Figure 1: Regional geological map of Chaohu area, Anhui Province and the localities of the Lower Triassic sections. A1+A2 Majiashan Section, B N-Majiashan Section, C W-Pingdingshan Section D N-Pingdingshan Section

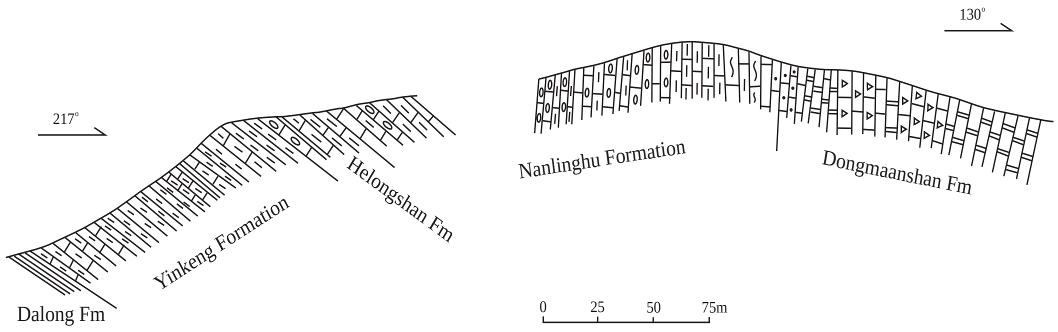

Figure 2: The Lower Triassic profile of the Majiashan Section, Chaohu, Anhui Province.

The first extension of Meishan section is on the Lower Yangtze block, where the section is located. Evidence indicates that the Lower Yangtze region (platform) was a separate block though it had a very similar sedimentary history to the Upper Yangtze platform during the Permian and Triassic (Yin et al., 1999). The Early Triassic sedimentary basin on the Lower Yangtze block was a carbonate ramp inclined northward. While the south part, where Meishan is situated, was occupied by the shallowing carbonate sediments, the north was still in relatively deep water in the most time of the early Triassic and formed fossil-rich argillaceous rocks.

The most outstanding Lower Triassic on the Lower Yangtze block is in Chaohu area, Anhui Province, where the Lower Triassic sequence is complete and rich of fossils from the PTB to the base of the Middle Triassic. In paleogeography Chaohu was in the deep part of the Lower Yangtze platform and its Lower Triassic is relatively thinner and contains more mudrocks than other areas of the Lower Yangtze region. It is at the northern edge of the present Lower Yangtze block, suturing the North China block.

The best-studied Lower Triassic sequence in Chaohu is the Majiashan Section in the north to the Chaohu Lake, about five kilometers from the center of Chaohu City. Chaohu is a mid-size city of Anhui Province and it has very good traffic, about one hour on the freeway or railway to Hefei City, the capital of Anhui Province (Fig.1). The Majiashan Section was first reported by the Anhui Geological Surveying Team (AGST) in their report of the 1:200000 Regional Geological Survey in 1978. The upper part of the Lower Triassic and the lower part of the Middle Triassic are mainly composed of carbonate rocks and they are superb materials of the cement plants so that they are quarried and exposed well. But the lower part of the Lower Triassic and the Upper Permian consist mainly of argillaceous rocks and thus usually covered heavily. During the AGST's geological survey a big prospecting trench was excavated to display all the argillaceous strata from the upper Upper Permian up to the Lower Triassic carbonate rocks. The trench had entirely exposed all the covered Lower Triassic. It was so big that it had existed for over decade and the most of the following studies were performed on its exposure. The upper part of the section is on the side of the road to the quarries of the cement plants.

The Lower Triassic of the Majiashan Section is about 270m thick (Fig.2). In lithostratigraphy it is subdivided into three formations from the lower to upper: Yinkeng Formation, Helongshan Formation and Nanlinghu Formation. The Yinkeng Fm and Helongshan Fm are predominated by mudrocks but intercalated frequently by marl and limestones to form various mudrock-marl/limestone couplets or cycles. The Nanlinghu Fm is mostly made of limestones but argillaceous components are common to form marl-limestone cycles though the argillaceous rocks are thin and inapparent in many cycles. The underlying upper Upper Permian is Dalong Formation composed of siliceous rocks and mudrocks while the overlying lower Middle Triassic, Dongmaanshan Formation, is mostly evaporites predominated by dolomites and evaporite-solution breccias. The lithological boundaries between the Lower Triassic formations and the Permian and the Middle Triassic formations are clear but not exactly coincident with the chronostratigraphic boundaries (Yin and Tong, 1995).

The fossils are very rich and diverse throughout the Lower Triassic at the Majiashan Section. The bivalves were firstly described by Li (1979) and two new genera, Periclaraia and Guichiella, were named based on the rich specimens from the section and its neighboring areas (Li and Ding, 1981a). But only three bivalve assemblages are proposed, two are in the lower, which are the basic biostratigraphic units as well in South China, and one in the upper, *P. circularis*, which is typical in the upper Lower Triassic of the region.

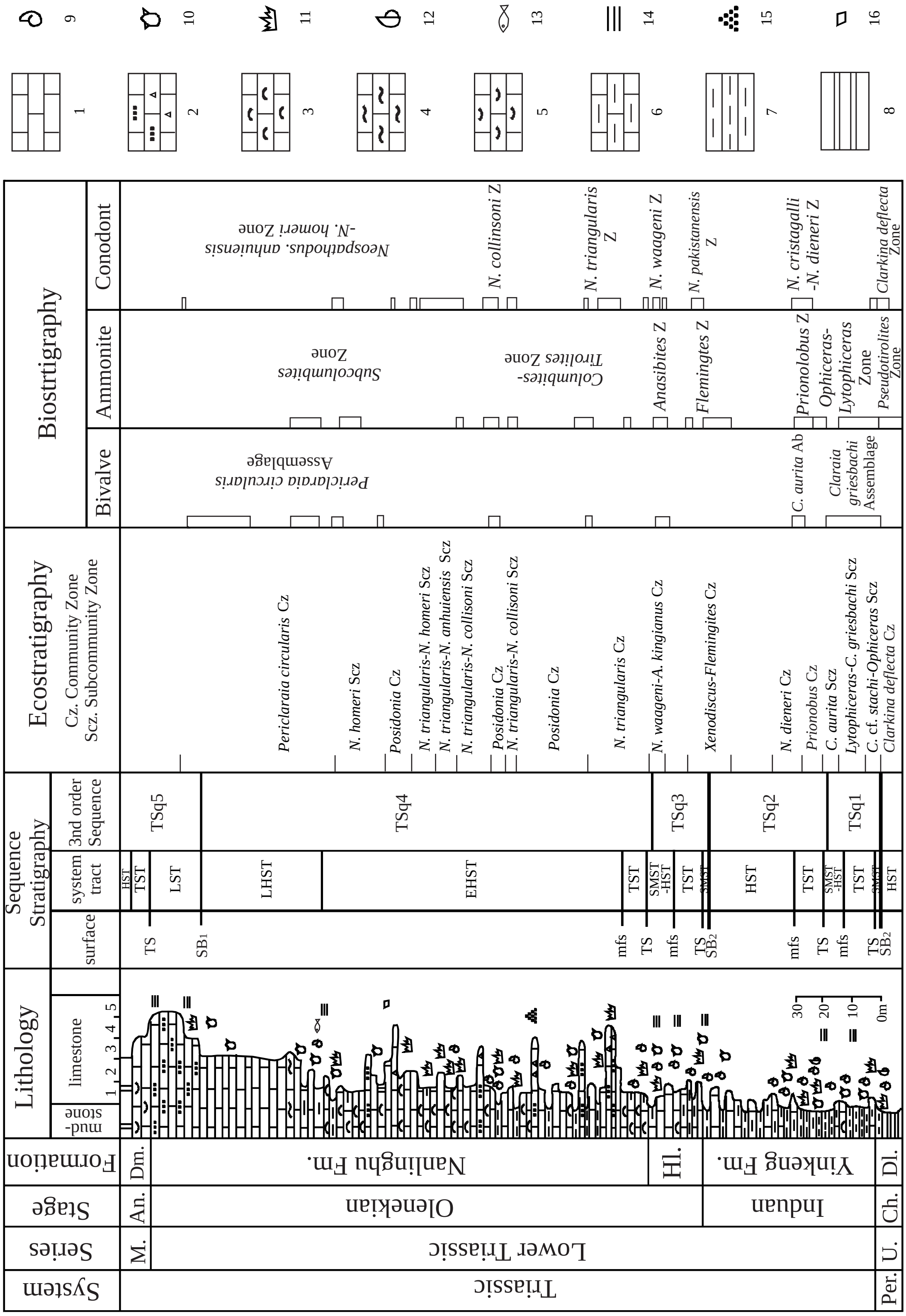

Figure 3: The comprehensive Lower Triassic sequence of the Majiashan Section, Chaohu, Anhui Province
1. micrite, 2. calcarenite-calcirudite, 3. shelly limestone, 4. myrmekite limestone, 5. nodular limestone, 6. marl, 7. mudstone, 8. siliceous rock, 9. ammonite, 10. bivalve, 11. conodont, 12. brachiopod, 13. vertebrate, 14. horizontal beddings, 15. grading beddings, 16. gypsum pseudomorph; An. Anisian, Ch. Changhsingian, Dl. Dalong Formation, Dm. Dongmaanshan Formation, EHST early highstand system tract, Hl. Helongshan Formation, HST highstand system tract, LHST late highstand system tract, LST lowstand system tract, M. Middle, mfs maxim flooding surface, Per. Permian, SMST shelf margin system tract, TS transgression surface, TST transgressive system tract, U. Upper.

Ammonoids are common and biostratigraphically significant fossils in the Lower Triassic of the Majiashan Section. Guo and Xu (1980) reported the ammonoids of the section and subdivided the Lower Triassic into six zones: *Lytophiceras-Ophiceras* Zone, *Prionolobus* Zone, *Flemingites* Zone, *Anasibirites* Zone, *Tirolites-Columbites* Zone and *Subcolumbites* Zone. These ammonoid Zones constitute the basic Lower Triassic ammonoid succession of the region but only the Majiashan Section has the whole sequence. Ding (1983) studied the Lower Triassic conodonts of the section and described six conodont zones: *Carkina carinata* Zone, *Neospathodus dieneri* Zone, *N. cristagalli* Zone, *N. waageni* Zone, *N. collinsoni* Zone and *N. anhuinensis*-*N. homeri* Zone. The further studies found a specimen of *N. pakistanensis* Zone and established *N. triangularis* Zone (Figure 3) (Yin et al., 1995). The conodonts are relatively rich in the middle and upper parts of the Lower Triassic as the lower part is composed largely of mudrocks and the top of dolomitic components. Ammonoids and conodonts are the basis of the biostratigraphical study in the Lower Triassic. The good Lower Triassic ammonoid and conodont sequences at the Majiashan Section make it outstanding in South China and it almost becomes the standard sequence in the region. The correlation of the lithostratigraphic, biostratigraphic and chronostratigraphic sequences is relatively clear.

In addition, some vertebrate fossils were collected from the Nanlinghu Formation of the Majiashan Section, including reptiles *Anhuisaurus chaoxianensis* Chen and *Chaohusaurus* sp., and *Perleidifermes*. Based on the accumulated wealthy fossil records, the ecostratigraphy had been properly applied to the Lower Triassic study of the section (Yin et al., 1995) and the Lower Triassic was divided into five community sequences: *Claraia* Community Sequence (Cs), *Neospathodus dieneri* Cs, *Flemingites* Cs, *Neospathodus triangularis* Cs and *Periclaraia circularis* Cs, and 15 community/subcommunity zones (Figure 3). These community and subcommunity zones were traced over the Lower Yangtze region (Yin et al., 1995), thus the stratigraphic resolution is greatly improved.

The ecostratigraphic achievements have been well applied to the study of the Permian and Triassic sequence stratigraphy in South China (Yin et al., 1997; Tong and Yin, 1998). The cyclic sedimentation of ramp carbonate rocks is also very helpful in the study of the sequence stratigraphy in the Lower Triassic of the Majiashan Section (Tong, 1997). Four third order sequences are subdivided in the Lower Triassic though the sequence boundaries are not exactly coincident to the chronostratigraphic boundaries (Yin and Tong, 1995). All the Lower Triassic sequences are type II sequence with sequence surface 2 (SB_2), including the sequence across the Permian and Triassic boundary (Tong and Yin, 1998; Tong et al., 1999). But the sequence across the Lower and Middle Triassic boundary is type I with SB_1 owing to the Middle Triassic regression caused by the Indosinian tectonic movement. As the Chaohu area was located in the relatively deeper part of the carbonate ramp during the Early Triassic, the sequence surfaces are not remarkable while the transgression surfaces and maxim flooding surfaces are clearly indicated by the variations of the fossil assemblages and lithological cycles (Tong, 1997; Tong and Yin, 1998).

Meanwhile, the sedimentology of the Lower Triassic at the section had been studied as well (Li and Wu, 1988). It was concluded that the Yinkeng Formation and Helongshan Formation were formed in the deeper shelf basin poor of carbonates while the Nanlinghu Formation deposited in a deep and relatively restricted carbonate basin with some intercalated beds of gravitative calcirudites in the lower part of the Formation. The basin became shallow, restricted and salty in the later of the Early Triassic and then the Anisian sediments were predominated by evaporates.

As a whole, Chaohu has the good Lower Triassic lithostratigraphical and biostratigraphical sequences, which are characteristic in South China and the Lower Triassic of the Majiashan Section is one of the best-studied sequences in stratigraphy in China. However, nowadays the Majiashan Section has a big problem. As the lower part of the Lower Triassic in the area is composed mostly of mudrocks the section was discovered by a man-made trench. All the studies were produced within this trench in the early years. But now the trench is filled in and the vegetation is blooming so that the strata are heavily covered. Moreover, the upper part of the section has been more or less quarried by the cement plants. Therefore it is hard to carry out any further successive researches at the original section in field.

These years we have found some better Lower Triassic exposures near the Majiashan Section, which are uncovered by road construction (Figure 1). Section D in Figure 1 is situated on the northern slope of the Pingdingshan Hill, which has a good exposure from the upper Dalong Formation till the Helongshan Formation. The Permian and Triassic boundary is well observed and a high-resolution cyclostratigraphy has been achieved here in the lower Yinkeng Formation on the basis of the bed-by-bed lithological and 2cm-interval elementary chemostratigraphic studies (Peng et al., 1999). At section C the road goes through the Upper Permian Longtan Formation and Dalong Formation till the

Lower Triassic Yinkeng Formation, Helongshan Formation and the lower part of Nanlinghu Formation at the western food of the Pingdingshan Hill. The section is quite continuous and all the boundaries between the formations are very distinctive but about two meters in the lower Yinkeng Formation is covered by a small road to the quarry up on the hill. Section B is on the side of the highway from Chaohu to Hefei and the Helongshan Formation and Nanlinghu Formation are well exposed here. But the detailed study at these newly discovered sections has not been reported yet. It is planed that a field excursion after the International Symposium on the Global Stratotype of the Permian-Triassic Boundary and the Paleozoic-Mesozoic Events (in Changxing on 10-13 August, 2001) will visit these sections in Chaohu. We will report the progression in the study of these sections in the coming volumes of Albertiana.

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References

Guo Peixia and Xu Jiacong, 1980, Knowledge on the age of Qinglong Group in Chaoxian, Anhui Province. Journal of Stratigraphy, 4(4): 310-315 (in Chinese).

Li Jinhua and Ding Baoliang, 1981a, Two new lamellibranch genera from Lower Triassic of Anhui. Acta Palaeontologica Sinica, 20(4): 325-330 (in Chinese with English abstract).

Li Jinhua and Ding Baoliang, 1981b, The boundary between the Lower and Middle Triassic in Lower Yangtze region. Journal of Stratigraphy, 5(1): 70-76 (in Chinese).

Province. Geology of Eastern China, (2): 96-103 (in Chinese).

Li Shangwu and Wu Shenghe, 1988, Study on petrology and sedimentary environments of the Qinglong Group of the Lower-Niddle Triassic in Chaoxian, Anhui. In: Feng Zengzhao et al. (eds.), Study on Lithofacies Paleogeography of Qinglong Group of Lower-Middle Triassic in the Lower Yangtze River Region. Yunnan Science and Technology Press, Kunming. pp.82-92 (in Chinese with English abstract).

Peng Yuanqiao, Tong Jinnan, Gao Yongqun, Zhang Jianjun, 1999, Lower Triassic Griesbachian cycle sediments in Chaohu, Anhui Province, China. In: Yin Hongfu and Tong Jinnan (eds), Proceedings of the International Conference on Pangea and the Paleozoic-Mesozoic Transition. China University of Geosciences Press, Wuhan. pp.29-34.

Sweet, W. C., Mosher, L. C., Clark, D. L., Collinson, J. W. and Hasenmueller, W. A., 1971, Conodont biostratigraphy of the Triassic. Geol. Soc. Am. Mem., 127:441-465.

Tong Jinnan and Yang Yin, 1998, Advance in the Study of the Lower Triassic Conodonts at Meishan Section, Changxing, Zhejiang Province. Chinese Science Bulletin, 43(16): 350-1353.

Tong Jinnan and Yin Hongfu, 1998, The Marine Triassic Sequence Stratigraphy of Lower Yangtze. Science in China, Series D, 41(3): 255-261.

Tong Jinnan, 1997, Lower Triassic sequence stratigraphy of Chaoxian, Anhui. Acta Geoscientia Sinica, 18(2): 215-219 (in Chinese with English abstract).

