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

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Cover: Oligoporella pilosa Pia. From Diener in Gürich (1925)

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### STS MEETING, HALLE 22 SEPTEMBER 1998

The Meeting of the Subcommission on Triassic Stratigraphy will be held in Halle during the International Symposium on the Epicontinental Triassic, the 22 of September at 4.00 p.m.

### Provisional Agenda

- 1) President' announcements.
- Status of GSSP' selection. To be noted that any decision cannot be taken during the meeting, because all the decisions must be done by postal ballot.
- 3) Up-dating of the list of Voting and Correspondent Members.
- 4) Next meetings.
- 5) Any other questions.

Maurizio GAETANI

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### FROM THE EDITOR

Several colleagues reacted on the announcement in ALBERTIANA 20 that I might be forced to step down as editor. All expressed their great appreciation for the work that has been done over the past eight years to establish ALBERTIANA as a flourishing STS newsletter and discussion forum. However, the general feeling was that ALBERTIANA should further be produced in Europe. Nevertheless, several North American colleagues offered to help editing texts written by non-English/American authors. This offer is greatly appreciated because editing of such texts often appears to be one of the most critical and time-consuming parts of the production process. With joint efforts the production process of ALBERTIANA can surely be speeded up considerably, thereby keeping the workload acceptable for everyone involved. With the support of a small editorial committee I will surely be able to continue my work for ALBERTIANA. Finally, I once again would like to thank for all the encouranging and positive reactions.

Hans KERP

### A GSSP CANDIDATE FOR THE LADINIAN/CARNIAN BOUNDARY: THE PRATI DI STUORES/STUORES WIESEN SECTION (DOLOMITES, ITALY).

### C. Broglio Loriga, S. Cirilli, V. De Zanche, D. di Bari, P. Gianolla, G.F. Laghi, W. Lowrie, S. Manfrin, A. Mastandrea, P. Mietto, G. Muttoni, C. Neri, R. Posenato, M. Rechichi, R. Rettori and G. Roghi

### Introduction

An Italian *ad hoc* working group, co-ordinated by C. Broglio Loriga, proposes the Prati di Stuores/Stuores Wiesen section (Dolomites, Italy) as a GSSP candidate for the definition of the base of the Carnian stage. The Prati di Stuores/Stuores Wiesen area is famous thanks to the classical works by Münster (1834), Wissmann and Münster (1841), Klipstein (1845), Laube (1869), Mojsisovics (1869, 1882), Ogilvie Gordon (1893). Besides being a rich and famous fossiliferous locality, it also includes the type-section of the Cordevolian substage *sensu* Mojsisovics, Waagen and Diener (1895) and Urlichs (1974). The Prati di Stuores/Stuores Wiesen section lies in the neighbourhood of Pralongià, on the southern slope of the crest separating the Badia/Abtei Valley and the Cordevole Valley (Fig. 1).

The section supplies a rich ammonoid fauna which predates the first appearance of *Trachyceras* and documents the presence of genus *Daxatina*, a particularly significant taxon for global correlations (Mietto and Manfrin, 1995a, b). Due to its possibility of correlating different paleolatitudinal provinces, the presence of the cosmopolitan genus *Daxatina* suggests placing the Ladinian/Carnian boundary in a lower position than previously indicated in the same section (cf. Urlichs, 1974, 1994; Krystyn,1978).

The candidature of the Prati di Stuores/Stuores Wiesen section is here outlined in a synthetic form with the indications of its main stratigraphical, biostratigraphical and magnetostratigraphical features. Lithostratigraphy and sequence stratigraphy are by V. De Zanche and P. Gianolla (Padova) and C. Neri (Ferrara), magnetostratigraphy by W. Lowrie and G. Muttoni (Zūrich), ammonoids and biochronostratigraphy by S. Manfrin and P. Mietto (Padova), conodonts by A. Mastandrea (Modena), palynomorphs by S. Cirilli (Perugia) and G. Roghi (Padova), isolated foraminifers by D. di Bari (Modena), foraminifers in thin section by C. Broglio Loriga (Ferrara) and R. Rettori (Perugia), gastropods, bivalves and brachiopods by R. Posenato (Ferrara), microcrinoids and holothurians by G.F. Laghi and M. Rechichi (Modena).

The Prati di Stuores/Stuores Wiesen section was permanently stacked out in order to avoid any possible dissension between samplings carried out by workers at different times.



Fig. 1. Location of the Prati di Stuores/Stuores Wiesen area and stratigraphic sections. Sections 1 and 1 bis correspond to the column in Fig. 2. Section 2 corresponds to the Stuores Wiesen section in Urlichs (1974, 1994) and to the section SW5 in Neri et al. (1995).

The section consists of two parts (Figs. 1 and 2). The westernmost one, herein named section 1, exactly corresponds to section SW4 in Neri et al. (1995) and to the section illustrated by De Zanche and Gianolla (1995) and by Mietto and Manfrin (1995 b). It extends downward for about 20 m below picket 0, which marks the base of the section studied by the team. The top of section 1 is correlatable to a short section (section 1 bis), lying just eastward, not stacked out and separated by faults with modest throw. Lastly, an eastern section (section 2) exists, which

corresponds to the Stuores Wiesen section in Urlichs (1974, 1994) and to the section SW5 in Neri et al. (1995). Due to tectonic omission, the base of the section 2 cannot be correlated with the top of the section 1 bis. Further indications on the relationships between the Prati di Stuores/Stuores Wiesen section as intended herein and the section in Urlichs (1974, 1994) are reported in Neri et al. (1995). In the following text, the term section 1 is intended as the Prati di Stuores/Stuores Wiesen section.

### Historical background

The name Carnian was introduced in 1869 by Mojsisovics to define the stratigraphical interval corresponding to the Trachyceras aonoides Zone. The Author listed six localities, then under Austro-Hungarian rule, where these rocks crop out. However, the correct origin of the name Carnian (*Karnische Stufe*) is uncertain. According to Tozer (1967, 1984) the term derives from Carinthia (*Kärnten*), within which the locality of Raibl (ancient name of Cave del Predil), explicitly indicated by Mojsisovics, was administratively included. On the contrary, even though referring to the Raibl succession in Carnia, Gaetani (1995) thinks that the name Carnian derives from Carnian Alps, although the section actually belongs to the Julian Alps.

Within their chronostratigraphical resettling of the Triassic, Mojsisovics, Waagen and Diener (1895), re-defined the Carnian stage and subdivided it into three substages, Cordevolian, Julian and Tuvalian, each of them respectively corresponding to the Trachyceras aon, T. aonoides, Tropites subbullatus ammonoid zones. In agreement with this subdivision, Urlichs (1974) considers the Prati di Stuores/Stuores Wiesen section as the type-section of the Cordevolian. On the basis of the major event philosophy, Krystyn (1978) considered the distinction between Aon Z. and Aonoides Z. of less importance and lowered them to the rank of subzones of the Aonoides Zone. As a consequence, he proposed a subdivision of the Carnian stage into two parts: the lower one corresponding to the Julian substage, obviously including the Cordevolian and comprising the Aonoides, Austriacum and "Sirenites" zones, the upper one corresponding to the Tuvalian. This proposal was rejected by Bizzarini and others (1986) and Urlichs (1994). On the basis of the ammonoid biostratigraphy in the Southern Alps, and particularly in the Prati di Stuores/Stuores Wiesen area, Urlichs considered the original zonal statement by Mojsisovics to be valid and, therefore, asserted the opportunity of maintaining the Cordevolian substage.

Leaving aside the not greatly differing opinions of various authors, up to now the general rule for locating the base of the Carnian was the first appearance of the genus *Trachyceras*. In the Tethyan domain, this event is believed to occur at the base of the Aon Subzone/Zone, while in North America it lies within the Desatoyense Zone (cf. Tozer, 1967, 1984, 1994).

Recently, Mietto and Manfrin (1995a, b) have defined a stratigraphical interval, characterized by species of *Trachyceras* different from *T. aon* and associated with *Daxatina* and *Clionitites*, which, in the Prati di Stuores/Stuores Wiesen section, is placed below the traditional base of the Carnian. The earlier occurrence of *Trachyceras* and the concomitant occurrence of a cosmopolitan genus such as *Daxatina*, encouraged the two authors to suggest the lowering of the Ladinian/Carnian boundary. In this way, the lowermost Carnian should include the upper part of the Frankites regoledanus Zone (Krystyn in Zapfe, 1983), usually considered Ladinian and correlated with the Frankites sutherlandi Zone in North America.

Fig. 2. A synthesis of the main stratigraphic results in the Prati di Stuores/Stuores Wiesen section. Lithostratigraphic columns correspond to sections 1 and 1 bis in Fig. 1. Numbers and triangles on the left indicate stakes. Ammonoid and palynomorph distribution refer to selected taxa.



Albertiana 21, September 1998

### Lithostratigraphy

The area is placed to SW of the village of San Cassiano/St. Kassian and belongs to the type-area of the San Cassiano Fm., defined by Wissmann (in Wissmann and Münster, 1841) as Schichten von St. Cassian and then named Cassianer Schichten. The S. Cassiano Fm. is a basinal unit, subdivided by Ogilvie Gordon (1900) into two members: "lower" (UCS, Unterer Cassianer Schichten) and "upper" (OCS, Oberer Cassianer Schichten) on the basis of lithological features and paleontological contents. According to this subdivision, the UCS overlie the La Valle Fm. (although their lower boundary is not well defined) and consist of alternating siltstones, claystones, calcarenites, marly limestones and turbiditic volcanoarenites, while the OCS, which overlie the highest volcanoarenitic layer (tuffsandstein in Urlichs, 1974), are mainly made up of muddy beds, siltstones and marls, with some limestone intercalations. The distinction between UCS and OCS on the basis of volcanic debris content was debated by De Zanche et al. (1993), De Zanche and Gianolla (1995) and Neri et al. (1995): they prefer not to consider the volcanic debris content as a diagnostic tool because it is paleogeographically controlled. In agreement with Richthofen (1860), the La Valle Fm./San Cassiano Fm. boundary (at 1.5 m from the bottom in section 1) is marked by the occurrence of oolitic turbidites, which also testify to the progradation of a carbonate platform (Cassian Dolomite). In conclusion, in the lower part of the section, mainly grey and dark grey marls with volcanoturbiditic intercalations crop out (La Valle Fm.), while in the upper part brown and yellowish marls with carbonate turbidites prevail (San Cassiano Fm.).

### Sequence stratigraphy

The Prati di Stuores/Stuores Wiesen section is illustrative of the basinal stratigraphy in the western Dolomites after the volcanic acme. The upper part of the La Valle Fm. records a strong decrease in sedimentary supply and, therefore, it consists of calcilutites, marls and claystones. Upwards, a progressive increase in neritic carbonate content and a new increase in volcanosedimentary supply follow (San Cassiano Fm.). In the upper part of the section, the latter is gradually replaced by carbonate neritic turbidites. The latter also document the progradation of a carbonate platform (Cassian Dolomite) and of a terrigenous coastline.

According to De Zanche et al. (1993) and Gianolla (1995), the whole Prati di Stuores/Stuores Wiesen section belongs to the Car 1 3<sup>rd</sup> order depositional sequence (DS). In the Stuores area, the Car 1 DS includes the following units: La Valle Fm., lower part of the San Cassiano Fm., Cassian Dm. 1 and, locally, basic volcanics. The lowstand systems tract (LST) mostly consists of more or less coarse-grained volcano-sedimentary deposits (e.g. Marmolada Conglomerate, Pachycardientuffe). Layers including karstified carbonate olistholiths ("Cipit limestones" p.p.), probably deriving from the destroying of previous carbonate buildups, are characteristic. TST deposits are defined by the strong decrease in terrigenous content and by the appearance of fine-grained terrigenous-carbonate facies (upper part of the La Valle Fm.). In the Prati di Stuores/Stuores Wiesen section, the maximum flooding surface (mfs) seems to lie close to La Valle Fm./San Cassiano Fm. boundary; it supplied ammonoids belonging to the topmost Regoledanus Subzone (sensu Mietto and Manfrin, 1995b). In the basinal areas the Car 1 HST corresponds to the lower part of the San Cassiano Fm., interfingered with the Cassian Dm. 1 (De Zanche et al., 1993). In carbonate shelf areas, the next SB is placed at the top of the eroded and karstified Cassian Dm. 1; in basinal areas, the Car 2 SB falls at the strong increase of clastic supply which is also recorded in the upper part of the Prati di Stuores/Stuores Wiesen (cf. Urlichs 1974, 1994), that is above biocalcarenitic and oolitic turbidites (Car 1 HST).

According to De Zanche et al. (1993) and to Gianolla et al. (1998), the Car 1 DS has a suprabasinal value. On the contrary, Mastandrea, Neri and Russo (1997) think that the complex stratigraphic setting of the western Dolomites during Ladinian-Carnian is so strongly controlled by tectonics that the eustatic signal is overcome. Therefore, according to the authors, a sequence stratigraphic framework defined in the Dolomites cannot be considered as a global standard. Moreover, they suggest that the post-volcanic succession in the region should include more carbonate platforms than those indicated in De Zanche et al. (1993) and Gianolla et al. (1998).

