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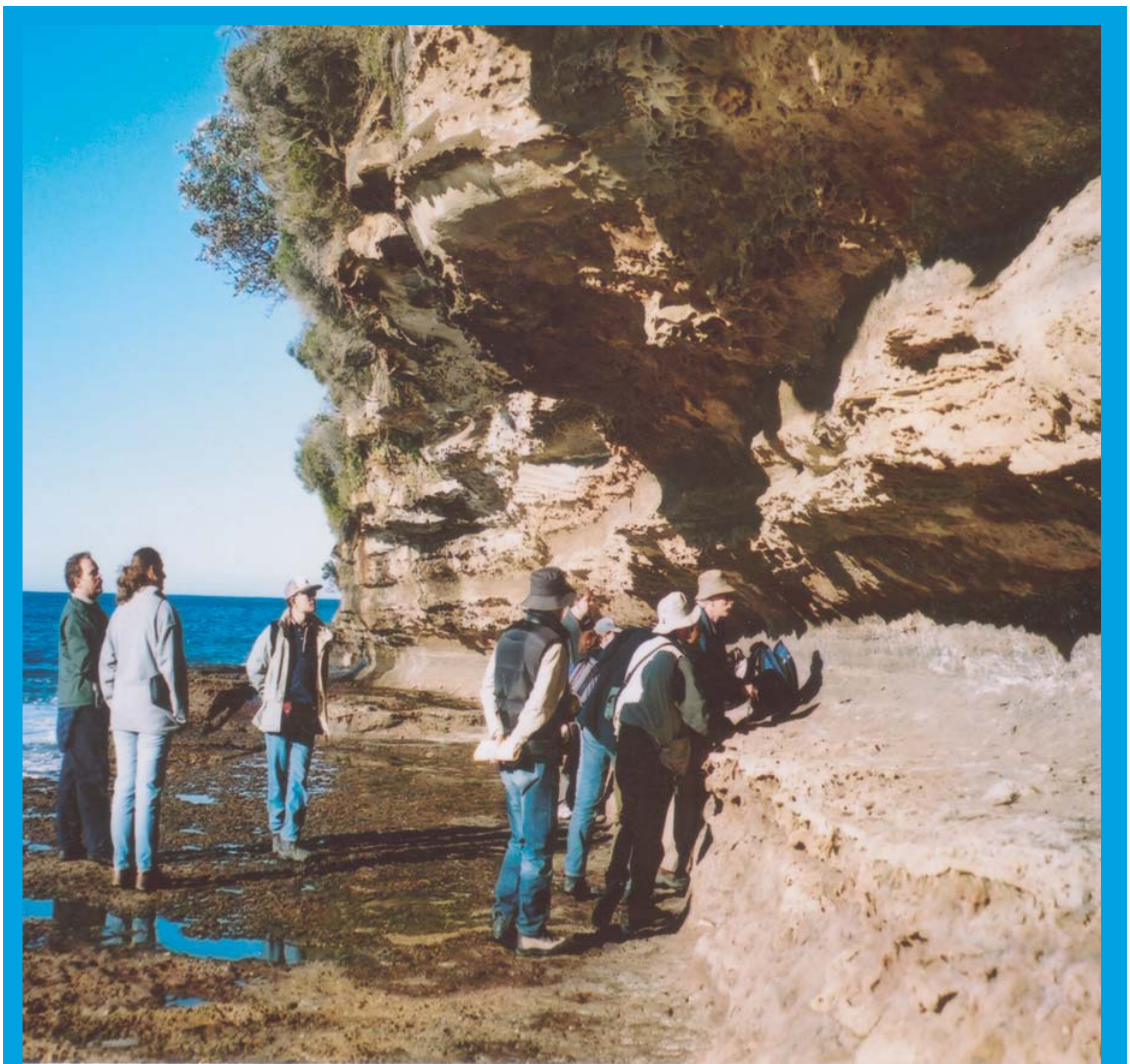

Contents

Cover Photo

First International Palaeontological Congress
Macquarie University, Sydney, Australia
Pre-4 Field Excursion: Permian Stratigraphy, Sedimentology and Palaeontology of the Southern Sydney Basin, Eastern Australia 1-5 July 2002

G.R.Shi and E.A.Weldon
Deakin University, Melbourne, Australia

In July 2002, 14 participants explored Permian outcrops along the south coast of New South Wales, Australia. The field stops were selected to illustrate the succession of the formations in the extensional back-arc to foreland basin setting. During the excursion depositional processes, glaciation, volcanism, and the interpretation of depositional environments based on ichnofossils were key topics for discussion.

EXECUTIVE NOTES

Notes from the SPS Secretary
Charles M. Henderson

Introduction and thanks

I want to thank those individuals who contributed articles for inclusion in the 40th issue of Permophiles and those who assisted in its preparation. Bruce Wardlaw and I did all of the editorial work for this issue during 2.5 days at the University of Calgary. We thank Cal Stevens, Prof. Giuseppe Cassinis, Gary Johnson, Prof. G.H. Bachmann, Donald Boyd, Shannon Rudine, Jerry Lewis, and Norman Newell for financial contributions to the Permophiles publication fund in support of this issue. We also thank Sharron Kaser (Department of Geology and Geophysics, University of Calgary) for handling the donations. Continuing publication and mailing of Permophiles requires additional contributions; readers are referred to the last page of this issue. Permophiles is currently distributed to over 285 individuals and institutions and donations have not covered the expenses of the past two issues. Please remember to specify Canadian or USA dollars ($25US = $40Can.). Permophiles is recognized by the ICS as an exceptional newsletter and the support of our readers is necessary to maintain that quality.

Previous SPS Meetings and Minutes

The subcommission met during the 36th Annual South-Central Section meeting of the Geological Society of America at Sul Ross University in Alpine, Texas on April 12th, 2002. There were no changes to the composition of the subcommission. The SPS executive includes SPS Chair (Bruce R. Wardlaw), First Vice-Chair (Ernst Ya. Leven), Second Vice-Chair (Clinton B. Foster), and the Secretary (Charles M. Henderson). The individuals in attendance at this meeting included Bruce Wardlaw, Charles Henderson, Merlynd Nestell, Galina Nestell, Natalie Esaulova, Boris Burov, Gordon Bell, David Rohr, Tim Walsh, Garner Wilde, Lance Lambert, Tamra Schiappa, Nancy Stamm, Heinz Kozur, Vladimir Davydov, and Christoph Korte. The meeting was held outdoors following the session chaired by David Rohr, Bruce R. Wardlaw, and Lance L. Lambert entitled "The Permian of the Southwest". The meeting was chaired by Bruce Wardlaw and considerable refreshments were available during this sunny afternoon. Bruce reported on the progress of the various working groups indicating in particular that the Guadalupian-Lopingian boundary would soon go to a vote. It was reported that the proceedings volume for the XIV International Congress on the Carboniferous and Permian (ICCP) held at the University of Calgary in 1999 was finally complete and that the XV ICCP will be held at Utrecht, The Netherlands August 10-16, 2003.

Business Arising from the Minutes

In Permophiles 39, I reported that an application for an ISSN number would be made. This has been done and this is the first issue of Permophiles to be so designated; this and future issues will show ISSN 1684-5927. Please note that we do not wish to see the tone of the newsletter change. The newsletter is an informal line of communication between our various members. It is not a refereed publication. We prefer to not recognize it as a formal publication for taxon names and we will continue to discourage its use as such a vehicle. Individuals considering the naming of new taxa should really consider a refereed journal such that the taxa are properly scrutinized.

The Guadalupian-Lopingian boundary working group has voted and the GSSP as defined by the FAD of *Clarkina postbitteri postbitteri* at the base of bed 6k at the Penglaitan Section in the Laibin area of South China was passed at 17.5 votes for and 1.5 votes against. An explanation of this vote is provided in a separate section below.

The proceedings volume for the XIV ICCP is now available for purchase at the Canadian Society of Petroleum Geologists (CSPG Memoir 19); see **www.cspg.org/memoir19memoirs.html** for details.

The XV ICCP will be held at Utrecht August 10-16, 2003. Please note that the abstract deadline is December 1, 2002; see **www.nitg.tno.nl/eng/iccp.shtml** for details.

Future SPS Meetings

The next scheduled SPS meeting will be held during the XV ICCP meeting at Utrecht, The Netherlands.

Future Issues of Permophiles

Issue 41 will be finalized in January 2003 and we request that all manuscripts be sent such that Charles Henderson receives them no later than Friday January 3rd, 2003. Issue 41 will be compiled at Boise State University on January 6th. Please see the note elsewhere in this issue regarding the preferred method of manuscript submission and format. Please follow the format as closely as possible and make our job of preparing Permophiles easier. Bruce and I ask you to *please follow the format (especially for references)*! Although Permophiles is not an official publication, it is increasingly referred to in many papers, which means that our reports should be professional and address scientific rather than personal issues. The primary function of Permophiles is for discussion of Permian issues so we are always interested in replies to the various contributions. These must also follow the format as outlined elsewhere. A report and list of names of the Cis-Uralian Working Group is requested for the next issue.

Our database is missing a number of e-mail addresses so if you haven't written to me recently I would appreciate receiving a very short e-mail after receiving Permophiles 40 (if you didn't do so after #39 or if any data has changed) so that I can check my records for addresses, phone numbers, and e-mail addresses. Send to henderson@geo.ucalgary.ca.

Report of Vote by the Guadalupian-Lopingian boundary working group

The working group consisted of the following individuals; their vote is indicated next to their name:

Yugan Jin	Yes
Brian Glenister	Yes
Bruce Wardlaw	Yes
Charles Henderson	Yes
Claude Spinosa	Yes
Douglas Erwin	Yes
Ernst Leven	Yes
Galina Kotlyar	Yes
Guangrong Shi	Yes
Jinzhang Sheng	Yes
Zhuoting Liao	Yes
Shilong Mei	Yes
Shuzhong Shen	Yes
Tatyana Leonova	Yes
Vladimir Davydov	Yes
Xiangdong Wang	Yes
Yukio Isozaki	Yes
Heinz Kozur	No
Chengyuan Wang	½ yes (he agreed to the point (6k)
and section);	½ no (he disagreed to the definition

as he preferred *C. dukouensis*).

Technically, this last vote is a spoiled ballot, but given the overwhelming favourable response I believe it can be counted. The vote was thus 17.5 in favour (92%) and 1.5 against. Only 60% was required for a positive vote. It is thus declared that the working group has passed the GSSP for the Lopingian base and that a proposal will be submitted later this year to the voting members of the SPS.

Report from the SPS Chair
Bruce R. Wardlaw

The Subcommission on Permian Stratigraphy (SPS) has had a very busy year this year. We sponsored a symposium on the Permian of the Southwest at the Southcentral G.S.A. meeting and held a subcommission meeting at that symposium, participated in the first meeting of the International Commission on Stratigraphy (ICS) on the future of stratigraphy, participated in ECOS 8, and sat on the steering committee of *Chronos,* a group to promote and coordinate interactive chronostratigraphy and stratigraphic databases. The working group on the Guadalupian finished up the final touches to its *Episodes* article on the stages of the Middle Permian, and, thus, has finished its task and is now officially dissolved. The working group on the Guadalupian-Lopingian boundary finally voted on the base of the Lopingian (see Secretary's report). The proposal was well thought out (see last issue of *Permophiles*) and properly distributed for a vote. I am withholding the proposal from the vote of the full Subcommission until after this issue of *Permophiles* is distributed (see Kozur and Wang and Replies, this issue). The working groups on Continental Permian and using transitional biota as gateways for global correlation both contributed substantial reports for this issue and I would like to thank them for a job well done.

SUBMISSION GUIDELINES FOR ISSUE 41

It is best to submit manuscripts as attachments to E-mail messages. Please send messages and manuscripts to my E-mail address. I will confirm in a reply whether I can read the files. Please only send a single version by E-mail or in the mail; if you discover corrections before the deadline, then you may resubmit, but indicate the file name of the previous version that should be deleted. Manuscripts may also be sent to the address below on diskettes (3.5", zip disks, or CDs) prepared with a recent version of WordPerfect or Microsoft Word; printed hard copies should accompany the diskettes. Word processing files should have no personalized fonts or other code and should be prepared in single column format. Specific and generic names should be *italicized*. Please refer to past issues of Permophiles (Glenister *et al*., Permophiles #34, p. 3; see website at http://pri.boisestate.edu/permophiles/ if you don't have a copy) for reference style (comma after the date and colon after the title please), format, *etc*. Maps and other illustrations are acceptable in tif, jpeg, eps, bitmap format or as CorelDraw files. The preferred formats for Adobe Pagemaker are Microsoft Word documents and tif files for images (minimum 150 dpi). We use Times Roman 12 pt. bold for title and author, 10 pt. for addresses and text, and 10 pt. bold for subheadings (flushleft). Indents for paragraphs are .2"; do not indent using the space bar. Word processing documents may include figures embedded at the end of the text, but these figures should also be attached as separate attachments in tif format or as CorelDraw or Adobe Illustrator files. Do not include figure captions as part of the image; include the captions as a separate section within the text portion of the document. If only hard copies are sent, these must be camera-ready, *i.e.*, clean copies, ready for publication. Typewritten contributions may be submitted by mail as clean paper copies; these must arrive well ahead of the deadline, as they require greater processing time. Any versions that require translation must also be submitted well ahead of the deadline. All paper versions of articles for Permophiles will be destroyed after the deadline of the subsequent issue, unless a request is made for return.

Please note that articles with names of new taxa are not normally published in Permophiles. Readers are asked to refer to the rules of the ICZN. All manuscripts will be edited for consistent use of English only.

I currently use a Windows 2000 PC with Corel Word Perfect 10, Corel Draw 10, Adobe Page Maker 6.5, Adobe Illustrator 9, and Microsoft Office 2000 programs; documents compatible with these specifications will be easiest to work with.

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SUBMISSION DEADLINE FOR ISSUE 41 IS JANUARY 3, 2003

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REPORTS

A view on the Permian continental stratigraphy of the Southern Alps, Italy, and general correlation with the Permian of Russia.

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Introduction

The southern Alpine domain of Italy was clearly characterized, during the Permian, by two main well-differentiated tectonosedimentary cycles, separated by a marked unconformity and a gap of as yet uncertain duration (Fig. 1). To the west of the Cadore-Comelico area, the lower cycle (1), as much as 2000 m thick, is essentially made up of Lower Permian acidic-to-intermediate volcanics and fluvial-to-lacustrine sediments, both generally infilling intramontane fault-bounded subsiding basins delimited by metamorphic and igneous structural highs. The upper cycle (2), in places reaching up to 600 metres and more, consists of the Upper Permian fluvial red clastics of the Verrucano Lombardo and the Val Gardena Sandstone, of which the latter is in part laterally and upwardly replaced, east of the Adige Valley, by the sulphate evaporite and shallow-marine carbonate deposits of the Tethyan Bellerophon Formation.

The Permian of the East-European Russian Platform can also be clearly subdivided into two distinct tectonosedimentary cycles (TSC). The lower one ranges from the Asselian up to early Ufimian (Solikamsk horizon), whereas the upper cycle pertains to late Ufimian (Shashma horizon) to Tatarian times. Thus, thanks to paleontological and other data, the Upper Permian succession in Eastern Europe appears more complete than that of the Southern Alps; in fact, the stratigraphic gap with the Russian lower cycle was relatively short, if compared with that generally inferred from the southern Alpine domain.

Southern Alps

a) the lower stratigraphic succession

In some areas of the continental Southern Alps, there are mono-polymict clastic bodies, which lie beneath Permian deposits and unconformably above the Variscan metamorphic basement. In western Lombardy, they include middle/late Westphalian plant-bearing conglomerates and sandstones, some of which, however, have also been locally related to slightly later times (Stephanian), but without any paleontological evidence.

These earliest detrital bodies are replaced in central Lombardy and to the east, as far as Carnia, by the so-called generic "Basal Conglomerates". These consist of laterally discontinuous, coarse- to fine-grained clastic, locally bioturbated alluvial bodies, from 0 to about 200 m thick, which still unconformably overlie the crystalline basement. Lithic fragments are mainly metamorphic; volcanic components may also occur, following the erosion of slightly earlier or coeval igneous products. The absence of fossils prevents their precise dating. However, due to the stratigraphic position, a range of these deposits from latest Carboniferous to Early Permian times could be envisaged.

All the aforementioned detrital deposits might already be related to the older Permian cycle (1); nevertheless, due to the lack of detailed research, they could also be the result of distinct tectonosedimentary events.

Paleontological research

Investigations of the macroflora (*e.g.* Geinitz, 1869; Venzo and Maglia, 1947; Dozy, 1935b; Jongmans, 1950, 1960; Tyroff, 1962 *in* Cassinis, 1966; Remy and Remy, 1978; Kozur, 1980; Visscher *et al*., 2001), palynomorphs (Clement-Westerhof *et al*., 1974; Cassinis and Doubinger, 1991, 1992; Barth and Mohr, 1994; Pittau *in* Conti *et al*., 1997 and AAVV, 2000), and tetrapod footprints (Haubold and Katzung, 1975; Ceoloni *et al*., 1987; Conti *et al*., 1991, 1997, 2000; Cassinis *et al*., 2000; Nicosia *et al*., 2000; Avanzini *et al.*, 2001) indicate that the aforementioned older cycle began locally in the Late Carboniferous (Westphalian), but developed generally during the Early Permian, and in some areas also extended to slightly more recent times, possibly up to the Kazanian.

a) Megafloras, Jongmans described the presence in the Manno molasses (Lugano) of *Linopteris neuropteroides*, *Pecopteridium*, *Sigillariaephyllum*, *Cordaites* cf. *borassifolius* (probably Westphalian C), whereas Venzo and Maglia recognized in the Logone deposits (west of lake Como) *Calamites* spp., *Pecopteris plumosa*, *Linopteris neuropteroides*, *Lepidodendron welthiemi*, *L. aculealeatum*, abundant *Sigillariae* and other forms (again Westphalian C).