Yin Hongfu and Tong Jinnan, 1995, Relationship between sequence stratigraphical boundary and chronostratigraphical boundary. Chinese Science Bulletin, 40(16): 1357-1362.

Yin Hongfu, Ding Meihua, Zhang Kexin, Tong Jinnan, Yang Fengqing, Lai Xulong et al., 1995, Dongwuan-Indosinian Ecostratigraphy of Yangtze Platform and its Margins. Science Press, Beijing (in Chinese with detailed English summary).

Yin Hongfu, Tong Jinnan, Zhang Kexin and Wu Shunbao, 1997, Application of ecostratigraphy to sequence stratigraphy. Science in China, Series D, 40(2): 137-144.

Yin Hongfu, Wu Shunbao, Du Yuansheng and Peng Yuanqiao, 1999, South China defined as part of Tethyan archipelagic ocean system. Earth Science Journal of China University of Geosciences, 24(1): 1-12 (in Chinese with English abstract).Li Jinhua, 1979, New data of the Lower Triassic lamellibranch fossils from Chaohu, Anhui.

Palaeozoic and Mesozoic Carbon-Isotopic Macrorhythms and Macrocycles of Solar Activity

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It has been realized that the high $\delta^{13}C$ values in organogenic carbonates from selected Upper Palaeozoic and Mesozoic horizons are the testimony of an abundance of organic carbon in ocean of appropriate time and that the sharp drop of the $\delta^{13}C$ values at Permian-Triassic and Cretaceous-Tertiary boundary transitions coincides with reduction of organic carbon accumulation (Magaritz et al., 1981, 1983, 1986, 1988, 1991; Magaritz & Turner, 1982; Anderson & Arthur, 1983; Holser, 1984; Holser & Magaritz, 1985; Holser et al., 1986, 1991; Zachos & Arthur, 1986; Baud et al., 1989, 1995; Zachos et al., 1989; Magaritz & Holser, 1991; Alcala-Herrara et al., 1992; Yang, 1992; Anderson et al., 1994; Jenkyns et al., 1994; Naidin & Kiyashko, 1994; Hirano & Takagi, 1995; Jenkyns et al., 1995; Hirano & Fukuju, 1997; Foster et al., 1998; Atudorei, 1999; Baud et al., 1999; Jenkins, 2000; Ando et al., 2000; Zakharov et al., 2000a; Zakharov et al., 2001a, in press among others). According to the opinions by previous authors, the degree of enrichment by a heavy isotope ^{13}C appears to reflect intensity of exception of a light isotope ^{12}C during photosynthesis, i.e. intensity of organic production.

As suggested by Alcala-Herrera et al. (1992), some variations in $^{13}C/^{12}C$ ratios recorded in deep-water marine organogenic carbonates might be controlled by such environmental factors as the carbon budget, upwelling and primary productivity. It is difficult to separate the effect of each of these factors in deep-water conditions; but when worldwide carbon isotope shifts are observed in shallow-water carbonates, they are generally attributed to changes in primary biological productivity, first of all in phytoplankton one. Therefore, $\delta^{13}C$ value can be used for a measure of biological productivity of ancient shallow seas. Agreeing with such rough, approximate estimation of the data on $\delta^{13}C$, Weimarn et al. (1998), however, scored that not any weighting of carbonate carbon can be treated so, as the carbon-isotopic anomalies in number of cases grow out of composite effect of many factors.

The peculiarities in distribution of some producents (phytoplankton), one of main utilizators of a solar energy on the surface of the present day ocean, are now well investigated (Bogorov, 1974). Their main biomass is contained in an upper 100-meter water mass that is connected with a feature of photosynthesis, but their location in it depends first of all on a degree of hydrological intermixing of waters under influence of considerable thermal gradients and winds and their distribution. The phytoplankton productivity is great in areas characterized by an intensive vertical circulation (boreal realms and the zone of equatorial uprising of waters between 10-12^{o} of Northern latitudes and 7-8^{o} of Southern latitudes). The uprising of deep waters reduces enrichment of surface layer by nutritious substances that promotes increase of phytoplankton production and intensity of its photosynthesis. The small amount of plankton in Recent Arctic and Antarctic seems to be originated in the short vegetal period of a phytoplankton of high latitudes.

In time of absence of polar ice on the Earth (it is expected at least for the significant part of Late Palaeozoic and Mesozoic) hydrological conditions, probably, considerably differed from Recent ones first of all in an "unusual" poleward transport of large equatorial warm water masses and weaker vertical circulation of waters in some climatic zones. During that time, another sort of regularities in distribution of phytoplankton in the surface layer of the ocean, apparently, took place, therefore the actual method for isotopic investigation of Phanerozoic organogenic carbonates can be applied only with considerable stipulation.

Recently, Pokrovsky, Letnikov and Samylin (1999) proposed a model which is compatible with observations on the Recent ocean and with the data on Quaternary glacial period: the high $\delta^{13}C$ values in carbonates of the Lower Proterozoic, Upper Rhyphean, Vendian and Permian seem to be connected with conditions of largest glacial epochs. We must briefly remark that their reference to Bauds et al. (1989) who examined the isotopic compositions of Upper Permian carbonates is not appropriate, but there is another publication (Rao, 1988) showing that Lower Permian Berriedale Limestone of Tasmania, formed, as they believed, during Main Gondwanian glacial epoch, is also characterized by anomalously high $\delta^{13}C$ values (up to +5.4‰).

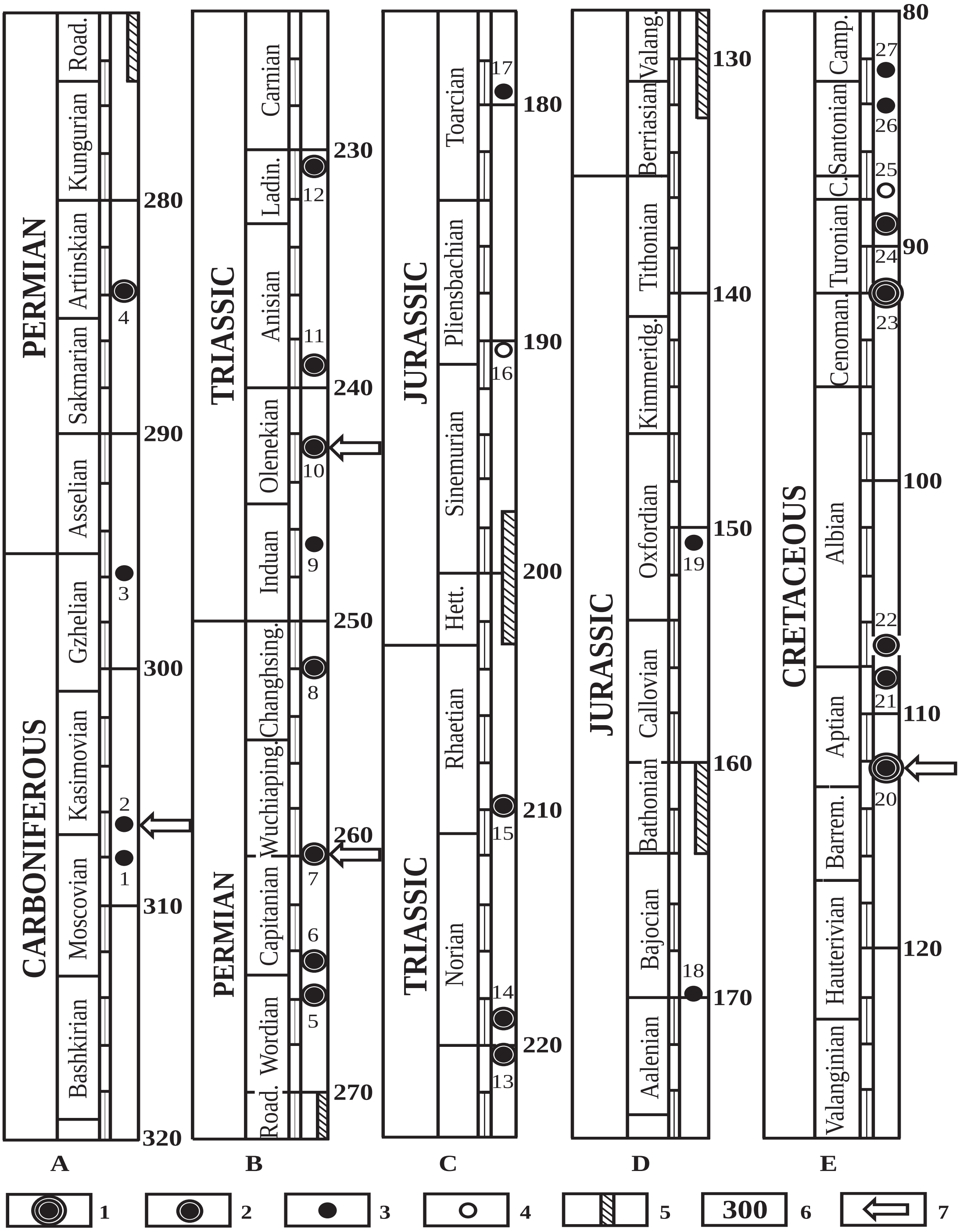

Figure 1:Late Palaeozoic and Mesozoic δ^{13}C anomalies. 1 – anomalies discovered in many localities and their number, 2 - anomalies discovered in some (2-7) localities and their number, 3 – anomaly discovered in a single locality and its number, 4 - anomaly in question and its number, 5 – brighest Phanerozoic event (d^{13}C more than 6‰, 6 - uninspected interval, 7 – age in Ma. Road. – Roadian, Wuchiaping. – Wuchiapingian, Changhsing. – Changhsingian, Ladin. – Ladinian, Hett. – Hettangian, Kimmeridg. – Kimmeridgian, Valang. – Valanginian, Barrem. – Barremian, Cenoman. – Cenomanian, C. – Coniacian, Camp. – Campanian. Information on 1-27 see in the text.

However, the present study, based on data from selected horizons of post-Sakmarian carbonates, characterized by high δ^{13}C values suggests that they were formed in more or less warm climate during eustatic transgressions. This interpretation is supported by following facts: (1) the primary concentration of a heavy oxygen-isotope in them is low, being comparable to temperatures of 19.6-27.9^{o}C ; which came from calcite of well-preserved brachiopod shells

No	Type	Duration MA
1	*Microcycle of solar activity (levels 1-3)*	*11^{-6}-1^{-3}*
2	*Macrocycle of solar activity*	*1.5-12.0, less often up to 15-18*
3	*Megacycle of solar activity*	*About 300*

Table 1. *Typification of cycles of solar activity, established in the present paper.*

from the Capitanian-Wuchiapingian transition beds in Transcaucasia (Zakharov et al., 1997), upper Lower Changhsingian of Transcaucasia (Zakharov et al., 1997) and North Caucasus (Zakharov et al., 2000a), and aragonitic portion of Inoceramus shells from the upper Santonian of Hokkaido (Zakharov et al., 1999), (2) calcitic material from the positive $d^{13}C$ anomalies is mostly characterized by high content of magnesium (Zakharov et al., 1997, 2000a); (3) sediment rocks showing positive anomalies record tracks of particular biological events, being represented by high taxonomic diversity of their fossils, which is common for assemblages of tropical and subtropical facies (Zakharov et al., 2001a, in press).

The stably warm climatic conditions at the time of eustatic transgressions promoted a high bioproductivity of the seas, and intensive photosynthesis, repeatedly arose during Phanerozoic. As was shown by Gao (1993), the Lower Devonian limestone of Central Oklachoma with approximately +2.6‰ $\delta^{13}C$ values was formed at temperature of about 25°C. The analysis of many positive carbon-isotopic anomalies made it possible to assume that during Late Palaeozoic and Mesozoic there were at least about 27 events, fixed by them, most part of which proved to be global.

(1) Moscovian. The anomaly (5.6‰) was discovered in Spain (Scotese et al., 1979) (Fig.1).

(2) Kasimovian. The anomaly (6.2‰) locates in Spain (Scotese et al., 1979). There are some problems in correlating the anomaly with the anomaly (5.6‰) known in the Winchell Formation (Missourian) in Texas (Grossman et al., 1991).

(3) Gzhelian (middle-late Virgilian) anomaly is known from the Colony Creek shale (5.6‰), shales of the Finis (4.3‰), Necessity (4.5‰) and Wayland (5.5‰) members of the Graham Formation (Virgilian) of Texas (Grossman et al., 1991),.

(4) Early Permian (Artinskian?). An anomaly was found in Kabayama Limestone of the Sakamotozawa Formation in Kitakami, Japan (4.7‰; Zakharov et al., 2000c). Anomaly (up to 5.4‰) discovered in Lower Permian Berriedale Limestone of Tasmania (Rao, 1988) seems to be the same age.

(5) Wordian. Anomalies of the Wordian level were observed on the basis of limestones of the two sections in Oman: in the Member A of the Maquam Formation (5.4‰) in the Wadi Maquam section and in the Unit 2 of the Wordian in the Wadi Wasit section (5.1‰) (Atudorei, 1999). It seems to be present also in the same level (Unit 2 of the Wargal Formation) of Salt Range (4.8‰) (Atudorei, 1999).

(6) Early Capitanian. Abnormally high $\delta^{13}C$ values were recognized in limestones of the Kattisawa member of the Kanokura Formation (4.5‰) (Zakharov et al., 2000c) and member 4a of the Wargal Formation in Salt Range (5.3‰) (Baud et al., 1995; Atudorei, 1999).

(7) Latest Capitanian - Earliest Wuchiapingian. Anomalies of the Capitanian-Wuchiapingian boundary transition were found in organogenic carbonates of many localities: Bell Canyon (upper part) (more than 3‰) and Castile (lower part) (6.5‰) Formations in Texas (Magaritz et al., 1983), Iwaizaki member of the Kanokura Formation in Kitakami (4.1‰) (Zakharov et al., 2000c), upper Chandalaz Formation (3.8‰) and Nakhodka reef limestone (4.1‰) in South Primorye (Zakharov et al., 1996), upper Khachik Formation in Transcaucasia (4.0 ‰) (Zakharov et al., 1997), lower unit of the Bellerophon Formation in the Alps (3.5‰) (Holser & Magaritz, 1985), Zechstein Formation of western Europe (Magaritz & Turner, 1982) and, apparently, the upper part of the Wargal Formation in Salt Range (5.4‰) (Baud et al., 1995; Atudorei, 1999) and the middle part of the Kapp Starostin Formation in West Spitsbergen (7.3‰) (Gruszczynski et al. 1983; Wignall et al., 1998).

(8) Early Late Changhsingian. Anomalies of the Upper Changhsingian level were discovered from organogenic carbonates of the three localities: Nikitin Limestone of North Caucasus (4.7‰) (Zakharov et al., 2000a), upper Akhura Formation in Transcaucasia (2.8‰) and lower Upper Changhsingian in South China (5.1‰) (Chen et al., 1984).

(9) Middle Induan - ?Early Olenekian. The 3.2-4.0‰ shifts of approximately Middle Induan-Lower Olenekian level were recorded in limestone exotics of Oman (Atudorei, 1999).

(10) Middle Olenekian. Anomalies of the *Tirolites* beds were discovered in limestones of the four Russian localities: Schmidt Formation of Primorye re-

gion (4.9‰) (Zakharov et al., 2000b), Yatyrgvart Formation of Belaya River (3.6‰), Sakhrai River (4.2‰), and Malaya Laba River (6.9‰) basins in North Caucasus (Zakharov et al., 2000a). According N.-V. Atudorei's (1999) data, the two additional positive excursions apparently of the same level in the Himalaya occur: in limestones of the middle part of the Mianwali Formation in Salt Range (4.7‰) and the middle part of the Tamba Kurkur Formation in Spiti (2.6‰).

(11) Early Anisian. Lower Anisian anomalies were discovered from limestones of the four localities: lower Malotkhachskaya Formation of Kapustin Ravine in North Caucasus (3.5‰) (Zakharov et al., 2000a), base of Nity Limestone of the Kurkur Formation in Kashmir (2.6‰) (Atudorei,1999), member A2 of Mottoled Limestone in North Dobrogea (more than 4‰) (Atudorei, 1999) and lower part of the Aegean of Albania (4.3‰) (Atudorei, 1999).

(12) Latest Ladinian – Lowermost Carnian. Anomalies of this level were discovered in Coryphyllia moiseevi beds of a large olistolite in the Lower Cretaceous olistostrome of Sikhote-Alin) (2.6‰) (Zakharov et al, 2000b) and lower part of Enisala Limestone of North Dobrogea (3.2‰) (Atudorei, 1999).

(13) Late Carnian. Upper Carnian anomalies have been discovered in limestones at the two localities: Opponiz Formation in the Alps (3.5‰) (Zakharov et al., 2000b) and Congaz Formation in Dobrogea (3.9‰) (Atudorei,1999).

(14) Early Norian. Lower Norian anomalies are known only in Russian territory: in *Margarosmilia melnikovae* beds of a large olistolith in the Lower Cretaceous olistostrome of Sikhote-Alin) (3.1‰) (Zakharov et al, 2000b) and limestones of the Shapkinskaya Formation of the Kuna River in North Caucasus (2.6‰).