### Biostratigraphy

Although at present research on ammonoids, conodonts and palynomorphs is still in progress, available data allow a biochronostratigraphical framework to be presented.

### Ammonoids and ammonoid biozones

The definition of a new subzonal unit below the Aon Subzone is the most important result of the biostratigraphical analysis in the Prati di Stuores/Stuores Wiesen section. Mietto and Manfrin (1995 a, b) named it as the Daxatina cf. canadensis Subzone. Its base (at 45 m) is placed at the appearance of *Daxatina* cf. canadensis (Whiteaves), which corresponds to the FAD of *Daxatina*; the genus *Clionitites* appears at 52.2 m, while the genus *Trachyceras* [*i.e. Trachyceras bipunctatum* (Münster)] is found beginning from 61.5 m. As shown in Fig. 2, ammonoid fauna lying below 45 m perfectly fits with horizon C of the Regoledanus Subzone (*sensu* Mietto and Manfrin 1995 b). Note that *Frankites apertus* (Mojsisovics) is present beginning from this horizon upwards at least till 79 m. The upper subzone boundary crops out in the section 1 bis (Fig. 2) at 194.3 m in which a specimen of a *probable Trachyceras aon* (Laube) occurs. Due to the high sedimentation rate, in the Prati di Stuores/Stuores Wiesen section the Daxatina cf. canadensis Subzone is 149 m thick. It directly underlies the Aon Zone in Urlichs (1974, 1994), at whose base the Author placed the Ladinian/Carnian boundary.

The specimens of *Daxatina* considered here cannot be confused with the exemplars of *Daxatina* in Urlichs (1974), which later (1994) the author correctly considered to be juvenile stages of *Trachyceras*. However, as illustrated in Mietto and Manfrin (1995b: fig. 6), at a whorl height of 1 cm they show an unequivocal ceratitic suture, with entire saddles and well rounded tips. Due to their morphological features, ornamentation and suture line, exemplars of *Daxatina* in the Southern Alps are well comparable with those splendidly illustrated by Tozer (1994) in Canada as *D.canadensis*.

The genus *Daxatina* is a cosmopolitan taxon. It was pointed out in the Boreal domain (e.g. Bjørnøya, Arctic Ocean), where Böhm (1903, 1904) defined it as *Dawsonites*; later emended in *Daxatina* by Strand (1929). Its type-species, *Trachyceras canadensis* Whiteaves (1889), comes from the Liard River (British Columbia; cf. also Smith, 1927; Mc Learn, 1947a, b; Tozer, 1967, 1994), therefore from a mid-latitude domain. Known also in Alaska (Martin, 1916), it is believed to be typical of the mid-high latitudes (Arkell, Kummel and Wright, 1957). Lastly, the discovery of *Daxatina* at low latitude in the Tethys realm allows is to be considered a useful tool for global correlation.

### Conodont biostratigraphy

The whole section is characterized by conodonts of the *Budurovignathus* group and by two longrange species belonging to genus *Gladigondolella: G. tethydis* (Huckriede) and *G. m. malayensis*  Nogami. The Budurovignathus group is represented by B. mungoensis (Diebel), B. longobardicus (Kovacs), B. diebeli (Kozur and Mostler) and B. mostleri (Kozur). All these taxa are typical of the diebeli Assemblage Zone in Krystyn (1983), referred by the author to the Regoledanus Zone (= uppermost Ladinian).

As shown in Fig. 2, the first occurrence of conodonts of the *Budurovignathus* group is documented at about 26 m. Unfortunately, the interval between 26 and 85 m is barren in conodonts: it contains the FAD of *Daxatina* cf. *canadensis* (at 45 m).

The upper part of the section (above 85 m) still contains *Budurovignathus* and long-ranging gondolellas (i.e. *G. tethydis*, *G. m. malayensis*). *B. diebeli* and *B. mostleri* occur until about 177 m, together with a broken specimen of *Gondolella* that, due to its bad preservation, had an uncertain classification (*G. inclinata* vel *G. polygnathiformis*).

*G. polygnathiformis* occurs together with *Trachyceras aon* near the base of section 2 (Fig. 1) which corresponds to the section in Urlichs (1974) as the stratotype of the Cordevolian substage. On the basis of data from sections in the Stuores area, it seems that the FAD of *Pseudofurnishius murcianus murcianus* is located slightly below the first occurrence of *G. polygnathiformis*. Moreover, in the lower samples of section 2, *B. diebeli* occurs together with *G. polygnathiformis*, confirming the overlap of the ranges of these taxa shown by a number of stratigraphic sections within Alpine Europe (Mastandrea et al. in progress).

### Ammonoid vs. conodont biozones: comparison and problems

The vertical distribution of conodonts and ammonoids across the Ladinian/Carnian boundary was discussed by Krystyn (1983) in the Epidaurus section and, more recently, by Kovacs et al. (1991) with regard to the Füred Limestone in the Balaton Highland. The above quoted papers present two contrasting sets of data.

According to Krystyn (1983), in the Epidaurus section the conodont assemblage characterized by *Budurovignathus diebeli*, marker of the Diebeli Zone, is correlatable with the Regoledanus Zone *sensu* Krystyn (1983). The first occurrence of *Gondolella polygnathiformis* is considered by Krystyn (1983) to coincide with the base of the Aon Subzone. Unfortunately, the "Carnian" tract of the section is quite poor in ammonoids, only represented in the Aonoides Zone *sensu* Krystyn (1978) by specimens of *Trachyceras* sp. The ranges of *Budurovignathus diebeli*, *B. mungoensis* and *B. mostleri* do not show any overlap with the range of *G. polygnathiformis*, although subsequently, on the basis of other stratigraphic sections (*i.e.* the Mayerling section), Krystyn reached the conclusion that the range of the *Budurovignathus* group goes upward into the Aonoides Zone (Gallet et al., 1998).

Clear evidence of overlap between the ranges of *Budurovignathus* and *G. polygnathiformis* are supplied by a number of stratigraphic sections, including the Prati di Stuores/Stuores Wiesen section and outcrops from the Apuseni Mts. (Rumania, Kozur, 1980; 1989). The real question is if the overlap is due mainly to a downward extension of the range of *G. polygnathiformis*, below the FAD of *Trachyceras aon* or, on the contrary, to the upward extension of the range of the *Budurovignathus* group into the Aonoides Zone.

In the Ladinian-Carnian succession of the Balaton Highland, conodonts of the *Budurovignathus* group (including *B. diebeli*) occur together with *G. polygnathiformis* from the base of the Füred Limestone (Kovacs et al., 1991); the lowermost part of the formation contains *Frankites* sp., and has been referred by the above quoted authors to the Regoledanus Zone. The conclusion of Kovacs et al. (1991) is that the base of the Carnian stage has to be located at the first appearance of *G. polygnathiformis* and thus they include the Regoledanus Zone in the Carnian.

According to two of us (S. Manfrin and P. Mietto), it is possible that the specimens of *Frankites* sp. in the Füred Limestone pertain to *F. apertus* rather than to *F. regoledanus*. This opinion is supported by a re-evaluation of the ammonoid fauna in Frech (1911) from the same stratigraphic unit: it includes "*Trachyceras (Anolcites) Richthofeni* MOJS.", classified, with some doubts, as *F. apertus* by Mietto and Manfrin (in progress). If this interpretation is correct, it may be possible to argue that the FAD of *G. polygnathiformis* falls within the Daxatina cf. canadensis Subzone and that its occurrence at the base of the Aon Subzone in the Prati di Stuores/Stuores Wiesen section 2 (Urlichs, 1974, 1994) is ecologically controlled. A significant environmental change from anoxic/dysoxic to fully oxygenated basin may occur near the base of Aon Subzone, as suggested by macro- and microbenthos assemblages. This fact may enforce the proposal to drawn the Ladinian/Carnian boundary at the base of the Daxatina cf. canadensis Subzone: its lower boundary falls into a tract of section not affected by significant paleoecological changes and thus may be regarded as "evolutionary"-controlled.

However, there is no agreement between the co-authors of the paper by Kovacs et al. (1991) about the real taxonomy of the conodonts classified as "G. polygnathiformis". According to Krystyn (personal communication to A. Mastandrea), G. polygnathiformis has never been found within the Regoledanus Zone (which, as intended by L. K., includes the Daxatina cf. canadensis Subzone).

The problem needs further discussion, in order to attest if the FAD of *G. polygnathiformis* is really more or less concomitant with the FAD of *T. aon* or, on the contrary, is within the upper Regoledanus Zone Auct. (= Daxatina cf. canadensis Subzone). Data from the Stuores area support the idea that the first appearance of *G. polygnathiformis* and *T. aon* are approximately coeval. This interpretation is congruent with data from Epidaurus; moreover, it is not in contrast with data from the Mayerling section (Gallet et al., 1998).

If the proposal to put the Ladinian/Carnian boundary at the base of Daxatina cf. canadensis Subzone is accepted, it must be taken into account that it most probably does not coincide with significant events affecting the conodont assemblages.

### Paleontological-paleoecological contributions

In order to make easier the comprehension of the paleontological characteristics of the interval including the Ladinian/Carnian boundary, data both on palynomorphs, which could be important from the biostratigraphic point of view, and on other fossils, which can give significant environmental indications, are included.

### Palynomorphs

Palynological analysis gave interesting preliminary results that have to be compared on a regional scale to be confirmed. Previous palynological studies (Van der Eem, 1983) on this area only concerned younger strata (cf. Urlichs levels). The palynological assemblages evolved, from the bottom to the top, as follow.

Assemblage A (from 0.5 to 45 m, Regoledanus Subzone): the palynological assemblage is highly diversified. In this interval, *Enzonalasporites vigens* Leschik occurs first. *"Lueckisporites"* cf. *singhii* Balme makes its first occurrence at just 50 cm below the Regoledanus/Daxatina cf. canadensis subzones boundary, and ranges up into the Daxatina cf. canadensis Subzone. Other important occurrences are *Lunatisporites acutus* Leschik and *Neoraistrikia taylori* Playford and Dettman. The most abundant species is the long ranging *Ovalipollis pseudoalatus* (Thiergart) Schuurman, which is present throughout the section.

Assemblage B (from 45 to 160 m, Daxatina cf. canadensis Subzone): at the Regoledanus/Daxatina cf. canadensis subzones boundary, a great diversification has been recorded. The Daxatina cf. canadensis Subzone is characterized by the first occurrence of *Patinasporites densus* Leschik and *Vallasporites ignacii* Leschik. Other important elements are *Camerosporites secatus* Leschik, *Weylandites magmus* (Bose and Kar) Van der Eem, *Concentricisporites bianulatus* (Neves) Antonescu, *Convertucosisporites* sp. B (cf. Van der Eem, 1983), *Concavisporites* sp. A (cf. Van der Eem, 1983) and *Concentricisporites insignis* Pautsch. In the uppermost part of the subzone, bad preserved specimens of *Partitisporites maljawkinae* (Klaus) Van der Eem also occurs for the first time. The long ranging species already present in the underlying subzone can also be regularly found together with new long ranging elements. The *Triadispora* group becomes more diversified towards the upper part of this subzone.

As reported by several authors (Clement-Westerhof et al., 1974; Schuurman, 1979; Scheuring 1978; Visscher et al., 1980; Visscher and Brugmann, 1981; Van der Eem, 1983), in this section the first appearances of *E. vigens* and "*L*". cf. singhii also occur respectively in the upper (secatus-vigens phase, Longobardian) and uppermost Ladinian. Differently, *W. magmus*, whose first occurrence was recorded by Van der Eem (1983) at the base of the secatus-vigens phase, first occurs in this section within the Daxatina cf. canadensis Subzone. The first income of *C. secatus*, which is considered Late Ladinian in age (Schuurman, 1979; Visscher and Krystyn 1978; Visscher and Brugman, 1981; Van der Eem, 1983; Brugman et al., 1994) also occurs in this section within the Daxatina cf. canadensis Subzone. The carnian age of other important elements such as *P. densus* and *V. ignacii* is fully confirmed.

### Benthic foraminifers

In order to obtain the most realistic assemblages, the study has been carried out both in thin section and washed material. Isolated foraminifers have been investigated from 33 samples of marls and clays. Foraminiferal assemblages from calcarenitic levels and muddy limestones have been studied in over 300 thin sections.

The foraminiferal assemblage evolves as follows:

A) 0 to 45 m (Regoledanus Subzone). This segment ranges from the base of the section to the FAD of Daxatina.

Isolated foraminifers - A rich fauna dominated by agglutinated foraminifers, such as Endothyra kuepperi Oberhauser, Palaeolituonella meridionalis (Luperto), Ammodiscus cf. infimus (Strickland), A. incertus (d'Orbigny), A. tenuissimus Gümbel, A. annulinoides Kristan-Tollmann, Glomospira perplexa Frank, Glomospirella facilis Ho, G. hemigordiformis (Tscherdynzew), Reophax eominutus Kristan-Tollmann together with the nodosariids Dentalina ex gr. subsiliqua Franke, D. cassiana Gümbel, Nodosaria primitiva Kübler and Zwingli, Pseudonodosaria obconica (Reuss), Kriptoseptida klebelsbergi (Oberhauser), Lenticulina cassiana (Gümbel), L. excavata (Terquem), L. bochardi (Terquem), L. karnica (Oberhauser) are present. The species Duostomina sp., D. biconvexa Kristan-Tollmann, D. alta Kristan-Tollmann, D. turboidea Kristan-Tollmann and Ophthalmidium cf. exiguum Köhn-Zaninetti are also present.