The studies of Geinitz and the Remys led to the identification in the Val Trompia Collio Formation of *Sphenopteris suessi*, *Hermitia* (al. *Walchia*) *geinitzii* and other forms of the German Rotliegend. The latter authors, more specifically, ascribed these floras to the "middle to higher Saxonian". In contrast, Kozur (1980) placed the cited formation between the uppermost Carboniferous (Asselian *s.l.*) and the basal Permian (lowermost Sakmarian), and assigned the immediately overlying units (Dosso dei Galli Conglomerate and the Auccia Volcanics), which mark the end of the first Permian tectonosedimentary cycle, again to the Sakmarian.

In contrast, Remys (1978) dated a few vegetal remains of the

Tregiovo Formation, which crops out towards the northeast, in the Trento/Bolzano provinces, including *Lesleya* (al. *Taeniopteris*) *cf. eckardti*, *Ulmannia frumentaria* and other floras, again to the "Saxonian", but to times later than the "Collio" flora. Consequently, these authors confirmed an age assessment, which had already been identified in some previous works (Dozy, 1935b; Visscher, 1973; and others). Later, bearing in mind the discovery of "*Ullmannia bronni*, *Lebachia laxifolia*, *L. piniformis*, *Ernestiodendron filiciforme*, *Quadrocladus orobiformis* and *Pseudovoltzia liebeana*", which seem to derive from the same considered lithostratigraphical unit, Kozur (1980) suggested that the Tregiovo beds were younger than the Artinskian and older than the Upper Permian Val Gardena and Bellerophon deposits.

b) Microfloras. Among the palynomorphs, Doubinger (1991, 1992) recognized in the Val Trompia "Collio" the presence of *Cordaitina* sp., *Potonieisporites* sp., *Nuskoisporites* sp., striate and alete disaccate pollen, *Lueckisporites microgranulatus*, *Falcisporites* cf. *zapfei*, and so on. These findings allowed correlation of the unit to a "Saxonian" time-span generally corresponding to a late Early Permian interval, more recent than the early Artinskian and probably including still younger times (Kungurian-Ufimian *p.p*., according to the Cis Ural./Russ. Platf. standard scale). In contrast, the investigations carried out on the typical Tregiovo Fm. led Doubinger to recognize two not fully similar palynological assemblages. The lower is characterized by the presence of *Potonieisporites* cf. *enormis*, *Jugasporites delasaucei*, *Distriatites* (al. *Hamiapollenites*) *insolitus* (very rare), striate and alete disaccate pollen, *Lueckisporites microgranulatus*, and other forms; whereas, the upper association from relatively higher strata of "Tregiovo" consists of *Potonieisporites* cf. *enormis*, *Nuskoisporites dulhuntyi*, *Jugasporites delasaucei*, *Distriatites* (al. *Hamiapollenites*) *insolitus*, striate and alete disaccate pollen, *Lueckisporites virkkiae*, *Corissacites alutas*, *Crucisaccites variosulcatus*, *Paravesicaspora splendens* and *Vittatina* spp. Altogether the assemblages in question are generally in favour of a slightly younger position for the "Tregiovo" compared with the "Collio"; this assertion appears mainly supported by the second association which seems to mark the beginning of "Middle" or Late Permian (according to the tri-bipartite subdivision of this period, respectively). Barth and Mohr (1994), themselves, suggested a Kungurian-Ufimian age-assessment for the aforementioned unit. However, the first palynological investigations carried out in the so-called "Tregiovo beds" gave a slightly older age, ranging from Artinskian to Kungurian (Klau, 1965).

Recently Pittau (*in* AAVV, 2000, pp. 69-70), during the Brescia Meeting on the continental Permian, also pointed out that the palynomorph assemblage of the Val Trompia Collio Fm. could be partially ascribed to the top of the Early Permian (*i.e.* Kungurian). Furthermore, from the sporomorph data given in the field guidebook (AAVV, 2000, pp. 83-85), she clearly suggested that a younger age for the typical Tregiovo Fm. may be hypothesized at least for the uppermost part of the unit. This opinion was emphasized by the presence of *Lueckisporites virkkiae*, because Utting *et al*. (1997) signalled its lowest occurrence in the lower Kazanian of the type area. As regards the age of the bulk of the Tregiovo succession, the main palynological characteristics show abundant nontaeniate disaccate pollen and, to a lesser extent, common monosaccate and taeniate disaccate pollen, with *Vittatina* (various species) of secondary importance; taking into account these variations, *i.e.* the low content of *Vittatina*, which is connected to other environments, a possible Kungurian to Ufimian (?) age may be suggested.

According to Pittau, comparison with the assemblages of the overlying Val Gardena Sandstone highlights remarkable differences in the qualitative and quantitative composition, even if an affinity in the suite of nontaeniate disaccate pollen and the presence of *Nuskoisporites dulhuntyi* is impressive. In this sense, the "vocation" of the upper part of the typical Tregiovo unit is towards the Late Permian rather than the Early Permian.

c) Vertebrate footprints. Among the tetrapod footprints, Haubold (*in* Haubold and Katzung, 1975) signalled in the Val Trompia "Collio" the presence of *Amphisauropus imminutus*, *A. latus*, *Dromopus lacertoides* and other forms. According to the above author, these forms would ascribe the unit in question to the "Middle European late Autunian" (Sakmarian?), considering it to be more or less coeval with the Thuringia "Oberhof beds". An approximately similar chronostratigraphical position, corresponding to this unit, has also been provisionally proposed by Ceoloni *et al*. (1987). However, further detailed research (Conti *et al*., 1991) and a central-western Mediterranean synthesis (Conti *et al*., 1997) led mainly to ascribing these tetrapod footprints to the Kungurian. After a partial revision, such Lower Permian ichnoassociation includes reptile (? *Camunipes cassinisi*, *Varanopus curvidactylus*, *Amphisauropus latus*, *Icniotherium cottae*, *Dromopus lacertoides*, *D. didactylus*) and less frequent amphibian footprints (*Batrachichnus* sp.).

This set of data was successfully compared with others from different sites of the Orobic Basin (Gümbel, 1880; Dozy, 1935a; Cassinis *et al*., 2000; Nicosia *et al*., 2000; Santi and Krieger, 2001), and from the Tregiovo Basin (Conti *et al*., 1997, 2000).

As the comparison with marine deposits is impossible, we can use floristic forms (*e.g*., those described from Cassinis and Doubinger, 1991, 1992; Cassinis and Ronchi, 2001; Cassinis and Santi, 2001; and other authors), as well as radiometric data (highlighted, *e.g.*, from AAVV, 2000 and Cassinis *et al*., in press) for dating. Actually, in this context, the time interval in which this tetrapod fauna is widespread in northern Italy is more or less limited between 286/283 Ma , at the base, and 278/273 Ma at the top (Avanzini *et al*., 2001, p. 97). Following the 2000 Menning's Permian time-scale (Menning, 2001, p. 356, fig. 1), this fauna generally continued up to the Artinskian and Kungurian; however, other scales drawn up in the same scheme (*e.g.* Harland *et al*., 1990; Odin, 1994; Gradstein and Ogg, 1996) clearly relate the above geochronometric values to Sakmarian and latest Asselian times. The above-mentioned southern Alpine ichnoassociation shows strong affinities with the Wolfcampian tetrapod footprints described from North America, thus indicating a close connection of this continent to the present Central and Western Europe. In conclusion, according to the global series of the marine Permian System, the above-mentioned fauna must undoubtedly be considered as coeval with the Lower Permian Cisuralian.

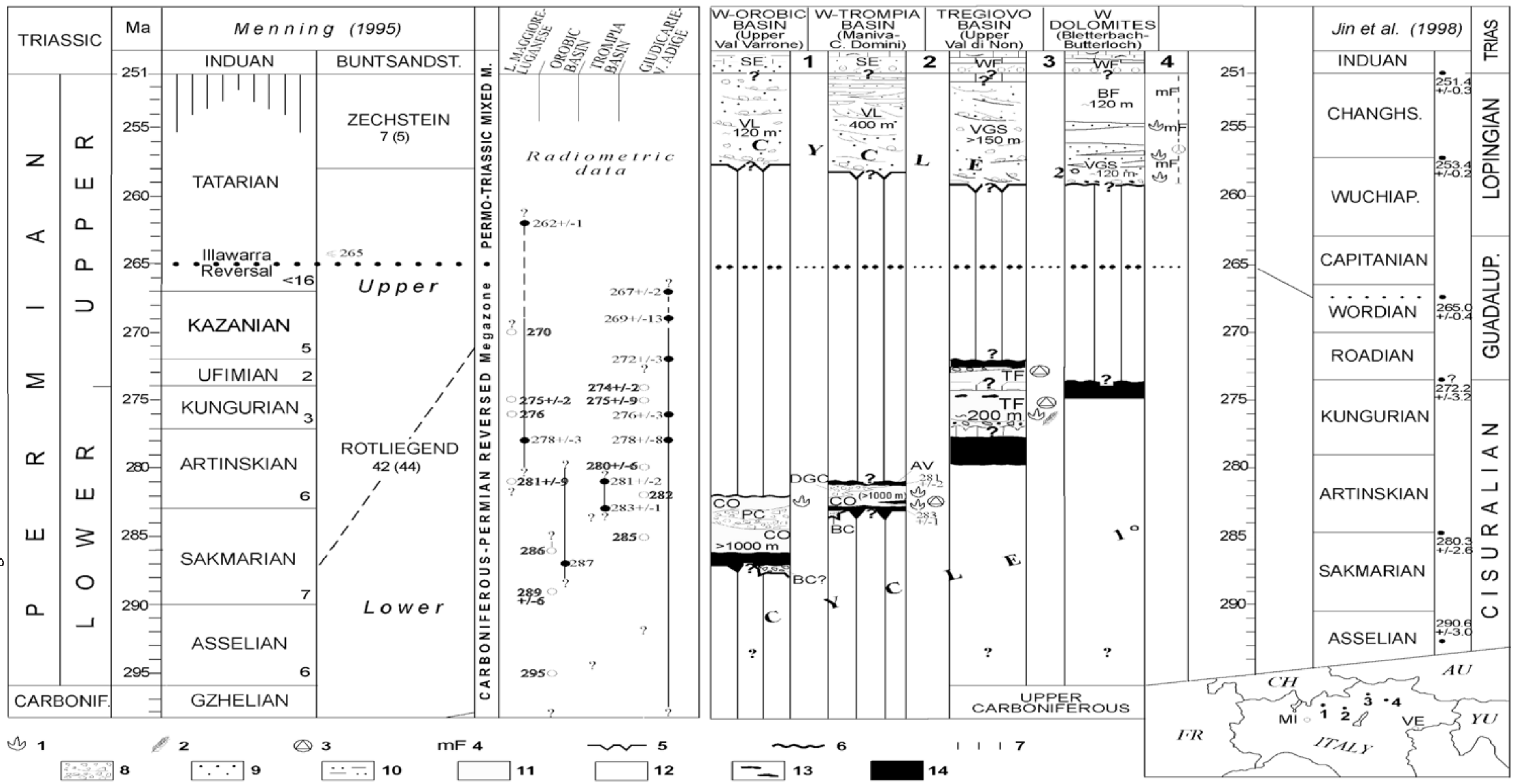

Figure 1. Permian stratigraphic successions (localities shown on the inset map) from the Southern Alps, between Lake Como and the western Dolomites. Westward, the lower part (Cycle 1) consists of continental volcanics and alluvial-lacustrine sediments, while the upper part (Cycle 2) is made up of fluvial redbeds, which, to the east of the Adige Valley (column 4), grade laterally and upwards to sulphate evaporites and shallow-marine sediments. Sections 3 and 4 are incomplete below, because the corresponding volcanic and sedimentary succession is still lacking in careful investigations. The Val Trompia section shows two radiometric data, recently obtained by Shaltegger and Brack (1999). *Lithostratigraphic units*: abbreviations (from bottom) - Lombardy, **BC**: Basal Conglomerate, **CO**: Collio Fm., **PC**: Ponteranica Conglomerate, **DGC**: Dosso dei Galli Conglomerate, **AV**: Auccia Volcanics, **VL**: Verrucano Lombardo, **SE**: Servino Fm. – Trentino-Alto Adige, **TF**: Tregiovo Fm., **VGS**: Val Gardena Sandstone, **BF**: Bellerophon Fm., **WF**: Werfen Fm. *Fossils* - 1: Tetrapod footprints, 2: Plant remains, 3: Palynomorphs, 4: Marine fossils. *Other symbols* – 5: Unconformity, 6: Erosion surface, 7 Stratigraphic gap. *Lithology* – 8: Conglomerates and breccias, 9: Sandstones and conglomerates, 10: Pelites and sandstones, 11: Lower Permian sediments of Cycle 1 (dark-grey colour), 12: Upper Permian deposits of Cycle 2 alternating, without symbols, with sulphate evaporites to shallow-marine sediments (light-grey colour), 13: Cherty nodules, 14: Undifferentiated volcanic rocks of cycle 1 (black colour). Geologic time scales from Menning (1995) and Jin *et al.* (1998). This scheme beside the subdivisions of the first author also includes a large number of radiometric data (in Ma) on intrusive (light-grey dotted) and volcanic (black) rocks generally cropping out between Lake Maggiore and the Val d'Adige region; the respective vertical lines indicate the assumed duration of the igneous activity in each area, whereas the dashed lines correspond to presumed or discontinuous manifestations. (modified from Cassinis and Ronchi, 2001).

Radiometric research

Radiometric investigations of post-Variscan igneous bodies of the Southern Alps, carried out by a number of authors, suggest that this magmatic activity began in the Late Carboniferous (Stephanian ?) but mostly developed during the Early Permian, and locally up to slightly younger times (Kazanian ?) (Fig.1). In the west, between the lakes Maggiore and Lugano, the Baveno, Ganna and other bodies generally emplaced at about 280-270 Ma (Barth *et al*., 1993), according to Rb-Sr total-rock isochron ages from Hunziker and Zingg (1980), Pinarelli *et al*. (1988) and Bakos *et al*. (1990), and to a preliminary U-Pb zircon age of 281 Ma for shallow intrusives from Brack and Shaltegger (1999). The chronostratigraphical implications of these studies obviously depend on the adopted time-scale (*e.g*. Harland *et al*., 1990; Menning, 1995; Jin *et al*., 1998). As a consequence, although the results are contradictory, we can reasonably relate the bulk of this western magmatism to the Early Permian.

Towards the east, the igneous products of the Orobic and Val Trompia basins plausibly developed again during the Early Permian (Cadel, 1986). However, the earliest activity of the Val Biandino intrusion might date back to the latest Carboniferous (De Capitani *et al*., 1988; Thöni *et al*., 1992). The ^{206}Pb-^{238}U ages of 283±1 Ma and ca. 281±2 Ma obtained from zircons respectively extracted from the lowermost and uppermost rhyolitic ignimbrites cropping out in the Brescian Prealps, along the Maniva-Croce Domini road (Shaltegger and Brack, 1999, 2000), also leads to controversy; in fact, according to some current time-scales (Harland *et al*., 1990), these dates appear in sharp contrast with the palynological age-assessment of the local lower cycle succession.

The post-Variscan magmatism of the Trentino-Alto Adige region covers an area of over 2000 km^2, and forms the most conspicuous example in the Southern Alps. Dates from intrusive and extrusive rocks generally indicate Early Permian activity (Borsi *et al*., 1966, 1972, 1976); however, latest Carboniferous and "middle" Permian ages have also been suggested by some authors (*e.g*. D'Amico *et al*., 1980; Hess, 1990; Barth *et al*., 1993).

b) the upper stratigraphic succession

As already mentioned, the Upper Permian Verrucano Lombardo and the Val Gardena Sandstone represent the reddish deposits of a new sedimentary cycle, which was marked by the cessation of the previous voluminous magmatic activity. However, both the units are in places immediately preceded by well known dissimilar mono- polymict ruditic bodies (*e.g*, the Daone Conglomerate in southwestern Trentino and further to the east, from the Cadore-Comelico region, the Sesto Conglomerate and the Tarvisio Breccia). The aforementioned succession forms a widespread blanket which unconformably covers the basins of the first cycle and the surrounding highs, separated by a long time gap of as yet uncertain and variable duration. Generally these sediments, compared with the products of the older cycle 1, appear more widely distributed although less thick.

Paleontological research

a) Megafloras. According to the Dutch authors (*e.g*. Clement-Westerhof, 1984, 1987; Poort and Kerp, 1990) and others, the Gardena flora from the Bletterbach gorge, in the western Dolomites, is characterized by the presence of coniferous remains. The dominant genera are *Ortiseia*, *Majonica*, *Dolomitia*, and *Pseudovoltzia*, rather than *Walchia*, *Ullmannia*, and *Voltzia* (Visscher *et al*., 2001).