(15) Early Rhaetian. Abnormally high $\delta^{13}C$ values of the Norian-Rhaetian transition beds of the Shapkinskaya Formation in North Caucasus were discovered in limestones at the three localities: Bzhebs (2.8‰) and Sakhrai (2.5‰) Rivers, and Tkhach-Bakh River watershed (2.5‰) (Zakharov et al., 2000a). The high $d^{13}C$ value (2.79‰) was identified also in the carbonates of the lower unit of the Koessen Formation in the Alps (Morante & Hallam, 1996).

(16) Early Pliensbachian. High $\delta^{13}C$ values (up to 2.6‰) were discovered recently at the Sinemurian-Pliensbachian boundary horizon (Redcar Mudstone Formation, bed 73) (Hesselbo et al., 2000).

(17) Toarcian. High positive $\delta^{13}C$ values (up to 4.4‰) occur in the Toarcian limestones of Siberia (Ignatiev et al., 1982).

(18) Aalenian-Bajocian. Abnormally high $\delta^{13}C$ values (about 4.0‰) were discovered in belemnite rostra from Passet member of KongsØya Formation of Kong Karls Land, Svalbard (Ditchfield, 1997).

(19). Oxfordian. The shift of $\delta^{13}C$ (3.0‰) was recognized in Oxfordian carbonates of England (Anderson et al., 1994).

(20) Early Aptian. Lower Aptian anomalies were discovered in organogenic carbonates from various regions of the world, including the Alps (4.5‰) (Erbacher, 1994) and the Koryak Upland (6.8‰) (Zakharov et al., 2001b, in press).

(21) Late Aptian. Upper Aptian anomalies were also distinguished in carbonates of western Europe (4.0‰) (Erbacher, 1994).

(22) Early Albian. Lower Albian anomaly (3.0‰) is known from carbonates of western Europe (Erbacher, 1994). Within large interval, from upper Albian to upper Cenomanian no $\delta^{13}C$ anomalies have been discovered (Price et al., 1998).

(23) Cenomanian-Turonian. Abnormally high $\delta^{13}C$ values (up to 4.7‰) were discovered from the Cenomanian-Turonian transition beds in carbonates of many regions of the world, including the Alps, South England and Tibet (Boersma & Schackleton, 1981; Douglas & Savin, 1973, 1975; Zachos & Arthur, 1986; Erbacher, 1994; Naidin & Kiyashko, 1994; Weimarn et al., 1998; Wan & Wang, 2000).

(24) Late Turonian. Upper Turonian $\delta^{13}C$ anomalies were discovered in the upper Penzhinskaya Formation of the Mamet River, Koryak Upland (up to 3.9‰) (Zakharov et al., 2001b, in press); Lewes Marl (3.46‰), Southstreet Marl (5.51‰), Zoophycus bed (3.61‰) and Snowdrop Flint 1 (3.15‰) of Navigation Pit, England; Bridgewick Marl 3 (3.64‰), Lewes Marl (4.18‰) and Navigation Marl 1 (3.34‰) of Shoreham, England; Bridgewick 2 (3.72‰) of Dover, England; Bridgewick 2 (3.04‰) of St. Margaret's Bay, England; Hitchwood Hardground ((3.29‰) of Kensworth, England; Glynde Marl 4 (3.08‰) of New Pit, England (Voigt, 2000); Micraster Marl (3.82‰) of Soehlde quarry, Germany; and upper Turonian (3.77‰) of Salzgitter-Salder quarry, Germany (Voigt, 2000).

(25) Coniacian. Abnormally high $\delta^{13}C$ value (up 5.0‰) was recently discovered by us only in aragonite of the single Coniacian inoceramid shell from the lower Haborogawa Formation, Inoceramus uwajimensis Zone in the Yutakazawa River, Hokkaido and therefore the existence of the Coniacian anomaly needs in verification (Zakharov et al., in prep.).

(26) Late Santonian. Comparativelly high $\delta^{13}C$ val-

ues (up 2.5‰) were recognized in some ammonoid shells from the middle Upper Yezo Group of Hokkaido (Zakharov et al., 1999).

(27) Early Campanian. Abnormally high $\delta^{13}C$ values (3.0-3.7‰) were obtained from lower Campanian planktonic foraminifers of Falkland Plateau, South Atlantic (Huber et al., 1995).

We can consider the four brightest Phanerozoic events, which were probably reflected by the greatest phytoplankton heyday and, accordingly, by an intensive photosynthesis: Kasimovian ($\delta^{13}C$ = 6.2‰) (Scotese et al., 1979), Capitanian-Wuchiapingian (6.5-7.3‰) (Gruszczynski et al.,1983; Magaritz et al., 1983), middle Olenekian (6.9‰) (Zakharov et al., 2000a) and Early Aptian (6.8‰) (Zakharov et al, 2001b, in press).

Thus, the data on isotopic composition of organogenic carbonates testify that the carbon-isotopic anomalies in many periods of the Phanerozoic appreciably are reflection of climatic fluctuation. Their positive maxima during the end of Paleozoic and Mesozoic fell, probably, on warm epochs caused by several factors, main of which seem to be: (1) rise of solar activity (Shcherbinovskij, 1964; Chistyakov, 1997), (2) macropulsations of an energy core of the sun (Chistyakov, 1997) and (3) number of astronomical variations (Milankovich, 1939; Lungersgausen, 1964; Naidin, 1989; Bolshakov & Bolshakov, 1999).

About eight solar cycles (Chistyakov, 1997, 1999) distinguishing on their duration are known now.

All eleven-year, secular and thousand-year cycles, confirmed by data on oxygen-isotopic rhythms of Quaternary carbonates (Naidin, 1989), sediment recurrence of evaporites of the Permian Zechstein Formation (Richter-Bernburg, 1968), and tape-clay and some other sediments of the Upper Cenozoic (Lungershausen, 1964; Zubakov. 1984; Chistyakov, 1997), we offer to name as solar microcycles of the different levels.

300 Ma-year cycles (Chistyakov, 1997), based on periodicity of largest glacial epochs, can be called, in our opinion, as solar megacycles (Table 1).

Carbon-isotopic macrorhythms of Late Palaeozoic and Mesozoic demonstrated here (Fig. 1) may testify to the existence of also cycles of solar activity of an intermediate type (solar macrocycles) by duration from 1.5 up to 12 Ma, less often up to 15-18 Ma.

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References

Alcala–Herrera, J. A., Grossman, E. L. & Gartner, S. 1992. Nannofossils diversity and equitability and fine–fraction $\delta^{13}C$ across the Cretaceous/Tertiary boundary at Walvis Ridge Leg 74, South Atlantic. Marine Micropaleontology, 20(1): 77-88.

Anderson, T. F. & Arthur, M. A. 1983. Stable isotopes of oxygen and carbon and their application to sedimentological and palaeoenvironmental problems. SEPM Short Course, 10: 1-151.

Anderson, T. F., Popp, B. N., Williams, A. C., Ho, L.-Z. & Hudson, J. D. 1994. The stable isotopic records of fossils from the Peterborough Member, Oxford Clay Formation (Jurassic), U.K.: paleoenvironmental implications. J. Geol. Soc., London, 151: 125-138.

Atudorei, N. V. 1999. Constraints on the Upper Permian to Upper Triassic marine carbon isotope curve. Case studies from the Tethys, 161 pp. PhD Thesis. Lausanne: University of Lausanne.

Ando, A. Saito, T., Kakegawa, T. & Kaiho, K. 2000. Aptian carbon-isotope stratigraphy based on terrestrial organic carbon: data from the Cretaceous Sorachi and Yezo Groups in Hokkaido, northern Japan. First Intern. Symposium of carbon cycle and bio-diversity change during the Cretaceous. Programs and Abstracts, p. 41. Tokyo, Waseda Univ.

Baud, A., Atudorei, V. & Marcoux, J. 1999. The Permian–Triassic boundary interval (PTBI) in Oman: carbon isotope and facies change. Pangea and the Paleozoic-Mesozoic transition, p.88-89. Wuhan: China Univ. of Geosci. Press.

Baud, A., Atudorei, V. & Sharp, Z. 1995. The Upper Permian of the Salt Range area revisited: New stable isotope data. Permophiles, 1995(27): 39-41.

Baud, A. M., Magaritz, M. & Holser, W. T. 1989.

Permian-Triassic of the Tethys: carbon isotope stratigraphy. Geol. Rundschau, 78: 649-677.

Boersma, A. & Shackleton, N. J. 1981. Oxygen and carbon isotope variations and planktonic-foraminifer depth habitats, late Cretaceous to Paleocene, Central Pacific, Deep Sea Drilling Project sites 463 and 465. In: J. Thiede, T.L. Vollier et al. (editors), Initial reports of the Deep Sea Drilling Project, 62: 513-526.

Bogorov, V. G. 1974. Plankton Mirovogo okeana (Plankton of World ocean), 320 pp.. Moskva, Nauka (in Russian).

Bolshakov, V. A. & Bolshakov, P. V. 1999 Astronomical theory of palaeoclimate – a new conception. Stratigraphiya. Geologicheskaya korrelyatsiya, 7(6): 3-13 (in Russian).

Chen, M., Shao, M., Huo, W. & Yao, Y. 1984. Carbon isotopes of carbonate strata at Permian-Triassic boundary in Changxing, Zhejiang. Sci. Geol. Sinica, 1: 88-93.

Chistyakov, V. F. 1997. Solar cycles and climatic fluctuation. Trudy Ussurijskoj astrophizicheskoj observatorii, 1997(1): 1-156 Vladivostok, Dalnauka (in Russian).

Ditchfield, P. W. 1997. High northern palaeolatitude Jurassic-Cretaceous palaeotemperature variation: new data from Kong Karls Land, Svalbard. Palaeogeography,Palaeoclimatology, Palaeoecology, 130: 163-175.

Douglas, R. G. & Savin, S. M. 1973. Oxygen and carbon isotope analyses of Cretaceous and Tertiary foraminifera from the central North Pacific. In: N. T. Edgar, J. B. Saunders (editors), Initial Reports of the Deep Sea Drillings Project, 17: 591-605.

Douglas, R. G. & Savin, S. M. 1975. Oxygen and carbon isotope analyses of Tertiary and Cretaceous microfossils from Shatsky Rise and other sites in the North Pacific Ocean. In: R.L. Larson, R. Moberly et al. (editors), Initial Reports of the Deep Sea Drillings Project, 32: 509-520.

Chistyakov, V. F. 1999. Solar activity and the periodicity El-Ninyo. Vestnik DVO RAN, 1999(5): 59-68 (in Russian).

Erbacher, J. 1994. Entwicklung und Palaeoozeanographie mittelkretazischer Radiolarien der westlichen Tethys (Italien) und des Nordatlantiks. Tuebinger Micropalaeontol. Mitteil. 1994(12): 1-139.

Foster,C. B., Logan, G. A. & Summons, R. E. 1988. The Permian-Triassic boundary in Australia: where is it and how is it expressed? In: G.R. Shi, N.W. Archbold & M. Grover, The Permian system: stratigraphy, palaeogeography and resources, p. 247-266. Melbourne, Royal Soc. Victoria.

Gao, Guoqiu. 1993. The temperatures and oxygen-isotope composition of Early Devonian Oceans. Nature, 361(6414): 712-714.

Grossman, E. L., Hang, C. Z. & Yancey, T. E. 1991. Stable-isotope stratigraphy of brachiopods from Pensilvanian shales in Texas. Geol. Soc. Amer. Bull., 103: 953-965.

Gruszczynski, M., Halas, S., Hoffman, A. & Malkowski, K. 1989. A braschiopod calcite record of the oceanic carbon and oxygen isotope shifts at the Permian/Triassic transition. Nature, 337(6202): 64-68.

Hesselbo, S. P., Meister, C. & Groecker, D. R. 2000. A potential global stratotype for the Sinemurian-Pliensbachian boundary (lower Jurassic), Robin Hood's Bay, UK: ammonite faunas and isotope stratigraphy. Geol. Mag., 137(6): 601-607.

Hirano, H. & Fukuju, T. 1997. Lower Cretaceous oceanic anoxic event in the Lower Yezo Group, Hokkaido, Japan. Journ. Geol. Soc. Philippines, 52(3-4): 173-182.

Hirano, H. & Takagi, K. 1995. Cretaceous oceanic anoxias in northwestern Pacific (current conditions and prospect of research). Proceedings of 15th Intern. Symp. of Kyungpook Nat. University, p. 343-355.

Holser, W. T. 1984. Gradual and abrupt shifts in ocean chemistry during Phanerozoic time. Patterns of change in Earth evolution, S. 123-144. Berlin, Heidelberg, New York, Tokyo, Springer-Verlag.

Holser, W. & Magaritz, M. 1985. The Late Permian carbon isotope anomaly in the Bellerophon basin, Carnic and Dolomite Alps. Jb. Geol. Bundesanstalt, 128(1): 75-82.

Holser, W., Magaritz, M. & Clark, D.L. 1986. Carbon-isotope stratigraphic correlations in the Late Permian. Amer. J. Sci., 286: 390-402.

Holser, W. T., Schoenlaub, H. P. Boeckelmann, K. & Magaritz, M. 1991. The Permian-Triassic of the Gartnerkofel-1 core: synthesis and conclusions. Abhandl. Geol. Bundesanstalt, 45:213-232.

Huber, B. T., Hodell, D. A. & Hamilton, C. P. 1995. Middle-Late Cretaceous climate of the southern high latitudes: Stable isotopic evidence for minimal equator-to pole thermal gradients. Geol. Soc. Amer., Bull., 107: 1164-1191.

Ignatiev, A.V., Nikolaev, V.I & Strizhov, V. P. 1982. On anomalously high $\delta^{13}C$ values in some organic carbonates. IX Vsesoyuzn. Simpozium po stabilnym izotopam v geokhimii (IX All-Union Symposium on Stable Isotopes in Geohemistry). 2, p. 404-406. Moskva (in Russian).

Jenkins, H. C. 1980. Cretaceous anoxic events: From continents to oceans. Geol. Soc. London J., 137: 171-188.

Jenkins, H. 2000. Cretaceous oceanic anoxic events and carbon isotopes : implications for global change. First Intern. Symp. of carbon cycle and bio-diversity change during the Cretaceous. Programs and Abstracts, p. 58-59. Tokyo, Waseda Univ.

Jenkyns, H. C., Gale, A. S. & Corfield, R. M. 1994. Carbon-oxygen-isotope stratigraphy of the English Chalk and Italian Scaglia and its palaeoclimatic significance. Geological Magazine, 131: 1-34.

Jenkyns, H. C., Mutterlose, J. & Sliter, W. V. 1995. Upper Cretaceous carbon- and oxygen isotope stratigraphy of deep–water sediments from the north–central Pacific (Site 869, Flank of Pikinni – Wodejebato, Marshall Islands). PODP, Scientific Results, 143: 105-108.

Lungershausen, G. F. 1964. On periodical climatic fluctuation in geological past of the Earth. In: V.V. Fedynsky (redactor), Zemlya vo vselennoj (Earth in the universe), p. 260-277. Moskva, Mysl (in Russian).

Magaritz, M., Anderson, R. Y., Holser, W. T., SALTZMAN, E. S. & GARBER, J. 1983. Isotope shifts in the Late Permian of the Delaware Basin, Texas, precisely timed by varved sediments. Earth Planet. Sci. Lett., 66: 111-124.

Magaritz, M., Bar, R., Baud, A. & Holser, W. T. 1988. The carbon isotope shift at the Permian/Triassic boundary in the southern Alps is gradual. Nature, 331: 337-339.

Magaritz, M. & Holser, W. T. 1991. The Permian-Triassic of the Gartnerkofel-1 core (Carnic Alps, Austria): carbon and oxygen isotope variation. Abhandl. Geol. Bundesanstalt, 45: 149-163.

Magaritz, M. & Turner, P. 1982. Carbon cycle changes of the Zechstein sea: isotopic transition zone in the Marl Slate. Nature, 297: 389-390.

Magaritz, M., Turner, P. & Kading, K.-Ch. 1981. Carbon isotopic change at the base of the Upper Permian Zechstein sequence. Geologisches Jahrbuch, 16: 243-254.

Milankovi*f*, M. 1939. Matematicheskaya klimatologiya i astronomicheskaya teoriya kolebanij klimata (Mathematical climatology and astronomical theory on climatic fluctuation), 207 pp. Moskva-Leningrad, GONTI (in Russian).

Morante, R. & Hallam, A. 1996. Organic carbon isotopic record across the Triassic-Jurassic boundary in Austria and its bearing on the cause of the mass extinction. Geology, 24(5): 391-394.

Naidin, D. P. 1989. Astronomical variation, climatic fluctuation and carbonate rhythms. Paper 1. Actual reasons. Data on Earth orbit and climate. Izvestiya vuzov. Geol. i razvedka, 1989(10): 35-47 (in Russian).

Naidin, D. P. & Kiyashko, S. I. 1994. Geochemical characteristics of the Cenomanian-Turonian boundary transition beds on Mountainous Crimea. Paper 2. Carbon and oxygen isotopic composition; conditions for organic carbon origin. Bull. MOIP, Otd. Geol., 69(2): 59-74 (in Russian).

Pokrovsky, B. G., Letnikov, E. F. & Samylin, S. G. 1999. Isotopic stratigraphy for Boksonskaya Series, Vendian-Cambrian, of Eastern Sayan. Stratigr. Geol. Korrelyatsiya, 7(3): 23-41 (in Russian).

Price, G. D., Sellwood, B. W., Corfield, R. M., Clarke, L. & Cartlidge, J. E. 1998. Isotopic evidence for palaetemperatures and depth stratification of Middle Cretaceous planktonic foraminifera from the Pacific Ocean. Geol. Mag., 135(2): 183-191.