Thin section - In a mudstone layer at 9.10 m the appearance of the very important assemblage *Gsollbergella spiroloculiformis* (Oravecz-Scheffer) - *Semimeandrospira* ex gr. *karnica -planispira* (Or.-Scheff.) - *Turriglomina carnica* Dager was recorded. *Piallina tethydis* Rettori et al. first occurs in a fine grained level at 19.25 m. The appearance of *Gordiospira triassica* Urosevic was recorded at 34 m, but this species is scarcely present in the rest of the section. *Gsollbergella spiroloculiformis* is constant along the succession both in

calcarenites and in muddy limestones, whilst *T. carnica* is more frequent from 29.60 m. In addition, just one specimen of *Palaeolituonella meridionalis* (Luperto) was recorded at 43.40 m. All taxa are small and, at present, are exclusively known in the "Carnian" of western and eastern Tethys, but very few species have been dated by ammonoids or conodonts. Several species belonging to *Ammobaculites, Gheorghianina, Glomospira, Glomospirella, Duostomina, Endoteba, Ophthalmidium, Reophax* and *Variostoma* may be associated. Nodosariidae and Textulariidae also occur.

B) 46 to 145 m (Daxatina cf. canadensis Subzone p.p.).

Isolated foraminifers - Most foraminifers in segment A continue their presence, but the nodosariids become dominant and some new taxa, such as *Schlagerina* sp., *Oberhauserella* sp., *Dentalina guembeli* Schwager, *Frondicularia* sp. and *Nodosaria nitidana* Brand occur. Thin section - Any peculiar change in foraminiferal assemblage was recorded in this segment except for the bloom of *S.* ex gr. *carnica-planispira* at 114 m. An increase in carbonate platform biota (*Tubiphytes*, bryozoans, *Cayeuxia*, calcareous sponges, thick shelled bivalves and encrusting foraminifers) become more abundant from 131.10 m.

C) 146 to 180 m (Daxatina cf. canadensis Subzone p.p.).

Isolated foraminifers - The foraminiferal assemblage is dominated by duostominids and involutinids. The taxa mainly represented are: *Duostomina biconvexa* Kristan-Tollmann, *Diplotremina astrofimbriata* Kristan-Tollmann, *Variostoma pralongense* Kristan-Tollmann, *V. exile* Kristan-Tollmann, *P. altoconica* (Kristan-Tollmann), *Papillaria* sp., *Lamelliconus* ex gr. *ventroplanus* (Oberhauser), *Aulotortus* ex gr. *sinuosus* Weynschenk, *Lamelliconus multi-spirus* (Oberhauser). In addition, a few nodosariids and agglutinated foraminifers also occur. The first appearance of *Ophthalmidium fusiforme* (Trifonova) and *Ammobaculites hiberensis* Marguez and Trifonova occurs at the top of the section.

Thin section - At 172 m, the foraminiferal assemblage is at first dominated by involutinids (Lamelliconinae) mainly referred to *Lamelliconus multispirus* (Oberhauser) and *L. procerus* (Liebus) in association with *G. spiroloculiformis, S.* ex gr. *karnica-planispira, T. carnica* and *P. tethydis* already quoted in the previous segments.

Segments A and B are mainly characterized by autochthonous deep-water foraminifers. According to the relations between foraminiferal test morphology and energy-oxygen level suggested by Kahio (1989) and Boudiche and Ruget (1993), *Dentalina, Pseudonodosaria* and *Nodosaria* belong to elongated and cylindric morphotype; *Frondicularia* to the elongated and flattened one; *Lenticulina* to the flattened and planispiral type. Deep-water infaunal habits have been inferred for these taxa. Agglutinated and tubular tests of *Glomospira*, *Glomospirella* and *Ammodiscus* pertain to epifauna which inhabits shallow- to deep-water during Early Mesozoic. The association of all three morphotypes suggest disaerobic and low-energy conditions of the sedimentary environment. Moreover, the duostominid and involutinid dominated associations in segment C (upper part of the Daxatina cf. canadensis Subzone) records an increase in energy and oxigen level of the environment.

In conclusion, foraminifers allow the following remarks.

- 1 The Carnian affinity in segments A and B is mainly testified by the taxa occurring in thin section.
- 2 Mainly on the basis of the involutinids, the assemblages recognized in washed material and in thin section are closely comparable in segment C.

- 3 Most species occurring in the Prati di Stuores/Stuores Wiesen section 1 are quoted in the Carnian of the Taurus (Altiner and Zaninetti, 1981), Carpatho-Balkans (Salaj et al., 1983; Trifonova, 1992, 1993), Transdanubian Central Range (Oravecz-Scheffer, 1987), Serbia (Urosevic, 1988), Northern Calcareous Alps (Oberhauser, 1957; Kristan-Tollmann, 1960, Köhn-Zaninetti, 1969; Zaninetti, 1969, 1976), Julian Alps (Rettori et al., in print), Turkey (Dager, 1978; Rettori et al., 1993), China (He and Yue, 1987; He and Norling, 1991) and Israel (Benjamini, 1988).
- 4 Change in taxonomical compositions may strongly depend on ecological factors.

### Bivalves, gastropods and brachiopods

Bivalves in the Prati di Stuores/Stuores Wiesen section mainly consist of *Posidonia wengensis* (Wissmann), while no specimens of *Daonella* or *Halobia* have been found. Brachiopods are rare and only occur in the upper part of the section. *P. wengensis* is mainly contained in laminated dark grey clays and argillaceous marls alternated with tuffites and calcarenites. According to Fürsich and Wendt (1977), *Posidonia* is a typical element of the San Cassiano Fm. "pelagic assemblage". The latter is characterized by the absence of benthic and dominance of nektic forms and was deposited in the deeper parts of the Cassian basin (depocentre). Due to: (1) high turbidity, (2) high water-content of the bottom sediment (very soupy substrate) or (3) oxygen deficient bottom-waters, this assemblage lacks benthic suspension feeders (Fürsich and Wendt, 1977). According to the new hypothesis concerning the tolerance of posidoniids to low-oxygen values and their benthic life habit (Wignall and Simms, 1990), the latter environmental factor seems to have played a dominant role in the composition of the "pelagic assemblage" occurring in the section.

Above 150 m, the disappearance of *P. wengensis* and the frequent occurrence of nuculoids (section 2) may suggest a change of the redox boundary which moved inside the sediments.

In conclusion, the depositional environment of the Prati di Stuores/Stuores Wiesen section corresponds to a basin in which prevailing anaerobic to disaerobic conditions of the bottom water occurred in the lower part (from 0 to 105 m). As the sediment infilled the basin, the water circulation increased. In the middle part (from 105 to 150 m), frequent aerobic events (*Koninckina* beds) alternated with disaerobic events (*Posidonia*-bearing marls). In the upper part of the section (from 150 to 180 m) more stable aerobic conditions allowed the settlement of nuculoids, which occur frequently in section 2 (Aon Subzone).

### Microcrinoids and holothurian sclerites

In the middle-upper Triassic of the Tethys Realm many microcrinoid occurrences have been observed. Kristan-Tollman (1970) compared this phenomenon to the Jurassic *Saccocoma* facies. Many species belong to Somphocrininae Peck and particularly to the genus *Osteocrinus* Kristan-Tollman. Many holothurian sclerites are also documented.

In the section 1, the taxonomic diversity of the microcrinoids is very high. The following species can be recognized: *Osteocrinus rectus* Krist.-Toll., *O. goestlingensis* Krist.-Toll., *O. saklibelensis* Krist.-Toll., *O. acus* Krist.-Toll., *O. sp., Ossicrinus reticulatus* Krist.-Toll., *Axicrinus alexandri* Krist.-Toll., *A.* sp., *Somphocrinus* sp., *Tulipacrinus* sp. and *Nodolanx multinodosa* Krist.-Toll.

Osteocrinus rectus, the close species O. goestlingensis, and the hardly determinable O. saklibelensis, commonly have a much wider range with respect to the extension of the Prati di

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Stuores/Stuores Wiesen section. However, strictly concerning the latter, it is possible to make the following considerations:

- between 20 and 45 m the first occurrences of many microcrinoids are documented;
- from 120 to 150 m, a short peak both in microcrinoids and sclerites can be recognized;
- above the peak, the taxonomic diversity decreases. According to Bizzarini (1993), the holothurian sclerites increase upwards;
- close to the top of the section, a few species disappear: the last occurrence of Osteocrinus acus is the most prominent event.

The above mentioned microcrinoid and holothurian sclerite association seems to be rather typical of the Daxatina cf. canadensis Subzone; with minor modifications, it also extends upwards into the Aon Subzone.

The variations in taxonomic diversity can probably be referred to ecological factors.

### Paleomagnetism

A total of 96 paleomagnetic core samples were analysed at the paleomagnetics laboratory of ETH Zürich. Stepwise thermal demagnetization treatments and measurements of natural remanent magnetization (NRM) were performed on all specimens in a shielded room. Magnetic remanences were measured on a 2G Model 760 3-axis cryogenic magnetometer mounting DC SQUID sensors. Least-square analysis was used to determine the component directions of the NRM, chosen by inspection of vector end point demagnetograms. Mean directions were determined with standard Fisher statistics. The rock magnetic properties were investigated by means of thermal unblocking characteristics of orthogonal-axes isothermal remanent magnetization (IRM).

### Paleomagnetic directions

Paleomagnetic samples typically show the presence, in *in situ* coordinates, of a scattered low unblocking temperature component of viscous origin consistent with acquisition along the present-day field direction and/or induced at random during drilling or cutting. Above this low temperature component, interpretable paleomagnetic directions were obtained in 93% of the specimens. In particular, a bipolar characteristic component oriented *in situ* north and positive or south and negative was isolated in 72% of the specimens in the temperature range comprised usually between about 200°C and 450°C to 550/580°C. In 10% of the specimens the characteristic component could be followed up to maximum unblocking temperatures of 600 to 630°C. An additional 11% of the samples show *in situ* westerly stable-end-point trajectories interpreted as transitional directions associated with excursions of the Earth's magnetic field or acquired during a field polarity reversal. The bipolar and transitional characteristic component directions become shallower upon correction for bedding tilt.

The thermal unblocking characteristics of orthogonal-axes IRM show that all lithologies are dominated by a low coercivity and ca. 580°C maximum unblocking temperature phase interpreted as magnetite, maybe co-existing with subsidiary sulphurs characterized by ca. 320-350°C maximum unblocking temperatures. A higher coercivity and unblocking temperature phase, like haematite, may be also present at places.

### Magnetostratigraphy

The latitude of the specimen virtual geomagnetic pole (VGP) with respect to the overall mean north paleomagnetic pole was used to delineate the magnetic polarity stratigraphy. VGP relative latitudes approaching +90°N (-90°N) are interpreted as recording normal (reversed) polarity.

The latitude of the VGPs defines at Stuores a lower normal (S1n)-reversed (S1r)-normal (S2n)reversed (S2r)-normal (S3n)-reversed (S3r)-normal (S4n) polarity sequence. Intermediate VGP latitudes are preferentially located at polarity transitions. The base of the Carnian, as defined by the base of the Daxatina cf. canadensis Subzone, falls towards the base of normal polarity interval S2n.

The Ladinian/Carnian boundary at Stuores can be tentatively correlated with the coeval Mayerling section in Austria from the literature (Gallet et al., 1998, fig. 10). We propose that the reversed polarity interval S1r in the Prati di Stuores/Stuores Wiesen section correlates with polarity interval MF- at Mayerling, and that normal polarity interval S2n at Stuores corresponds to interval MG+ at Mayerling (Fig. 1) [polarity nomenclature at Mayerling is here informally introduced after Gallet et al (1998) for clarity]. Towards the top the correlates at Mayerling with a small "excursion" located somewhat below meter 40 at a lithological transition, and here named MH-?. If so, the overlying normal polarity interval S3n at Stuores corresponds to interval MI+ at Mayerling and so forth. This correlation would suggest that the first occurrence of *Gondolella polygnathiformis* at Stuores, presently located at the base of section 2, may be lower, within normal polarity interval S3n.

### Conclusions and proposals

The present paper proposes that the base of the Carnian stage should be placed at the base of the Daxatina cf. canadensis Subzone. This assumption is mainly supported by the occurrence of the genus *Trachyceras* below the FAD of *T. aon*, within the Daxatina cf. canadensis Subzone. Also due to its good magnetostratigraphic record, the Prati di Stuores/Stuores Wiesen section is proposed as the candidate stratotype for the Ladinian/Carnian boundary.