The most prominent pteridosperm fragments from the Val Gardena Formation correspond to the species formerly known from the Zechstein Basin of NW-Europe as *Callipteris martinsii*. On the basis of a detailed analysis of foliage and ovuliferous organs, this species is now included in the natural genus *Peltaspermum* (*P. martinsii*) of the family Peltaspermaceae (Poort and Kerp, 1990).

Visscher *et al*. (2001) generally agree that the age of the Val Gardena flora, to the east of the Adige Valley, is Late Permian. All recognized species become extinct at or close to the Permian-Triassic junction. This extinction illustrates the profound effect of the Permian-Triassic biotic crisis on gymnosperm diversity in the Late Paleozoic Euramerican floral realm (Visscher and Brugman, 1988; Visscher *et al*., 1996; Poort *et al*., 1997).

Further to the west, given the lack of fossils, the timing of the Verrucano Lombardo-Val Gardena lithosome is still a subject of uncertainty and discussion. However, as both the units rest generally above the Lower Permian and, in places, probably slightly younger volcanosedimentary products of cycle 1 and below the Lower Triassic marine Werfen and/or Servino Fms, a general Late Permian age again appears very plausible.

b) Microfloras. Palynological research on the typical Val Gardena Sandstone has been published by a number of authors (*e.g.* Klaus, 1963; Clement-Westerhof, 1984; Italian IGCP-203 Research Group, 1986; Visscher and Brugman, 1988; Massari *et al*., 1988, 1994, 2000; Conti *et al*., 1997; Cirilli *et al*., 1998; Pittau, 2000, 2001). The large quantity of palynomorphs from the Bletterbach section was initially subdivided by Pittau (in Massari *et al*., 1988) into three informal associations: A) not defined by particular taxa, B) identified by the concurrent presence of *Protohaploxypinus microcorpus* and *Endosporites exareticulatus* and, upwards, C) characterized by the occurrence of *Lunatisporites noviaulensis*, *Inaperturopollenites dolomiticus* n. sp. and *Lueckisporites* sp. However, the impossibility of extending this biostratigraphical scheme to all the sections of the Val Gardena outcrops, later induced Pittau (in Massari *et al*., 1994) to use further sets of taxa.

Despite the presence-absence of *Protohaploxypinus microcorpus* and *Endosporites exareticulatus*, other taxa have also been used successfully to correlate the lower and central parts of the Val Gardena-Bellerophon succession (respectively, corresponding to A and B associations of the Bletterbach section), whereas *Lueckisporites parvus* and *Guttulapollenites* sp. have been used to identify its upper part (equivalent to the C association of the above section).

According to Pittau (2000), the combination of these two taxa and other pollen grains does not seem to have an equivalent in the Tatarian continental red beds of the type area (Urals), thus probably indicating a younger age; in contrast, the underlying taxa of the Val Gardena Fm. lead to correlations with the Upper

Tatarian Viatsky Horizon (Koloda and Kanev, 1996).

c) Vertebrate footprints. Tetrapod trackways are also widespread and well known in the Bletterbach area from the western Dolomite Alps. According to Ceoloni *et al*. (1988) and Conti *et al*. (2000), typical Permian genera (*Ichniotherium*, *Hyloidichnus*) have been found together with taxa displaying clear Triassic affinities (such as *Rhyncosauroides* and *Dicynodontipus*). *Pachipes dolomiticus* represents the most typical element of this ichnofauna, which Conti *et al*. (1997), just for its particularity, qualified as the "Faunal Bletterbach Unit".

d) Magnetostratigraphy. Only two studies on the magnetostratigraphy of the Val Gardena Sandstone are available for the whole Southern Alps area (Mauritsch and Becke, 1983, on the Paularo section, Carnic Alps; Dachroth, 1988, on the Balest section near Ortisei, Western Dolomites). In both papers, the discovery of the Illawarra reversal is reported. According to Menning (1995), this event can be dated to about 265 Ma and ascribed to the lower Tatarian (partly corresponding to the Capitanian). However, these magnetostratigraphical data do not fit well either with the sequence-stratigraphic model elaborated by Massari *et al*. (1994), or with biochronostratigraphical interpretation based on tetrapod footprint associations and palynomorphs, both indicating a very Late Permian age for the Val Gardena Sandstone-Bellerophon Fm. (as they correlate to the mid-Zechstein succession). In the absence of good chronostratigraphical framework, we cannot be sure that the reversals found in the above-quoted Dolomite Alps section, in intervals that Massari and Neri (in AAVV, 2000, p. 34) ascribe to different depositional sequences, is the real Illawarra reversal or, in contrast, one of the several reversals that characterize the Late Permian.

For this reason, until new magnetostratigraphical research is carried out, we believe that these very scattered paleomagnetic data do not provide significant constraints for chronostratigraphy.

A general correlation with the Permian of Russia

As already mentioned, the Permian succession of the East-European Russian Platform can be clearly subdivided into two tectonosedimentary cycles (TSC): the lower one pertains to the Asselian-early Ufimian (=Solikamsk horizon) and the upper cycle to late Ufimian (=Sheshma horizon) to Tatarian times. (Fig. 2).

The first cycle began during the Asselian with the downwarping of the Pre-Urals foredeep (Chuvashov and Dupina, 1978). It consists of the following facial zones (west to east): (1) laminated limestones (280 m) with varied marine fauna, which accumulated on the waste territories of the East-European Platform; (2) marginal bryozoan-brachiopodian reefs (up to 500 m), which served as a natural barrier between the East-European Platform and the PreUrals foredeep; (3) a restricted zone of laminated limestones similar to the first but with less diverse fauna (120 m); (4) depression zone, where thin claystones and clayey limestones were deposited in deep-water conditions (150 m); and (5) a flysch zone (up to 1000 m).

The main transgressive phase occurred during the Sakmarian, giving deposits up to 600m thick, showing the same facial zonation. From the Artinskian the influx of terrigenous material on the eastern part of the Pre-Ural foredeep sharply increased, reaching a total thickness of about 2 km, and was probably due to one of the first significant uplifts of the Uralian orogen.

A regressive phase of the Lower Permian TSC developed during the Kungurian, when the salt-bearing formation (over 1500m thick) in the south and the coal measures (exceeding 2500 m) in the north were formed.

The Solikamsk horizon ends at the top with carbonate-sulphate deposits, 120-300 m thick, only in the Pre-Urals foredeep central area. They include a lagoonal and continental fauna and flora associated with marine brachiopods, pelecypods and foraminifers in very thin layers (from 1 to 10 cm), which testify to repeated salinity changes in the residual Kungurian basin. As a consequence, the Lower Ufimian (Solikamsk horizon) marks the closing phases of the first Early Permian cycle.

The Lower Permian in Western Europe, as well as in North America, is characterized by a pelycosaurid fauna ("Edaphosaurid" empire of Anderson and Cruickshank, 1978). In this context, the Russian authors highlight that the aquatic tetrapod fauna from the Inta Fm. (upper part of the Vorkuta series, Petchora basin), named the "Inta complex of Eryopoid supercomplex" (Ivakhnenko *et al*., 1997), mainly contains an eryopid *Clamorosaurus* and captorhinid *Riabininus* (Fig. 2), which are very similar to early Permian eryopoids of North America (Gubin, 1984), bolosaurids, captorhinids, enosuchuds *Nyctiboetus*, anthracosaurs *Aversor*, and endemic *Intasuchus* and *Syndiosuchus*. This Inta fauna strongly reflects those found in the West-European and North-American Lower Permian and are therefore related to the above-mentioned empire (Lozovsky, in press). Also Kanev and Koloda (2000), based on the study of non-marine pelecypods and sporomorph assemblages, believe that the largest part of the Inta Fm. (including the tetrapod-bearing beds) corresponds to the Solikamsk horizon, and consequently they agree with the above-stated conclusions.

The Early Permian cycles of Western and Eastern Europe developed in completely different palaeogeographical conditions (continental in the former area, and marine in the latter) and palaeotectonic regimes (late post-orogenic and platform respectively). Their correlation can be made only by using sporomorph associations. The recent discovery by Sciunnach (2001) of rare calcareous foraminifers (*cf. Agathammina* sp. and *cf. Hemigordius* sp.) within the continental Lower Permian in the western part of the Orobic chain (central Southern Alps, Italy), reflects a short marine episode linked to a presumed Sakmarian eustatic event, which could be correlated to the main transgressive phase during the first Permian TSC in Eastern Europe. It is worth mentioning that a similar episode has also been recorded within the Lower Permian of New Mexico, North America (Lucas and Heckert, 1995).

The second tectonosedimentary cycle begins with the upper Ufimian (Sheshma horizon) (Fig.2). It is made up of continental red beds, up to 300m thick, bearing rare limestone layers, dolomites and gypsum. Within the limits of the Pre-Urals foredeep this horizon rests on the Solikamsk succession. Westwards and eastwards, where the latter is absent, Sheshma directly overlies the deeply eroded and karstic surface of the Sakmarian-Kungurian carbonate and sulphate deposits

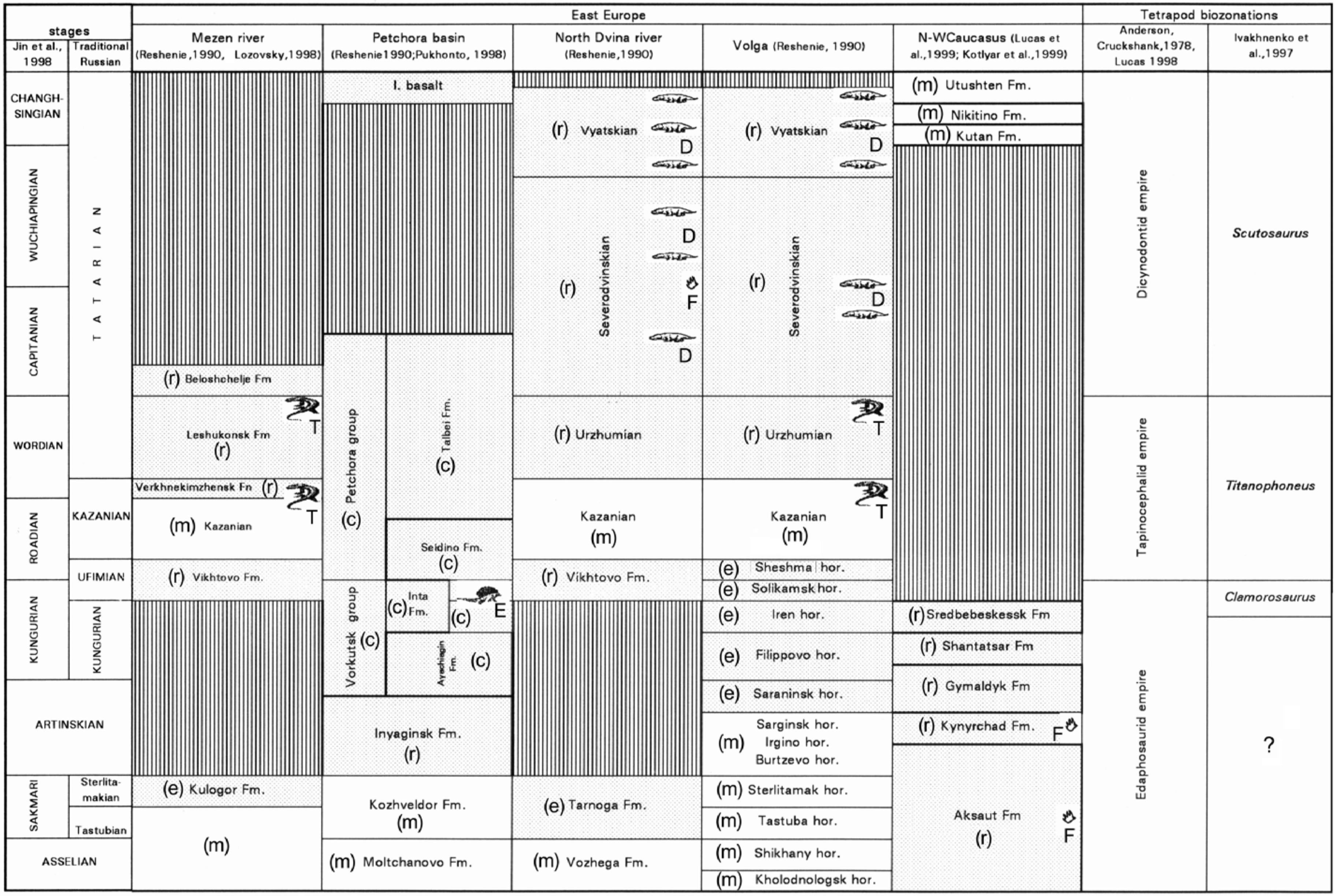

Figure 2. Permian successions in the Eastern European Russia. *Symbols* (inserted in the scheme) – Fossils: tetrapod footprints, **F**; Edaphosaurids, **E**; Tapinocephalids, **T**; Dicynodontids, **D**. – Deposits: The light-dotted intervals of the stratigraphic columns include red beds (**r**) (replaced by basalts in the uppermost part of Petchora basin), coal measures (**c**), and evaporites (**e**), whereas the blank indicates the presence of marine carbonates (**m**). Vertical lines: stratigraphic gaps.

(Stepanov, 1966). The maximum transgression of the Upper Permian TSC took place during the Kazanian stage, which is generally represented by marine limestones and claystones. Recent findings of Roadian ammonites (Leonova, pers. comm.) testify to a direct palaeogeographical connection between the Kazan marine basin and the Boreal sea. At the same time, no link between the Kazanian Basin and the Zechstein Basin in the west was highlighted, and therefore both basins were isolated and developed independently.

West of the Kazan meridian, deep-water limestones are replaced by coastal oolitic and dolomitic shelves, which directly overlap the Sakmarian. In contrast, the Kazanian beds of the western marginal areas of the Moscow syneclise overlie the Lower Permian (Asselian) and the Middle Carboniferous, thus clearly emphasizing the stratigraphic break between the Lower and Upper Permian cycles.

The regressive part of the latter cycle is characterized by a complex of lagoonal and continental Tatarian deposits (the maximum thickness of this succession reaches up to 700 m, *i.e.* three times more than the value of 250 m estimated for the Kazanian rocks). The Tatarian is in turn overlain by the Lower Triassic Vetlugian, of which the fauna from the lowest horizon (Nedubrovo beds) allows correlation with the oldest Buntsandstein, as well as with the Tesero Oolite Member from the Southern Alps (Lozovsky *et al*., 2001).

The boundary between the Lower and Upper cycles - which corresponds to that between the Lower/Upper Ufimian, *i. e.* between the Solikamsk/Sheshma horizons - can be clearly followed in Eastern Russia, *e.g.* in the Siberian platform, the Kuznetsk basin, and Verkhoyanie (Budnikov *et al.*,1997; Durante and Pukhonto, 1999). In this last region and other parts of Siberia there are typical Kungurian (*Tumaroceras*, *Epijureresanites* and *Baraioceras*) and Roadian (*Sverdrupites* and *Daubichites*) ammonites in the local formations which are coeval with Solikamsk and Sheshma horizons respectively (Bogoslovskaya and Shkolin, 1998; Budnikov *et al*.,1997; Klets *et al.*,1998). Thus we support the opinion of many Russian stratigraphers (Lutkevich, Stepanov, Tykhvinskaya, Posanov) about the non-validity of the Ufimian stage: its lower part (Solikamsk horizon) should be attached to the top of the Kungurian stage, and the upper part (Sheshma horizon) to the base of the Kazanian (Kotlyar, 1999).

The West and East European floristic assemblages, which are respectively characterized by the Laurasian and the sub-Angarian provinces (Meyen, 1987), are different. However, it is interesting to point out that the floristic changes between the Lower and Upper Permian successions, such as the Oten and Zechstein flora in Western Europe (Meyen,1987) and the Vorkuta and Petchora flora in Eastern Europe (Pukhonto, 1998), are both indicative of an aridisation of climate.

The changes of tetrapods at the Lower/Upper Permian boundary are very distinctive, being marked principally by the appearance of therapsids and the flourishing of parareptiles. The first therapsid (Deinocephalian) fauna (=”Tapinocephalid” empire of Anderson and Cruickshank, 1978) characterizes the lower part of the Russian Upper Permian cycle (Kazanian and Lower Tatarian). This fauna is unknown in the Dolomite Alps, whereas it is distinguished in East Europe, mainly in Kazanian (Golussherminsk complex of the Volga region), Kazanian-Lower Tatarian (Mezen complex of the basin of the Mezen river) and the Lower Tatarian (Ocher complex of the Perm region and two complexes, Isheevo and Mal.Kinel, of the Volga region). Coeval tetrapod footprints have been found in the Pradineaux Fm. (Provence, South France). In fact, in this area, the first appearance of therapsids (*Lunaepes, Planipes*) was recently recorded (Durand and Gand, 1995).