Rao, C. P. 1988. Oxygen and carbon isotope composition of cold-water Berriedale Limestone (Lower Permian Tasmania, Australia). Sedimentary Geology, 60: 221-231.

Richter-Bernbourg, H. 1968. Influence of the cycles of solar activity and some other climatic cycles on formation of thin-bedded evaporites. In: A. E. M. Nairn (editor), Problemy paleoklimatologii, p. 336-344. Moskva, Mir (in Russian).

Scotese, C. R., Bambach, R. K., Barton, C., Van der Voo, R., Ziegler, A. M. 1979. Paleozoic base maps. J. Geol. 87: 217-277.

Shcherbinovsky, N. S. 1964. Rhythms of mass reproduction of organisms caused by cyclic solar activity. In: V.V. Fedynsky (redactor), Zemlya vo vselennoj (Earth in the Universe), p. 400-417. Moskva, Mysl (in Russian).

Voigt, S. 2000. Stable oxygen and carbon isotopes from brachiopods of southern England and northwestern Germany: estimation of Upper Turonian palaeotemperatures, Geological Magazin, 137(6): 687-703.

Wan Xiaoqiao & Wang Chengshan. 2000. The $\delta^{13}C$ records from Cenomanian-Turonian passage beds of Gamba, Tibet. . First Intern. Symp. of carbon cycle and bio-diversity change during the Cretaceous. Programs and Abstracts, p. 68. Tokyo, Waseda Univ.

Weimarn, A. B., Naidin, D. P., Kopaevich, L. F., Alekseev, A. S., & Nazarov, M. A. 1998. Metody analiza globalnykh sobytij pri detalnykh stratigraphicheskikh issledovaniyakh. Metodicheskie rekomendatsii (Methods of analysis of global catastrophic events for detail stratigraphical studies. Methodical recomendation), 190 pp. Moskva, Izd. MGU. (in Russian).

Wignall, P. B., Morante, R. & Newton, R. 1998. The Permo-Triassic transition in Spitsbergen: $*^{13}C_{org}$ chemostratigraphy, Fe and S geochemistry, facies and trace fossils. Geol. Mag., 135(1): 47-62.

Yang Zunyi & Lian-Pang YE. 1992. Carbon isotope event markers near the K/T boundary at Shanshan section, Kingjiang, China. 29th Int. Geol. Congr. Abstr., 1: 236. Kyoto.

Yin Hongfu & Zhang Kexin. 1996. Eventostratigraphy of the Permian-Triassic boundary at Meishan section, South China. In: Yin Hongfu (editor), The Palaeozoic-Mesozoic boundary candidates of global stratotype section and point of the Permian-Triassic boundary, p. 84-96. Wuhan, China Univ. of Geosci. Press.

Zachos, J. C. & Arthur, M. A. 1986. Paleoceanography of the Cretaceous/Paleogene boundary event: Inferences from stable isotopic and other data. Paleoceanography, 1986(1): 5-26.

Zakharov, Y. D., Boriskina, N. G., Ignatiev, A. V., Tanabe, K., Shigeta, Y., Popov, A. M., Afanasyeva, T. B. & Maeda, H. 1999. Palaeotemperature curve for the Late Cretaceous of the northwestern circum-Pacific. Cretaceous Research, 20: 685-697.

Zakharov, Y. D., Boriskina, N. G. & Popov, A. M. 2001a (in press). Rekonstruktsiya uslovij morskoj sredy pozdnego paleozoya i mezozoya po izotopnym dannym (na primere severa Evrazii) (The reconstruction of Late Paleozoic and Mesozoic marine environments from isotopic data (evidence from North Eurasia)). Vladivostok, Dalnauka.

Zakharov, Y.D., Ignatyev, A.V., Kotlyar, G.V., Ukhaneva, N.G. & Cherbadzhi, A.K. 1996. Stable carbon isotopes and Ca-Mg ratio in the Permian-Triassic carbonates and mass extinction. Geol. of Pac. Ocean, 13: 1-20.

Zakharov, Y. D., Ignatiev, A. V., Velivetskaya, T. A., Smyshlyaeva, O. P., Tanabe, K., Shigeta, Y., Maeda, H., Afanasyeva, T. B., Popov, A. M., Golozubov, V. V., Bolotsky, Y. L. & Moriya, K. 1991b (in press). Early-Late Cretaceous climate of the northern high latitudes: Results from brachiopod and mollusc oxygen and carbon isotope ratios, Koryak Upland and Alaska. Jour. Geol. Soc. Thailand.

Zakharov, Y.D., Ukhaneva, N. G., Ignatyev, A. V., Afanasyeva, T. B., Buryi, G. I., Panasenko, E. S., Popov, A. M., Punina, T. A. & Cherbadzhi, A. K. 2000a. Latest Permian and Triassic carbonates of Russia: new palaeontological findings, stable isotopes, Ca-Mg ratio, and correlation. In: H. Yin, J.M. Dickins, G.R. Shi and J. Tong (editors), Permian-Triassic evolution of Tethys and western circum-Pacific. Developments in paleontology and stratigraphy, 18: 141-171. Amsterdam, Elsevier Science B.V.

Zakharov, Y. D., Ukhaneva, N. G., Ignatyev, A. V., Popov, A. M. & Punina, T. A. 2000b. Preliminary evidence of carbon and oxygen isotopic composition of Triassic organogenous carbonates from the Tethyan Belt and marine bioproductivity in Triassic time. Geol. of Pac. Ocean, 16: 469-480.

Zakharov, Y. D., Ukhaneva, N. G., Kiseleva, A. V., Kotlyar, G. V., Nikitina, G. V., Tazawa, J., Gvozdev, V. I., Ignatyev, A. V. & Cherbadzhi, A. K. 2000c. Kitakami (Japan) and Primorye Permian limestones: Stable carbon isotopes, Ca-Mg ratios, correlation. Geol. of Pac. Ocean, 15: 523-546.

Zakharov, Y. D., Ukhaneva, N. G., Ignatyev, A. V., Afanasyeva, T. B., Vavilov, M. N., Kotlyar, G. V., Popov, A. V. & Popov, A. M. 1997. Isotopic composition of oxygen and carbon of organogenic carbonates of upper Paleozoic and Mesozoic in Eurasia. Tikhookeanskaya geologiya, 16(1): 45-58 (in Russian).

Zubakov, V. A. Using of evidences on the climatic fluctuation in stratigraphy. In: V.A. Krassilov, V.A. Zubakov, V.I. Shuldiner & V.I. Remizovsky (editors), Ecostratigraphiya. Teoria i metody (Ecostratigraphy: theory and methods), p. 81-115. Vladivostok, Dvnc AN SSSR (in Russian).

New Triassic Literature

Triassic Bibliography

W. M. Kürschner, H. Kerp. H, Visscher, G. Warrington & S. Lucas

Abdala, F. & Ribeiro, A. M. 2000. A new therioherpetid cynodont from the Santa Maria Formation (middle Late Triassic), southern Brazil. Geodiversitas 22 (4): 589-596.

Ahmed, S. M. & Osman, R. A. 1999. Lithostratigraphy and sedimentary facies of the Upper Palaeozoic-Lower Mesozoic sequence in southwestern Sinai, Egypt. Annals of the Geological Survey of Egypt 22: 115-141.

Afonin, S. A., 2000. A Palynological assemblages from the transitional Permian-Triassic Deposits of European Russia. Paleontological Journal, 34, Suppl. 1: s29-s34.

Ando, A., Kodama, K. & Kojima, S. 2001. Low-latitude and Southern Hemisphere origin of Anisian(Triassic) bedded chert in the Inuyama area, Mino terrane, central Japan. Journal of Geophysical Research, 106 (B2): 1973-1986.

Arribas, C. P. & Macarrón, P. L. 2000. Huellas de *Eubrontes* y *Anchisauripus* en Carrascosa de Arriba (Soria, España). Boletin Geológico y Minero 111 (1): 21-32.

Ash, S., 2000. Evidence of oribatid mite herbivory in the stem of a Late Triassic tree fern from Arizona. Journal of Paleontology, 74: 1065-1071.

Ash, S. R. & Creber, G. T. 2000. The Late Triassic *Araucarioxylon arizonicum* trees from the Petrified Forest National Park, Arizona, USA. Palaeontology 43 (1): 15-28.

Ausich, W. I., Donovan, S. K., Hess, H. & Simms, M. J. 1999. Fossil occurrence. Pp. 41-49 in Hess, H., Ausich, W. I., Brett, C. E. & Simms, M. J. (eds). Fossil Crinoids. Cambridge University Press.

Bai Guoping & Keene, J. B. 2000. Fluid flow history in Lower Triassic Bulgo Sandstone, Central Sydney Basin, Australia. Journal of the China University Geoscience 11 (1): 47-55.

Balini, M., Germani, D., Nicora, A. & Rizzi, E. 2000. Ladinian/Carnian ammonoids and conodonts from the classic Schilpario-Pizzo Camino area (Lombardy): revaluation of the biostratigraphic support to chronostratigraphy and paleogeography. Rivista Italiana di Paleontologia Stratigrafia 106 (1): 19-58.

Bamford, M.K., 2000. Fossil woods of Karoo age deposits in South Africa and Namibia as an aid to biostratigraphical correlation. Journal of African Earth Science, 31: 119-132.

Bandopadhyay, R. K. 1996. Supra-Barakar rocks of the South Rewah Basin and its stratigraphic enigma. Geological Survey of India Special Publications 20: 24-31.

Barber, A.J., 2000. The origin of the Woyla terranes in Sumatra and the Late Mesozoic evolution of the Sundaland margin. Journal of Asian Earth Science, 18: 713-738.

Barboza-Gudina, J. R., Tristán-González, M. & Torres-Hernández, J. R. 1999. Tectonic setting of pre-Oxfordian units from central and northeastern Mexico: a review. Geological Society of America Special Papers 340: 197-210.

Bartolini, C., Lang, H. & Stinnesbeck, W. 1999. Volcanic rock outcrops in Nuevo Leon, Tamaulipas and San Luis Potosí, Mexico: remnants of the Permian-Early Triassic magmatic arc? Geological Society of America Special Papers 340: 347-356.

Bashari, A., 2000. Petrography and clay mineralogy of volcanoclastic sandstones in the Triassic Rewan Group, Bowen Basin, Australia. Petrological Geoscience, 6: 151-163.

Becker, L., Proeda, R. J., Hunt, A. G., Bunch, T. E. & Rampino, M. 2001. Impact event at the Permian-Triassic boundary: evidence from extraterrestrial noble gases in fullerenes. Science, 291: 1530-1533.

Belocky, R. Slapansky P., Ebli, O., Ogorelec, B. & Lobitzer, H., 1999.Die Uran-Anomalie in der Trias-Deckscholle des Gaisberg/Kirchberg in Tirol (Österreich) – Geophysikalische, geochemische und mikrofazielle Untersuchungen. Abhandlungen der Geologischen Bundesanstalt, 56: 13-33.

Benatov, S., Budurov, K., Trifinova, E. & Petrunova, L. 1999. Parallel biostratigraphy on micro- and megafauna and new data about the age of the Babino Formation (Middle Triassic) in the Iskur Gorge, Western Stara Planina Mountains. Geologica Balcanica 29: 33-40.

Benton, M.J., Juul, L., Storrs, G.W. & Galton, P.M., 2000. Anatomy and systematics of the prosauropod dinosaur *Thecodontosaurus antiquus* from the Upper Triassic of Southwest England. Journal of Vertebrate Paleontology, 20: 77-108.

Bhargava, O. N. & Bassi, U. K. 1998. Geology of Spiti-Kinnaur, Himachal Himalaya. Geological Survey of India, Memoirs Volume 124, 210pp.

Bochkarev, V.S., Brekhuntsov, A.M., Deshenya, N.P., Braduchan, Yu.V. & Khafizov, F.Z., 2000. Basic problems associated with Mesozoic stratigraphy of petroleum-bearing sedimentary rocks in West Siberia. Geol. Nefti i Gaza, 1: 2-12.

Botha, J. & Chinsamy, A., 2000. Growth patterns deduced from the bone histology of the cynodonts *Diademodon* and *Cynognathus*. Journal of Vertebrate Paleontology, 20: 705-711.

Brack, P. & Muttoni, G., 2000. High-resolution magnetostratigraphic and lithostratigraphic correlations in Middle Triassic pelagic carbonates from the Dolomites (northern Italy). Palaeogeography Palaeoeclimatology Palaeoecology, 161: 361-380.

Brack, P., Schlager, W., Stefani, M., Maurer, F. & Kenter, J., 2000. The Seceda drill hole in the Middle Triassic Buchenstein Beds (livinallongo formation, Dolomites, northern Italy) - A progress report. Riv. Ital. Paleont., 106: 283-292.

Bragin, N.Y. & Egorov, A.Y., 2000. Middle-Late Triassic radiolarians from the Dzhugadzhak section (the Omolon massif). Strat. Geol. Correl., 8: 362-371.

Brea, M., 2000. Paleoflora Triásica de Agua de la Zorra, Uspallata, provincia de Mendoza, Argentina: Lycophyta y Filicophyta. Ameghiniana, 37: 199-204.

Bromley, R. G. & Mørck A. 2000. The trace fossil *Phoebichnus trochoides* in the condensed Triassic-Jurassic-boundary sequence of Svalbard. Zentralblatt für Geologie und Paläontologie Teil I, 1998, H.11-12: 1431-1439.

Bucephalo Palliani, R. & Riding, J. B. 2000. Subdivision of the dinoflagellate cyst Family Suessiaceae and discussion of its evolution. Journal of Micropalaeontology, 19 (2): 133-137.

Bucur, I. I. 1999. Stratigraphical significance of some skeletal algae (Dasycladales, Caulerpales) of the Phanerozoic. Palaeopelagos, Special Publication 2: 53-104.

Budikovic, T., 1999. Geology of the Slovene part of the Karavanke road tunnel. Abhandlungen der Geologischen Bundesanstalt, 56: 35-48.

Buffetaut, E., Suteethorn, V., Cuny, G., Tong, H.Y., Le Loeuff, J., Khansubha, S. & Jongautchariyakul, S., 2000. The earliest known sauropod dinosaur. Nature, 407: 72-74.

Calabro, R. A. & Quassoli, G. 2000. Il bacino tardo-Triassico di Alone (Prealpi Bresciane): stratigrafia ed evoluzione paleogeografica. Atti Ticinensi di Scienze della Terra 41: 133-143.

Casshyap, S.M. & Khan, A., 2000. Tectono-sedimentary evolution of the Gondwanan Satpura Basin of central India: evidence of pre-Trap doming, rifting and palaeoslope reversal. Journal of African Earth Science, 31: 65-76.

Ciarapica, G. & Passeri, L. 2000. Le facies del Triassico inferiore e medio (fm. di Monte Facito Auctt.) nelle aree di Sasso di Castalda e di Moliterno (Basilicata). Bollettino dello Società Geologica Italiana 119: 339-378.

Chang, E.Z., 2000. Geology and tectonics of the Songpan-Ganzi fold belt, southwestern China. Int. Geol. Rev., 42: 813-831.

Coombs, D.S., Landis, C.A., Hada, S., Ito, M., Roser, B.P., Suzuki, T. & Yoshikura, S., 2000. The Chrystalls Beach-Brighton block, southeast Otago, New Zealand: Petrography, geochemistry, and terrane correlation. New Zealand Journal of Geology and Geophysics, 43: 355-372.

Costamanga, L. G. 2000. Analisi di facies della successione Triassico-Giurassica di Porto Pino (Sardegna Sud-Occidentale). Atti Ticinensi di Scienze della Terra 41: 65-82.

Costamanga, L. G., Barca, S., Del Rio, M. & Pittau, P. 2000. Stratigrafia, paleogeografia ed analisi di facies deposizionale del Trias del Sarcidana-Gerrei (Sardegna SE). Bollettino dello Società Geologica Italiana, 119: 473-496.

Cozzi, A., 2000. Synsedimentary tensional features in Upper Triassic shallow-water platform carbonates of the Carnian Prealps (northern Italy) and their importance as palaeostress indicators. Basin Research, 12: 133-146.

Clark, J.M., Sues, H.-D. & Berman, D.S., 2000. A new specimen of *Hesperosuchus agilis* from the Upper Triassic of New Mexico and the interrelationships of basal crocodylomorph archosaurs. Journal of Vertebrate Paleontology, 20: 683-704.

Dadlez, R., Narkiewicz, M., Pokorski, J. & Wagner, R. 1998. Subsidence history and tectonic controls on the Late Permian and Mesozoic development of the Mid-Polish Trough. Prace Parstwowgo Instytutu Geologicznego 165: 47-56.

Damiani, R.J., 2000. Early Triassic mastodonsaurids (Temnospondyli, Stereospondyli) from Western Australia, with remarks on mastodonsauroid palaeobiogeography. Alcheringia, 24: 299-305.

Damiani, R., Neveling, J., Hancox, J. & Rubidge, B., 2000. First trematosaurid temnospondyl from the *Lystrosaurus* Assemblage Zone of South Africa and its biostratigraphic implications. Geological Magazin, 137: 659-665.

Dang Tran Huyen & Nguyen Kinh Quoc. 2000. Stratigraphical and paleontological data on Lower Triassic sediments in the An Chau structure-facies zone. Geology and Mineral Resources (Research Institute of Geology and Mineral Resources, Hanoi) 7: 9-24.