The proposal is supported by the following data:

- Daxatina is the only cosmopolitan genus within the studied chronological interval, occurring both in Tethyan and Boreal realms, while the distribution of the genus *Trachyceras* is restricted to low-intermediate latitudes. Moreover, the vertical range of *Daxatina* is distinctly narrow;
- 2) no significant biostratigraphic event seems to affect the ammonoid assemblage at the base of the Aon Subzone (as well as in its boreal equivalent, Desatoyense Zone); a significant faunal turn-over may only be identified at the FAD of *Daxatina*;
- the base of the Carnian, as defined by the base of the Daxatina cf. canadensis Subzone, falls towards the base of normal polarity interval S2n;
- 4) the biostratigraphic events affecting conodont assemblages do not seem to be synchronous with ammonoid events: Gondolella polygnathiformis occurs at the base of the Aon Subzone in a number of sections, including the section 2 in the Stuores area; although data from

Fig. 3. Comparison of magnetostratigraphic and biostratigraphic data from this study and the Mayerling section from Austria (Gallet et al., 1998). Biostratigraphy at Mayerling is based on conodonts. The thickness of the reversed polarity interval located at Mayerling in the lowermost part of the Diebeli conodont zone, and here informally named MF-, has been here reinterpreted (i.e., shortened) after Gallet et al. (1998, fig. 10). A small departure of the characteristic component direction towards shallower inclinations observed at Mayerling in the upper part of the Diebeli conodont zone is here highlighted and informally named MH-. This "excursion" occurs at or close to a lithological transition. Thicknesses are expressed in meters from the base of sections.



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Balaton may suggest that its occurrence within basinal successions may be ecologically controlled, further data are required in order to define the fitting between ammonoid and conodont events. The correlation between Mayerling and Stuores would suggest that the first occurrence of *Gondolella polygnathiformis* at Stuores, presently located at the base of section 2, may be lower, within normal polarity interval S3n.

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### QUANTITATIVE AMMONOID BIOCHRONOLOGICAL ASSESSMENT OF THE ANISIAN-LADINIAN (MIDDLE TRIASSIC) STAGE BOUNDARY PROPOSALS

### J. Pálfy and A. Vörös

Nearing the vote on the Anisian-Ladinian GSSP, we reassess the western Tethyan ammonoid stratigraphic record, which could serve as the basis for defining the boundary. There are three competing and widely debated proposals which variably equate the stage boundary with the base of the Reitzi, Secedensis, or Curionii Zones. To provide an unbiased evaluation of the boundary proposals, we analysed the ammonoid distribution of 14 key stratigraphic sections from the Southern Alps and the Balaton Highland using quantitative biochronology. Published ranges of more than 60 taxa were processed by the computer-assisted Unitary Association method in order to assess the correlation potential of the three proposed boundary levels. The most pronounced faunal change occurs within the Reitzi Zone. On the basis of its faunal content, this zone offers the most robust correlation between the Southern Alps and the Balaton Highland, whereas its base is clearly marked by the first appearance of *Kellnerites* in both areas. On the other hand, the Unitary Associations corresponding to the Secedensis and Curionii Zones are characterized by significantly fewer taxa, some of which are restricted to only one area. These results provide an additional argument in favor of the Reitzi Zone as the base of the Ladinian.

### Introduction

The Triassic stratigraphic community is coming to an historic decision to fix the Anisian-Ladinian boundary by designating its Global Boundary Stratotype Section and Point (GSSP). Much has been written and discussed about the boundary in question. It is not our goal to review the flurry of research papers leading to the vote on the GSSP scheduled for this year. For thorough summaries, the reader is referred to several recent articles, many of which appeared in Albertiana (e.g., Brack and Rieber, 1993, 1994; Mietto and Manfrin, 1995; Võrös et al., 1996).

Practicality dictates the use of various fossil groups and stratigraphic methods, but tradition justifies that the eventual GSSP be defined primarily on the basis of ammonoid succession in the western Tethys. However, there remains three major candidates for the exact stratigraphic level of the boundary and at least two other possibilities were also raised (Kozur, 1995; Mietto and Manfrin, 1995). The three zones which have been repeatedly proposed to serve as the basal unit of the Ladinian Stage (Gaetani, 1993) are (from older to younger): the Reitzi Zone (Vörös et al. 1996), the Secedensis Zone (originally Nevadites Zone, Krystyn, 1983), and the Curionii Zone (Brack and Rieber, 1993). Without reiterating the point of views previously expressed in favor of one candidate or the other, herein we focus on assessing the utility of the proposals by employing quantitative biochronology to compare their correlation potential. The scope of our analysis is restricted to the ammonoid biochronology of the western Tethys. We feel that such a test of the contending proposals is necessary to ensure that the correlation power, arguably the single most important attribute of any stratigraphic boundary choice, will be duly considered by the voters.

### Methods

Quantitative biochronology offers several advantages over the traditional methods: it allows fast processing of large amount of range data from a multitude of sections while it eliminates biases that are often inherent in expert judgements that rely on hand-picked index taxa. From the several available quantitative methods (Edwards, 1991), we chose the Unitary Association (UA) method (Guex, 1991) as best suited to discuss the Anisian-Ladinian boundary and its correlation problem. The UA method is attractive because its underlying principle essentially corresponds to that of the Oppel (or assemblage) zone concept. It is based on a deterministic approach that employs graph theory to establish the succession of elementary units of co-occurring taxa, the Unitary Associations. Its algorithmic formulation, through the BioGraph program (Savary and Guex, 1991), affords relatively easy, computer-assisted data processing. The output offers several possibilities (e.g., number of incoming taxa, reproducibility, estimation of correlation uncertainty, etc.) to quantify the correlation potential of biochronological units. Previously, the UA method was found to efficiently construct biochronologically meaningful zonations from complex data (Baumgartner,, 1984). Notably, it was successfully used for estimating the biochronological dating error (Pálfy et al., 1997) and was demonstrated to closely reproduce the ammonite zonation developed by traditional methods (Dommergues and Meister, 1987).

We considered all published references that deal with Anisian and Ladinian (Trinodosus to Curionii zones) ammonoid faunas of the Southern Alps and Balaton Highland, and provide raw distribution data from measured stratigraphic sections. Priority was given to sections with continuous ammonoid record spanning several zones, preferably with abundant and diverse faunas that are taxonomically well-documented. The selected sections will be discussed in detail below. Care was taken to eliminate those intervals within the sections where mixing or condensation was documented or suspected, which could alter the true stratigraphic relationship of taxa. To ensure that the range data are based on consistent taxonomy, nomenclature and identifications were revised according to Voros (in press). A list of taxa occurring in more than one of the selected sections (i.e. those enabling meaningful correlation) was compiled. We omitted the long-ranging forms with little correlation value, e.g. ptychitids, gymnitids, arcestids, and Norites. To complement the species-based approach and strengthen correlation, composite genus ranges were added for each section. Thus the ranges of 61 taxa from 14 sections were entered into the database. The BioGraph program was used to construct a biochronologic scheme of Unitary Associations which were then compared to the traditional zonal scheme. Various outputs of the program form the basis of the present discussion.

### Sections and faunal distribution data

Four sections were selected from the Balaton Highland, where a wealth of recently obtained stratigraphic information is summarized by Vőrös (*in press*). The original sources and section descriptions can also be found in the following sources: Felsőörs, Mencshely and Vászoly – Vőrös et al. (1996), Szentkirályszabadja – Vörös (1993). At Felsőörs, the beds 111/A-111/K were omitted because they are interpreted as debris flow deposits containing mixed faunas in limestone clasts (Vörös et al., 1996). The exclusion of Bed 16/A from the Vászoly section is warranted on the basis of its physical discontinuity (Vőrös and Pálfy, 1989) and apparently condensed fauna (Vörös et al., 1996). Other sections, including Vörösberény, Szentantalfa (Vörös, 1993), and Sóly (Vőrös, *in press*), were also considered in a preliminary phase, when only the sections from the Balaton Highland were processed. They were found to corroborate the correlations without adding to the list of taxa or the UA scheme. Because these sections

mainly contain the record of the Reitzi Zone, we omitted them from the final processing to avoid any potential bias in overemphasizing this zone.

Among the ten sections chosen from the Southern Alps, Adaná and Stabol Fresco (Balini et al. 1993) represent the Trinodosus Zone and are important to provide lower limits of taxon ranges of the studied interval. Bagolino (Brack and Rieber 1993) is the most complete section in the region, whereas Seceda (Brack and Rieber 1993) and Monte San Giorgio (Brack and Rieber, 1993; Rieber, 1973) are important reference sections from the Reitzi Zone upwards. The ammonoid distribution of Pértica and Prezzo (Brack et al., 1995) furnishes supplementary stratigraphic information from the higher part of the critical interval. Three sections (Latemar, Adige Valley and Marmolada) from the Dolomites are also included (based on Fig. 5 in De Zanche et al., 1995) as they contain important new data obtained by the Padova team. Without published and detailed documentation of the fauna and taxon ranges, some doubt remains regarding the comprehensiveness of the available stratigraphic data.

Outside the Southern Alps and the Balaton Highland, another western Tethyan section at Epidauros is known to have exquisitely preserved ammonites from the Anisian-Ladinian interval (Krystyn, 1983). However, both its condensed nature and the lack of detailed ammonoid studies preclude its inclusion in this study.

### Results

Processing of the stratigraphic distribution data using the BioGraph computer program resulted in 24 successive Unitary Associations (Fig. 1). Each UA is characterized by a unique suite of cooccurring taxa and represents an elementary biostratigraphic unit that cannot be further subdivided. Based on their faunal content, the UA or groups of them can be readily assigned to the zones or subzones of traditional biostratigraphy, as shown on Fig. 1. A simple measure of the correlation potential of a zone is the number of taxa which first appear in it. Obviously, a higher number of taxa occurring at various localities in a unit allows for its better definition and easier correlation. In the Reitzi Zone, 21 species and 11 genus make their first appearance and are also confined to the unit. The Secedensis Zone contains only three such species and one genus, whereas the Curionii Zone includes four key species and one key genus. The highest standing diversity is observed within the Avisianum Subzone (UA 10-19). The significantly higher number of taxa making up the Reitzi Zone also affords finer subdivions. This zone comprises 14 UA as compared to the two and three UA which make up the Secedensis and Curionii zones, respectively.

However, the UA are only useful as long as they represent reproducible stratigraphic units, i.e. if they are unambiguously recognizable in more than one section. A reproducibility chart (Fig. 2) reveals that 10 out of the total 24 UA are restricted to a single key section. Of the 14 UA within the Reitzi Zone, 9 can only be distinguished at a single locality. Nevertheless, groups of UA, corresponding in scope to traditional zones or subzones, are more readily correlatable among the two areas. Notably the Reitzi Zone comprises UA that are equally or alternately present in the Balaton Highland and the Southern Alps. On the other hand, there is only a single case where a UA belonging to the Secedensis Zone is discernible in the Balaton Highland (UA 21 at Felsöörs) and the UA of the Curionii Zone appear to be restricted to the Southern Alps. Apart from the assessment of the zones, the distribution of UA also allows a simple test of the proposed boundary levels. For reliable correlation, it is desirable that the UA below and above the boundary be widespread in both key areas. The base of the Reitzi Zone is well-defined as UA 6, the basal horizon of the zone (=*Kellnerites* datum) occurs in both areas, in three sections altogether. The underlying UA 5 is present in two sections in the Southern Alps as well as another two sections in the Balaton Highland. Around the base of the Secedensis Zone, only two occurrences of UA 20 and one occurrence of UA 19 are recorded, all from the Southern Alps. Immediately below the base of the Curionii Zone, UA 21 (=*Chieseiceras* horizon) is the most widespread UA in this study with six occurrences, one of them from the Balaton Highland. However, the actual base of the zone, UA 22, is represented only at three localities, all of them in the Southern Alps.

The two principal metrics to analyze in tandem or to weigh against each other are the correlatability of the adjacent units across the regions and the magnitude of faunal turnover across the boundary. In fact, it is a dilemma of emphasizing the practicality of correlation versus the evolutionary underpinning of biochronology. Having demonstrated the aspects of correlatability, we turn our attention towards the evolutionary implications. It is of paramount importance to quantify the disparity across a boundary. We define a boundary disparity index (D), a binary coefficient to measure the faunal turnover across a stratigraphic boundary.

$$D = \frac{F_{i} + l_{i-l}}{n_{i} + n_{i-l} - n_{e}}$$

where  $F_i$  is the number of first apperances in the UA above the boundary,  $L_{i-1}$  is the number of last apperances in the UA below the boundary,  $n_i$  is the number of taxa in the UA above the boundary,  $n_{i-1}$  is the number of taxa in the UA below the boundary, and  $n_c$  is the number of common taxa in the two adjacent UA.

Arguably, a logical boundary would represent the highest turnover rate within a given stratigraphic interval. Here the highest turnover of 92% is observed between UA 5 and 6, i.e. at the base of the Reitzi Zone. Successively less high turnover rates occur at the base of UA 21 (83%: base of chiesense horizon), UA 20 and 22 (80%: base of Secedensis and Curionii zones), and UA 10 (69%: base of Avisianum Subzone).

Our conclusions can only be validated if they are based on solid data and robust analysis. The characteristics of the biostratigraphic graph constructed reveal that the quality and consistency of data are satisfactory. Only one strongly connected component and five undetermined relationships were detected during the processing of primary biostratigraphic data. The computer input and output files of this study are available upon request from the first author.

Fig. 1. (on facing page) Ammonoid taxon ranges in the Anisian-Ladinian boundary interval of the Southern Alps and Balaton Highland, relative to the 24 Unitary Associations produced by the BioGraph program and the traditional zonal/subzonal scheme. Shaded areas contain taxa which first appear in the Reitzi and Curionii Zones, respectively. The intervening unshaded area shows taxa which first appear in the Secedensis Zone.