The youngest pareiasaurian-gorgonopsian fauna (=”Dicynodontid” empire of Anderson and Cruickshank, 1978) is well known from the Upper Tatarian of European Russia (Severodvinsky and Viatsky horizons). They include amphibians, therapsids (eotheriodonts, theriodonts and anomodonts) and pareiasaurs, and correspond to the *Scutosaurus* tetrapod superzone (Ivakhnenko *et al*., 1997). A coeval ichnofauna is known in the Val Gardena Fm. of the Southern Alps (Ceoloni *et al*.,1988). It is also worth mentioning that in the north of European Russia a lot of footprints and trackways of big terrestrial tetrapods have recently been collected from some limestones of the Isada Mb., Poldarsa Fm., belonging to the middle part of Severodvinsky horizon, Upper Tatarian in age. Gubin, however, points out that the pareiasaur imprints, even if similar in shape and general features to *Pachipes dolomiticus* of the Val Gardena Fm. in the Dolomite region, differ from those of this form because of some characteristics, such as the position of the longest finger (paper in press).

Undoubtedly, the Upper Permian tectonosedimentary cycle of Eastern Europe appears more complete than that of Western Europe; in fact, the stratigraphic break with the Lower Permian cycle was relatively short, whereas in Western Europe it generally developed over a long period .

Conclusion and Discussion

From the above paleontological and other correlation data, the following new chronostratigraphical scenario for the continental South Alpine domain could be suggested, although the present interregional time-scales need further research and/or refinement. In addition, this overview has conveniently involved, for further details, some Permian aspects of pre-Ural Russia.

a) In western Lombardy, from Lake Maggiore to the Bergamasc Alps, the post-Variscan succession is locally represented by basal clastics and igneous, acidic-to-intermediate calcalkaline products, both extending from the Late Carboniferous up to Permian times. The former deposits began during the middle-upper Westphalian, whereas the latter took place during slightly later episodes, mainly developing at the transition with, and/or throughout the Early Permian. In this context, fluvial to lacustrine sedimentary deposits (such as the Ponteranica, Mesenzana and Collio Fms) also crop out upwards. The current biotic elements (tetrapods, palynomorphs, megafloras), together with radiometric data, probably indicate a Sakmarian up to Artinskian age, as shown by various current time-scales.

Recently, throughout a section of the western Orobic Basin, Sciunnach (2001) highlighted the presence of very thin marine layers, with rare calcareous foraminifers (cf. *Agathammina* sp. and cf. *Hemigordius* sp., along with other indeterminate forms) and small gastropod fragments, from the uppermost Collio Fm., some metres below the unconformable Verrucano Lombardo. This discovery led the author to suggest that a temporary seaway spread locally into the continental basin, which therefore could at least locally be interpreted as a coastal lake. Furthermore, according to Lozovsky (2001 and pers. comm.), this marine, presumably eustatic event could be correlated with that established in the Lower Permian red beds of North America during Sakmarian times. The author also points out that this event represents, in the same time interval, a second episode, *i.e*. not fully correspondent with the previous one. However, this correlation must still be evaluated in a more accurate interregional context.

The Verrucano Lombardo of western Lombardy undoubtedly changes stratigraphically according to the adopted chronological scales. The unit certainly developed during the Late Permian, and probably throughout post-early Tatarian times. If so, the local gap between the two aforementioned Permian successions reaches, in the western Orobic Basin (upper Val Varrone), a duration which can generally be interpreted as about 25 Ma.

b) In eastern Lombardy, the paleontological data from the Val Trompia Basin are still under discussion. Past authors correlated the Collio Fm. to the German Rotliegend. In later times, only Doubinger (*in* Cassinis and Doubinger, 1991, 1992), on the basis of some palynomorphs, related this unit to a late Early Permian and slightly Late Permian age, from the late Artinskian to early Ufimian. However, this dating, which was also generally followed by some other authors (*e.g*. Conti *et al*., 1997; Pittau *in* AAVV, 2000) must be considered simply as a new chronostratigraphical interpretation after the previous tentative steps by Clement-Westerhof *et al.* (1974) with wider Southalpine Permian palynological research, who generally assigned the Collio Fm. to a more or less similar chronostratigraphical interval.

However, this attribution is not in keeping with the radiometric data recently obtained by Shaltegger and Brack (1999, 2000), which resolutely place the local Permian first tectonosedimentary cycle, and thus the included Collio Fm., into an older stratigraphic context. In fact, the ages of 283±1 Ma and 281±2 Ma (or 280.5±2 Ma; Shaltegger and Brack, 2000) calculated respectively from U-Pb zircon analyses from the lowermost and uppermost rhyolitic ignimbrites as exposed along the Maniva-Croce Domini road, allow attribution of the entire succession to the lower – (?)middle part of Lower Permian. Consequently, according to a large number of already mentioned time-scales (Harland *et al*., Odin and other authors *in* Menning, 2001), these numeric values appear globally concentrated from Asselian to Kungurian times. In conclusion, this palynological/radiometric contrast needs further research for a definite solution. However, the discovery of abundant Wolfcampian tetrapod footprints and Early Permian (post-Autunian ?) vegetal remains, along with the attainment of some radiometric dates, would so far seem to indicate a lower-middle Lower Permian age for the Collio Fm. cropping out in the Brescian and Bergamasc Alps.

As in western Lombardy, the gap between this lower succession and the superimposed Verrucano Lombardo of cycle 2 could be evaluated again in the Val Trompia Basin at about 24 Ma.

c) Toward the east, in the Trento and Bolzano region, the post-Variscan succession began locally with the already mentioned “basal conglomerates”. This Ponte Gardena fluvial unit (Dal Cin, 1972) is usually referred to the Early Permian, but without any paleontological evidence. The overlying succession of volcanic products, which reaches up to a maximum thickness of about 2000 m, was often subdivided into two groups: a lower one, mainly consisting of andesitic lavas, and an upper group, mostly represented by a rhyodacitic to rhyolitic ignimbrites. Sedimentary clastic intercalations are also common.

Radiometric ages for these volcanics, and for the coeval intrusive bodies, generally pertain to the Early Permian (*in* AAVV, 2000 and Cassinis *et al*., in press). According to a number of time-scales, these dates span from the Sakmarian (or earlier?) to the Kungurian, but also to a slightly more recent interval (up to Kazanian?). A Late Carboniferous inception for this magmatism also cannot be excluded. Palynomorph research from the embedded clastic sediments seems to emphasize the presence of Artinskian and later stages (Doubinger *in* Cassinis and Doubinger, 1991, 1992; Barth and Mohr, 1994; Pittau, 2000; and other authors). As already recorded, the typical Tregiovo Basin includes forms from Kungurian-Ufimian and perhaps Kazanian times (Pittau *in* Conti *et al*., 1997; Pittau, 2000; and Cassinis *et al*., in press).

In conclusion, the Trento/Bolzano provinces highlight a first Permian cycle which is more extensive, and at least in part also younger, than that in Lombardy. In this frame, the temporal continuity of the local Permian magmatic-tectonic activity, clearly supported by field and radiometric data, could be considered as one of the main causes.

As a consequence, a shorter gap with the overlying unconformable fluvial red clastics of the later Permian cycle (2) appears clearly justified. This gap might be evaluated in the Tregiovo area as approximately 10 Ma.

d) East of the Adige Valley, in the western Dolomites, the huge Bolzano volcanics are again in erosional contact with the Val Gardena red siliciclastics. This Permian portion of the second tectonosedimentary cycle also includes sulphate evaporites and shallow-marine carbonates of the Bellerophon Fm., all mutually interfingering and piled up with an overall transgressive trend. The transgression progressively encroaches on western areas, so that on a broad scale the Bellerophon Fm. appears as a sedimentary wedge pinching out westwards.

Unlike the deposits of the lower cycle, which are confined within isolated basins, those of the upper cycle extend as a continuous blanket from Lombardy to Carnia and Slovenia. According to Massari *et al*. (1994) and to Massari and Neri (1997), the 2nd cycle also includes the Lower Triassic Werfen Fm. and the overlying Olenekian-Lower Anisian Lower Serla Fm.

As already recorded, age data from the first Upper Permian red beds are mainly based on megafloras, palynostratigraphy, and tetrapod footprints, as well as magnetostratigraphic investigations, which, however, based on the above-mentioned observations, must be reviewed.

It is worth repeating that, according to a recent work by Pittau (2001), the Val Gardena Sandstone palynomorphs from the Bletterbach section partly correspond with those discovered in the Upper Tatarian of the type area (Urals), locally pertaining to the Severodvinsky and the Viatsky horizons, but probably the Southalpine highest forms reach up to slightly younger Permian.

Dating of the Upper Permian Bletterbach succession by marine time-scales was also tentatively performed. A late Middle Permian (? Capitanian) age for the lowermost part of that sedimentary section and an Abadehian to Changhsingian age for the overlying succession was suggested in previous papers (Conti *et al*., 1986; Massari *et al*., 1988), even though the striking similarities with the Zechstein microfloras of Central and Northern Europe, as well the successions of other countries, were pointed out. At present, Pittau (2001) ascribes the Val Gardena Sandstone mainly to late Dzhulfian time, and the Bellerophon Fm. from part of this stage to the Changhsingian, the latter also supported by other suitable paleontological data (Broglio Loriga *et al*., 1988; Posenato, 1988; Posenato and Prinoth, 1999).

e) According to the aforementioned palynological results, the tetrapod ichonofauna of the Val Gardena red beds confirms the latest Late Permian age of this unit (according to the two-fold subdivision of this period). It is also worth mentioning that, in the North of European Russia, a lot of footprints and trackways of big terrestrial tetrapods have been collected recently from some limestones of the Isada Mb., Poldarsa Fm., which belong to the middle part of the Severodvinskian horizon, Upper Tatarian in age. They include amphibians, therapsids (eotheriodonts, theriodonts and anomodonts) and pareiasaurs, and correspond to the *Proelginia permiana* tetrapod zone (Ivakhnenko *et al*., 1997). However, as already indicated, Gubin Yuri M. (writt. comm.) points out that the pareiasaur imprints, even if close in shape and general features to *Pachipes dolomiticus* of the Val Gardena Fm. in the Dolomite region, differ from this form in some characteristics, as such as the position of the longest finger (paper in press).

f) Due to the above paleontological observations, the beginning of the second Permian cycle, *i.e.* the inception of the Val Gardena Sandstone seems to have developed only from post-early Tatarian times. Thus, at least in the Dolomites, the recognition near Ortisei of the Illawarra Reversal Event (Dachroth, 1988) should be carefully reset, since in the stratigraphic scheme (Fig.1) of this paper, it runs within a large intra-Permian gap. In fact, in this context, Menning's investigations (1995, 2001) pointed out that this event can be dated to about 265 Ma and referred to the Lower Tatarian.

g) The interposed stratigraphic gap between the Permian cycles 1 and 2 of the investigated area, clearly related to extensive erosion surfaces and/or very conspicuous non-depositional activity, changes abruptly from one succession to another. In the selected sections, the gap possibly spanned from approximately 15 to 30 Ma, but this interval is obviously also constrained by the adopted time-scales, which vary according to the authors. In this context, Nicosia (pers. comm.) judges that only a long-time, as indicated above, could explain the significant differences between the two recorded tetrapod footprint assemblages. However, this and other problems highlighted in this paper must be subject to further research and interregional correlation.

h) Furthermore, the Permian tectonosedimentary cyclic subdivision of the Southern Alps could potentially be correlated with the coeval German succession and those of other European regions (such as the Balkan peninsula and the southwestern Mediterranean areas). Very recently, Ziegler and Stampfli (2001) also agreed with a latest Carboniferous-Early Permian “syn-tectonic” cycle and a Late Permian-Early Triassic “post-tectonic” cycle of the Variscan domain. Therefore, from this wide geological scenario it follows that the boundary between cycles 1 and 2 of the South-Alpine domain coincided with a significant structural reorganisation, possibly linked to the opening of Neotethys.

i) Lastly, this article has also emphasized, throughout the Permian of the East-European Platform of Russia, the presence of two tectonosedimentary cycles, generally separated by a short gap. Consequently, this Permian tectonosedimentary subdivision shows a very wide distribution, even though, as already depicted, the chronostratigraphical development of both cycles, which are however in some places of as yet uncertain duration, shows contrasting values from region by region. Our opinion is that this palaeogeographical and structural change coincided with a major geodynamic event in Europe.

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Joint Report of SPS Working Group on 'Using Transitional Biotas as Gateways for Global Correlation' and the 'Permian Research Group of SE Asia'

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Introduction

Significant progress has been made by members of both working groups since our last report (*Permophiles* #35, p. 5-7). Below we provide a summary of our recent research activities and progress directly related to the aims of both working groups. The references listed at the end of this report are not meant to be exhaustive, rather they represent a sample of recent publications by members of both working groups, and they are all cited in this report.

The Northern Transitional Zone (East and northeast Asia)

South Primorye, Far East Russia: In September 2000, Drs. Galina Kotlyar, L. I. Popeko, Yuri Zakharov and Guang Shi carried out a joint 10-day field investigation on several Permian sections in South Primorye. We were particularly impressed with the section in the Barabash area in southwestern Primorye and the Senkina Shapka section in the Partizanskaya Valley area. In the former, the mixed Cathaysian and Boreal brachiopod fauna is found in a volcaniclastic sandstone unit at the base of the Chandalaz Horizon. The mixed brachiopod fauna is characterized by both typical Cathaysian genera (*e.g.* C*ompressoproductus* and *Leptodus*) as well as diagnostic Boreal elements such as *Yakovlevia* sp, *Kaninospirifer* sp., and *Blasispirifer reedi* (Likharev). In addition, several genera of bitemperate and bipolar distributions are also present: *Stenoscisma*, *Waagenoconcha* and *Spiriferella*. Of particular interest at this section is the direct association of an apparently monospecific fusulinacean *Monodiexodina* assemblage with the mixed brachiopod fauna.

At the Senkina Shapka section, the Permian lithostratigraphy is quite different from that of the Barabash area. Here, the Permian succession is dominated by limestones with abundant foraminiferan fossils. Three fusulinacean zones have been recognized; they are in ascending order: *Monodiexodina sutschanica-Neomisellina dutkevitschi* Zone, *Parafusulina stricta* Zone, *Neomisellina lepida-Lepidolina kumanensis* Zone (Kotlyar *et al.*, 1999). Although brachiopods are relatively uncommon in this succession, several species have been collected by Guang Shi from the *Monodiexodina sutschanica* Zone: *Tyloplecta yangtzeensis*, *Spiriferella* sp., and *Cleiothyridina* sp.

The age of the mixed Cathaysian/Boreal brachiopod fauna mentioned above is well constrained by associated fusulinaceans and ammonoids. Kotlyar *et al.* (1999) report that from at least three localities in East Russia the mixed brachiopod faunas have been found closely associated with or immediately overlain by the index Capitanian ammonoid genus *Timorites*. For example, at the Birobidzhan-Leninskoe railway cutting (Amur Region of Far East Russia), Kotlyar *et al.* (1999) found that the mixed brachiopod fauna is closely associated with *Timorites* and *Waagenoceras*, overlying a layer bearing *Altudoceras*. In Transbaikal, fragments of *Timorites* sp. have also been found (Kotlyar *et al.*, 1999). Here, no fusulinaceans are seen in the *Timorites*-bearing layer, but the ammonoid is found in the same layer with the brachiopod *Cancrinelloides curvatus* and bivalve *Maitaia bella*, both being typical Boreal forms of the Kolyma-Omolon region of NE Siberia. At the Senkina Shapkia section, Dr. Yuri Zakharov has recently identified *Tauroceras*? sp., together with bryozoans, from a limestone block apparently originated from the upper part of the *Monodiexodina sutchanica-Neomisellina dutkevitchi* Zone, which in Dr. Zakharov's opinion indicates a Wordian age.

It is apparent from the summary outlined above that given the nature of its mixed Permian Boreal and Cathaysian faunas and the presence of biostratigraphically more sensitive faunas (*e.g.* fusulinaceans and ammonoids), South Primorye has the potential to serve as an important biostratigraphic gateway for correlating Permian sequences between the cool to cold-water

Boreal Realm and the warm-water palaeoequatorial Realm. Dr. Galina Kotlyar and her team are currently working on this aspect and have a few papers in press.

Northeast China: Two recent studies have further highlighted the significance of the Permian sequences and biotas in NE China for assisting with Permian global correlations. Wang *et al.* (2000) have reported a *Mesogondolella*-dominated conodont fauna from the Fanjiatun Formation of Jilin Province in NE China. The conodont fauna occurs in a 39.4 metre thick unit immediately underlying a mixed Cathaysian and Boreal brachiopod fauna that also contains *Waagenoceras* sp. In comparing this conodont fauna with faunas from North America and South China, Wang *et al.* (2000) suggest a Wordian (or Wordian to Early Capitanian) age. This would imply that the mixed brachiopod fauna, which appears closely comparable with similarly mixed brachiopod faunas elsewhere in East Asia (Shi and Tazawa, 2001), is not older than Wordian, being most likely Late Wordian or Late Wordian to Early Capitanian.