De Bono, A., Vavassis, I., Stampfli, G. M., Martini, R., Vachard, D. & Zaninetti, L. 1998. New stratigraphic data on the Pelagonian pre-Jurassic units of Evia Island (Greece). Annales géologiques des pays helléniques, sér. 1, 38, fasc. A: 11-24.

De Zanche, V., Gianolla, P. & Roghi, G., 2000. Carnian stratigraphy in the Raibl/Cave del Predil area (Julian Alps, Italy). Ecolg. Geol. Helv., 93: 331-347.

Demathieu, G. R., Péréz-López, A. & Pérez-Lorente, F. 1999. Enigmatic ichnites in the Middle Triassic of southern Spain. Ichnos 6 (4): 229-237.

Di Bari, D., 1999. Globigerina-like foraminifera (Oberhauserellidae) from the Triassic (Ladinian-Carnian) of the San Cassiano Formation (Dolomites, Italy). Abhandlungen der Geologischen Bundesanstalt, 56: 49-67.

Diedrich, C. 2000. Neue Wirbeltierfährten aus dem Unteren Muschelkalk (Mitteltrias) des Osnabrücker Berglandes und Teutoburger Waldes (NW-Deutschland) und ihre stratigraphische und paläontologisce Bedeutung im Germanischen Becken. Neues Jahrbuch für Geologie und Paläontologie Abhandlungen, 217, H.3: 369-395.

Diedrich, C. & Oosterink, H. 2000. Bergings- en documentatietechniek van *Rhynchosauroides peabodyi* (Faber) – sauriërsporen op de grens Boven-Bontzandsteen/Muschelkalk van Winterswijk. Grondboor & Hamer 54 (6): 125-130.

Dolenec, T., Lojen, S., Buser, S. & Dolenec, M. 1999. Stable isotope event markers near the Permo-Triassic boundary in the Karavanke Mountains (Slovenia). Geologia Croatica 52 (1): 77-81.

Donovan, S.K., 2000. Processes and patterns of mass extinction. Geology Today, 16: 116-120.

Dostal, J., Church, B.N. & Hoy, T., 2001. Geological and geochemical evidence for variable magmatism and tectonics in the southern Canadian Cordillera: Paleozoic to Jurassic suites, Greenwood, southern British Columbia. Canadian Journal of Earth Science, 38: 75-90.

Drew, D. P. & Jones, G. Ll. 2000. Post-Carboniferous pre-Quaternary karstification in Ireland. Proceedings of the Geologists' Association 111 (4): 345-353.

Edmunds, W. M. & Smedley, P. L. 2000. Residence time indicators in groundwater: the East Midlands Triassic sandstone aquifer. Applied Geochemistry, 15: 737-752.

Egorov, A. Y. & Mørk, A. 2000. The East Siberian and Svalbard Triassic successions and their sequence stratigraphical relationships. Zentralblatt für Geologie und Paläontologie Teil I, 1998, H.11-12: 1377-1430.

Ernstson, K., Rampino, M.R. & Hiltl, M., 2001. Cratered cobbles in Triassic Buntsandstein conglomerates in northeastern Spain: An indicator of shock deformation in the vicinity of large impacts. Geology, 29: 11-14.

Fara, E. & Hungerbühler, A., 2000. *Paleorhinus magnoculus* from the Upper Triassic of Morocco: a juvenile primitive phytosaur (Archosauria). Compte Rondue Acad. Sci. Paris, Sér. IIA, 331: 831-836.

Faure, M., Lin, W., Shu, L.S., Sun, Y. & Scharer, U., 2000. Tectonics of the Dabieshan (eastern China) and possible exhumation mechanism of ultra high-pressure rocks. Terra Nova, 11: 251-258.

Fedorenko, V., Czamanske, G., Zen'ko, T., Budahn, J. & Siems, D., 2000. Field and geochemical studies of the melilite-rearing Arydzhangsky Suite, and an overall perspective on the Siberian alkaline-ultramafic flood-volcanic rocks. Int. Geol. Rev., 42: 769-804.

Fichter, J., Heggemann, H. & Kunz, R., 1999. Neue bzw. bisher nicht veröffentlichte Tetrapodenfährten-Lokalitäten im mittleren Buntsandstein Nordhessens und Südniedersachsens. Geologisches Jahrbuch Hessen, 127: 33-55.

Fiorillo, A.R., Padian, K. & Musikasinthorn, C., 2000. Taphonomy and depositional setting of the Placerias quarry (Chinle Formation: Late Triassic, Arizona). Palaios, 15: 373-386.

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

Freudenberger, W., Fritzer, T. & Geiger, A., 2000. Der Keuper in der Kernbohrung bei Coburg. Geologica Bavarica, 105: 137-200.

Galton, P. M. 2000. The prosauropod dinosaur *Plateosaurus* Meyer, 1837 (Saurischia: Sauropodomorpha). I. The syntypes of *P. engelhardti* Meyer, 1837 (Upper Triassic, Germany), with notes on other European prosauropods with distally straight femora. Neues Jahrbuch für Geologie und Paläontologie Abhandlungen, 216, H.2: 233-275.

Galton, P. M. 2000. Are Spondylosoma and Staurikosaurus (Santa Maria Formation, Middle-Upper Triassic, Brazil) the oldest saurischian dinosaurs? Paläontologische Zeitschrift 74 (3): 393-423.

Gand, G., Vianey-Liaud M., Demathieu, G. & Garric, J. 2000. Deux nouvelles traces de pas de dinosaures du Trias Supérieur de la Bordure Cévenole (La Grand-Combe, Sud-est de la France). Geobios 33 (5): 599-624.

Garassino, A., Hagdorn, H. & Schulz, M. 1999. A decapod crustacean assemblage from the Middle Triassic Upper Muschelkalk of Grossenlüder (Hessen, Germany). Geologisches Jahrbuch Hessen 127: 71-81.

Gardner, G. E. Jr, & Mapes, R. H. 2000. The relationships of color patterns and habitat for Lower Triassic ammonoids from Crittenden Springs, Elko County, Nevada. Revue de Paléontologie, Special Volume No.8: 109-122.

Gawlick, H.-J. 2000. Paläogeographie der Ober-Trias Karbonatplattform in den Nördlichen Kalkalpen. Mitteilungen der Gesellschaft der Geologie und Bergbaustudenten in Österreich 44: 45-95.

Gawlick, H.-J., Lein, R., Piros, O. & Pytel, C., 1999. Zur Stratigraphie und Tektonik des Hallein – Bad Dürrnberger Salzberges – Neuergebnisse auf der Basis von stratigraphischen und faziellen Daten (Nördliche Kalkalpen, Salzburg). Abhandlungen der Geologischen Bundesanstalt, 56: 69-90.

Gawlick, H.-J. & Böhm, F. 2000. Sequence and isotope stratigraphy of Late Triassic distal periplatform limestones from the Northern Calcareous Alps (Kälberstein Quarry, Berchtesgaden Halstatt Zone). International Journal of Earth Sciences 89 (1): 108-129.

Gawlick, H.-J. & Lein, R. 2000. Die Salzlagerstätte Hallein – Bad Dürrnberg. Mitteilungen der Gesellschaft der Geologie und Bergbaustudenten in Österreich 44: 262-280.

Gazdzicki, A., Michalik, J. & Tomasovych, A., 2000. *Parafavreina* coprolites from the uppermost Triassic of the Western Carpathians. Geologica Carpathica, 51: 245-250.

Gallet, Y., Krystyn, L., Besse, J., Saidi, A. & Ricou, L.E., 2000. New constraints on the Upper Permian and Lower Triassic geomagnetic polarity timescale from the Abadeh Section (central Iran). Journal of Geophysical Research, B, 105: 2805-2816.

Galton, P. M., 2000. Are *Spondylosoma* and *Staurikosaurus* (Santa Maria Formation, Middle Upper Triassic, Brazil) the oldest saurischian dinosaurs? Palaeontologische Zeitschrift, 74: 393-423.

Gand, G., Vianey-Liaud, M., Demathieu, G., et al., 2000. New upper triassic dinosaur footprints from la 'Bordure cevenole' (La Grand-Combe, SE of France). Geobios, 33: 599-624.

Garassino, A., Hagdorn, H. & Schluz, M., 1999. A decapod crustacean assemblage from the Middle Triassic Upper Muschelkalk of Großenlüder (Hessen, Germany). Geologisches Jahrbuch Hessen, 127: 71-81.

Gardner Jr., G. E. & Mapes, R. H., 2000. The relationships of color patterns and habitat for Lower Triassic Ammonoids from Crittenden Springs, Elko County, Nevada. Revue Paléobiologie, 8: 109-122.

Godefroit, P. & Sigogneau-Russell, D., 1999. Kuehneotheriids from Saint-Nicholas-de-Port (Late Triaasic of France). Geologia Belgica, 2: 181-196.

Goldhammer, R. K. & Johnson, C. A. 1999. Mesozoic sequence stratigraphy and paleogeographic evolution of northeast Mexico. Geological Society of America Special Papers, 340: 1-58.

Golonka, J. & Bocharova, N.Y., 2000. Hot spot activity and the break-up of Pangea. Palaeogeography Palaeoclimatology Palaeoecology, 161: 49-69.

Golonka, J. & Ford, D., 2000. Pangean (Late Carboniferous - Middle Jurassic) paleoenvironment and lithofacies. Palaeogeography Palaeoclimatology Palaeoecology, 161: 1-34.

Gonzalez-Leon, C.M., Stanley, G.D. & Taylor, D.G., 2000. Ammonoid discoveries in the Antimonio Formation, Sonora, Mexico: new constraints on the Triassic-Jurassic boundary. Journal of South American Earth Science, 13: 491-497.

Gow, C. E. 2000. A new procolophonid (Parareptilia) from the *Lystrosaurus* Assemblage Zone, Beaufort Group, South Africa. Palaeontologia africana 36: 21-23.

Gower, D. J. 2000. Rauisuchian archosaurs (Reptilia, Diapsida): an overview. Neues Jahrbuch für Geologie und Paläontologie Abhandlungen 218, H.3: 447-488.

Granier, B. R. C. & Grgasovi?, T. 2000. Les Algues Dasycladales du Permien et du Trias. Nouvelle tentative d'inventaire bibliographique, géographique et stratigraphique. Geologica Croatica 53 (1): 1-197.

Green, P. F., Duddy, I. R., Hegarty. K. A., Bray, R. J., Sevastopulo, G., Clayton, G. & Johnston, D. 2000. The post-Carboniferous evolution of Ireland: evidence from Thermal History Reconstruction. Proceedings of the Geologists' Association 111 (4): 307-320.

Grgasovic, T., Halamic, J., Gorican, S., Slovenic, D. & Kolar-Jurkovsek, T., 2000. Triassic deep-water sediments of selected localities in Nortwestern Croatia. Proc. Sec. Croat. Geol. Cong.: 181-188.

Grunt, T.A. & Zezina, O.N., 2000. Tan latitudinal biological zoning in the Late Paleozoic seas. Oceanology, 40: 222-227.

Haas, J. & Budai, T. 1999. Triassic sequence stratigraphy of the Transdanubian range (Hungary). Geologica Carpathica 50 (6): 459-475.

Haas, J., Korpás, L., Török, A., Dosztály, L., Gózcán, F., Hámorné Vidó, M., Oraveczné Scheffer, A., Tardiné Filácz, E., 2000. Felso-triász medence- és lejtofáciesek a Budai-hegységben – a Vérhalom téri fúrás vizsgálatának tükrében. Földtani Közlöny, 130: 371-421.

Hagdorn, H. 1999. Triassic Muschelkalk of Central Europe. Pp. 164-176 in Hess, H., Ausich, W. I., Brett, C. E. & Simms, M. J. (eds). Fossil Crinoids. Cambridge University Press, Cambridge.

Hallam, A., Wignall, P.B., Yin, J.R. & Riding, J.B., 2000. An investigation into possible facies changes across the Triassic-Jurassic boundary in southern Tibet. Sedimentary Geology, 137: 101-106.

Hamberg, L. & Nielsen, L.H., 2000. Shingled, sharp-based shoreface sandstones; depositional response to stepwise forced regression in a shallow basin, Upper Triassic Gassum Formation, Denmark. in: Hunt, D. & Gawthorpe, R.L. (eds.), Sedimentary responses to forced regressions. Geological Society Special Publications, 172: 69-89.

Hames, W. E., Renne, P. R. & Ruppel, C. 2000. New evidence for geologically instantaneous emplacement of earliest Jurassic Central Atlantic magmatic province basalts on the North American continent. Geology, 28 (9): 859-862.

Harrowfield, M. J. & Wilson, C. J. L. 2000. Triassic orogenesis in southwest China: the structural origins of the northeast Tibetan Plateau. Earth Science Frontiers 7 (Supplement: Abstract Volume, 15th Himalaya-Karakorum-Tibet Workshop): 293.

Hatira, N., Smati, A., Mansouri, A., Perthuisot, V. & Rouvier, H., 2000. Le Trias à caractère extrusif de la zone des domes; example de la structure de Debadib-Ben Gasseur (Tunisie septentrionale). Bulletin Societe Géologique France, 171: 319-326.

Hautmann, M., 2001. Taxonomy and phylogeny of cementing Triassic bivalves (families *Prospondylidae*, *Plicatulidae*, *Dimyidae* and *Ostreidae*). Palaeontology, 44: 339-373.

Heckert A. B. & Lucas S. G., 2000, Global correlation of the Triassic theropod record: Gaia, no. 15, p. 63-74.

Heckert, A. B., Lucas S. G. & Sullivan R. M., 2000, Triassic dinosaurs in New Mexico: New Mexico Museum of Natural History and Science Bulletin 17, p. 17-26.

Heckert, A. B., Zeigler K. E., Lucas, S. G., Rinehart L. F. & Harris J. D., 2000, Preliminary description of coelophysoids (Dinosauria: Theropoda) from the Upper Triassic (Revueltian: Early-mid Norian) Snyder quarry, north-central New Mexico: New Mexico Museum of Natural History and Science Bulletin 17, p. 27-32.

Hendrix, M. S. 2000. Evolution of Mesozoic sandstone compositions, southern Junggar, northern Tarim, and western Turpan basins, northwest China: a detrital record of the ancestral Tian Shan. Journal of Sedimentary Research, 70 (3): 520-532.

Herbst, R., 2000. Upper Triassic Dipteridaceae (Filicales) from Chile. Rev. Geol. Chile, 27: 65-81.

Herbst, R. & Troncoso, A. 2000. Triassic cycadophyta from the La Ternera and El Puquen formations (Chile). Ameghiniana, 37: 283-292.

Hess, H., Ausich, W. I., Brett, C. E. & Simms, M. J. (eds). 1999. Fossil Crinoids. Cambridge University Press, Cambridge, xv+275pp.

Heydari, E., Hassandzadeh, J. & Wade, W.J., 2000. Geochemistry of central Tethyan Upper Permian and Lower Triassic strata, Abadeh region, Iran. Sedimentary Geology, 137: 85-99.

Hochuli, P.A. & Frank, S.M., 2000. Palynology (dinoflagellate cysts, spore-pollen) and stratigraphy of the Lower Carnian Raibl Group in the Eastern Swiss Alps. Eclog. Geol. Helv., 93: 429-443.

Hoffman U., 2000. Die Forschungsbohrung Ebenhausen bei Bad Kissingen (Unterer Keuper / Oberer Muschelkalk / Mittlerer Muschelkalk). Geologica Bavarica, 105: 123-135.

Hofmann, A., Tourani, A. & Gaupp, R., 2000. Cyclicity of Triassic to Lower Jurassic continental red beds of the Argana Valley, Morocco; implications for palaeoclimate and basin evolution. Palaeogeography Palaeoclimatology Palaeoecology, 161: 229-266.

Hongfu, Y., Dickins, J. M., Shi, G. R., Jinnan, T., 2000. Permian – Triassic Evolution of Tethys and Western Circum-Pacific. Developments in Palaeontology and Stratigraphy Vol. 18. Elsevier. 412 pp.

Hopson, P. M. 2000. Geology of the Fareham and Portsmouth district – a brief explanation of the geological map. Sheet explanation of the British Geological Survey. 1:50 000 Sheet 316. Fareham and part of Sheet 331 Portsmouth (England and Wales). Keyworth, Nottingham: British Geological Survey, 30pp.

Hunt, A. P., Lucas, S. G., Lockley, M. G. & Heckert A. B. 2000, Occurrence of the dinosaurian ichnogenus *Grallator* in the Redonda Formation (Upper Triassic: Norian) of eastern New Mexico: New Mexico Museum of Natural History and Science Bulletin 17, p. 39-41.

Hotinski, R.M., Bice, K.L., Kump, L.R., Najjar, R.G. & Arthur, M.A., 2001. Ocean stagnation and end-Permian anoxia. Geology, 29: 7-10.

Hou Zhong-Jian, Chen Hong-De, Tian Jing-Chun, Qin Jian-Xiong & Peng Jun. 2000. Genesis of sequence boundary and basin evolution in Youjiang Basin during the Devonian to the Middle Triassic. Acta Sedimentologica Sinica 18 (2): 205-209.

Hubbard, R. L. N. B. & Boulter, M. C. 2000. Phytogeography and paleoecology in western Europe and eastern Greenland near the Triassic-Jurassic boundary. Palaios 15: 120-131.