Key to zone/subzone names: Sec. - Secedensis, C - Camunum, P - Pseudohungaricum, F -Feolsoersoensis, L - Liepoldti, R - Reitzi.

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### Discussion

On the basis of a quantitative biostratigraphic analysis using the Unitary Association method, a case can be made that the Reitzi Zone is better than the other two candidates for the basal Ladinian in its correlation potential. Among the three proposed units, the Reitzi Zone includes the





greatest number of taxa available for correlation and offers the best possibility for further subdivision. Its lower boundary, the potential GSSP level, is more suitable than that of the Secedensis and Curionii zones in that it is defined by two UA which occur in several sections in both key areas, the Southern Alps and the Balaton Highland. It is also characterized by the highest turnover rate. The UA method permits an instructive thought experiment: without any prior history of stratigraphic subdivisions in the studied interval, which level could be selected as a most suitable boundary? Based on the metrics discussed above, the lower boundary of UA 6 (i.e. the base of the Reitzi Zone) scores highest overall among all the boundaries separating the 24 UA distinguished here.

An obvious question is whether the UA-based biostratigraphy and the conclusions presented are applicable globally. Initially we attempted to compile a global database by including the North American record. Two well-known areas outside Europe are Nevada (Silberling and Nichols, 1982) and the Canadian Rocky Mountains (Tozer, 1994) but neither has yielded species which would be common to the western Tethyan sections considered here. Although there are a few common genera, well-established Jurassic examples suggest that first appearances of genera in Europe and in North America may be offset by as much as one ammonid zone (Smith et al., 1988: Jakobs et al., 1994). Consequently, genus-based intercontinental correlations should not be given chronostratigraphic value until independently proved. At present the best approach is to chose the boundary on the basis of the western Tethyan record and implement its global correlation using integrated stratigraphic methods.

In closing, we shall emphasize that we do not endeavor to offer any definitive judgement, only demonstrated some testable ways to quantify the merits of different boundary levels from the perspective of ammonoid biostratigraphy. The selection of GSSP should still include careful measuring of all arguments put forward so far, particularly in a context of integrated chronostratigraphic correlation.

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### IN SEARCH OF THE LADINIAN/CARNIAN BOUNDARY: PERSPECTIVES FROM SPITI (TETHYS HIMALAYA)

### Marco Balini, Leo Krystyn and Valentina Torti

### Introduction

The Spiti region (Tethys Himalaya) is well known for its Lower and Middle Triassic invertebrate faunal succession which is the most complete within the Tethys and therefore of outstanding biostratigraphic importance for this particular realm.

With the search of a GSSP for the Middle/Upper Triassic (i.e. Ladinian/Carnian) boundary in Northern Italy well in progress (Broglio Loriga et al., 1998), we decided to add the preliminary data obtained during our 1997 joint expedition to the Guling and Muth area of the Pin Valley

(Spiti, for location see Krystyn & Orchard, 1996). Our results complement those of Broglio Loriga et al. (1998) as we report also distribution data of conodonts and halobiids, two fossil groups of specific importance for long distance correlations between different biogeographic (i.e. Tethys-North America) and paleoclimatic (i.e. Tethys-Boreal) realms.

According to the recently revised Triassic lithostratigraphy of Spiti (Garzanti et al., 1995) the Ladinian-Carnian boundary interval falls into the Hanse Group (Kaga, Chomule and Grey beds Fm.), in particular between the upper part of the Kaga Fm. and the Chomule Fm. For this interval, however, no new biostratigraphic data have been provided so that at present the only available referring data are those by early authors (Bittner, 1899, Krafft in Hayden, 1904; Diener, 1908 and 1912). These authors used a more traditional lithostratigraphical nomenclature with "Formation" names based on the main occurring fossil groups (Daonella Shales = Kaga Fm.; Daonella and Halobia Lmst. = Chomule Fm.). Dealing primarily with the fossil content we continue to use their now informal names for the greater chance to integrate new and old faunal records. Halobiids and Upper Ladinian ammonoids are reported in the Daonella Shales, while in the overlying Daonella Limestone Krafft (in Hayden, 1904) distinguished a lower portion with *Daonella* and an upper part with *Halobia* and the Ladinian-Carnian boundary in between. No ammonoids of stratigraphical significance were reported.

### Guling section

The section was measured 500 m westward from the village of Guling, from the top of the Muschelkalk Member of the Tamba Kurkur Fm to the middle part of the Daonella Limestone (Fig. 1). A second segment covering the upper part of the Daonella Limestone to the Grey beds was not studied in detail. Pelagic bivalves of the genera *Daonella* and *Halobia* are common throughout the studied section, while stratigraphically significant ammonoids are restricted to distinct and widely spaced levels. Some conodont samples have also been processed. As the lithology is laterally constant over tens of kilometers, we have integrated into the Guling section some samples from the classical locality of Muth.

The fauna of the Daonella Shales is mostly concentrated in the lenticular or bedded limestone levels that occur in two intervals: 2 to 15 m and 24 to 43 m from the base. The interbedded shales are difficult to sample because of cleavage. In the Daonella Limestone fossils occur in both limestones and marly interbeds. The base of the Daonella Limestone is characterized by a distinct 1-2 m thick stilolithic limestone band ("Traumatocrinus Limestone").

### Amonoid distribution

The distinct ammonoid bearing horizons allow a quite good timing of the section. The Upper Ladinian age of the top of the Tamba Kurkur Fm. is demonstrated by *Protrachyceras archelaus* found in its last bed (M47) at Muth. At the base of the second limestone interval of the Daonella Shales a rich ammonoid fauna can be referred to the Meginae Zone on the basis of *Meginoceras*, *Protrachyceras* and *Anolcites*.

The base of "Traumatocrinus Limestone" provided "Celtites" epolensis, Protrachyceras, Rimkinites together with a specimen equivalent to Frankites in ribbing and style of the venter, while the thickness of the whorl is unusually greater. As the specimen is just a body chamber fragment it may belong either to a new genus or to a new species of the genus Frankites. If not condensed, the fauna could represent either the top of the Archelaus Zone s.l. (=Neumayri Zone sensu Mietto & Manfrin, 1995a) or the base of the Regoledanus Zone. A true Frankites (F. cf.

*regoledanus*) has been found in Muth 1 m above the sample 97/179, but could not be extracted from the rock. Further collections are clearly necessary for a definite solution.

The lenticular limestones immediately above the "Traumatocrinus Limestone" yielded at Muth a small sized *Muensterites* (sample 97/175), while some meters above (sample 97/176) a specimen probably belonging to *Daxatina* has been found. The specimen shows the typical ventral morphology of *Trachyceras*, but the definite attribution is not sure because the specimen is a body chamber and misses the suture line.

Above this level some long ranging ammonoids as *Sirenotrachyceras*, *Joannites* and *Carnites floridus* are frequently found, but two levels (VT48 and VT52) provided well preserved and undoubtful *Trachyceras* of the group of *T. aon* (here intended as inclusive of *T. (Brotheotrachyceras)* Urlichs, 1994). A *Trachyceras aonoides* fauna has been found in the lateral continuation of the outcrop with a position just above the top of the section (sample I5).

### Pelagic bivalves distribution

At the base of the first limestone interval the Upper Ladinian speies *Daonella pichleri* occurs in one level (VTS16). Above this level *D. indica* and *D. lommeli* are very common. Especially *D. lommeli* shows a very long range, from the lower part of the Daonella Shales up into the Daonella Limestone. In general *D. indica* is less frequent than *D. lommeli*.

From the levels VT36 to VT 46 the bivalves show some modifications with respect to the typical *D. lommeli* morphology. In VT36 the specimens referred to *D. lommeli* group, show affinities with *D. hagighiolensis*, due to the presence of a smooth triangular posterior sector. In the literature (Krystyn & Gruber, 1974) this species is considered as stratigraphically younger than *D. lommeli*, beeing referred to the Sutherlandi Zone.

The specimens from sample VT46 are very similar to *D. lommeli*, but show some morphological characters typical of the genus *Halobia*, as for example the curved pattern of radial costae.

The first true *Halobia* comes from level VT50, and a few meters above we have found *H. zitteli*. The latter is a typical form of the Aon Zone and an excellent guide for cross-latitudinal correlations.

### Conodont distribution

As just few samples have been collected, we cannot provide a complete range chart for the recognized species. Nevertheless, the transition from *P. inclinata* to *Metapolygnathus polygnathiformis* is recorded between the *Muensterites* level and the bed with the questionable *Daxatina*. Sample 97/175 contains exclusively *P. inclinata*, while in 97/180 we have found intermediate forms and just 30 cm above (sample D11) the first true representatives of *M. polygnathiformis* together with *P. inclinata*. The F.O. of *M. polygnathiformis* is therefore much lower in the Guling section than the one of *Trachyceras* gr. *aon* (respectively at 63 m and 88 m from the base).

The integrated analysis of our data shows that between the Ladinian "Traumatocrinus Limestone" with *Frankites* and the first *Trachyceras* gr. *aon* in the overlying Daonella Limestone there is a 25 m thick rock interval without time-diagnostic fossils in a strict sense. This boundary interval, which may represent the Daxatina cf. canadensis Subzone *sensu* Mietto & Manfrin, 1995a and a part of the Aon Zone *sensu* Urlichs, 1994, has to be carefully resampled before final conclusions can be drawn.



Fig. 1. Upper Ladinian to Lower Carnian faunal succession in Spiti (Pin Valley) based on the Guling section integrated with samples (framed) from Muth.

### Remarks on the Ladinian/Carnian boundary

Due to the scarcity of Ladinian/Carnian fossiliferous sequences in the Tethys the Guling section can be considered a good test for the criteria to define the base of the Carnian Stage. Till now most of the suggestions come from the ammonoids. We have the possibility to test halobiids and conodonts referred to an ammonoid record that is one of the most complete, beeing represented by a succession of up to 5 ammonoid zones across the boundary (Archelaus to Aonoides Zone).

At present two possible solutions can be discussed.

F.O. of Daxatina. This boundary has been proposed by Mietto & Manfrin (1995a and 1995b) because according to their data corresponds to a moment of major changes in ammonoid assemblages (F.A.D. of Daxatina and Clionitites almost coincident with F.A.D. of Trachyceras: Mietto & Manfrin, 1995b, p. 24). The boundary is potentially very useful because Daxatina has a worldwide distribution, but the synchronicity of its F.O. in the different paleobioprovinces has still to be demonstrated and its forerunner is also unknown. Moreover we see other problems. The first problem is, in some respects, formal. Daxatina is not easy to be identified, if the suture line is not visible (i.e., steinkern of body chamber or shelled specimens), so that it does not completely fulfil the requirements of a guide fossil. Recent literature demonstrates that a misinterpretation is possibile, also to experienced specialists. A possible solution could be the choice of the F.O. of Trachyceras that according to Mietto & Manfrin occurs slightly above the F.O. of Daxatina, but once again the worlwide synchronicity of this event has to be demonstrated. In North America for example Trachyceras appears far above Daxatina. As regard the appeareance of Clionitites, in Epidauros section this genus occurs already at the base of the Regoledanus Zone (sample A16 in Krystyn 1983, fig.3 p.244) then Mietto & Manfrin's sections record a F.O., not the F.A.D. of the genus.

In our section the comparison of ammonoid with bivalve distribution lead to conclude that the doubtful *Daxatina* is not accompanied by any event in the distribution of halobiids. In particular the typical Ladinian guide fossil *Daonella lommeli* occurs also above. Spiti data in this respect fit well with those from the Western Tethys where the *D. lommeli* group is also recorded up to Lower Carnian (Krystyn & Gruber, 1974). Finally as regard the conodonts our scarce data do not allow a definite solution. The early appearence of *M. polygnatiformis* within the Spiti boundary interval may be seen as a possible hint that the species is already present within the Tethyan "*Daxatina* beds". This unfortunately is not true for North America and the Arctic (Orchard & Tozer, 1998).

Base of the Aon Subzone (sensu Krystyn, 1978). This traditional boundary (see Krystyn, 1978 and Urlichs, 1994 for historical summary) can be drawn at the F.O. of *Trachyceras* of the *T. aon* group. Advantage of this solution is the easier identification of the index ammonoid and the better integration with the F.O. of *Halobia*. The two bioevents are not exactly coeval (F.O. of *Halobia* is a little younger), but the approximation is very good. In fact Lower Carnian corresponds to a radiation period for halobids, with the extinction of genus *Daonella* and the appeareance of genus *Halobia*. It must also be pointed out that *Halobia* is climatic independant so that it could play an important role for the correlation of Tethyan and Boreal successions (Krystyn, 1978).

### Conclusions

No doubt the sequence described in the San Cassiano area by Broglio Loriga et al. (1998) is good and may have the potential for a GSSP. But its proper designation, in our opinion, seems to be premature for several reasons. The greatest problem is that the section presently lacks comparable data (except for ammonoids) from the overlying (basal) Aon Zone. This hampers seriously a thorough comparison of the pros and cons pointing for the former or the now proposed boundary.