Zhesi area (Inner Mongolia) (contribution from T. Grunt and her colleagues): From the Zhesi area of Inner Mongolia, Leven *et al.* (2001) have recently proposed a revised stratigraphy and biostratigraphy on this classic locality of mixed Permian cold-water and warm-water faunas and sequences. In addition to the fusulinacean, brachiopod and bryozoan faunas reported by Leven *et al.* (2001), Dr. T. Grunt and her colleagues have also found a modest conodont fauna from six samples, which according to the identification by V. Silantiev and G. Sungatyllina comprise the following species: Z-1-4 – *Jinogondolella postserrata* (Clark et Behnken) (6 specimens), ?*Neogondolella* cf. *denticulata* Clark et Behnken (3 specimens), Z-2-2 – *Diplognathodus* sp. (1 specimen), Z-3-2 – *Diplognathodus* sp. (1 specimen), Z-3-3 – *Pseudoclarkina* cf. *bitteri* (3 specimens), *Pseudoclarkina* sp. (3 specimens), Z-3-6 – ?*Streptognathodus* sp. (2 specimens), and Z-5-12 – *Diplognathodus* sp. All these six conodont-bearing samples originate from the upper part of the Lower Yihewusu Fm. (Leven *et al*., 2001, fig. 4, Mb.7) or from separate lenses of limestones equivalent to Mb.7, and they suggest a Wordian – Early Capitanian age for the Lower Yihewusu Fm. in terms of the international Permian chronostratigraphic scale referred to by Mei *et al.* (1999).

Japan: Between October 2000 to March 2001, Guang Shi spent six months in Japan working with Professor Jun-ichi Tazawa (Niigata University) on several small projects related to the Permian transitional faunas of East Asia. They have jointly examined some Permian brachiopod faunas from Russian Far East, NE China and Japan (*e.g.,* Shi and Tazawa, 2001), and also undertook a joint field trip to some of the Permian type sections in the South Kitakami Belt in NE Japan.

Kanin Peninsula, Russia (contribution provided by T. Grunt): The Ufimian – Kazanian stratigraphic interval on the Kanin Peninsula is composed of continuous shallow-water marine facies. Biogeographically this territory belonged to the Barentz Shelf Area during the Late Permian. Here, the Ufimian/Kazanian boundary was originally defined by D. Stepanov (Stepanov *et al.,* 1975) based on brachiopod assemblages, which change from the *Sowerbina* layers to *Licharewia* layers across the boundary. Later Molin *et al.* (1983) defined the boundary between two local brachiopod zones: *Sowerbina granulifera* and *Licharewia stuckenbergi* Zones.

Detailed lithological description of the Kanin Peninsula section and new collections of organic remains (brachiopods, bryozoans, bivalves, nautiloidea, ostracods, and ichthyoliths) were carried out in 2001. This work has resulted in the recognition of five successive brachiopod/bivalve assemblages; they are in ascending order: (1) *Sowerbina ganulifera – Oriocrassatella komiorum* layers (assignable to the Solikamsk horizon of the Ufimian); (2) *Cancrinella cancrini – Schizodus rossicus* layers**;** (3) *Licharewia schrencki – Schizodus* aff. *rossicus* (sp. Nov.) layers (correlatable with the Lower Kazanian in the Volga-Urals area on account of the abundant appearance of Licharewiinae brachiopods); (4) *Kaninospirifer borealis – Parallelodon licharewi* layers (assignable to the Upper Kazanian substage - Krasnovidovo horizon of the Volga-Urals area; and (5) the *Pinegathyris alata – Schizodus subobscurus* layers (Upper Kazanian). Of particular note about this last assemblage is the presence of abundant branched zoarian bryozoan genus *Stellahexaformis* Gilmor and Snyder. Elsewhere this genus is only known from the Gerster Formation (Wordian) in southeastern Nevada.

The Southern Transitional Zone

Karakorum to the Middle East (contribution provided by L. Angiolini): The Early to Middle Permian interval was characterized by a trend toward distinct provincialism, culminating with the end-Guadalupian mass extinction. This trend towards a global biotic endemism tends to hamper correlation – especially during the Guadalupian - among the different biogeographic realms and the existing time scales. However, as successfully defined by Shi (2000a), mixed transitional biota can play the role of real “biostratigraphic gateways”, allowing correlation between adjacent realms. This in turn may help in the correlation among the different Permian regional time-scales.

Statistical analyses comparing brachiopod faunas along the Peri-Gondwanan fringe, from Oman to South Thailand (Angiolini, 2001) reveal the dynamic nature of the provincial patterns during the Permian and a significant change of marine bioprovinciality from Sakmarian to Wordian times. This approach has led to the individualization of one province in the Sakmarian (Westralian Province) and two provinces in the Roadian-early Wordian (Sibumasu and Transhimalayan Provinces) as a consequence of the opening of the Neotethys and of the global climatic warming.

During the late Sakmarian, the Westralian Province extended all along the Peri-Gondwanan fringe in response to raised humidity and lowering of temperature gradients immediately after the waning of the Gondwanan ice cap. At this stage, a strong link between Central Afghanistan and Interior Oman is evident, whereas a gradual eastward variation in the distribution of brachiopod genera is observed from Karakorum to Peninsular India and South Thailand in response to the paleolatitudinal gradient. At the beginning of the Middle Permian (Roadian- early Wordian), two provinces are clearly identified along the Gondwanan margin and the Cimmerian blocks: the Transhimalayan Province (Angiolini, 2001) embracing Afghanistan, Armenia, SE Pamir and Karakorum, and the Sibumasu Province (Fang 1991), including also Oman and Salt Range, located southward and south eastward of the former. In fact, the increased proportion of Paleoequatorial genera in the Transhimalayan province indicates its northern and peripheral position with respect to the Sibumasu Province, both belonging to the Cimmerian Region.

By the late Wordian-Capitanian, the Transhimalayan and Sibumasu Provinces still existed, but the Salt Range and north Oman belonged to the incipient Himalayan Province (Shen & Shi, 2000), stretching along the southern margin of the Neotethys. This complex pattern supports the implication advanced by Shen & Shi (2000) that the mixed nature of the Himalayan Province was not caused by tectonic vicariance, but by climatic evolution and ocean currents.

In this complex pattern, noteworthy is the evolution of the brachiopod provinciality in the Oman-Afghanistan sector. In fact, the strong faunal link between South Oman and Central Afghanistan, clearly documented at Sakmarian times, abruptly ended before the end of the Early Permian. Middle Permian faunas in Central Afghanistan show only weak relationships with those of Oman and Salt Range, but are strongly connected to the Karakorum faunas. This major change in marine bioprovinciality supports initial opening of the Neotethys before the Middle Permian, with the creation of a sufficiently large oceanic space to prevent biotic interchanges between the Gondwanan margin and the Cimmerian continents, resulting in disjunct distribution of fossil biota (Angiolini *et al.*, submitted). For what concerns the causes of the biodiversity evolution, both along the Gondwanan margin (*i.e*. Oman) and in the Cimmerian blocks (*i.e*. Karakorum), the transitional character of the former biota can be explained with the occurrence of an oceanic space in front of the margin – the Neotethys Ocean - with free migration enhanced by warm surface currents (Archbold, 1998). On the other hand, the transitional Roadian-Wordian Karakorum faunas are related to the northward drift of the Cimmerian blocks since the Early Permian, coupled with a global climatic warming and broadening of the palaeotropical belt, as suggested also by Shi and Archbold (1998) for SE Asia (Shan Thai and Baoshan Blocks).

The consistent increase in biodiversity during the Wordian-Capitanian was followed in turn by a clear extinction pattern at the end of the Capitanian with a major faunal turnover in the Wuchiapingian, indicating that the end-Guadalupian mass extinction also affected the Cimmerian Region, besides being particularly evident in the middle-high latitude regions of both hemispheres (Shi *et al.*, 1999). By the beginning of the Wuchiapingian, the Cathaysian brachiopod elements were much less affected by the crisis, since the Tethyan Realm acted as a refuge area (Shi *et al.*, 1999), and invaded the Cimmerian blocks, which were therefore incorporated into the Cathaysian Province. Furthermore, the patterns of brachiopod biodiversity seems to indicate that the crisis did not start in the Wordian, at least not in the Cimmerian Region and Himalayan Province, where the brachiopods show significant diversification in the late Wordian and up to the Capitanian, so that the end-Guadalupian extinction was probably as rapid as that occurring in the Changhsingian. This is in contrast to the progressive decline of gastropods observed by Erwin (1996) since the Wordian.

During 2001, field work was performed in Interior Oman, Turkey (Antalya) and Greece (Chios) by a research group from the University of Milan (L. Angiolini, A. Nicora, M. Gaetani, A. Tintori, A. Zanchi), funded by Italian COFIN Project to M. Tongiorgi, Italian COFIN Project to M. Gaetani, Italian MURST 60%, Italian CNR Project to M. Gaetani. Dr. Angiolini's recent publications on the Permian transitional faunas of South Asia and the Middle East include Angiolini (2001a-c) and Angiolini *et al.* (2002a-b).

Tibet: Dr. Shuzhong Shen and his team continue their fieldwork and productive research in the high mountains of southern and central Tibet (*e.g*., Shen *et al.*, 2000, 2001a,b). Their recent focus has been on the exotic limestone blocks preserved along the Yanglung-Tsangbo suture zone. Almost all of these so-called exotic limestone blocks remain under-studied despite their widely perceived significance in under-standing the palaeogeographical and plate tectonic evolution of the suture zone. Many of these limestone outcrops contain mixed Cathaysian/Gondwana faunas, hence also being important constituents of the Southern Transitional Zone (*e.g.*, Shen *et al.*, 2003; Shi *et al.* 2003).

Western Yunnan: Dr. Xiangdong Wang and his collabora-tors have carried on their tradition of hard fieldwork in the remote areas of SW China, with numerous recent publications (Wang *et al.*, 2001a, b; 2002a, b; Wang and Sugiyama, 2002; Shen *et al.*, 2000; 2002). The imminent publication of their study (Ueno *et al.*, 2002) on the conodont fauna from the upper Dingjiazhai Formation will no doubt testify to the much discussed significance of Permian mixed/transitional faunas as biostratigraphic gateways for assisting in Permian global correlations.

Southeast Asia (contribution provided by Prof. Ian Metcalfe): Ian Metcalfe and Masatoshi Sone are working on various aspects of the biostratigraphy, biogeography, tecton-ics and palaeogeography of East and Southeast Asia. M. Sone is in the first year of his PhD studies at University of New England and is studying the biogeography (brachiopods, cephalopods and bivalves), tectonics and palaeogeography of the East Malaya block and adjacent regions in Southeast Asia (Sone *et al.*, 2001a, b). Ian Metcalfe continues studies of the tectonics of the Southeast Asian region and also studies of peri-Gondwana Permian conodont faunas with Bob Nicoll (Australian National University) (see Metcalfe, 2000a-b, 2001a-c; 2002a-b; Metcalfe and Allen, 2000; Jones *et al*., 2000, Mudil *et al*., 2001, Nicoll *et al.*, 2000).

M. Sone is currently investigating some interesting links between Middle Permian brachiopod faunas of East Malaya and Sibumasu/Cimmeria, which requires clarification of these transitional biotas. This contributes to the reconstruction of the main Palaeo-Tethys in SE Asia, which is generally thought to be a Gondwana–Cathaysia divide. His project will be further developed using the Cambridge University ATLAS palaeogeographic reconstruction software.

Occurrence of Gondwana floral elements in SE Asia (contribution provided by Dr. A. K. Srivastava**):** Dr. A. K. Srivastava has carried out a review study on the occurrences of previously reported occurrences of Permian Gondwanan floral elements in SE Asia. His conclusions are that "The review of Permian plant fossil assemblages from South East Asian regions strongly favour the intermixing of Gondwana and Cathaysian elements in central and southern part of Tibet, Mamal flora of Kashmir and West New Guinea area of Indone-sia; however Malaysian, Thailand and the Djambi floras of

Indonesia essentially belong to Cathaysian flora." Dr. A. K. Srivastava also observes that certain elements *e.g. Cordaites, Phyllotheca, Schizoneura, Sphenophyllum (Trizygia,Psynophyllum, Rhipidiopsis* are commonly found in all the floral provinces i.e. Angara, Cathaysia, Euramerica and Gondwana, and their distribution is not restricted to any particular flora; most probably they are the survivors of a cosmopolitan flora of Carboniferous.

Late Paleozoic faunas and biogeography of SE Asia: Guang Shi continues his work on various Permian brachiopod collections from SE Asia and their biogeographical connections with East and NE Asia and Gondwanaland (Shi, 2000, 2001; Shi and Grunt, 2000; Shi and Shen, 2001; She *et al.*, 2001, 2002). Neil Archbold also continues his effort in documenting and elucidating the complex biogeographical and palaeogeographical relationships between the peri-Gondwana region and Gondwanaland (Archbold, 2000, 2001a-c). Monica Campi is in her final year of Ph.D study with a focus on Middle Permian brachiopod faunas from the Sichuan Province of southwest China and central Peninsular Malaysia (Campi *et al.*, 2000; Campi and Shi, 2002). Elizabeth Weldon has just completed a very interesting study on the global distribution and biogeography of Permian conulariids, which will add significantly to the understanding of the origin and implications of the Permian transitional biota.

Announcement

We are pleased to announce that a Special Issue of the Journal of Asian Earth Sciences on the Permian of SE Asia has just been published (Shi and Metcalfe, 2002 for details). This is a direct result of both working groups; it also forms a formal contribution to the IGCP Project No. 411. A collection of 13 papers dealing with different aspects of the Permian in the region are included. Guang Shi and Ian Metcalfe would like to take this opportunity to thank all the authors for their contributions and all the reviewers for their careful and critical reviews of the original manuscripts.

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North American Permian tetrapod footprint biostratigraphy

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In North America, tetrapod footprints of Permian age are found primarily in the western United States in Arizona, New Mexico and Texas, and some important sites are also known in the adjoining states of Utah, Colorado and Oklahoma (Fig. 1). In western Europe, tetrapod footprints have long played a significant role in the correlation of nonmarine Permian strata (see Haubold, 1984 for a review). Here, I review the stratigraphic distribution of Permian tetrapod footprints in North America (Fig. 2) and assess their current biostratigraphy.

Permian tetrapod footprints have been assigned to two principal ichnofacies, an eolian *Chelichnus* ichnofacies and a red-bed ichnofacies with various named subdivisions. Swanson and Carlson (2002) recently described Early Permian tetrapod footprints from dolomitic strata in Oklahoma and suggested that they may represent a third, little known ichnofacies.

The *Chelichnus* ichnofacies in North America is best known from eolian strata of the Coconino Sandstone in Arizona, although some other Permian eolianites also yield tracks in Arizona, Utah and Colorado. Lull (1918) and Gilmore (1926, 1927, 1928) first described the Coconino tracks from the Grand Canyon of Arizona, and Middleton *et al.* (1990) provide a recent summary. The Coconino Sandstone is of late Leonardian age (Fig. 2). Note that it is directly overlain by marine strata of the late Leonardian Kaibab Formation (Hopkins, 1990), and that the Coconino is equivalent to the Glorieta Sandstone of New Mexico and the San Angelo Formation of Texas (Middleton *et al.*, 1990). In effect, Coconino dune fields were landward of the shorelines and coastal plains that deposited the Glorieta and San Angelo sediments.

The eolian trackmakers were mostly the same animals as the red-bed trackmakers, and indeed one ichnogenus, *Dromopus*, is found in both ichnofacies. But, in general, the eolian track assemblages cannot be directly compared and correlated with the red bed tracks—the tracks of both ichnofacies are too different in morphology. The fact that Permian units such as the Coconino, DeChelly and Supai formations in the USA, the Corncockle and Lochabriggs sandstones in Scotland and the Cornberger Sandstein in Germany have similar tetrapod ichnofossils (e.g., McKeever and Haubold, 1996) is more a reflection of shared lithofacies than of age equivalence.

In North America, the red bed ichnofacies is best understood in New Mexico, where numerous and extensive red-bed track assemblages of Early Permian age are known (see articles in Lucas and Heckert, 1995; Lucas *et al.*, 1998). These assemblages are from red-bed ichnofacies of the Earp Formation (Big Hatchet Mountains), the Robledo Mountains Formation of the Hueco Group (Robledo, Doña Ana and San Andres Mountains), the Abo Formation (Caballo and Fra Cristobal Mountains, Joyita Hills, Abo Pass) and the Sangre de Cristo Formation (Villanueva). Relative abundances of the ichnotaxa vary between sites, but *Dromopus* and *Batrachichnus* dominate, and co-occur with *Dimetropus*, *Gilmoreichnus*, *Hyloidichnus* and *Limnopus* (*e.g.*, Haubold, 2000; Haubold and Lucas, 2001a). Recently, Lucas *et al.* (2001) reported *Amphisauropus* and *Varanopus* from the Abo Pass tracksite, which is stratigraphically low in the Abo Formation (Fig. 2).

Tracksites in the Sangre de Cristo and Abo formations are of Wolfcampian age, but a more precise correlation and stratigraphic ordering of these sites has not yet been completed. Tracksites in the Robledo Mountains Formation in southern New Mexico are close in age to the Wolfcampian-Leonardian boundary. The New Mexican red bed track record thus encompasses most or all of Wolfcampian time. Similar red-bed tracks from the Hermit Formation in Arizona are also of Wolfcampian age, but a more precise correlation is not possible.