Hungerbühler, A., 2000. Heterodonty in the European phytosaur *Nicrosaurus kapffi* and its implications for the taxonomic utility and functional morphology of phytosaur dentitions. Journal of Vertebrate Paleontology, 20: 31-48.

Hungerbühler, A. & Hunt, A.P., 2000. Two new phytosaur species (Archosauria, Crurotarsi) from the Upper Triassic of Southwest Germany. Neues Jahrbuch für Geologie und Paläontologie Abhandlungen Monatshefte, 2000(8): 467-484.

Irmen, A. P. & Vondra, C. F. 2000. Aeolian sediments in lower to middle (?) Triassic rocks of central Wyoming. Sedimentary Geology 132: 69-88.

Isintek, I., Altiner, D. & Koca, U. 2000. Middle Triassic foraminifera from the type section of the Laleköy Formation (Karaburun Peninsula, western Turkey): remarks on *Paleolituonella meridionalis* (LUPERTO, 1965). Revue de Paléobiologie 19 (1): 191-205

Ito, M., Aita, Y. & Hada, S., 2000. New radiolarian age information for the Chrystalls Beach Complex, southwest of Dunedin, New Zealand. New

Zeal. J. Geol. Geophys., 43: 349-354.

Jamal, M., Bizra, Y. & Caron, C., 2000. Palaeogeography and hydrocarbon habitat of the Triassic series in Syria. C.R. Acad. Sci., II A 331: 133-139.

Jantos, K., Thein, J. & Dittrich, D., 2000. Tektonik und Feinstratigraphie der Trias im Bereich der Gipslagerstätte des Mittleren Muschelkalk bei Ralingen/Südeifel. Mainzer geowiss. Mitt., 29: 231-276.

Johnson, C. & Gallagher, K. 2000. A preliminary Mesozoic and Cenozoic denudation history of the north east Greenland onshore margin. Global and Planetary Change 24: 261-274.

Karamata, S. 2000. Mineralization related to the Triassic rifting in the Borovica- Vareš-?evljanovi?i-Kalinovik zone (Bosnia). Acta Geologica Hungarica 43 (1): 15-23.

Karamata, S. & Cvetkovi?, V. K. V. 2000. Petrology of the Triassic basaltoid rocks of Vareš (Central Bosnia). Acta Geologica Hungarica 43 (1): 1-14.

Karnkowski, P. H. 1999. Origin and evolution of the Polish Rotliegend Basin. Polish Geological Institute, Special Papers 3.

Kashfi, M.S., 2000. Greater Persian Gulf Permian-Triassic stratigraphic nomenclature requires study. Oil Gas J., 98: 36.

Katz, B.J., Dittmar, E.I. & Ehret, G.E., 2000. A geochemical review of carbonate source rocks in Italy. J Petrol. Geol. , 23: 399-424.

Kerr, R. A. 2001. Whiff of gas points to impact mass extinction. Science, 291: 1469-1470.

Kelber, K.-P., 1999. Neue Befunde ueber die Schachtelhalme des Keupers. In: Trias – Eine ganz andere Welt. pp. 355-370.

Kelber, K.-P., 2000. Exkursion 7 - Paläobotanisch-geologische Exkursion in die Obere Trias Frankens. Terra Nostra, 2000/4: 120-142.

Kemkin, I. V. & Kemkina, R. A. 2000. Structure and genesis of the Taukha Mesozoic accretionary prism (southern Sikhote-Alin, Russia). Geodiversitas 22 (4): 481-491.

Kent, D. V. & Olsen, P. E. 2000. Magnetic polarity stratigraphy and paleolatitude of the Triassic-Jurassic Blomidon Formation in the Fundy basin (Canada): implications for early Mesozoic tropical climate gradients. Earth and Planetary Science Letters 179: 311-324.

Kiessling, W. & Flügel, E., 2000. Late Paleozoic and Late Triassic limestones from North Palawan block (Philippines): Microfacies and paleogeographical implications. Facies, 43: 39-77.

Kimura, T. & Ohana, T. 2000. A unique *Cycadocarpidium* from the Upper Triassic Nariwa Group, west Japan. Bulletin of the Kitakyushu Museum of Natural History 19: 111-116.

Kirby, G. A., Baily, H. E., Chadwick, R. A., Evans, D. J., Holliday, D. W., Holloway, S., Hulbert A. G., Pharaoh, T. C., Smith, N. J. P., Aitkenhead, N. & Birch, B. 2000. The structure and evolution of the Craven Basin and adjacent areas. Subsurface Memoir of the British Geological Survey. London: The Stationery Office, ix+130pp.

Klug, C. 2001. Functional morphology and taphonomy of nautiloid beaks from the Middle Triassic of southern Germany. Acta Palaeontologica Polonica, 46 (1): 43-68.

Knudsen, T.L., 2000. Contrasting provenance of Triassic/Jurassic sediments in North Sea Rift: a single zircon (SIMS), Sm-Nd and trace element study. Chem. Geol., 171: 273-293.

Kojima, S. & Saito, M. 2000. Triassic and Jurassic radiolarians from the Tokuyama area, Mino terrane, central Japan. Bulletin of the Geological Survey of Japan 51 (4): 143-165.

Köppen, A. & Carter, A., 2000. Constraints on provenance of the Central European Triassic using detrital zircon fission track data. Palaeogeogr. Palaeoclimatol. Palaeoecol., 161: 193-204.

Kowalski, W. M. & Hamimed, M. 2000. Diapirisme polyphase ou glacier de sel Albien? Dilemme du matériel triasique des confins Algéro-Tunisiens. Bulletin du Service Géologique de l'Algérie 11 (1): 29-60.

Krassilov, V.A., Lozovskii, V.R., Afonin, S.A. & Morkovin, I.A., 2000. The first find of fossil flora in Permian-Triassic boundary layers of the Moscow syneclise. Dokl. Earth Sci., 372: 636-637.

Kribek, B., Pasava, J. & Lobitzer, H., 1999. The behavior of selected trace elements in Alpine Soils developed on black shales in the upper part of the Hauptdolomit (Seefeld Area, Tyrol, Austria). Abh. Geol. B.-A., 56: 91-97.

Krull, E. S. & Retallack, G. J. 2000. ^{13}C depth profiles from paleosols across the Permian-Triassic boundary: evidence for methane release. Bulletin of the Geological Society of America 112 (9): 1459-1472.

Lachkar, G., Ouarhache, D. & Charriere, A. 2000. Nouvelles données palynologiques sur les formations sédimentaires associées aux basaltes triasiques du Moyen Atlas et de la Haute Moulouya (Maroc). Revue de Micropaléontologie 43 (4): 281-299.

Lampe, C. 1999. Zur faziellen und sedimentologischen Entwicklung des Buntsandsteins in der östlichen Frankenberger Bucht. Geologisches Jahrbuch Hessen, 127: 57-70.

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: 633-652.

Lei Shao, Stattegger, K. & Garbe-Schoenberg, C.-D. 2001. Sandstone petrology and geochemistry of the Turpan Basin (NW China): implications for the tec-

tonic evolution of a continental basin. Journal of Sedimentary Research, 7 (1): 37-49.
Lein, R. 2000. Die Hallstätter Trias der Mürztaler Alpen. Mitteilungen der Gesellschaft der Geologie und Bergbaustudenten in Österreich, 44: 289-296.
Lepper, J., Raath, M.A. & Rubidge, B.S., 2000. A diverse dinocephalian fauna from Zimbabwe. South African Journal of Science, 96: 403-405.
Li, Y.J., Sun, L.D., Gong, F.H., Yin, J.X., Tan, Z.J. & Huang, Z.B., 2000. A preliminary study on the tectonic setting of Upper Triassic flysch at Chasang, North Tibet. Acta Petrol. Sinica, SIN 16: 443-448.
Lin, W., Faure, M., Monie, P., Scharer, U., Zhang, L.S. & Sun, Y., 2000. Tectonics of SE China: New insights from the Lushan massif (Jiangxi Province). Tectonics, 19: 852-871.
Lindgreen, H. & Surlyk, F., 2000. Upper Permian-Lower Cretaceous clay mineralogy of East Greenland: provenance, palaeoclimate and volcanicity. Clay Mineralogy, 35: 791-806.
Liu, S. & Yang, S. 2000. Upper Triassic-Jurassic sequence stratigraphy and its structural controls in the western Ordos Basin, China. Basin Research, 12: 1-18.
Liu Zhao-Sheng. 1999. Triassic palynological assemblages from the northern margin in Tarim Basin of Xinjiang, NW China. Acta Palaeontologica Sinica, 38 (4): 474-504.
Liu Zhao-Sheng. 2000. Sporopollen assemblage from the Karamay Formation at Zhaobishan in Shanshan, Xinjiang, NW China. Acta Micropalaeontologica Sinica 17, (3): 291-298.
Lockley, M. G., Lucas S. G. & Hunt A. P., 2000, Dinosaur tracksites in New Mexico: A review: New Mexico Museum of Natural History and Science Bulletin 17, p. 9-16.
Looy, C. V., 2000. The Permian - Triassic biotic crises: collapse and recovery of terrestrial ecosystems. PhD. thesis Utrecht University, LPP Contributions Series, 13: pp. 114.
Lucas, S. G., 2000. Pathological aetosaur armor from the Upper Triassic of Germany: Stuttgarter Beiträge zur Naturkunde Serie B, no. 281, 6 pp.
Lucas, S. G., Heckert, A. B. & Hunt, A. B. 2000. Probable turtle from the Upper Triassic of east-central New Mexico. Neues Jahrbuch für Geologie und Paläontologie Monatshefte 2000 (5): 287-300.
Lutz, A. I., Crisafulli, A. & Herbst, R. 1999. Gymnospermous wood from the Upper Triassic of northern Chile. Palaeobotanist 48: 31-38.
Maisch, M. W., 1999. Observations on Triassic ichthyosaurs. Part VI. On the cranial osteology of *Shastasaurus alexandrae* MERRIAM, 1902 from the Hosselkus Limestone (Carnian, Late Triassic) of Northern California with a revision of the genus. Neues Jahrbuch für Geologie und Paläontologie Abhandlungen 217 (1): 1-25.
Maisch, M. W., 2001. Observations on Triassic ichthyosaurs. Part VII. New data on the osteology of *Chaohusaurus geishanensis* Young & Dong, 1972 from the Lower Triassic of Anhui (China). Neues Jahrbuch für Geologie und Paläontologie Abhandlungen 219 (3): 305-327.
Makhlouf, I.M., 2000. Early Triassic intertidal/subtidal patterns of sedimentation along the southern margins of the Tethyan Seaway, Jordan. Journal of Asian Earth Science, 18: 513-518.
Maluski, H., Lepvrier, C., Jolivet, L., Carter, A., Roques, D., Beyssac, O., Ta Trong Tang, Nguyen Duc Thang & Avigad, D. 2000. Ar-Ar and fission-track ages in the Song Chay Massif: Early Triassic and Cenozoic tectonics in northern Vietnam. Journal of Asian Earth Sciences, 19: 233-248.
Maquil, R., Ek C. & Faber, A. 1994. Le Muschelkalk supérieur: stratigraphie et hydrogéologie de la région de Diekirch-Moestroff. Publications du Service Géologique du Luxembourg 27: 29-43.
Márquez, L. & Trifonova, E. 2000. Tasas evolutivas de algunos subórdenes de foraminíferos Triásicos del área occidental del Tethys. Revista Española de Micropaleontología 32 (1): 1-19.
Márquez-Aliaga, A., Valenzuela-Rios, J. I., Calvet, F. & Budurov, K. 2000. Middle Triassic conodonts from northeastern Spain: biostratigraphic implications. Terra Nova, 12 (2): 77-83.
Márquez-Aliaga, A. & Márquez, L. 2000. Fosildiagénesis de bivalvos del Triasico Medio del Prebético (Murcia, España): una aproximación. Boletín Geológico y Minero 111 (5): 33-46.
Marsicano, C. A., Perea, D. & Ubilla, M. 2000. A new temnospondyl amphibian from the Lower Triassic of South America. Alcheringa, 24: 119-123.
Martini, R., Zaninetti, L., Villeneuve, M., Cornée, J.-J., Krystyn, L., Cirilli, S., De Wever, P., Dumitrica, P. & Harsolumakso, A. 2000. Triassic pelagic deposits of Timor: palaeogeographic and sea-level implications. Palaeogeography Palaeoclimatology Palaeoecology, 160: 123-151.
Maulik, P. K., Chakraborty, C., Ghosh, P. & Rudra, D. 2000. Meso- and macro-scale architecture of a Triassic fluvial succession: Denwa Formation, Satpura Gondwana Basin, Madhya Pradesh. Journal of the Geological Society of India, 56 (5): 489-504.
Maurer, F., 2000. Growth mode of Middle Triassic carbonate platforms in the Western Dolomites (Southern Alps, Italy). Sedimentary Geology, 134: 275-286.
McKee, J. W., Jones, N. W. & Anderson, T. H. 1999. Late Paleozoic and early Mesozoic history of the Las Delicias terrane, Coahuila, Mexico. Geological Society of America Special Paper, 340: 161-189.
Meng, Q. R. & Zhang, G.W., 2000. Geologic framework and tectonic evolution of the Qinling orogen,

central China. Tectonophysics, 323: 183-196.
Meng X., Chaoshun H,, Wang W. & Liu H., 2000. Magnetostratigraphic study of Meishan Permian-Triassic section, Changxing, Zhejiang Province, China. Journal of the China University of Geosciences, 11 (3): 361-365.
Menning, M. 2000. Stratigraphische Nomenklatur für die Germanische Trias (VON ALBERTI 1834) und die Dyas (MARCOU 1859, GEINITZ 1861). Zeitschrift für geologische Wissenschaften, 28 (1/2): 281-290.
Merlotti, S., 1999. Um novo lenho gimnospérmico da Formação Rio Bonito, SC, Brasil – Aterradoxylon solidum gen. Et sp. Nov.. Pesqisas, 26: 79-89.
Metcalfe, I., 2000. The Bentong-Raub Suture Zone. Journal of Asian Earth Science, 18: 691-712.
Michaelsen, P. & Henderson, R.A., 2000. Sandstone petrofacies expressions of multiphase basinal tectonics and arc magmatism: Permian-Triassic north Bowen Basin, Australia. Sedimentary Geology, 136: 113-136.
Miller, M.F., 2000. Benthic aquatic ecosystems across the Permian-Triassic transition: record from biogenic structures in fluvial sandstones, central Transantarctic Mountains. Journal of African Earth Science, 31: 157-164.
Mišík, M. & Jablonský, J. 2000. Lower Triassic quartzites of the western Carpathians: transport directions, source of clastics. Geologica Carpathica, 51 (4): 251-264.
Mohr, P. 2000. Late Palaeozoic and Palaeocene magmatic intrusion levels in West Connacht and inferences for palaeotopography. Proceedings of the Geologists' Association, 111 (4): 337-343.
Molina-Garza, R.S., Geissman, J.W. & Lucas, S.G., 2000. Palaeomagnetism and magnetostratigraphy of uppermost Permian strata, Southeast New Mexico, USA; correlation of the Permian-Triassic boundary in non-marine environments. Geophysical Journal Int., 141: 778-786.
Morata, D., Aguirre, L., Oyarzun, M. & Vergara, M., 2000. Crustal contribution in the genesis of the bimodal Triassic volcanism from the Coastal Range, central Chile. Rev. Geol. Chile, 27: 83-98.
Morel, E. M., Ganuza, D. G. & Zúñiga, A. 1999. Revisión paleoflorística de la Formación Paso Flores, Triásico superior de Río Negro y del Neuquén. Revista de la Asociación Geológica Argentina 54 (4): 389-406.
Muttoni, G., Kent, D. V., Di Stefanao, 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.
Narkiewicz, K. 1999. Conodont biostratigraphy of the Muschelkalk (Middle Triassic) in the central part of the Polish Lowlands. Geological Quarterly 43 (3): 313-328.
Nakrem, H. A., Szaniawski, H. & Mørk, A., 2001. Permian-Triassic scolecodonts and conodonts from the Svalis Dome, central Barents Sea, Norway. Acta Palaeontol. Pol., 46: 69-86.
Nawrocki, J. & Szulc, J., 2000. The Middle Triassic magnetostratigraphy from the Peri-Tethys basin in Poland. Earth Planet. Sci. Lett., 182: 77-92.
Naylor, D. & Clayton, G. 2000. Palynological and maturation data and their bearing on Irish post-Variscan palaeogeography. Irish Journal of Earth Sciences 18: 33-39.
Nesterov, I.I. & Ushatinsky, I.N., 2000. Composition and catagenesis of Triassic-Jurassic rocks in the northern sector of Western Siberia. Dokl. Earth Sci., 374: 1084-1087.
Nishimura, Y., Coombs, D.S., Landis, C.A. & Itaya, T., 2000. Continuous metamorphic gradient documented by graphitization and K-Ar age, southeast Otago, New Zealand. Amer. Mineral., 85: 1625-1636.
Novikov, I. V. & Shishkin, M. A., 2000. Triassic Chroniosuchians (Amphibia, Anthrocosauromorpha) and the evolution of trunk dermalscutes in Bystrowianids. Paleontological Journal, 34, Suppl. 2: s165-s178.
Noyan, Ö. F., Vrielynck, M. & Vrielynck, B., 2000. Importance of morphogenetic analysis in taxonomy: an example from Triassic platform conodonts. N. Jb. Geol. Paläont., Mh., 2000(10): 577-594.
Ochev, V.G. & Shishkin, M.A., 2000. Hierarchy of Lower Triassic stratigraphic units in the eastern part of European Russia. Dokl. Earth Sci., 374: 1103-1106.
Oda, H. & Suzuki, H., 2000. Paleomagnetism of Triassic and Jurassic red bedded chert of the Inuyama area, central Japan. J. Geophy. Res., 105(B11): 25743-25767.
Odinsen, T., Reemst, P., Van Der Beek, P., Faleide, J. I. & Gabrielsen, R. H. 2000. Permo-Triassic and Jurassic extension in the northern North Sea: results from tectonostratigraphic forward modelling. Geological Society, London, Special Publication 167: 83-103.
Ogilvie, S., Glennie, K. & Hopkins, C. 2000. Excursion guide 13: The Permo-Triassic sandstones of Morayshire, Scotland. Geology Today 16 (5): 185-190.
Ogorelec, B., Oroherek, S. & Budkovic, T., 1999. Lithostratigraphy of the Slovenian part of the Karavanke road tunnel. Abhandlungen der Geologischen Bundesanstalt, 56: 99-112.
Okay, A. . 2000. Was the Late Triassic orogeny in Turkey caused by the collision of an oceanic plateau? Geological Society, London, Special Publi-