More paleontological work is also needed to demonstrate the suitability of the new boundary as an international standard. The proposed GSSP for example is not sufficiently representative concerning such biostratigraphically significant groups as conodonts and halobiids. A possible paleoenvironmental or paleobiogeographical influence on the distribution of some taxa (i.e., lack of halobiids, "late" appeareance of *Clionitites* and *M. polygnathiformis*) should be tested.

Finally with regard to the ammonoids two serious problems have to be solved. At first the *Trachyceras* and *Daxatina* species from the Daxatina cf. canadensis Subzone have to be properly described and illustrated. The *Trachyceras* species in the Daxatina cf. canadensis Subzone could be a good reason for the new boundary, but at present the features of these species are unknown and the taxonomy does not seem to be stable: the only *Trachyceras* from the Subzone (*Trachyceras muensteri*: Mietto & Manfrin, 1995a, pl. 5, fig. 5; 1995b, pl. 2, fig. 16) is from debris, moreover it has been recently renamed as *Daxatina* cf. *canadensis* (Broglio Loriga et al., 1998, pl. 2, fig. 16).

Secondly, based on a careful study of both the type material as well as the figures in Mietto & Manfrin (1995b) and unpublished material from Epidauros we see no chance for a morphologic (and taxonomic) separation of *Frankites regoledanus* and *Frankites apertus* as done by the mentioned authors. When adopting the new zonation this will lead to serious confusion in the future stratigraphic scale.

### Acknowledgements

Field work has been supported by CNR grant to Prof. M. Gaetani (MB & VT) and by "Austrian National Committee for IGCP" - IGCP 359 (LK). Daniela Germani (Milano) helped during field sampling.

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## IMPORTANT DATES

| June 1998: Deadline for submission of respons | Deadline for submission of response to |
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| first circular                                | first circular                         |

December 1998: Deadline for submission of abstracts
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registration

THEMES

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- Tectonics and dynamics of Gandwana break-up, Pangea integration and Tethys evolution;
  - Palcogcography, palcoclimatology and palcoccology during the Pangea interval;
- Stratigraphy, sca level changes, high-resolution events, inter- and intra-system boundary and refinement of geochronology;
- Biotic crisis, mass extinction, recovery and evolution at the Paleozoic-Mesozoic transition.

## FIELD EXCURSION

Pre-conference Field Excursion: Huangsi, Southeast Hubei Province (7-8 March, 1999)

This two-day field excursion will visit some typical marine Carboniferous-Lower Triassic and terrestrial Middle Triassic sections in Huangsi, southeastern Hubei Province. Some key boundaries will be examined there as well. Post-conference Field Excursion: the Yangtze Gorges (12-16 March, 1999) The Yangize Gorges areas are not only famous for the attractive scenery and the constructing Dam, but also for the well-exposed Pre-Cambrian-Triassic stratigraphic sequences and their special geological benefits. The excursion is planned to mainly examine the stratigraphic sequence and its

related geological aspects. As the Yangtze Gorges Dam will cut off the river at the end of 1997, an exploration might be afread of us.

## PUBLICATIONS

We anticipate that refereed and accepted papers will be published either as a book or as a special issue of an international journal series. The paper must be presented (either orally or in poster) before being considered for publication.

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## HOTEL ACCOMMODATION

Several hotels within and nearby China University of Geosciences are arranged for participants. Room rate of standard double rooms ranges from \$20 to \$80 US Dollors per night. Details and reservation form for hotels will be distributed in the second orcular.

## TRANSPORTATION

Wuhan is the capital of Hubei Province, situated in the center of China. The international airport has daily flights from Hong Kong, Beijing, Shanghai, Guangzhou and other major cities in China. Wuhan is on the mid-way of Beijing-Guangzhou Railway with more than 20 express and rapid trains daily from Beijing and Guangzhou. Meanwhile, Wuhan is situated in the middle part of Yangtze River with

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To

Dr. Tong Jinnan and Peng Yuanqiao

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## NEW BOOK

Baud, A., Popova, I., Dickins, J.M., Lucas, S. and Zakharov, Y. (Eds), 1997. Late Paleozoic and Early Mesozoic Circum-Paciric Events: Biostratigraphy, Tectonic and Ore Deposits of Primoryie (Far East Russia). IGCP Project 272. Mémoires de Géologie (Lausanne), No. 30.

The International Field Conference on Permian-Triassic Biostratigraphy and Tectonics of IGCP Project 272 was held in Vladivostok, September 6-12, 1992. This volume includes 21 scientific papers contributed to this meeting.

This volume can be ordered for CHF 30 from the Instit de Géologie et Paléontologie, Université de Lausanne, BFSH-2. CH-1015 Switzerland (http://www-sst.unil.ch/publidep.htm).

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For abstracts of papers on Triassic stratigraphy see the "Annotated Triassic Literature"

## ANNOTATED TRIASSIC LITERATURE

## HANS KERP AND HENK VISSCHER 1

ADAMS, C.J. and KELLEY, S., 1998. Provenance of Permian-Triassic and Ordovician metagraywacke terranes in New Zealand: Evidence from <sup>40</sup>Ar/<sup>39</sup>Ar dating of detrital micas. G.S.A. Bull., 110: 422-432.

Single-crystal <sup>40</sup>Ar/<sup>39</sup>Ar ages of detrital micas from Greenland Group (Ordovician) low grade metagraywackes of the West Coast, South Island, New Zealand, indicate a source area having muscovite age patterns of 490-515 Ma. The detrital muscovite ages are characteristic of granitoid and gneiss terranes of the Ross-Adelaide fold belt of Antarctica; therefore, the source area far the Greenland Group sedimentary rocks was the immediately adjacent Pacific margin of Gondwana. Similar age determinations for Rakaia terrane (Permian-Triassic) Torlesse Supergroup metagraywackes of the Wellington and Canterbury regions of New Zealand indicate that their source area included rocks having prominent muscovite cooling ages populations of 210-290 Ma (80%) and 410-460 Ma (15%). The Torlesse detrital muscovite age data thus suggest that the source area of the metagraywackes was not within the Lachlan fold belt of southeast Australia and analogues in Antarctica, nor in the adjacent Ross-Adelaide fold belt. Rather, the Rakaia terrane of the Torlesse metagraywackes is a true suspect terrane derived from a source area within the Hunter-Bowen fold belt of northeast Australia and the immediately adjacent older orogens of eastern Queensland.

ALONSO-AZCARATE, J., ARCHE, A., BARRENECHEA, J.F., LOPEZ-GOMEZ, J., LUQUE, F.J. and RODAS, M., 1997. Palaeogeographical significance of clay mineral assemblages in the Permian and Triassic sediments of the SE Iberian Ranges, eastern Spain. Palaeogeogr. Palaeoclimatol. Palaeoecol., 136: 309-330.

The evolution of the palaeogeography of the SE Iberian Basin during the Permian and Triassic represents a general evolution from continental to marine environments. It has been recently studied from the sedimentological, stratigraphical, tectonic and palaeontological points of view. In spite of these results, many aspects of this palaeogeography are still a matter of discussion. In this study, clay mineralogy analysis complements previous studies representing a new aspect for understanding the evolution of the sedimentary environment and the palaeogeography of the Iberian Basin during the periods in question and thus of the palaeogeography and the location of the major high areas in the westernmost border of the Tethys sea. In spite of late diagenetic transformations the original clay mineral associations of the Permian-Triassic sediments of the SE Iberian Ranges can be reconstructed. 77 samples of siliciclastic and carbonate sediments of these ages have been studied (SEM and XRD), revealing six new aspects that help to precise the palaeogeographical interpretation of the area: (1) Two major mineral assemblages have been found: illite + kaolinite + pyrophyllite in the continental facies and illite + chlorite + vermiculite + mixed-layer clays in the

The continuous Help of Mrs. Gaby Schwenzien (Münster) and Dr. Zwier Smeenk (Utrecht) in tracing relevant Triassic literature is gratefully acknowledged. Thanks are also due to all authors who sent information on their recent publications. Of some papers without English abstracts and those traced from secondary sources only titles are given. Some references have been traced from secondary sources. Therefore diacritical signs may sometimes be missing. Original abstracts have not been corrected. Congress abstracts are not referenced.

marine facies. (2) The Mg-rich clay minerals are here considered to be of marine origin. (3) Active phases of basin boundary faults are marked in the sediments by the presence of pyrophyllite, derived directly from the Palaeozoic metamorphic basement. (4) Unconformities separating major depositional sequences also separate formations with different clay mineralogy. (5) Different groups of clay minerals can be separated clearly coinciding with the different palaeogeographical stages also distinguished in the westernmost border of the Tethys sea. (6) The clay mineral associations back up the data of a previous hypothesis of a humid climate for the end of the Permian in the study area just prior to the first incursion of the Tethys sea.

ARCUCCI, A. and MARSICANO, C.A., 1998. A distinctive new archosaur from the Middle Triassic (Los Chanares Formation) of Argentina. J. Vertebr. Paleont., 18: 228-232.

ARDILL, J., FLINT, S., CHONG, G. and WILKE, H., 1998. Sequence stratigraphy of the Mesozoic Domeyko Basin, northern Chile. J. Geol. Soc. London, 155: 71-88.

The Domeyko Basin of northern Chile records Late Triassic to Early Cretaceous mixed carbonate and siliciclastic marine deposition along the western margin of Gondwana. Sequence stratigraphical analysis has identified five long-term sequences of 11-17 Ma duration. Comparison of the relative sea-level fluctuations interpreted from the Domeyko Basin succession with those documented from other similar-aged South American marginal basins and northern hemisphere basins allows the distinction of regional from global events.

AXSMITH, B.J., TAYLOR, T.N. and TAYLOR, E.L., 1998. A new fossil conifer from the Triassic of North America: Implications for models of ovulate cone scale evolution. Int. J. Plant Sci., 159: 358-366.

Vegetative shoots, ovulate cones, and putative seeds of *Conewagia longiloba* gen. et sp. nov., a fossil conifer from the Upper Triassic New Oxford Formation of York County, Pennsylvania are described. Vegetative shoots represent up to three orders of branches bearing robust, spirally arranged leaves. Leaves are somewhat flattened and falcate with a papillate cuticle. Ovulate cones bear closely spaced, helically arranged bract-scale complexes. Ovulate cone scales possess a stalk-like basal portion fused to a subtending bract, with an expanded upper part consisting of 11 proximally fused foliar components oriented in a single plane. Each component forms a narrow, tooth-like lobe on the distal cone scale margin. The acute apex of the bract is free and lies adjacent to a groove in the abaxial come scale surface. Dispersed seeds with a longitudinal ridge or rudimentary wing may have been produced by this conifer. The 11 ovulate cone scale foliar components of *C. longiloba* are the greatest number known in any early Mesozoic conifer, and the taxon helps to fill a previously unappreciated temporal gap in the fossil record between the Paleozoic and modern conifers that have numerous ovulate cone scale components.

AXSMITH, B.J., TAYLOR, T.N. and TAYLOR, E.L., 1998. Anatomically preserved leaves of the conifer *Notophytum krauselii* (Podocarpaceae) from the Triassic of Antarctica. Am. J. Bot., 85: 704-713.

Permineralized leaves of the Triassic podocarpaceous conifer *Notophytum krauselii* are described from the Fremouw Formation of Antarctica. The leaves are elongate and apetiolate with 8-12 parallel veins. The adaxial epidermis consists of rows of rectangular to pentagonal cells: the abaxial epidermis is papillate. Longitudinally oriented stomata occur on both surfaces. An adaxial palisade layer is present and auxiliary sclereids are common in the mesophyll. The vascular bundles have a weakly defined sheath and are flanked by transfusion tracheids. Bundles in the basipetal area of the leaf are capped by sclerotic tissue and

subtended by resin canals. These leaves cue superficially similar to those of the extant podocarp genus *Nageia*, but probably represent a distinct acquisition of this leaf type within the Podocarpaceae. *Notophytum* leaves are similar to the common compression fossil *Heidiphyllum elongatum* and may be closely related or even conspecific. Evidence from Antarctica suggests that *Heidiphyllum* and the seed cone *Telemachus* were produced by the same plant, and may be closely related to several other early Mesozoic conifers with multiveined leaves.

BALINI, M., 1998. Taxonomy, stratigraphy and phylogeny of the new genus *Lanceoptychites* (Ammonoidea, Anisian). Riv. Ital. Strat. Paleont., 104:

For the first time a population analysis of compressed Ptychitidae (Ammonoidea) bed-by-bed collected from Prezzo Limestone (Upper Anisian, Southern Alps) is performed. The analysis allows to demonstrate that within some populations of compressed ptychitids during the growth the venter may become subacute/fastigate and the section lanceolate. This modification is not due to growth anomalies, as sometimes believed in literature, but is a normal ontogenetic development. The ammonoids with this peculiar ontogeny are moved from the genus *Flexoptychites*, that groups the compressed ptychitids with rounded venter, into the new genus Lanceoptychites. The new genus is a secondary descendent of Flexoptychites and comprises 4 species: *L. velox* (type) sp.n., *L. styx* sp.n., *L. indistinctus* (Mojsisovics) and *L. charlyanus* (Diener). *L. styx* and its peramorphic descendant *L. velox* are stratophenetic species. They are described from the Prezzo Limestone, where they are confined to the middle part of the *Paraceratites trinodosus* zone (Illyrian). No bed-by-bed information is available for *L. indistinctus* (Mojsisovics) and *L. charlyanus* (Diener). These morphospecies are revised on the basis of the type material.