Much less is known of Leonardian age tracks in North America, and I have been working with H. Haubold, A. Lerner and N. Suneson to remedy this omission. A single specimen of *Dimetropus* is known from the Leonardian Schnebbly Hill Formation near Show Low in Arizona. A locality found by Suneson in the lower part of the Hennessey Formation at Oklahoma City yields *Amphisauropus* and possible *Dromopus* (Lucas and Suneson, 2002). The classic North American Leonardian tracksite is in the upper part of the Choza Formation at Castle Peak near Abilene, Texas (Moodie, 1929, 1930). Haubold and Lucas (2001b) revised the ichnotaxonomy at Castle Peak, and it is dominated by *Amphisauropus*, *Varanopus* and *Dromopus*. I have recently collected a tracksite in the Arroyo Formation at Lake Kemp in Baylor County, Texas, and *Varanopus*, *Amphisauropus* and *Dromopus* also dominate this assemblage. Indeed, it is tempting to suggest that an abundance of *Amphisauropus* and *Varanopus* is characteristic of the Leonardian, though too few Leonardian age tracksites are known to confirm this. Furthermore, the Castle Peak and Lake Kemp tracksites are in playa and mudflat deposits of a broad, low relief coastal plain, quite different from the Wolfcampian tracksites in New Mexico, which come from strata that represent both inland floodplains (Sangre de Cristo and Abo formations) and coastal tidal flats (Robledo Mountains and Earp formations). Thus, the differences now perceived between Wolfcampian and Leonardian tetrapod tracks may be due to facies differences and not temporally significant.

The stratigraphically highest Permian tetrapod footprints from North America are in the San Angelo and Blaine formations at San Angelo, Tom Green County, Texas. Pittman *et al.* (1996) provided preliminary data on these tracks, which can be assigned to "*Pachypes*" (common, and evidently the tracks of a caseid pelycosaur) and *Amphisauropus* (rare). The San Angelo and Blaine are late Leonardian in age (Fig. 2), and these youngest North American Permian tracks mirror the abundance of caseid pelycosaurs seen in the San Angelo Formation body fossil fauna (*e.g.*, Olson, 1962). It is also interesting that the common Coconino ichnogenus *Chelichnus* has been thought by some to be a caseid track, so this may provide another tiepoint between the eolian and red-bed ichnofacies.

So, what sort of tetrapod footprint biostratigraphy can be developed here? At the ichnogenus level, relatively little (Fig. 2). Indeed, the track record well reflects the chronofaunal stability in the Lower Permian tetrapod body fossil assemblages recognized by Olson (*e.g.*, 1962). It is possible to differentiate provisionally a Wolfcampian-early Leonardian assemblage dominated by *Dromopus* and *Batrachichnus*, a middle-late Leonardian assemblage dominated by *Amphisauropus* and *Varanopus* and a latest Leonardian assemblage dominated by "*Pachypes*." But, much work remains to be done in the Leonardian strata to establish better the stratigraphic distribution of tetrapod tracks in a variety of lithofacies, before a robust tetrapod footprint biostratigraphy can be recognized in North American Lower Permian strata.

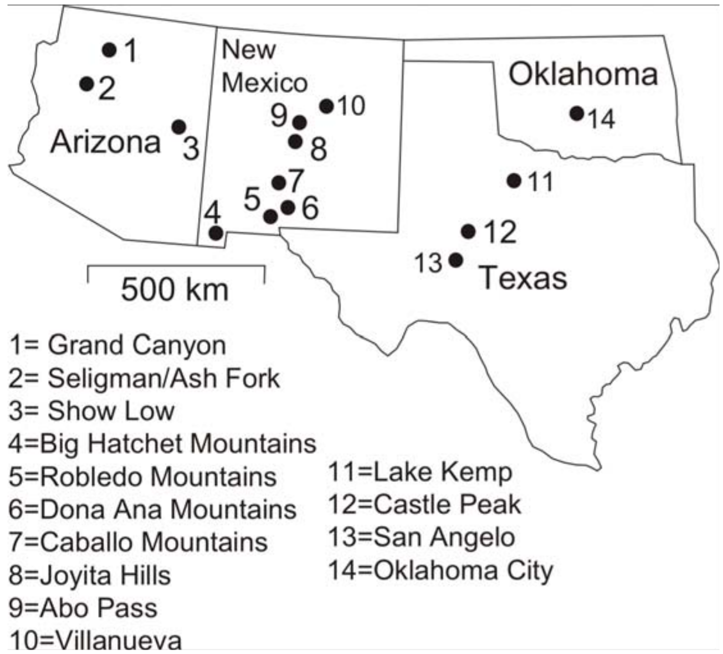

Figure 1. Distribution of principal Permian tetrapod tracksites in the western United States.

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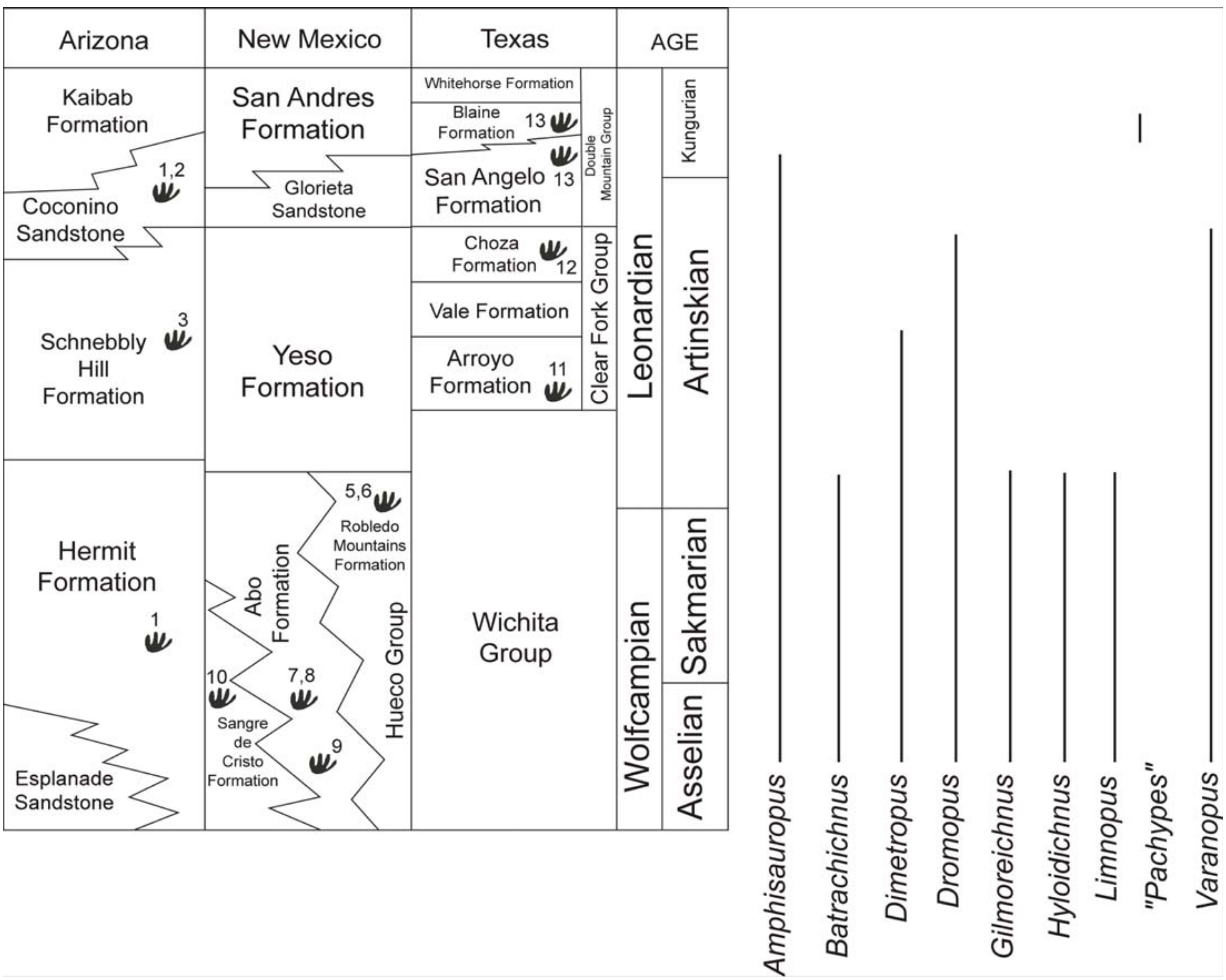

Figure 2. Correlation of North American Permian tetrapod tracksites (numbers of sites correspond to locality numbers in Figure 1) and the stratigraphic distribution of the ichnogenera of the red-bed ichnofacies.

***Editors Note:** Because of the rather inflammatory nature of this paper, it was essentially unedited so that the reader may get its full flavour.

Comments to the base of the Lopingian Series defined in the Penglaitan section

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Abstract

All features of the holotype of *Clarkina postbitteri hongshuiensis* Henderson & Mei, 2001 are present in the holotype of *C. postbitteri*. Therefore, *C. postbitteri hongshuiensis* is a junior synonym of *C. postbitteri* Mei & Wardlaw, 1994. This is in agreement with the stratum typicum of *C. postbitteri,* as sample LPD 115 from Penglaitan with the holotype of *C. postbitteri* is not from bed 6k, but from bed 6j. *C. postbitteri postbitteri* sensu Henderson & Mei does not correspond to the holotype of *C. postbitteri* which is a violation of the ICZN. Therefore, these forms - the FAD of which is used to define the base of the Lopingian - cannot be the nominate subspecies. They are endemic forms of the South Chinese intraplatform basins and are not present in the Tethys, where *C. postbitteri* s.s. is common. Primitive *C. postbitteri* occur also in the Delaware Basin. The taxonomically invalid *C. postbitteri postbitteri* sensu Henderson & Mei cannot be used to define the base of the Lopingian, the more as this form is an endemic form. According to Wang Cheng-yuan the base of the Lopingian should be defined by the FAD of *C. dukouensis.* According to him, this species in its original definition begins in bed 6k of the Penglaitan section, whereas Henderson *et al.* (2002) assume that *C. dukouensis* in a new definition begins only in bed 7d. According to Kozur the Penglaitan section is unsuitable for GSSP of the base of the Lopingian. It has a longer gap and a shallow water interval without gondolellids between the Guadalupian and Lopingian, which comprise together the entire transitional fauna between *Mesogondolella* and *Clarkina* as well as the largest part of the *C. postbitteri* Zone. The original definition of the Lopingian with the FAD of *Clarkina* and *C. postbitteri* s.s. (= *C. postbitteri hongshuiensis* sensu Henderson & Mei, 2001) is according to Kozur a good definition because the FAD of gondolellids with plane lower side of the keel is an important step in conodont evolution. Moreover, this level coincides with a distinct change in radiolarian and probably also in ammonoid faunas. It is world-wide recognizable because *C. postbitteri* occurs in the South Chinese intraplatform basins, in the Tethys (Oman) and in North America (Delaware Basin) and in gondolellid-free radiolarite sequences of Panthalassa and the Tethys it can be recognized by a distinct change in the radiolarian fauna which lies in the same level as the FAD of *C. postbitteri*. When the endemic "*C. postbitteri postbitteri*" sensu Henderson & Mei or *C. dukouensis*, which are both taxonomically disputed, are used to define the base of the Lopingian, the rather long interval (one radiolarian zone) of the complete *C. postbitteri* Zone (in Penglaitan only the uppermost *C. postbitteri* Zone is present) would be assigned to the Capitanian. The base of a stratigraphic unit should not be fit to an unsuitable stratotype, but defined by a well recognizable faunal change which should be documented in a suitable stratotype by a phylomorphogenetic cline between two species. The first author considers that it is not necessary to define the lower boundary of the Lopingian in Penglaitan or South China at all. Also the lower boundary of other stratigraphic units are defined outside the type area.

Introduction

Three weeks before the deadline of a voting about the base of the Lopingian Kozur as a member of the Lopingian Boundary Working Group (LBWG) and the other members of the LBWG get from Charles Henderson the publication about new or newly defined conodont taxa with which the base of the Lopingian should be defined. Only Wang, also member of the LBWG, received exceptionally the material few weeks earlier before the publication, but also not early enough to discuss the proposals with all members of the LBWG. As the time was too short for discussion in the working group, Kozur asked for the e-mail addresses of the members of the working group which neither Wang nor Kozur had (9 of 19), but Henderson could not send them because he was abroad. As it is useless to discuss the problems among a part of the LBWG, we will publish our ideas to the proposal and make our proposals for definition. A Working Group makes no sense, if it is used only as a "confirmation gremium" of a single proposal, which is unfortunately based on an endemic form which is only known from a few sections in a restricted area of South China and therefore not correlatable with any section outside South China, independent of the very doubtful taxonomy of the definer taxon. For the first time in the entire Phanerozoic an endemic taxon (restricted to a few sections in South China) is used to define the base of a Series and Stage. Before even no Substage base was defined with such a taxon. A very dangerous development which elevates the interests of a group over the establishment of a globally applicable stratigraphic boundary.

Even the original definition of the Lopingian with the FAD of *Clarkina* and *C. postbitteri* was not presented for final voting despite the fact that it is favoured by many geologists. As only one GSSP and one level for the boundary is presented, there is even not a real discussion about different proposals possible. We will explain, why the proposed boundary is not a reliable boundary and we will present our two different proposals for the definition and position of the base of the Lopingian in the hope that there will be a discussion before the voting of the Subcommission after the voting of the Working Group.

Remarks to *Clarkina postbitteri postbitteri* and *C. postbitteri hongshuiensis*

For the new definition of the base of the Lopingian Henderson *et al.* (2001) subdivided *Clarkina postbitteri* Mei & Wardlaw, 1994 into two new subspecies, which Henderson & Mei (in Henderson *et al.*, 2001, 2002) named as *C. postbitteri*

postbitteri Henderson & Mei n. subsp. and *C. postbitteri hongshuiensis* Henderson & Mei n. subsp. This establishment of two "stratigraphic subspecies" contains two basic violations of the ICZN.

(1) The nominate subspecies cannot be a new subspecies, if the valid species was established several years ago. Thus, *C. postbitteri postbitteri* Henderson & Mei, 2001 is a junior objective synonym of *C. postbitteri postbitteri* Mei & Wardlaw, 1994. As several colleagues immediately recognised this violation of the ICZN, under influence of Wardlaw *C. postbitteri postbitteri* was correctly assigned to Mei & Wardlaw, 1994 by Henderson *et al.* (2002), which, however, must be defined by the holotype of *C. postbitteri*.

(2) As Henderson & Mei (in Henderson *et al.*, 2001; furthermore only quoted as Henderson *et al*., 2001, 2002 despite the fact that the name of Wardlaw is only added; even in the references of Henderson & Mei, December 2001, the paper Henderson *et al.*, 2002 was quoted under Henderson & Mei) did not know that the holotype of species is automatically the holotype of the nominate subspecies, they selected *C. postbitteri postbitteri* from a level which is younger than the stratum typicum (with the holotype) for forms that do not correspond to the holotype.

The holotype has been derived from sample LPD 115, which was derived according to the original designation from bed 6 j. Henderson *et al.* (2001, 2002) wrote that the holotype of *C. postbitteri* is from bed 6 k, but in the original papers the sample LPD 115 is indicated from bed 6 j (!). To avoid future discussions that sample LPD 115 was erroneously put into bed 6j during establishing *C. postbitteri*, we have dissolved large amounts of limestones from bed 6 j and adjacent beds. We, as already Wang (2000a), found in bed 6j exactly the same intraspecific variation of *C. postbitteri* as in the specimens which Mei *et al.* (1994b) illustrated together with the holotype from the stratum typicum. Thus, the holotype of *C. postbitteri* has been derived from bed 6j. Henderson *et al.* (2001, 2002), however, wrote that in bed 6j only *C. postbitteri hongshuiensis* Henderson & Mei, 2001 is present ! Taking this into consideration, *C. postbitteri hongshuiensis* Henderson & Mei, 2001 is a junior synonym of *C. postbitteri* Mei & Wardlaw, 1994 and, if any subspecies is discriminated, automatically also of *C. postbitteri postbitteri*. This is fully confirmed by comparison of the two holotypes. Both holotypes have perfectly the same outline. The posterior and middle part of the carina of *C. postbitteri* has densely spaced denticles and no very wide gap between the cusp and the last denticle of the carina. The same is the case in the holotype of *C. postbitteri hongshuiensis*. The anterior platform tapers in both holotypes rather gradually.

There is possible also a different explanation to the stratum typicum. In contrast to Henderson *et al.* (2001, 2002) bed 6k contains among the adults a few specimens of *C. postbitteri* "*hongshuiensis*" among strongly dominating *C.* " *postbitteri postbitteri*". We regard the paper of Mei *et al.* (1994b) as a careful paper. However, if Henderson *et al.* (2001, 2002) would be right, this paper must be a very superficial paper, in which not only the stratum typicum is erroneously shown (could happen during drawing), but the authors had just such a form as holotype, which is rare and untypical for the assemblage of bed 6k. We do not believe this and have the opinion that Mei *et al.* (1994) have taken a typical and common form as the holotype and not the exceptional forms. If this is the case, the stratum typicum from where the sample LPD 115 was taken, must be bed 6j.