cation 173: 25-41.
Olsen, P.E., Sues, H.-D. & Norell, M.A., 2000. First record of *Erpetosuchus* (Reptilia : Archosauria) from the Late Triassic of North America. J. Vertebr. Paleont., 20: 633-636.
Orchard, M. & Krystyn, L., 1998. Conodonts of the Lowermost Triassic of Spiti, and a new zonation based on *Neogondolella* successions. Riv. It. Paleont. Strat., 104: 341-368.
Orchard, M. & Rieber, H., 1999. Multielement *Neogondolella* (Conodonta, Upper Permian – Middle Triassic). Bul. Soc. Paleont. It., 37: 475-488.
Osborn, J.M., Phipps, C.J., Taylor, T.N. & Taylor, E.L., 2000. Structurally preserved sphenophytes from the Triassic of Antarctica: reproductive remains of *Spaciinodum*. Rev. Palaeobot. Palynol., 111: 225-235.
Ouarhache, D., Charriere, A., Chalot-Prat, F. & El-Wartiti, M. 2000. Sédimentation détritique continentale synchrone d'un volcanisme explosif dans le Trias terminal à infra-Lias du domaine atlasique (Haute Moulouya, Maroc). Journal of African Earth Sciences, 31 (3/4): 555-570.
Oujidi, M. & Elmi, S., 2000. Evolution de l'architecture des monts d'Oujda (Maroc oriental) pendant le Trias et au début du Jurassique. Bull. Soc. Géol. France, 171: 169-179.
Ouyang Shu, Deng Xi-Guang, Shen Yan-Bin, Zheng Xiang-Shen & Liu Xiao-Han. Late Triassic plant microfossils from Miers Bluff Formation of Livinston Island, South Shetland Islands, Antarctica. Antarctic Science 12 (2): 217-228.
Pal, P. K. & Ghosh, A. K. 1998. Late Early Triassic mioflora from the Panchet Formation of East Bokaro Coalfield, India. Geophytology 26 (2): 103-107.
Pálfy, J. & Smith, P.L., 2000. Synchrony between Early Jurassic extinction, oceanic anoxic event, and the Karoo-Ferrar flood basalt volcanism. Geology, 28: 747-750.
Pálfy, J., Smith, P.L. & Mortensen, J.K., 2000. A U-Pb and $^{40}Ar/^{39}Ar$ time scale for the Jurassic. Can. J. Earth Sci., 37: 923-944.
Pálfy, J. & Dosztaly, L., 2000. A new marine Triassic-Jurassic boundary section in Hungary. In: Hall, R.L. & Smith, P.L. (eds.), Advances in Jurassic research 2000; proceedings of the Fifth international symposium on the Jurassic system. GeoResearch Forum. 6: 173-179.
Palliani, R.B. & Riding, J.B., 2000. Subdivision of the dinoflagellate cyst Family Suessiaceae and discussion of its evolution. J. Micropalaeont., 19: 133-137.
Paul, J. & Peryt, T.M., 2000. Kalkowsky's stromatolites revisited (Lower Triassic Buntsandstein, Harz Mountains, Germany). Palaeogeography Palaeoclimatology Palaeoecology, 161: 435-458.
Peng Yo., Pan G., Luo J. & Wan M., 2000. Triassic sequence stratigraphy and correlation from polyarc and back-arc system in eastern Tibet. Earth Science Frontiers 7 (Supplement: Abstract Volume, 15th Himalaya-Karakorum-Tibet Workshop): 292-293.
Peng Yu., Tong J. & Shi G., 2000. High-resolution geochemical significance of lowest Triassic at Majiashan section, Chaohu, Anhui Province, China. Journal of China University of Geosciences 11 (3): 319-324.
Peters, D. 2000. A reexamination of four prolacertiforms with implications for pterosaur phylogenesis. Rivista Italiana di Paleontologia e Stratigrafia 106 (3): 293-336.
Pika-Biolzi, M., Hochuli, P.A. & Flisch, A., 2000. Industrial X-ray computed tomography applied to paleobotanical research. Rev. Ital. Paleont. Strat., 106: 369-378.
Prestholm, E. & Walderhaug, O., 2000. Synsedimentary faulting in a Mesozoic deltaic sequence, Svalbard, Arctic Norway – fault geometries, faulting mechanisms and sealing properties. AAPG Bulletin 84 (4): 505-522.
Prinz-Grimm, P. & Mojica, J., 1999. Obertriassische ammoniten der unteren Saldaña-Formation (Chicalá-Schichten) bei Payandé, Provinz Tolima, Kolumbien. Profil 16: 21-33.
Ptaszyski, T., 2000. Lower Triassic vertebrate footprints from Wióry, Holy Cross Mountains, Poland. Acta Palaeontologica Polonica 45 (2): 151-194.
Putiš, M., Kotov, A. B., Uher, P., Salnikova, E. B. & Korikovsky, S. P., 2000. Triassic age of the Hron?ok pre-orogenic A-type granite related to continental rifting: a new result of U-Pb isotope dating (western Carpathians). Geologica Carpathica 51 (1): 59-66.
Rameil, N., Gotz, A.E. & Feist-Burkhardt, S., 2000. High-resolution sequence interpretation of epeiric shelf carbonates by means of palynofacies analysis: An example from the Germanic Triassic (Lower Muschelkalk, Anisian) of East Thuringia, Germany. Facies, 43: 123-143.
Rampino, M. R., Prokoph, A. & Adler, A. 2000. Tempo of the end-Permian event: high-resolution cyclostratigraphy at the Permian-Triassic boundary. Geology 28 (7): 643-646.
Ravnås, R., Nøttvedt, A., Steel, R. J. & Windelstad, J. 2000. Syn-rift sedimentary architectures in the North North Sea. Geological Society, London, Special Publication 167: 133-177.
Reinhardt, L. & Ricken, W., 2000. The stratigraphic and geochemical record of playa cycles; monitoring a Pangaean monsoon-like system (Triassic, middle Keuper, S. Germany). Palaeogeogr. Palaeoclimatol. Palaeoecol. 161: 205-227.
Riccardi, A. C. & Iglesia Llanos, M. P. 1999. Primer hallazgo de amonites en el Triásico de la Argen-

tina. Revista de la Asociación Geológica Argentina 54 (3): 298-300.

Rieppel, O., Liu, J. & Bucher, H., 2000. The first record of a thalattosaur reptile from the Late Triassic of Southern China (Guizhou Province, Pr China). Journal of Vertebrate Paleontology, 20: 507-514.

Roniewicz, E. & Stolarski, J., 2001. Triassic roots of the amphiastraeid scleractinian corals. Journal of Paleontology, 75: 34-45.

Rubidge, B. S. 2000. Permo-Triassic fossil vertebrates from the Karoo of South Africa and their use in basin analysis (abstract). Journal of African Earth Sciences 30 (4A): 76.

Rueda-Gaxiola, J., López-Ocampo, E., Dueñas, M. A., Rodríguez, J. L. & Torres-Rivero, A. 1999. Palynostratigraphical method: basis for defining stratigraphy and age of the Los San Pedros allogroup, Huizachel-Teregrina anticlinorium, Mexico. Geological Society of America Special Paper 340: 229-269.

Sandy, M.R. & Aly, M.F., 2000. A southern Tethyan brachiopod fauna from the Late Triassic of the United Arab Emirates. Geobios, 33: 561-567.

Sanz De Galdeano, C., Andreo, B., García-Tortosa, F. J. & López-Garrido, A. C. 2001. The Triassic palaeogeographic transition between the Alpujarride and Malaguide complexes. Betic-Rif Internal Zone (S Spain, N Morocco). Palaeogeography, Palaeoclimatology, Palaeoecology, 167: 157-173.

Sashidal, K., Salyapongse, S. & Nakornsri, N., 2000. Latest permian radiolarian fauna from Klaeng, eastern Thailand. Micropalaeontology, 46: 245-263.

Sashida, K., Igo, H., Adachi, S., Ueno, K., Kajiwara, Y., Nakornsri, N. & Sardsud, A., 2000. Late Permian to Middle Triassic radiolarian faunas from northern Thailand. Journal of Paleontology, 74: 789-811.

Savage, R. J. G. 2000. Mines and quarries of Clifton, Bristol. Proceedings of the Bristol Naturalists' Society (1999) 59: 65-76.

Schmid, J.C., Ratschbacher, L., Hacker, B.R., Gaitzsch, I. & Dong, S.W., 1999. How did the foreland react? Yangtze foreland fold-and-thrust belt deformation related to exhumation of the Dabie Shan ultrahigh-pressure continental crust (eastern China). Terra Nova, 11: 266-272.

Schober, T. 1999. Der Buntsandstein-Aquifer im Main-Tauber-Gebiet. Profil 16: 315-335.

Schoch, R. R., 2000. The status and osteology of two new cyclotosaurid amphibians from the Upper Moenkopi Formation of Arizona (Amphibia: Temnospondyli; Middle Triassic). Neues Jahrbuch für Geologie und Paläontologie Abhandlungen 216 (3): 387-411.

Schoch, R.R., 2000. The origin and intrarelationships of Triassic capitosaurid amphibians. Palaeontology, 43: 705-727.

Schröder, B., 2000. Exkursion 2 - Aktuelle Aufschlüsse im locus – typicus - Gebiet der Keuperstratigraphie. Terra Nostra, 2000/4: 31-44.

Schweitzer, H.-J., Kirchner, M. & Van Konijnenburg-Van Cittert, J. H. A. 2000. The Rhaeto-Jurassic flora of Iran and Afghanistan. 12. Cycadophyta II. Nilssoniales. Palaeontographica B 254 (1-3): 1-63.

Seidler, L., 2000. Incised submarine canyons governing new evidence of Early Triassic rifting in East Greenland. Palaeogeography Palaeoclimatology Palaeoecology, 161: 267-293.

Sen, C. R. & Dutta, R. K. 1996. Permo-Triassic boundary in the terrestrial sediments of Raniganj Gondwana Basin. Geological Survey of India Special Publication 20: 32-38.

Sen, K. K. 1996. Birbhum coal basin – its evolution, stratigraphy and coal potentiality: an overview. Geological Survey of India Special Publication 20: 49-56.

Senowbari-Daryan, B. & Hamadani, A. 2000. Obertriadische (Nor) Dasycladaceen aus der Nayband-formation vom Zentraliran. Revue Paléobiologie 19(1): 97-121.

Senowbari-Daryan, B. & Zankl, H. 2000. Goellipora triasica n.gen. n.sp: Eine sessile Foraminifere aus den norischen Dachstein-Riffkalken des Hohen Gölls (Nördlichen Kalkalpen, Österreich). Senkenbergiana Lethaea 80 (2): 397-403.

Shi X., 2000. Major sedimentary cycles and basin evolution of Mesozoic in northern Himalayas, south Tibet. Earth Science Frontiers 7 (Supplement: Abstract Volume, 15th Himalaya-Karakorum-Tibet Workshop): 41-42.

Shi X., 2000. Triassic sequence stratigraphy and sea-level changes in Qomolongma area, Southern Tibet, China: from epicontinental sea to rift basin. Journal of China University of Geosciences 11 (3): 241-251.

Shi X. & Sun K., 2000. Triassic sequence stratigraphy and depositional environments in the Qomolongma area, south Tibet. Earth Science Frontiers 7 (Supplement: Abstract Volume, 15th Himalaya-Karakorum-Tibet Workshop): 67-68.

Shimizu, H., Kunimara, T., Yoneda, S. & Adachi, M. 2001. Sources and depositional environments of some Permian and Triassic cherts: significance of Rb-Sr and Sm-Nd isotopic and REE abundance data. The Journal of Geology 109: 105-125.

Shishkin, M.A. & Rubidge, B.S., 2000. A relict rhinesuchid (Amphibia : Temnospondyli) from the Lower Triassic of South Africa. Palaeontology, 43: 653-670.

Siblik, M., 1999. On Carnian brachiopods of the Gaisberg near Kirchberg in Tirol (Northern Calcareous Alps, Tyrol). Abhandlungen der Geologischen Bundesanstalt, 56: 113-120.

Silva-Pineda, A. & Buitrón-Sánchez, B. E. 1999. Mesozoic redbed floras in east-central Mexico and their stratigraphic relationships with marine beds. Geological Society of America Special Paper 340: 151-160.

Simms, M. J. 1999. Systematics, phylogeny and evolutionary history. Pp. 31-40 in Hess, H., Ausich, W. I., Brett, C. E. & Simms, M. J. (eds). Fossil Crinoids. Cambridge University Press, Cambridge.

Singh, R., Jamwal, J.S. & Singh, K., 2000. Geology of part of Warwan valley, Doda District, Kashmir Himalaya. Journal of the Geological Society of India, 56: 651-659.

Singharawarapan, S., Berry, R. & Panjasawatwong, Y. 2000. Geochemical characteristics and tectonic significance of the Permo-Triassic Pak Pat Volcanics, Uttaradit, northern Thailand. Journal of the Geological Society of Thailand No.1: 1-7.

Singharajwarapan, S. & Berry, R., 2000. Tectonic implications of the Nan Suture zone and its relationship to the Sukhothai Fold Belt, northern Thailand. Journal of Asian Earth Science, 18: 663-673.

Sinitshenkova, N. D., 2000. A review of Triassic Mayflies, with description of new species from western Siberia and Ukraine (*Ephermirida* = *Ephemeroptera*). Paleontological Journal, 34, Suppl. 3: s275-s283.

Spalletti, L. A. 1999. Cuencas triásicas del Oeste argentino: origen y evolución. Acta Geologica Hispanica 32 (1-2): 29-50.

Spencer, P.S., 2000. The braincase structure of *Leptopleuron lacertinum* Owen (Parareptilia; Procolophonidae). Journal of Vertebrate Paleontology, 20: 21-30.

Stanley, G. D. & Fautin, D. G. 2001. The origins of modern corals. Science, 291: 1913-1914.

Steiner M. B. & Lucas S. G., 2000, Paleomagnetism of the Late Triassic Petrified Forest Formation, Chinle Group, western United States: Further evidence of "large" rotation of the Colorado Plateau: Journal of Geophysical Research, v. 105, no. B11, p. 25,791-25,808.

Stiller, F., 2000. Polychaeta (Annelida) from the Upper Anisian (Middle Triassic) of Qingyan, south-western China. Neues Jahrbuch Geologische Paläontolgische Abhandlungen 217: 245-266.

Streetly, M., Chakrabarty, C. & McLeod, R. 2000. Interpretation of pumping tests in the Sherwood Sandstone Group, Sellafield, Cumbria, UK. Quarterly Journal of Engineering Geology and Hydrology 33: 281-299.

Tanner, L.H., 2000. Palustrine-lacustrine and alluvial facies of the (Norian) Owl Rock Formation (Chinle Group), Four Corners region, southwestern USA: Implications for Late Triassic paleoclimate. Journal of Sedimentary Research, 70: 1280-1289.

Taylor, E.L., Taylor, T.N. & Cúneo, N.R., 2000. Permian and Triassic high latitude and paleoclimates; evidence from fossil biotas. In: Huber, B.T., MacLeod, K.G. & Wing, S.L. (eds.), Warm climates in Earth history, pp. 321-350. Univ. Cambridge.

Tekin, U. K. 2000. The late Ladinian-early Carnian radiolarian fauna from the Antalya nappes, Sugözü village, Gazipa?a, Antalya, Turkey (abstract). 53 Geological Congress of Turkey, Abstracts volume: 259-260.

Tekin, U. K. & Sönmez, ?. 2000. The Rhaetian-Hettangian radiolarian fauna from Antalya nappes, Dikmeta? village, Antalya, Turkey. 53 Geological Congress of Turkey, Abstracts volume: 268-269.

Therrien, F. & Fastovsky, D. E. 2000. Paleoenvironments of early theropods, Chinle Formation (Late Triassic), Petrified Forest National Park, Arizona. Palaios 15: 194-211.

Tian J.-C., Chen H.-D., Peng J., Qin J.-X., Hou Z.-J., Shou J.-F., Yang X.-N., Sheng A.-J. & Chen Z.-L., 2000. Sequence division, correlation and framework of Lower and Middle Triassic in Sichuan-Guizhou-Yunnan-Guangxi region. Acta Sedimentologica Sinica 18 (2): 198-204.