BANERJI JAYASRI, 1997. Floral change across the Permian-Triassic Boundary in Damodar and Auranga Valleys. Palaeobotanist, 46: 97-100.

Megafloral change across the Permian-Triassic boundary is distinct but not very abrupt. The general composition of the flora is more or less similar in the Upper Permian-Lower Triassic time slice except for the appearance of a few significant taxa in the Lower Triassic, such as, *Lepidopteris and Dicroidium*. The size of *Glossopteris* leaves becomes smaller in the Panchet beds. *Dicroidium* appeared a little later than *Lepidopteris* in the uppermost part of Lower Triassic. Palynological studies of Panchet beds (Maitur Formation) indicate that striate disaccate rich mioflora gradually declines accompanied by the emergence of some new elements like Decisporis, *Verucosiporites, Playfordiaspora and Arcuatipollenites (Lunatissporites)*. The megaspores - *Banksisporites, Maiturisporites* and *Pantiella* - are confined to the Panchet Formation.

BAUD, A., POPOVA, I., DICKINS, J.M., LUCAS, S. and ZAKHAROV, Y. (Eds.), 1997. Late Paleozoic and Early Mesozoic Circum-Pacific events: biostratigraphy, tectonic and ore deposits of Primoryie (Far East Russia) - IGCP Project 272. Mém. Géol. (Lausanne), 30: 1-202.

A collection of 21 papers contributed to International Field Conference in Permian-Triassic Biostratigraphy and Tectonics of IGCP 272 in Vladivostok (1992). Topics include palaeobotany, conodonts, ostracodes, sphinctozoans, radiolaria, ammonoids, biostratigraphy, sedimentology, tectonics and ore deposits. Abstracts of all Triassic papers are given elsewhere in this section.

BEGG, J.G. and GRANT-MACKIE, J.A., 1997. New Zealand Triassic pleurotomariid gastropods. Geol. Soc. New Zealand, Misc. Publ. 9SA: 17.

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BELL, C.M., 1997. Saline lake turbidites in the La Coipa area, Northern Chile. Rev. Geol. Chile, 24: 259-267.

An unusual and very distinctive occurrence of evaporitic gypsum in association with elastic turbidites was deposited in a still, anoxic lake environment in the La Coipa area of Northern Chile. The sequence of exceptionally fine-grained, red-coloured mudstones and graded sandstones is characterised by abundant small gypsum nodules and veins. The nodules probably resulted from the recrystallization of gypsum-anhydrite transported by turbidity currents and slumps from the shallow lake margins into deeper water. Following the formation of the superficial slumps the strata were subjected to compressive thrusting. This, in turn, was followed by vertical extension and a second episode of NNE-directed thrusting. The gypsum-filled veins, produced during the vertical extension, possibly originated as a result of the dissolution of underlying evaporites. The strata, apparently, form the oldest part of the Lower Triassic La Coipa Beds, which are themselves part of a widespread succession of Triassic marine and continental rift-related sediments in Northern Chile.

BENTON, M.J. and ALLEN, J.L., 1997. *Boreopricea* from the lower Triassic of Russia, and the relationships of the prolacertiform reptiles. Palaeontology, 40: 931-953.

Boreopricea funerea from the Lower Triassic of northern Russia is a prolacertiform diapsid, superficially similar to *Prolacerta* from the Lower Triassic of South Africa. The skull is damaged, but relatively complete. The lower temporal bar is absent. Some parts of the skeleton of *Boreopricea*, in particular some of the vertebrae and the foot, are well preserved, and offer clear evidence of prolacertiform affinities. Nineteen species of prolacertiform have been described. Their affinities are difficult to resolve because available specimens for many of the taxa are incomplete. A series of cladistic analyses shows the existence of a tanystropheid clade (*Tanystropheus, Tanytrachelos*), to which are allied *Cosesaurus, Malerisaurus, Boreopricea*, and *Macrocnemus* as successive outgroups. A new synapomorphy of prolacertiforms may be the tight association of astragalus, calcaneum, centrale, and distal tarsal 4 in the ankle, with the centrale in contact with the tibia.

BERRA, F. and CIRILLI, S., 1997. Preservation and thermal alteration of organic matter in the Ortles and Quattervals nappes (upper Austroalpine, north-eastern Lombardy, Italy): Preliminary results and implications for regional geology. Eclog. Geol. Helv., 90: 325-336.

About 150 samples collected in the Triassic sedimentary successions of the Ortles and Quattervals Nappes (Central Austroalpine) have been processed in order to evaluate and compare the thermal history of the two tectonic units. The study of the organic matter preservation based on the optical comparison of the palynofacies components colour (TAI) demonstrated that the Quattervals Nappe (occupying a tectonically higher position) had been subjected to higher diagenetic-metamorphic temperatures (estimated above 300° C) with respect to the Ortles Nappe (few tens of degrees lower), Heating is mainly ascribed to tectonic burial related to higher tectonic units eroded or tectonically displaced after the thermal peak and before the development of the present-day nappe edifice: it occurred before the emplacement of the present thrust nappes which was not followed by a new temperature rise able to overprint previously recorded temperatures. Heating and thrust development of the succession both occurred during the eo-alpine orogenetic stages (post-Turonian). The presence, in the study area, of a previously documented increasing metamorphic gradient from west to east fits with the hypothesis of a southeastern provenance of the higher tectonic unit (Quattervals Nappe) with respect to the lower one, as earlier suggested by different authors.

BOWRING, S.A., ERWIN, D.H., JIN, Y.G., MARTIN, M.W., DAVIDEK, K. and WANG, W., 1998. U/Pb zircon geochronology and tempo of the end-Permian mass extinction. Science, 280: 1039-1045. The mass extinction at the end of the Permian was the most profound in the history of life. Fundamental to understanding its cause is determining the tempo and duration of the extinction. U/Pb zircon data from Late Permian and Early Triassic rocks from south China place the Permian-Triassic boundary at 251.4 ±0.3 million years ago. Biostratigraphic controls from strata intercalated with ash beds below the boundary indicate that the Changhsingian pulse of the end-Permian extinction, corresponding to the disappearance of about 85% of marine species, lasted less than 1 million years. At Meishan, a negative excursion in δ<sup>13</sup>C at the boundary had a duration of 165,000 years or less, suggesting a catastrophic addition of light carbon.

BOYD, D.W. and NEWELL, N.D., 1997. A reappraisal of Trigoniacean families (Bivalvia) and a description of two new Early Triassic species. American Museum Novitates, No. 3216, 14 pp.

The authors' 1975 proposal that the complex trigonian dentition was independently acquired by three separate but related families assumed that external morphology was more stable than hinge structure during evolution of the Trigoniacea. This hypothesis is not supported by our further work and the experience of other workers, so we have reinter-preted the Schizodidae, Myophoriidae, and Trigoniidae emphasizing hinge grades as family characteristics. The myophorian grade is distinguished by myophorous buttresses and a posterior wing on tooth 2, both lacking in the schizodian hinge. Tooth striation is either absent or sporadically developed. By contrast, the tight-fitting teeth and sockets of the strongly buttressed trigonian hinge interlock along conspicuously striated faces, and tooth 2 is broad and biramous. In returning to the conventional distinction between Myophoriidae and Trigoniidae. Two additions to the sparse Early Triassic record of the Trigoniacea, *Neoschizodus elongatus* n.sp. and *Lyriomyophoria paullorum* n.sp., are described from the Spathian Virgin Limestone of southern Nevada. The hinges of these new species represent a transitional state between myophorian and trigonian grades.

BREA, M., 1997. Una nueva especie del genero Araucarioxylon Kraus 1870, emend. Maheshwari 1972 del triasico de Agua de la Zorra, Uspallata, Mendoza, Argentina. Ameghiniana, 34: 485-496.

Petrified wood of a new species of *Araucarioxylon* has been described from Triassic sediments of Agua de la Zorra, Uspallata, Mendoza province, Argentina. The description of this fossil is based on anatomically preserved stems. The secondary xylem shows conspicuous growth rings. Pitting on the radial and tangential walls of the tracheids is bordered. Rays are low, uniseriate. Three to nine bordered pits are present in the cross fields. The comparisons of these fossils with an other conifers stems and their paleoclimatic evidence are also analyzed.

BRINKMANN, W., 1998. Sangiorgiosaurus n.g. - eine neue Mixosaurier-Gattung (Mixosauridae, Ichthyosauria) mit Quetschzähnen aus der Grenzbitumenzone (Mitteltrias) des Monte San Giorgio (Schweiz, Kanton Tessin). N. Jb. Geol. Paläont. Abh., 207: 125-144.

From the Middle Triassic of Southern Ticino two mixosaurs with crushing teeth are reported which belong to different taxa. On the larger individual the type *species Sangiorgiosaurus kuhnschnyderi* n.g. n.sp. of the new genus *Sangiorgiosaurus* is erected. It shows only in the lower jaw three or four remarkably small, widely spaced crushing teeth. The smaller specimen, which is provisionally refered to as aff. *Sangiorgiosaurus* n.g., has in the upper and lower jaw much larger crushing and considerable less pointed teeth. A common feature

of both mixosaurs seems to be the presence of a pointed tooth in the gap between the first two crushing teeth of the mandible.

BRUGUIER, O., LANCELOT, J.R. and MALAVIEILLE, J., 1997. U-Pb dating on single detrital zircon grains from the Triassic Songpan-Ganze flysch (Central China): provenance and tectonic correlations. Earth. Planet. Sci. Letters, 152: 217-231.

The Songpan-Ganze flysch belt (Central China) covers a huge triangular area of more than 200,000 km<sup>2</sup> and is bounded by the continental blocks of South Chins North China and the Tibetan plateau. Detrital zircons extracted from three flysch samples collected in the central part of the belt were analyzed grain by grain using the U-Pb method. Two samples of Middle Triassic sandstones, collected at different locations in the belt, provide identical results, which suggests similar source regions, The detrital zircons yield a wide range of ages and indicate their principal derivation from Mid-Proterozoic (1.8-2.0 Ga) source rocks with minor contribution from late Archean (ca. 2.5-2.6 Ga) material. The discordance and Pb loss patterns from low-U zircons indicate disturbances during a subsequent event which may be of Caledonian age, as suggested by concordant zircon grains at ca, 420 and 450 Ma. One sample collected within the Palang Shan Pass zone provides concordant zircon grains at around 230 Ma (231  $\pm$ 1 Ma and 233  $\pm$ 1 Ma). These Triassic ages are synchronous to flysch deposition and suggest intense geological activity (calc-alkaline volcanism?) at that time in the area close to the basin. The data support an origin of the elastic material mainly from a northeastern landmass, corresponding to the southern margin of the Sino--Korean craton, To a lesser degree, inputs from the Yangtze craton and possibly from the northern margin of the basin (Kunlun are) are also detected. The age spectrum from the Upper Triassic sandstone is significantly different and shows predominance of Sinian (ca. 760 Ma) grains, probably derived from the Yangtze craton. This change in the source region is interpreted as reflecting the tectonic evolution of this area and in particular as being linked to the late Triassic collision between South China and North China. In the Middle Triassic, while subduction of the Songpan sea northward beneath the North China plate was still taking place, continental subduction of South China in the Dabie region was responsible for uplift of the overriding plate (i.e. the Sino-Korean craton) which supplied large volumes of sediments. During the Late Triassic, clockwise rotation of the South China block uplifted the Indo-Sinian part of the Qinling belt and closed the basin. As the accretionary wedge was thickening along the southern margin of North China, detritus derived from this source region were unable to reach the flysch basin. The age spectrum presented by detrital zircons indicates predominance of Sinian material derived from source area located on the northern margin of the Yangtze craton; a source region which was until this period swamped by Luliang material from the Sino-Korean craton.

BUCHER, H., NASSICHUCK, W.W. and SPINOSA, C., 1997. A new occurrence of the Upper Permian ammonoid *Stacheoceras trimurti* Diener from the Himalayas; Himachal Pradesh, India. Eclog. Geol. Helv., 90: 599-604.

The Dzhulfian vidrioceratid ammonoid *Stacheoceras trimurti* Diener was found associated with the brachiopod *Elivina tibetana* (Diener) in the Kuling Formation in the northwestern Himalayas in Himachal Pradesh province, India. It was recovered from a horizon of dark weathering phosphatic lime stone nodules 2 m below the Permian Triassic boundary in the Lingti River valley near Chumik Marpo. The Triassic ammonoid *Ophiceras* sp. indet. was found a few metres above the base of the overlying Tamba Kurkur Formation, the transgressive base of which is correlated with the *Otoceras* bed of the Spiti area. The Permian-Triassic boundary is marked by a distinctive 10 cm thick red-weathering, iron oxide-rich layer at the top of the Kuling Formation. For this part of the Gondwana shelf, this

horizon suggests erosion accompanied by weathering during latest Permian time (Dorashamian).

BURIJ, I.V., 1997. Paleogeography of Triassic sedimentation in south Primorye. Mém. Géol. (Lausanne), 30: 25-33.