The specimens illustrated by Henderson *et al.* (2002) under *C. postbitteri postbitteri* have widely spaced discrete denticles in the posterior and middle part of the carina unlike the holotype of *C. postbitteri*. And they have a wide gap between the cusp and the posteriormost denticle of the carina. Thus, also the direct comparison of their holotypes shows that *C. postbitteri* and *C. postbitteri hongshuiensis* are identical, whereas the somewhat younger "*C. postbitteri postbitteri*" sensu Henderson *et al.* (2002) is different from the typical *C. postbitteri* defined by the holotype.

In this connection it is interesting to regard the specimens figured by Mei *et al.* (1994b) under *C. postbitteri* from the stratum typicum. As already pointed out above, the holotype from Mei *et al.*, 1994, Pl. 1, Fig.6) has densely spaced denticles in the posterior and middle part of the carina that touch each other at the base (as in *C. postbitteri hongshuiensis*) because they are not cyclindrical. The gap between the cusp and the posteriormost denticle of the carina is rather short. The narrowing of the anterior platform is rather gradual. A juvenile specimen on Pl. 1, Fig. 3 has widely spaced denticles and a large gap in front of the cusp. This is typical for most of the juvenile forms of *C. postbitteri.* The specimen on Pl. 1, Fig. 4 has widely spaced denticles, a large gap in front of the cusp and on one side an abrupt narrowing of the platform. This form corresponds to "*C. postbitteri postbitteri*" sensu Henderson *et al.* (2001, 2002). The specimen on Pl. 1, Fig. 5 has rather densely spaced denticles on the posterior and middle part of the carina, but somewhat wider spaced as in the holotype. A wide gap between the cusp and the posteriormost denticle of the carina and a moderately rapid narrowing of the anterior platform is present. This form corresponds to *C. postbittei*, but with some transitional character to the forms which are designated as "*C. postbitteri postbitteri*" by Henderson *et al.* (2001, 2002). Thus, if the authors wanted to correctly show the intraspecific variability of their new species *C. postbitteri* in the original paper by Mei *et al.* (1994b), then they have shown from the stratum typicum a full transitional series from the two subspecies which they later discriminated. When they, however, wanted to show that with the two discriminated subspecies within *C. postbitteri* the base of the Lopingian can be defined, then they have chosen only the extreme forms showing a strong difference between them. For the stratum typicum of bed 6j (sample LPD 115) they indicate that only *C. postbitteri hongshuiensis* occurs. But in the original type series from the stratum typicum they figured typical *C. postbitteri hongshuiensis* (including the holotype of *C. postbitteri*, and, therefore, *C. postbitteri hongshuiensis* is a junior synonym of *C. postbitteri* !), and typical "C. *postbitteri postbitteri*" sensu Henderson & Mei in Henderson *et al.* (2001, 2002) which does not correspond to the holotype and, therefore, can not be *C. postbitteri postbitteri*. Thus, the type series of *C. postbitteri* from the stratum typicum contains both subspecies and transitional forms between them (we confirmed these original data by Mei *et al.*, 1994b from the stratum typicum by or own material from bed 6j), whereas for bed 6j (= stratum typicum) is indicated by Henderson *et al.* (2001, 2002) that only *C.*

postbitteri hongshuiensis occurs and for bed 6k is indicated that only *C. postbitteri postbitteri* occurs. Thus, alone by regarding the type series of *C. postbitteri* from the stratum typicum illustrated by Mei *et al.* (1994b) can be demonstrated that the definition of the base of Lopingian by Henderson *et al.* (2001, 2002) and *Jin* Yugan *et al.* (2002, in press) is inacceptable not only by the fact that *C. postbitteri hongshuiensis* is in reality *C. postbitteri postbitteri* (see above).

The diagnosis of *C. postbitteri postbitteri* and *C. postbitteri hongshuiensis* by Henderson *et al.* (2001, 2002) shows no other difference, then *C. postbitteri hongshuiensis* is highly variable, "*C. postbitteri postbitteri"* sensu Henderson *et al.* (2001, 2002) not *C. postbitteri hongshuiensis* (= *C. postbitteri* s.s.) occurs immediately after a gondolellid-free shallow water interval with high environmental stress for gondolellids close to the upper water-depth boundary of gondolellid occurrence. The high intraspecific variability in this interval is the logic and normal reaction to high environmental stress which descreases with the continuous deepening of the basin, when also the intraspecific variability decreases. Polymorphism due to high environmental stress is also known in other fossil groups, e.g. ammonoids (Guex, 1992, 2002).

"*C. postbitteri hongshuiensis*" has 7-9 closely spaced denticles in the posterior and middle part of the carina. The gap between the posteriormost denticle of the carina and the cusp varies from large to short. The anterior platform narrows rather gradually, but in some specimens rather abruptly. As *C. postbitteri hongshuiensis* has all features of the holotype of *C. postbitteri*, in reality *C. postbitteri hongshuiensis* must be *C. postbitteri postbitteri.* On the other hand, "*C. postbitteri postbitteri* " sensu Henderson *et al.* (2002) may be separated as an independent subspecies or species, which is characterized by widely separated denticles on the posterior and middle part of the carina and by generally abrupt narrowing of the anterior platform. As these forms are different from the holotype of *C. postbitteri*, they cannot be named as *C. postbitteri postbitteri*

There is a general problem with these forms. Those specimens of "*C. postbitteri postbitteri*" sensu Henderson & Mei, 2001 which have perfectly the outline of *C. dukouensis* (relatively short and broad platform, abrupt narrowing of the anterior platform, blunt posterior platform end without or very narrow platform brim, Henderson *et al.*, 2002, Pl. 2, Figs. 4 and 6) are morphologically much closer to the holotype of *C. dukouensis* than to the holotype of *C. postbitteri*, from which they are only distinguished by the wider spaced denticles on the posterior and middle part of the carina. The holotype of *C. postbitteri* is also distinguished from these forms by more densely spaced denticles of the posterior and middle part of the carina, but additionally also by distinct differences in the platform outline, which is longer and more slender, has a gradual narrowing of the anterior platform, a rounded posterior platform margin and a more pronounced platform brim around the posterior end of the carina. Forms of "*C. postbitteri postbitteri*" with rounded posterior margin of the platform are more equidistant to *C. postbitteri* and *C. dukouensis*. They are distinguished from the holotype of *C. dukouensis* by the wider spaced denticles of the posterior and middle part of the carina and by the round posterior platform margin. From the holotype of C. *postbitteri* they are distinguished by the wider spaced denticles of the posterior and middle part of the carina and by the abrupt narrowing of the anterior platform margin. As the denticulation of the carina of *C. dukouensis* implies a direct connection to *C. postbitteri* s.s. (= *C. postbitteri hongshuiensis* Henderson & Mei, 2001), "*C. postbitteri postbitteri*" sensu Henderson & Mei (2001) is probably an endemic side branch of the *C. postbitteri-C. dukouensis* lineage, which is not present in the Tethys or elsewhere outside the South Chinese intraplatform basins. For this reason Kozur prefers to regard these forms as an independent species and not as *C. postbitteri* as Henderson *et al.* (2001, 2002), and Jin Yugan *et al.* (in press), and also not as *C. dukouensis* to which, however, the forms with blunt posterior margin of the platform are much closer related than to *C. postbitteri.* Wang Cheng-yuan regards the forms with blunt posterior end to *C. dukouensis* to which they are more closely related than to *C. postbitteri* (see above).

The disregarding of the holotype of *C. postbitteri* in the papers of Mei *et al.* (2001, 2002) is probably caused by their new taxonomy regarding conodont populations. One of the authors (Kozur) has worked extensively for many years on ostracods and radiolarians, in which the shell morphology and inner structure define in most cases natural species. For these fossils it is necessary and in most cases also possible to work with populations which have partly a strong polymorphism caused by sexual dimorphism, ontogenetic morphologic changes *etc*. However, conodonts are, like scolecodonts, teeth/jaws of a larger organism. Both the conodonts and scolecodonts are mostly described in form taxonomy. Even apparatuses are only a small part of the animal. In this case we cannot speak about populations. Even the jaw apparatuses of recent Eunicida (most scolecodonts are jaws of Eunicida) do not show the variability of a Eunicida population, but only morphologic variability of the apparatus which does not refer to the variability of the specimens within a population. The same can be assumed for Lopingian conodonts, where even attached apparatuses are unknown. From a single form taxon cannot be concluded to the variability of the conodont animal population and only this variability of the conodont animals defines the population. Independent from this fact, the holotype defines the species also in taxonomy based on populations.

In Oman pelagic limestones of the Guadalupian-Lopingian boundary interval were discovered in which the conodont fauna starts with the smooth *Mesogondolella stampflii* Kozur n. sp. (described in an independent paper), which gradually changed into typical *C. postbitteri* s.s. As there is no sea-level drop close to the Guadalupian-Lopingian boundary, *C. postbitteri* has a very low intraspecific variability, all specimens have rather closely spaced denticles in the posterior and middle part of the carina and a moderately fast narrowing of the anterior platform as typical for the holotype of *C. postbitteri* and the holotype of the junior synonym *C. postbitteri hongshuiensis*. There is an interval with transitional forms between *M. stampflii* and *C. postbitteri*, and a long interval with *C. postbitteri* of several tens of metres in pelagic limestone with a low sedimentation rate, which comprises two radiolarian zones. This indicates a rather long gap in the Penglaitan section, in which the Capitanian is followed by the uppermost *C. postbitteri* Zone and the uppermost Capitanian and a large part of the Lopingian *C. postbitteri* Zone are missing in the gap and the following gondolellid-free part. Forms with widely spaced denticles were not found in the Tethyan sections and may be an endemic taxon, which is restricted to the South Chinese intraplatform basins, where it occupies the interval from the uppermost *C. postbitteri* Zone to the lower *C. dukouensis* Zone.

Independent from the fact that the separation of *C. postbitteri* into two subspecies was done under serious violation of the ICZN, the choice of an endemic and taxonomically disputed taxon which is only known from the South Chinese intraplatform basins to define the base of the Lopingian is not a good proposal for definition of a series boundary. The more, as in the Penglaitan section a distinct gap and a gondolellid-free interval are present around the Capitanian-Lopingian boundary. Moreover, never before in the entire Phanerozoic a Series, stage or Substage was defined with a taxon, which is only known in few sections from a small area.

Both authors agree that the definition of the base of the Lopingian by Henderson *et al.* (2001, 2002) and Jin Yugan *et al.* (2002) is the worst variant from all possible proposals. It was never discussed among all members of the Lopingian working group. Both authors have, however, different proposals for the definition of the base of the Lopingian Series.

Proposal for definition of the Lopingian Series by Wang Chengyuan

As stated above, the base of the Lopingian cannot be defined by the FAD of *C. postbitteri* in the Penglaitan section because there is a gap and a gondolellid-free interval between the Capitanian and the FAD of *C. postbitteri.* The FAD of "*C. postbitteri postbitteri*" sensu Henderson *et al.* (2001, 2002) can also not taken for definition of the Lopingian base, because the holotype of the nominate subspecies is the holotype of the species, and the holotype of *C. postbitteri* corresponds to the holotype of *C. postbitteri hongshuiensis* and not to "*C. postbitteri postbitteri*". Therefore, *C. postbitteri postbitteri* sensu Henderson & Mei, 2001, 2002 is an invalid taxon.

According to Wang Cheng-yuan the best possibility to define the base of the Lopingian is the FAD of *C. dukouensis.* In contrast to Henderson *et al.* (2002) and Jin Yugan *et al.* (2002), Wang Cheng-yuan assumes that *C. dukouensis* begins in bed 6k. He uses the original definition of *C. dukouensis* in Mei *et al.* (1994a) and the original separation from *C. postbitteri* by Mei *et al.* (1994b). In this definition all features are used and not only the development of the posterior carina as later by Henderson (2001) and Henderson *et al.* (2001, 2002). The carina of the holotype of *C. postbitteri* has the same development as the carina of the holotype of *C. dukouensis* (densely spaced denticles in the posterior and middle carina, no small denticle in the gap between the last denticle of the carina and the cusp). Therefore, it is not possible to make a new separation of *C. postbitteri* and *C. dukouensis* exclusively based on the development of the posterior and middle part of the carina as done by Henderson (2001) and Henderson *et al.* (2001, 2002). *C. dukouensis* is distinguished from *C. postbitteri* in agreement with the original diagnosis, the two holotypes and the original description and separation by Mei *et al.* (1994a,b) by a generally shorter and broader platform with abrupt narrowing of the anterior platform, by a blunt posterior end in all specimens, by the absence of a platform brim behind the carina, and additionally often, but not always, by the presence of a small denticle of the carina in the gap in front of the cusp. More advanced forms than the typical *C. postbitteri* (against the ICZN regarded as "*C. postbitteri postbitteri*" by Henderson *et al.*, 2001, 2002) have already the same platform outline, but generally a rounded platform end. Those forms, which have a blunt posterior end, are regarded by Wang as primitive *C. dukouensis* distinguished from the holotype by widely spaced denticles. These carina differences are, as in *C. postbitteri*, only regarded as subspecies differences. *C. dukouensis* begins, therefore, in bed 6k. The base of the Lopingian is defined by the FAD of *C. dukouensis* in bed 6 k of the Penglaitan section.

We have to consider the "population" characters of the definer (*C. dukouensis*) at its FAD and, therefore, four characters of the earliest "populations" of the definer has been listed by Wang (2000b, see there).

Proposal for the definition of the base of the Lopingian by Heinz Kozur

According to Kozur the first definition of the base of the Lopingian by Mei *et al.* (1994b) with the FAD of *Clarkina* represented in the Penglaitan section by *C. postbitteri* was a good definition which shows the real difference between the Guadalupian and Lopingian in the conodont faunas. However, the GSSP cannot be in the Penglaitan section. There, two unrelated faunas overlie each other separated by a gap and a gondolellid-free interval. The uppermost Guadalupian warm water intraplatform basin fauna with *Mesogondolella granti* of the Ouachita-Cathaysia faunal province (Kozur *et al.*, 2001) which occurs below the gap, died out without successor by a regional regression from which the entire intraplatform region of South China was affected. Within the lower Lopingian this area was flooded by a transgression from the Tethyan sea which brought the lower Lopingian Tethyan conodont fauna in the area of the former Ouachita-Cathaysia conodont province.

In the Tethys (Oman) a continuous succession across the Gudalupian-Lopingian boundary was found, in which no sea-level drop can be observed. The Tethyan smooth *Mesogondolella*, *M. stampflii* Kozur n. sp. changes in a complete transition series into *C. postbitteri* s.s. (= *C. postbitteri hongshuiensis*). This transition is characterized by the development of a plane lower side of the keel with only an indistinct , narrow, low ridge at its outer part. In transition forms the excavation of the keel in *M. stampflii* became very shallow, then indistinct and finally it disappeared in *C. postbitteri*. The platform outline and the development of the carina did not change from advanced *M. stampflii* to *C. postbitteri*.

Under environmental stress (close to the upper water depth boundary for gondolellids) in the shallow South Chinese intraplatform basin forms with widely separated denticles on the posterior and middle part of the carina evolved, in which also the trend to more abrupt narrowing of the anterior platform is realised, which characterises also the stratigraphically younger *Clarkina* of the open sea Tethys. In the Tethys forms with widely separated denticles in the posterior and middle part of the carina ("*C. postbitteri postbitteri*" sensu Henderson & Mei, 2001, 2002) seemingly does not occur. This excludes the use of this endemic Chinese form for definition of the base of the Lopingian independently from the fact that they were erroneously regarded as the nominate subspecies of *C. postbitteri*.

But there is a second important reason which makes this definition of the base of the Lopingian with the FAD of these forms and also with the FAD of *C. dukouensis* unsuitable. Contemporaneously or nearly contemporaneously with the change of *M. stampflii* into *C. postbitteri* a distinct change in the radiolarian fauna can be observed. The radiolarian fauna of the latest Capitanian *Follicucullus* ? *charveti – F. porrecta* Zone changed in the typical Lopingian radiolarian fauna of the *F. ventricosus -Ishigaconus scholasticus* Zone. Whereas *F. ventricosus* is restricted to the Capitanian-Lopingian boundary interval and to the lowermost Lopingian, *I. scholasticus* ranges up to the top of the Lopingian. Probably also the first Araxoceratidae began close to the FAD of *C. postbitteri*. As the interval with *C. postbitteri* in the Qarari Limestone of Oman with rather low sedimentation rate is long and comprises an entire radiolarian Zone of typical Lopingian character, the definition of the base of the Lopingian with an advanced *C. postbitteri* or endemic species of the same level or *C. dukouensis* would left a rather long part with typical Lopingian fauna within the Capitanian.