Tian J., Zhang K. & Gong Y., 2000. Advances in Lower and Middle Triassic stratigraphic research in east of eastern Kunlun orogenic belt. Earth Science – Journal of China University of Geosciences 25 (3): 290-294.

Tong J. & Liu Z., 2000. Middle Triassic stratigraphy and sedimentary paleogeography of South China. Journal of China University of Geosciences 11 (3): 264-270.

Tong J., Xiao S. & Liu Z., 2000. Stratigraphic correlation of Middle Triassic sequences among different paleogeographic sedimentary facies in South China. Journal of China University of Geosciences 11 (1): 1-8.

Torres, R., Ruiz, J., Patchett, P. J. & Grajales, J. M. 1999. Permo-Triassic continental arc in eastern Mexico: tectonic implications for reconstructions of southern North America. Geological Society of America Special Paper 340: 191-196.

Trappe, J., 2000. Pangea; extravagant sedimentary resource formation during supercontinent configuration, an overview. Palaeogeography Palaeoclimatology Palaeoecology, 161: 35-48.

Tritlla, J., Cardellach, E. & Sharp, Z. D. 2001. Origin of vein hydrothermal carbonates in Triassic limestones of the Espadán Ranges (Iberian Chain, E Spain). Chemical Geology 172: 291-305.

Turner, P., Shelton, R., Ruffell, A. & Pugh, J. 2000. Palaeomagnetic constraints on the age of the Red Arch Formation and associated sandstone dykes (Northern Ireland). Journal of the Geological Society, London 157: 317-325.

Turnsek, D., Dolenec, T., Siblik, M., Ogorelec, B., Ebli, O. & Lobitzer, H., 1999. Contributions to the fauna (Corals, Brachiopods) and stable isotopes of the Late Triassic Steinplatte Reef/Basin-Complex, Northern Calcareous Alps. Abhandlungen der Geologischen Bundesanstalt, 56: 121-140.

Twitchett, R. J., Looy, C. V., Morante, R., Visscher, H. & Wignall, P. B., 2001. Rapid and synchronous collapse of marine and terrestrial ecosystems during the end-Permian biotic crisis. Geology, 29: 351-354.

Uno, K., 2000. Clockwise rotation of the Korean Peninsula with respect to the North China Block inferred from an improved Early Triassic palaeomagnetic pole for the Ryeongnam Block. Geophys. J. Int., 143: 969-976.

Uno, K. & Chang, K.H., 2000. Paleomagnetic results from the lower Mesozoic Daedong Supergroup in the Gyeonggi Block, Korean Peninsula: an eastern extension of the South China Block. Earth Planet Sci. Newsl., 182: 49-59.

Vecsei, A., Goldbeck, A., Heunisch, C., Luppold, F. W. & Mandau, T. 2000. Stratigraphie und Faziesanalyse im Muschelkalk des südwestlichen Germanischen Beckens (nördlisches Saarland). Zeitschrift der Deutschen Geologischen Gesellschaft 151 (3): 247-276.

Velledits, F. 2000. Evolution of the area from the Berva Valley to the Hór Valley in the Middle – Upper Triassic. Földtani Közlöny 130 (1): 47-93.

Visonà, D. & Zanferrari, A. 2000. Some constraints on geochemical features in the Triassic mantle of the easternmost Austroalpine-Southalpine domain: evidence from the Karawanken pluton (Carinthia, Austria). International Journal of Earth Sciences 89 (1): 40-51.

Wachtler, M. & van Konijnenbyurg-van Cittert, J, H, A., 2000. La flora fossile della Formazione di La Valle – Wengen (Ladinico) nelle Dolomiti (Italia). Studi Trentini di Scienze Naturali – ActaGeologica, 75: 113-146.

Wang, J.P., 2000. Geological features of the eastern sector of the Bangong Co-Nujiang River suture zone: Tethyan evolution. Acta Geol. Sinica, 74: 229-235.

Ward, P.D., Montgomery, D.R. & Smith, R., 2000. Altered river morphology in South Africa related to the Permian-Triassic extinction. Science, 289: 1740-1743.

Welch, M.J. & Turner, J.P., 2000. Triassic-Jurassic development of the St. George's Channel basin, offshore Wales, UK. Mar. Petrol. Geol., 17: 723-750.

Werneburg, R. & Schneider, J.W., B., 2000. Exkursion 5 - Klassische Fossillokalitäten der kontinentalen Perm- unf Triaszeit im südlichen Thüringen. Terra Nostra, 2000/4: 75-97.

Westermann, G. E. G. 2000. Marine faunal realms of the Mesozoic: review and revision under the new guidelines for biogeographic classification and nomenclature. Palaeogeography, Palaeoclimatology, Palaeoecology 163: 49-68.

Whatley, R. & Boomer, I., 2000. Systematic review and evolution of the early Cytheruridae (Ostracoda). Journal of Micropalaeontology, 19: 139-151.

Wieczorek, J. 2000. Mesozoic evolution of the Tatra Mountains (Carpathians). Mitteilungen der Gesellschaft der Geologie und Bergbaustudenten in Österreich 44: 241-262.

Willis, A. & Wittenberg, J., 2000. Exploration significance of healing-phase deposits in the Triassic Doig Formation, Hythe, Alberta. Bull. Can. Petrol. Geol., 48: 179-192.

Wood, G. D. & Benson Jr. D. G., 2000. The North American occurrence of the algal coenobium Plaesiodicton: Paleogeographic, Paleoecologic, and biostratigraphic importance in the Triassic. Palynology, 24: 9-20.

Woods, A.D. & Bottjer, D.J., 2000. Distribution of ammonoids in the Lower Triassic Union Wash Formation (eastern California): Evidence for paleoceanographic conditions during recovery from the end-Permian mass extinction. Palaios, 15: 535-545.

Xia W. & Zhang N., 2000. Middle Triassic radiolaria from turbidites in Ziyun, Guizhou, South China. Micropaleontology 46 (1): 73-87.

Zakharov, Y. D. & Shigeta, Y. 2000. Gyronautilus, a new genus of Triassic Nautilida from South Primorye, Russia. Palaeontological Research, 4 (4): 231-234.

Zonneveld, J.-P., Gingras, M. K. & Pemberton, S. G. 2001. Trace fossil assemblages in a Middle Triassic mixed siliciclastic-carbonate marginal marine depositional system, British Columbia. Palaeogeography, Palaeoclimatology, Palaeoecology 166: 249-276.

British Triassic Palaeontology: Supplement 25

G. Warrington

Since the completion of the writer's previous supplement (No.24; ALBERTIANA, 24: 51) 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., Juul, L., Storrs, G. W. & Galton, P. M. 2000. Anatomy and systematics of the prosauropod dinosaur Thecodontosaurus antiquus from the Upper Triassic of southwest England. Journal of Vertebrate Paleontology, 20 (1): 77-108.

Bloos, G. 1999. Aspekte der Wende Trias/Jura. pp.43-68 in Hauschke, N. & Wilde, V. (eds) Trias - Eine ganz andere Welt. Munich, Verlag Dr Friedrich Pfeil, 647pp.

Bucephalo Palliani, R. & Riding, J. B. 2000. Subdivision of the dinoflagellate cyst Family Suessiaceae and discussion of its evolution. Journal of Micropalaeontology 19 (2): 133-137.

Edwards, R. A. & Scrivener, R. C. 1999. Geology of the country around Exeter. Memoir of the British Geological Survey, 1:50000 geological sheet 325 (England & Wales). London: The Stationery Office, xii+183pp.

Galton, P. M. 2000. The prosauropod dinosaur Plateosaurus Meyer, 1837 (Saurischia: Sauropodomorpha). I. The syntypes of P. engelhardti Meyer, 1837 (Upper Triassic, Germany), with notes on other European prosauropods with distally straight femora. Neues Jahrbuch für Geologie und Paläontologie Abhandlungen, 216, H.2: 233-275.

Glennie, K. W. 2000. Invited Review: Contribution of the Scottish offshore to the advancement of geology. Scottish Journal of Geology, 36: 17-32.

Gower, D. J. 2000. Rauisuchian archosaurs (Reptilia, Diapsida): an overview. Neues Jahrbuch für Geologie und Paläontologie Abhandlungen, 218, H.3: 447-488.

Hubbard, R. N. L. B. & Boulter, M. C. 2000. Phytogeography and paleoecology in western Europe and Eastern Greenland near the Triassic-Jurassic boundary. Palaios, 15: 120-131.

King, M. J. & Thompson, D. B. 2000. Triassic vertebrate footprints from the Sherwood Sandstone Group, Hilbre, Wirral, northwest England. Proceedings of the Geologists' Association, 111: 111-132.

Milroy, P. G. & Wright, P. V. 2000. A highstand oolitic sequence and associated facies from a Late Triassic lake basin, south-west England. Sedimentology, 47: 187-209.

Powell, J. H., Glover, B. W. & Waters, C. N. 2000. Geology of the Birmingham area. Memoir of the British Geological Survey, 1:50000 geological sheet 168 (England & Wales). London: The Stationery Office, viii+132pp.

Radley, J. D. & Carpenter, S. C. 1999. The Late Triassic strata of Manor Farm, Aust, south Gloucestershire. Proceedings of the Bristol Naturalist's Society, 58: 57-67.

Spencer, P. S. 2000. The braincase structure of Leptopleuron lacertinum) Owen (Parareptilia: Procolophonidae). Journal of Vertebrate Paleontology, 20 (1): 21-30.

Sumbler, M. G., Barron, A. J. M. & Morigi, A. N. 2000. Geology of the Cirencester district. Memoir of the British Geological Survey, 1:50000 geological sheet 235 (England & Wales). London: The Stationery Office, viii+103pp.

Turner, N. S. 2000. A catalogue of the type, figured and cited fossils in the Nottingham Natural History Museum, Wollaton Hall, Nottingham, U.K. The Geological Curator, 7 (3): 111-121.

Whatley, R. & Boomer, I. 2000. Systematic review and evolution of the early Cytheruridae (Ostracoda). Journal of Micropalaeontology 19 (2): 139-151.

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ORGANIZERS:

China University of Geosciences, China Geological Survey, Government of Changxing County, Zhejiang Province

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OBJECTIVES:

This symposium is designed to provide a forum to all kinds of scientists who are interested in the Permian-Triassic boundary and its related great events for examining the key section of the Permian and Triassic boundary at Meishan, Zhejiang Province and discussing the great transition between the Paleozoic and Mesozoic and its associated events.

The field excursions provide you opportunity to visit some typical sequences from the Carboniferous to Lower Triassic and/or some paralic and continental Permian-Triassic boundary sections in South China.

DATE, VENUE AND LANGUAGE:

Pre-symposium Field Excursion: 8-9 August 2001

Symposium: 10-13 August 2001

During-symposium Field Excursion: 11 August 2001

Post-symposium Field Excursion 1: 14-15 August 2001

Post-symposium Field Excursion 2: 14-18 August 2001

Place: Changxing, Zhejiang Province

Language: English will be the official language for all presentations

IMPORTANT DATES:

1 February 2001: Deadline for submission of response to first circular

1 May 2001: Deadline for submission of abstracts for the proceedings

1 July 2001: Deadline for submission of pre-registration

13 August 2001: Deadline for submission of papers for the special symposium volume

THEMES:

The symposium will be structured into four main themes:

The global stratotype of the Permian-Triassic boundary and its geological setting;

Stratigraphy of the Permian and Triassic boundary and its global correlation over various facies;

Tectonics, paleogeography, paleoclimatology and paleoecology during the Paleozoic and Mesozoic transition;

Biotic crisis, mass extinction and recovery, and connected events across the Permian and Triassic boundary.

FIELD EXCURSIONS:

Pre-Symposium Field Excursion: Guangde, Anhui Province and Changxing, Zhejiang Province (8-9 August 2001)

This two-day field excursion will provide you an overview of the geological setting in Meishan area, Changxing County. You will visit some typical sections from the Devonian to Triassic, which well recorded the evolution of the eastern Tethys during the Pangea from late Paleozoic to Triassic. The differentiation of the Changhsingian facies and some key boundaries will be observed as well.

During-Symposium Field Excursion: Meishan Section, Changxing, Zhejiang Province (11 August 2001)

During the symposium we will spend one day at the well-known Meishan Section of the Changxing Limestone and Permian-Triassic boundary to examine the sequence and discuss its related aspects.

Post-Symposium Field Excursion 1: Chaohu, Anhui Province (14-15 August 2001)

The Permian and Triassic stratigraphical and paleontological sequence at Chaohu, Anhui Province is one of the best and well-studied sections in the Lower Yangtze region. The Changhsingian and Lower Triassic here were formed on deep shelf (or slope) while Meishan was on shallow shelf. Here you will visit an excellent Permian and Triassic sequence, and especially the Lower Triassic as well as the Middle Permian is quite exemplary. In addition, we might have a stop in Nanjing, Jiangsu Province, where you could observe a section situated in the transitional facies from Meishan to Chaohu.

Post-Symposium Field Excursion 2: Liuzhi-Weining, Guizhou Province (14-18 August 2001)

This excursion supposes to provide you for a unique chance to trace the Permian-Triassic boundary from marine to continental via paralic facies. Many excellent marine Permian-Triassic boundary sequences have been studied in the central and southern Guizhou while the continental sections are in the western Guizhou and northeastern Yunnan. The paralic Permian-Triassic boundary sections are located in the central-western Guizhou Province. During the excursion you will visit a series Permian and Triassic boundary sections from marine to continental via paralic facies in the central-western Guizhou Province so that you might figure out a correlation between the marine and continental boundaries.

PUBLICATIONS:

We anticipate that refereed and accepted papers will be published either as a book or as a special issue of an international journal. The paper must be presented (either orally or in poster) before being considered for publication. But all abstracts will be collected into the Proceedings of the Symposium, which will be delivered to every participant at the Symposium. All the papers and abstracts must be in English and submitted to the secretariat before the deadlines. Refer to the second circular for the details of the submission of the papers and abstracts.

REGISTRATION:

Registration should be made to the registration form attached on the second circular, which will be sent to all who respond to the first circular. Registration fee for the symposium (including the Proceedings, morning and afternoon teas, and the during-symposium field excursion and during-symposium sightseeing in Changxing County) will be $200 US Dollars. Pre-Symposium field excursion fee (including field guidebook, transportation and meals) will be $100 US Dollars. The post-symposium field excursion 1 to Chaohu costs $150 US Dollars (including field guidebook, transportation, and accommodation). The post-symposium field excursion 2 to Guizhou will be $450 US Dollar (including field guidebook, accommodation, transportation during the field excursion in Guizhou, and a single flight from Nanjing to Guiyang). Refer to the second circular for the details.

HOTEL ACCOMMODATION:

Several hotels in the downtown of Changxing County are arranged for participants. Room rate ranges from $20 to $50 US Dollars per night for standard double rooms and $15 to $30 US Dollars per night for standard single rooms. Details and reservation forms for hotels will be distributed in the second circular.

TRANSPORTATION:

Changxing is located in the northern Zhejiang Province, to the west of Taihu Lake, bordering on Jiangsu and Anhui provinces. It is in the mid-way of the Nanjing-Hanzhou freeway, 110 km to Hanzhou and 200 km to Nanjing. A highway also connects it to Shanghai in about 150 km. The Hanzhou-Chaohu railway goes through Changxing City with a few trains daily from Hanzhou.

Pre-Registration Form for:

The GSSP of the Permian-Triassic Boundary and the Paleozoic-Mesozoic Events

Forename:

Initial(s):

Surname:

Sex (M/F):

Title:

Institution:

Full Address:

Country:

Telephone:

Fax:

Email:

I plan to attend the Symposium (Please tick)

_ very probably   _ probably   _unlikely

I plan to contribute with an

_oral paper   _poster

Tentative title:

I plan to attend the pre-Symposium field excursion

_ very probably   _probably   _unlikely

I plan to attend the post-Symposium field excursion 1 to Chaohu

_very probably   _probably   _unlikely

I plan to attend the post-Symposium field excursion 2 to Guizhou

_very probably   _probably   _unlikely

Comments/Suggestions:

Date:

Signature:

NEW GUIDELINES FOR THE SUBMISSION OF MANUSCRIPTS TO ALBERTIANA

Albertiana is published twice a year. Contributions should be sent to the editor. In order to facilitate the production of this newsletter and reduce typing errors, authors are kindly requested to submit their contributions electronically, preferably by email or on 3½ inch MS-DOS formatted floppy discs together with a printed hard copy. You may also use the Utrecht Albertiana FTP server ftp://131.211.28.160 to upload larger files that cannot be sent as email attachments. The user name is “Alb”, even so the password is “Alb”. Please DO NOT use BinHex-encoded files (MacIntosh) as these cannot be read! Those who are unable to submit a manuscript in electronic format are kindly requested to send flat (unfolded), clearly typed manuscripts in a 12-point typeface (sans serif) with single line spacing.

Text files can be submitted formatted as *.wpd, *.doc or *.rtf files and illustrations as pixel based graphics (e.g: *.bmp, *.tif, *.gif or *.jpeg) or vector based graphics (e.g: *.ai, *.cdr) that can be directly imported into Adobe PageMaker. Please provide good, clean, flat, printed copies (NOT xerox copies) of any illustrations, which MUST be designed to fit on an A4 page (centered, with at least 2.54 cm wide margins left and right, and 4 cm margins at the top and bottom).

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.

Subcommission on Triassic Stratigraphy

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