Thus, Kozur agrees with the original definition of the base of the Lopingian with the FAD of the genus *Clarkina* and of *C. postbitteri* s.s. by Mei *et al.* (1994b). This is a natural boundary, well recognizable in the Tethys and its marginal basins, in North America and in the radiolarite sequences of Panthalassa and of the Tethys. However, this boundary cannot be defined by a GSSP in the Penglaitan section and not at all in the South Chinese intraplatform basins. A definition in South China is not necessary, the more as uppermost part of the lowermost Lopingian conodont zone is present in Penglaitan. The base of a priority unit can be defined outside the type area, when in the type area no suitable GSSP can be found. For instance, the Anisian Stage is defined in the Alps, where the entire lower Anisian is in an ammonoid-, conodont and radiolarian-free facies. Therefore, the definition of the base of the Anisian will be outside the Alps, perhaps in the Dobrogea (Romania), but this will not change the name Anisian and its type area in the Alps. We should not change the content of a faunistic unit (*e.g.* Lopingian, Anisian) to fit it into an unsuitable GSSP. The Anisian cannot be defined with the base of the Pelsonian in the Alps leaving the lower Anisian in the Olenekian because in the type area of the Anisian the base of the Pelsonian is the oldest level which can be defined by pelagic fossils. Likewise, a definition of the base of the Lopingian with the fauna of bed 6k in Penglaitan, independently, whether by the FAD of an invalid taxon subspecies *C. postbitteri postbitteri* or by *C. dukouensis* (both debated in their scope) would leave a longer interval with typical Lopingian fauna in the Capitanian with no change to correlate this boundary outside South China.

In this connection the idea about a world-wide pronounced sea-level drop at the Guadalupian-Lopingian boundary must be discussed. In the South Chinese intraplatform basins everywhere a gap is present around the Guadalupian-Lopingian boundary. Sometimes it is lithologically very pronounced, when pelagic limestones with gondolellids and radiolarians are overlain by coal-bearing beds followed by thin gondolellid-free shallow-water limestones and again by gondolellid-bearing pelagic beds. In other places, such as Penglaitan, this gap is lithologically not so pronounced. Pelagic uppermost Guadalupian limestones are cut by a gap and the Lopingian transgression begins with gondolellid-free shallow water limestones, which are overlain by shallow-pelagic limestones with gondolellids.

In the Delaware Basin ammonoid-, gondolellid- and radiolarian-bearing rocks are suddenly overlain by hypersaline rocks with the Castile gypsum. This was interpreted as the expression of the same global sea-level drop which caused the gap in the South Chinese intraplatform basins. However, this facies change is neither strictly contemporaneous with the gap in the South Chinese intraplatform basins nor it indicates a sea-level drop. In South China the upper Capitanian fauna below the transition fauna to the Lopingian is cut by the gap and also the largest part of the *C. postbitteri* Zone is missing. In the Delaware Basin the transition fauna of the uppermost Capitanian and the lowermost *C. postbitteri* Zone are present before the hypersaline Castile Formation began. Immediately before the beginning of the hypersaline Ochoan beds a distinct sea-level rise is indicated which is preceded by a regression. In the upper Capitanian Lamar Limestone a sea-level drop is indicated, when the Lamar Limestone advanced into the basin. In that time interval adjacent to the reef very shallow water limestone without pelagic gondolellid conodonts and without radiolarians is present. In the uppermost centimetres of the Lamar a distinct sea-level rise is indicated by ostracods and radiolarians. This sea-level rise was so strong that the limestone sedimentation ended nearly in the entire basin. Only adjacent to the reefs and in the Glass Mountains and Apache Mountains the limestone sedimentation continued. But there beds without radiolarians or with very few *Entactinaria* changed into very radiolarian-rich limestones and also the ostracods show a distinct sea-level rise (e.g., in the topmost Altuda Formation). In other places, radiolarian-bearing rocks without *Albaillellaria* changed into beds with *Albaillellaria* indicating as the ostracod fauna also for these deposits a clear sea-level rise. This sea-level rise is contemporaneous with the strong sea-level drop in the South Chinese intraplatform basins. For global sea-level drop contemporaneous sea-level rise in one place and sea-level drop in an other place is not possible. In the Apache Mts. the uppermost radiolarian-rich rocks are intercalated by hypersaline papery limestone with the same type of lamination as in the Castile gypsum, where it indicates year-related rhythmic lamination. By counting the laminae can be recognized that the first gypsum deposition began 2000 years after the youngest radiolarian rich rocks. This is too fast for explanation by a global sea-level drop. The change from pelagic to hypersaline rocks in the Delaware Basin is better to explain by closure of the connecting channel with the open sea, either by volcanism (wide-spread in that time in northeastern Mexico, Coahuila, or by reefs. In the hot and arid climate around the Guadalupian-Lopingian boundary the interruption or strong restriction of the connection to the open sea would lead to a strong and rapid sea-level drop within the Delaware intraplatform basin. This kind of sea-level drop, which is present also in the upper Anisian Middle Muschelkalk of the Germanic Basin (Kozur, 1974), is not a global, but a regional sea-level drop within a restricted intraplatform basin, when the evaporation is stronger than the water input.

This interpretation is clearly confirmed in the Tethys. From Central Iran to Transcaucasia numerous sections with very shallow water limestones are known across the Guadalupian-Lopingian boundary. Independent from the final position of the Guadalupian-Lopingian boundary, there is no recognizable sea-level drop in these shallow-water deposits throughout the Capitanian and lowermost Lopingian before a strong sea-level rise occurred in the lower Lopingian. However, if the change from pelagic rocks to coal-bearing rocks in South China and the somewhat younger change from pelagic rocks to hypersaline rocks in the Delaware Basin is explained by a strong global sea-level drop, a distinct gap must be produced in the very shallow water limestones without conodonts in this area. Also in the pelagic rocks across the Guadalupian-Lopingian boundary in Oman no sea-level drop can be recognized. In all these Tethyan areas around the Guadalupian-Lopingian boundary either no change in the sea-level or a slight rise in the sea-level can be observed. The strong sea-level drop in the Chinese intraplatform basins is therefore a regional tectonic elevation of the area followed by new subsidence in the Lopingian.

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Reply to Kozur and Wang's "Comments to the base of the Lopingian Series defined in the Penglaitan section"

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The authors do not have time to respond to the endless chatter of Drs. Kozur and Wang. Suffice it to say that they do not agree with either the proposed G-L boundary, or with our taxonomic approach. A true response can only take place when Kozur and Wang present detailed stratigraphic sections and illustrations of the rocks and fossils. Until then we will continue to document our interpretations on Permian correlations based upon our research (Henderson *et al*., 2002; Mei and Henderson, 2001, 2002a,b; Mei *et al*., 2002) and not on the unsubstantiated negative claims of others. We leave it to the readers of Permophiles to determine the merits of an argument requiring derogatory and belittling comments in order to make its case. The Guadalupian-Lopingian boundary is very well defined and 92% of the Working Group agrees. Let's move on!

The simplest way to describe our taxonomic approach is that it involves a population approach. This approach has proven very valuable for establishing a high-resolution and reliable global conodont zonation and led us to recognize profound Permian provincialism and geographic clines (Henderson and Mei, 2000a,b; Mei and Henderson, 2002a; Mei *et al*. 2002). Permian gondolellid Pa-elements demonstrate considerable morphologic variability and individual characters evolve at different rates. As a result, within a given sample (in our concept used as an approximation of a population sample, although more than one taxa may be present, which can be recognized by a complete growth series) rare morphotypes are similar to, but not identical with possible ancestors and descendants (similar with respect to one or more characters, but not the entire character set that defines a species), but the vast majority of specimens reflect the nominate species for the interval. In sample 6k there are rare specimens that are similar to *C. dukouensis*, but those types with the full character set do not dominate population samples until bed 7d and above. Dr. Wang's approach recognizes individual form taxa (but not growth series) that suggest that bed 6k (the FAD of our *C. postbitteri postbitteri*) includes specimens of *C. dukouensis* and *C. leveni* that define subsequent zones. Those specimens are uncommon and are not identical in all characters to *C. dukouensis* and *C. leveni* and are therefore rare forms within the *C. postbitteri postbitteri* population.

It may be possible to define the Guadalupian-Lopingian GSSP as the FAD of *C. postbitteri postbitteri* in which rare specimens occur that are similar to, but not identical with *Clarkina dukouensis,* and thereby partially provide a compromise for at least one of the objecting authors.

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Reply to Kozur and Wang's "Comments to the base of the Lopingian Series defined in the Penglaitan section"

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Essentially, the whole argument of Kozur and Wang revolves around two points:

1. that the *stratum typicum* of *Clarkina postbitteri* Mei and Wardlaw (and therefore, *C. postbitteri postbitteri*) is bed 6j rather than 6k at the Penglaitan section, and
2. that they cannot discriminate the differences between *Clarkina postbitteri hongshuiensis*, *C. postbitteri postbitteri* and *C. dukouensis*.

The first is patently untrue and the second is regrettably quite true.

The senior author has spent 20 years trying to convince his Chinese colleagues not to use a bed system in collecting sections, but rather to report everything in metres above base, because the bed system leaves too much room for mistakes. This is one such case. However, Jin Yugan, who has collected or supervized the collecting of the Penglaitan section since the 70's categorically states that the type bed for *Clarkina postbitteri* is bed 6k. The specimens illustrated by Wang (2000) and Henderson *et al.* (2002) from bed 6k clearly match those illustrated by Mei *et al.* (1994, 1998) from the *stratum typicum*.

Dr. Jin Yugan provided the following information regarding the definition of bed numbers at Penglaitan in an email response on August 5th, 2002. "The stratigraphic succession of the Penglaitan Section was progressively refined since 1991.

1. Zhu Zhili made the first collection in 1991. Zhu collected 4 samples (LPD 115-LPD118) from Bed 18.
2. In 1993, Zhu Zhili and I collected a sample from each single bed of Bed 18 and the lower part of Bed 117. Based on a red mark Zhu Zhili pinpointed the level, from which he collected sample 115 in 1991. According to the original copy of his field note that I have at hand, LPD 114.6 is a lenticular limestone between Bed 18 and Bed 17. LPD 115 is 30 cm thick and LPD 115' is 15 cm. The thickness of these three beds indicates clearly that LPD 115 corresponds to Bed 6k, LPD 115' to Bed 6j and LPD 114.6 to an intercalation between Bed 6k and Bed 7a. This collection enabled Mei and Wardlaw (1994) to point out that *Clarkina postbitteri* "ranges through upper 0.55 m of Bed 18".
3. Unfortunately, when a group renumbered each single bed from Bed 6a to 6k, Bed 7a to 7j in 1994, LPD 115' was miscorrelated to Bed 6i and LPD 114.6 to the upper part of Bed 6k. Mei and Wardlaw (1998) adopted this correlation in their figure 3. As senior editor of Palaeoworld 9, I should apologize that I did not notice this mistake at the time.
4. In our proposal, correction was made following Zhu Zhili's original field record, that is, LPD 115 corresponding to Bed 6k, LPD 115' to Bed 6j and LPD 114.6 to an intercalation between Bed 6k and 7a."

What Kozur and Wang point out, after you get over their diatribes of the *stratum typicum,* is that an evolutionary continuum is displayed from beds 6i to 6k in which they are unable to distinguish separate species. However, from all the material published (Mei *et al.*, 1994, 1998, Wang, 2000, Henderson *et al.*, 2002), it is clear that all specimens below 6k do not show an extended anterior flaring of the platform before a sharp anterior narrowing, which specimens at 6k and above do. Regardless of the fact that Henderson's *et al.* (2002) diagnosis for *Clarkina postbitteri hongshuiensis* may be vague, their description is not, and the diagnosis has been revised (Lambert *et al.*, 2002, in press) to the following:

"A subspecies of *Clarkina postbitteri* characterized by a tear-shaped platform with a distinct anterior narrowing and lowering of the platform, wide furrows, slightly raised and upturned lateral margins at the anterior narrowing, discrete to partially fused carinal denticles, and a blade that is higher than the highest carinal denticle". *C. postbitteri postbitteri* differs by the above mentioned features of a highly flared platform just posterior to a sharp anterior narrowing of the platform, less fused mostly discrete carinal denticles, and an ending or a marked reduction of the reticulate micro-ornamentation at or near the narrowing, whereas on *C. postbitteri hongshuiensis* the micro-ornament continues nearly to the anterior end of the platform.

Clarkina dukouensis differs from *C. postbitteri postbitteri* by the blunt posterior termination of the platform in most growth stages, which only occurs in a few very large specimens of *C. postbitteri postbitteri*, the common feature of a miniscule to small denticle filling the posterior "gap" between cusp and the remaining, more closely spaced carinal denticles, and the cusp at the posterior terminus of the platform, lacking a brim. Yes, they are similar, as they are in an evolutionary continuum, BUT, they can be consistently differentiated by apparently everyone except Kozur and Wang!

Other points:

One of the authors (Wang) desires 6k as a boundary definer, but with a different taxon FAD. This variation in nominate species name results from differences of taxonomic philosophy that, based on conversations, appear unresolvable. What does appear resolvable is that Henderson and Mei and Wang all believe that they can recognize this level (6k) taxonomically. This indicates that 6k is a good boundary and we should move on!

The material from the Delaware Basin is badly misinterpreted. Please refer to the soon to be published article by Lambert *et al.* (2002) for the correct distribution of conodonts from the upper part of the Guadalupian in its type area. Of important note here, is that the Chinese succession documented at Penglaitan is represented there including the first occurrence of *Clarkina postbitteri hongshuiensis* and that Lambert *et al.* correlate the Delaware Basin sections bed for bed to those at Penglaitan. If this is endemic, then certainly we can live with this kind of endemism in global correlation.

The authors objected to the process of the vote for the Guadalupian-Lopingian boundary. The working group (LBWG) was composed of individuals that had visited the Penglaitan section at one time or another. Discussion regarding this GSSP has been ongoing for years and a straw vote was reported in Permophiles 39 with a recommendation to vote for the FAD of *Clarkina postbitteri postbitteri* at the base of bed 6k. The working group was formed for the purpose of voting, not to prolong the discussion. Everyone on the working group had to first agree to the secretary's email request in September 2001 to be named to this committee for the purpose of voting. According to ICS statute 9.7 voting members are to vote yes, no or abstain to a proposal and that 60 days are required for receipt of votes. The ballots and a copy of Henderson *et al.* (2002) were sent on May 8, 2002 by courier to Nanjing and by airmail to all other members with a deadline for voting of July 15th (68 days later). No other objections were received and all individuals of the LBWG voted.

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The Upper Roadian Willis Ranch Member of the Word Formation is the Third Limestone Member of the Word Formation of King (1931)

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There has been some confusion over which limestone of the Word Formation was originally designated as the third limestone member by King (1931). This confusion apparently springs from a mistake in recently published papers by Harris *et al.* (2000) and Lambert *et al.* (2000) where in figures (the same figure in both articles) they show the Willis Ranch corresponding with the second limestone member of King, but they left out the China Tank Member which is the second limestone member of King (1931). Cooper and Grant (1964) formally named the members of the Word Formation as the following:

First limestone member = Road Canyon Member (later elevated to formation)

Second limestone member = China Tank Member

Third limestone member = Willis Ranch Member

Fourth limestone member = Appel Ranch Member (not Apple)

I was prompted to write this note because this mistake is starting to show up in the literature. Please do not promote this error any further.

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Plan to visit Utrecht in August 2003

XVth International Congress on Carboniferous and Permian Stratigraphy (XV ICCP)

The XVth International Congress on Carboniferous and Permian Stratigraphy will be organized by the Netherlands Institute of Applied Geoscience TNO - *National Geological Survey* (TNO-NITG) and the Faculty of Earth Science of the Utrecht University, in Utrecht, the Netherlands. The congress will take place at the campus of the Utrecht University in the period between 10 - 16 August 2003. The venue is within 5 minutes walking distance from the buildings of the Faculty of Earth Sciences of Utrecht University and TNO-NITG.

The theme of the XV- ICCP is the 'Permo-Carboniferous around the Southern North Sea Basin'. Permian and Carboniferous deposits are of great economic importance around this basin. Numerous gas fields occur in these deposits in this mature exploration area. In addition, this area has a long tradition of mining activities related to Carboniferous coal and Permian copper and salt. This led to a good understanding of the geology and stratigraphy of these deposits. Despite the fact that recent oil and gas exploration studies contributed to several new insights, few of these have been published to date. The objective is to bring these new results to the attention of the participants of this Congress.

In order to visualize the geology of the Southern North Sea Basin, various field excursions will be organized to several classical exposures in Germany, Belgium and the U.K.

We invite you to come to Utrecht to meet and discuss ideas with university, industry and consulting geoscientists working in different fields of research.

Abstract deadline is December 1, 2002. See the website at **www.nitg.tno.nl/eng/iccp.shtml** for details.

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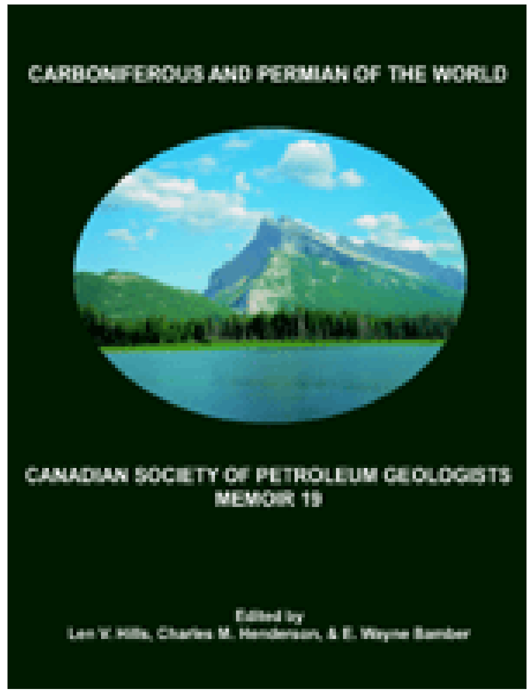

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