The stratigraphy and conditions of Triassic deposit formation in South Primorye are discussed.

BURYI, G.I., 1997. Early Triassic conodont biofacies of Primorye. Mém. Géol. (Lausanne), 30: 35-44.

Conodont assemblages of various facies of the Tobisin Horizon (Lower Olenekian) of Primorye differ in composition and size at the generic and species level. In the coastal innershelf facies (Russian Island) the *Parachirognathus* biofacies was recognized, in the outershelf facies (recent Ussuri Gulf coast, Artemovka and Kamenushka River systems) *Neogondolella-Smithodus* occur, and the oceanic facies (the Taukha terrane in the Dalnegorsk region) is characterized by *Smithodus-Neospathodus*.

BURYI, G.I., 1997. Triassic conodont biostratigraphy of the Sikhote-Alin. Mém. Géol. (Lausanne), 30: 45-60.

Over 700 samples were collected from complete series of biogenic limestones and cherts of the Rudnaya River basin (Dalnegorsk region), the Ussuri River right bank sections (Chuguevka region), as well as from the sections in the Gur, and Bikin River basins, and 343 samples vielded conodonts. More than one thousand conodont elements were identified. Conodonts from the Dalnegorsk region provide the basis for the biostratigraphic zonation of the Triassic of the Sikhote-Alin. Twelve conodont zones were distinguished, and represent the Olenekian to Rhaetian interval (1 - Neospathodus waageni, 2 - N. homeri - Olenekian; 3 - N. timorensis - Aegean, Bithynian and Lower Pelsonian; 4 N. kockeli Upper Pelsonian; 5 -Paragondolella excelsa - Illyrian, Fassanian and Lower Langobardian, 6 P. foliata Upper Langobardian; 7 - P. polygnathiformis - Cordevolian, Julian and Lower Tuvalian; 8 -Metapolygnathus nodosus - Middle and Upper Tuvalian; 9 - Epigondolella abneptis - Lacian; 10 - E. postera Alaunian; 11 - E. bidentata - Sevatian; 12 - Misikella posthernsteini -Rhaetian). Strong analogy to the Zones observed in Nevada, Pakistan, Poland, Austria, Yugoslavia, and Bulgaria exists. The zone's limits were defined according to the first occurrence of species replacing successively each other in the line Neospathodus -Paragondolella - Metapolygnathus - Epigondolella - Misikella. The reconstructed section of Sikhote-Alin may represent one of the most complete Triassic conodont sequences worldwide. The Triassic conodont fauna of Sikhote-Alin are similar to the conodont assemblages of Japan.

CAPLAN, M.L. and MOSLOW, T.F., 1997. Tectonic controls on preservation of Middle Triassic Halfway reservoir facies, Peejay Field, northeastern British Columbia: a new hydrocarbon exploration model. Bull. Can. Petrol. Geol., 45: 595-613.

Abundant hydrocarbons have been produced from the Middle Triassic Halfway Formation of northeastern British Columbia; however, the facies relationships and geological history of this strata are poorly understood. To address these issues, 132 cores and well logs from 345 wells were examined from the Peejay Field of northeastern British Columbia in order to: (1) establish a depositional model; (2) identify the origin of all reservoir facies; and (3) construct an exploration model to better predict the trend of reservoir facies. Middle Triassic deposits of the Peejay Field comprise four west-southwestward prograding shoreface parasequences which form a progradational parasequence set. Palaeoshoreface

deposits, referred to as Lithofacies Succession I (L.S.I), have been truncated and replaced with sharp-based cross-stratified bioclastic grainstone and litharenite tidal inlet fills, referred to as Lithofacies Succession II (L.S.II). Tidal inlet fills trend north-northwest to south-southeast and exhibit the best reservoir quality in the field. Successively younger parasequences are thicker and contain coarser grained lithofacies. However, the youngest parasequence (P.A. 4) varies laterally in thickness due to postdepositional erosion. Isopach maps and cross- sections through the Middle Triassic strata reveal the occurrence of a post-Halfway erosional surface that truncates successively older strata to the northeast. Superimposed on the northeastward thinning of Middle Triassic regional isopach trends are local north-south-trending thickness anomalies interpreted as post-Halfway block faulting. The combination of post-Halfway erosion and block faulting has resulted in reservoir facies preservation being completely controlled by structure. Based on reconstruction of the geological history, a hydrocarbon exploration model has been developed for the Peejay Field in order to predict the genesis, distribution and degree of preservation of reservoir facies.

CHEN, JIN-HUA, 1998. On some problems of Triassic and Jurassic biogeography in south China. Acta Palaeont. Sinica, 37: 99-107.

This paper discusses four problems correlated with the Triassic and Jurassic palaeobiogeography of South China: (1) A regression occurring in late Middle Triassic (late Anisian-Ladinian) on the Yangtze platform; (2) Collision of the South China continental blocks with the North China blocks, which is considered as happening in late Middle Triassic (late Anisian-Ladinian) according to data of continental biotic migration and diffusion across the collision zone; (3) The Triassic Nanpanjiang "geosyncline" (located in the Guangxi-Guizhou-Yunnan border area) which is believed to be a fault-basin actually with a strongest activity in late Middle Triassic accompanied by the regression of Yangtze platform and the collision between South China and North China blocks; and (4) A discrepancy of geological development between east and west parts of South China obviously appearing since late Middle Triassic, especially in Late Triassic and Early-Middle Jurassic.

CHENG, J., DENG, J., LI, B. and TANG, J., 1997. Sedimentary characteristics and copper ore provenance effect of Jiapela Formation of Upper Triassic in East Xizang. Acta Sediment. Sinica, 15: 111-117.

The relationship between the provenance effect and the Yulong copper ore zone is discussed in this paper. The copper ore provenance effect by sedimentation of Jiapela Formation of Upper Triassic in the East Tibet is first put forward by the authors based on the latest data and research from stratigraphy, sedimentology, geochemistry of trace elements and rare earth elements etc. The research shows that the copper ore was been principally affected by sedimentation in Late Triassic, and its forming environment was an active continental margin.

CHILDE, F.C., THOMPSON, J.F.H., MORTENSEN, J.K., FRIEDMAN, R.M., SCHIARIZZA, P., BELLE-FONTAINE, K. and MARR, J.M., 1998. Primitive Permo-Triassic volcanism in the Canadian Cordillera: Tectonic and metallogenic implications. Econ. Geol., 93: 224-23.

Volcanogenic massive sulfide deposits of various ages, types, and geochemical affinities occur within allochthonous and para-autochthonous terranes of the Cordillera of western Canada. The terrane affiliation, age, and chemical association of volcanic rocks can be used as a guide in the exploration for volcanogenic massive sulfide mineralization. The Kutcho massive sulfide deposit occurs within volcanic rocks of the Kutcho assemblage, in the fault-bounded King Salmon allochthon in northern British Columbia. The Kutcho Creek deposit is characterized by a Permo-Triassic age of mineralization and primitive chemical and

radiogenic isotope compositions of the host rocks which are distinct from those of other volcanogenic massive sulfide deposits in the Canadian Cordillera. The Kutcho deposit is interpreted to have formed within a primitive intraoceanic are environment, distinct from the setting ascribed to more typical felsic volcanic-hosted (kuroko) massive sulfide deposits. The age, mineralogy, and chemical and isotopic compositions of rocks from the Kutcho assemblage are comparable to those of two other fault-bounded slivers in the Cordillera, the Sitlika assemblage and the Venables Valley-Red Hill area. These similarities suggest that rocks from the three areas may have formed within the same period and tectonic environment; as such, the latter two areas are prospective for volcanogenic massive sulfide exploration in the Canadian Cordillera.

CIRILLI, S., RADRIZZANI, C.P. PONTON, M. and RADRIZZANI, S., 1998. Stratigraphical and palaeoenvironmental analysis of the Permian-Triassic transition in the Badia Valley (Southern Alps, Italy). Palaeogeogr. Palaeoclimatol. Palaeoecol., 138: 85-113.

A sedimentological, palynological and microfaunal integrated analysis was carried out across the Permian-Triassic transition in a 35 m thick section near Seres (Badia Valley, northern Italy). This section includes the uppermost part of the Bellerophon Formation and the base of the Werfen Formation (Tesero Horizon and the lowermost Mazzin Member). The Bellerophon Formation ("badiota facies") displays a general shallowing-upward trend. It has been subdivided into three intervals on the basis of facies, microfacies, biofacies and palynofacies associations. The Bellerophon-Werfen Formation boundary was located at the boundary between a thin black organic-rich layer and a 50 cm thick limestone bed, containing in the upper part the first oolitic bands. The palynological assemblages show throughout the Bellerophon Formation a gradual decrease of exclusive Permian palynomorphs and a concomitant increase of Triassic ranging forms. Triassic palynomorphs were found in the lower part of the Tesero Oolitic Horizon (TOH), where the Permian-Triassic transition can be recognized. Foraminifers with Triassic affinity appear just above the proposed Permian Triassic transition. This multidisciplinary approach led to evidence the palaeoenvironmental evolution which was characterized by variations in the water column oxygenation from dysoxic to oxic conditions related to climatic and/or physiographic changes influencing the water layering. Palynofacies studies show a shift from relatively distal to more proximal conditions which reached the maximum during the deposition of the black organic-rich level at the upper boundary of the Bellerophon Formation. The overlying shallowing upward cycle at the base of the TOH starts with an anoxic transgressive layer and ends with the oolitic beds.

**COPE, J.C.W.**, 1998. Discussion on estimates of the amount and rate of sea-level change across the Rhaetian-Hettangian and Pliensbachian-Toarcian boundaries (latest Triassic to Early Jurassic). J. Geol. Soc., 155: 421-421.

Cox, C.B., 1998. The jaw function and adaptive radiation of the dicynodont mammal-like reptiles of the Karoo basin of South Africa. Zool. J. Linn. Soc., 122: 349-384.

The structure and functioning of the dicynodont jaw system are described. A pivoting action of the lower jaw around the palate posteromedian to the caniniform processes is as basic to the jaw movement as is the well-known double-convex jaw articulation. The sequence of origin of the characteristic features of the dicynodonts is analysed cladistically; this demonstrates the patterns of association of these characters into functional character-complexes. The structures of the palate and lower jaw, and their functional integration in feeding, are described and illustrated in standard format. Five different lineages of dicynodont can be identified: Eodicynodon: the robertoids (including *Diictodon*); the dicynodon-

toids (including *Dictynodon* and the majority of the large dicynodont genera of the Permian and Triassic) the endothiodontoids (including *Prodicynodon* [= "*Chelydontops*"] and *Pristerodon*), and the emydopoids (including *Cistecephalus*, *Myosaurus* and *Kingoria*). *Eodicynodon* or a similar form could have been ancestral to the other four lineages. The robertoids probably fed upon the stems and rhizomes of equisetaleans, while the varied dicynodontoids probably fed upon the varied glossopterid seed-ferns. The endothiodontoids, too, were probably herbivorous, but many, perhaps all, of the small emydopoids were burrowing and may have been omnivorous. The dicynodonts were probably ectothermal, and the dicynodontoids may have migrated to warmer latitudes in the winter. Only c. 20 genera of Karoo dicynodont are now recognized as valid, and it is suggested that this fauna is now almost completely known. Their distribution in the Karoo biozones is reviewed and correlated with environmental changes. The Permian ancestors of the Triassic dicynodonts, including *Lystrosaurus*, probably lived on higher, drier ground, and were therefore already adapted to the more fibrous food that spread into the basins as the climate became drier in the Triassic.

CZIER, Z., 1998. *Ginkgo* foliage from the Jurassic of the Carpathian Basin. Palaeontology, 41: 349-381.

Mesophytic Ginkgo foliage from the Carpathian Basin (Romania and Hungary) is revised using a new statistical method for identification. The genera Ginkgoites and Baiera are suppressed in favour of Ginkgo. New combinations G. marginata and G. skottsbergii are studied for the first time using scanning electron microscopy. G. baieraeformis banaticus subsp.nov. is an Indo-European member of the Dictyophyllum-Clathropteris Flora. G. marginata banatica subsp. nov. is characteristic of the Clathropteris meniscioides Biozone (Hettangian-Sinemurian) of the European Province. G. polymorpha is of western origin, later spreading out into Siberia. G. skottsbergii europeica subsp. nov. possibly belongs to the Dictyophyllum-Clathropteris Flora that originated in the Late Triassic in eastern South-east Asia, spread to Europe in the Early Jurassic and to South America in the Mid Jurassic, where it persisted until the Early Cretaceous.

DALLMEYER, D.R., KRAUTNER, H.G. and NEUBAUER, F., 1997. Middle-Late Triassic <sup>40</sup>Ar/<sup>39</sup>Ar hornblende ages for early intrusions within the Ditrau Alkaline Massif, Rumania: Implications for Alpine rifting in the Carpathian orogen. Geol. Carpathica, 48: 347-352.

Multigrain hornblende concentrates from two samples of massive gabbro and diorite collected within "early" intrusive phases of the Ditrau Alkaline Complex (Rumania) record well-defined  ${}^{40}$ Ar/ ${}^{39}$ Ar vs.  ${}^{40}$ Ar/ ${}^{39}$ Ar plateau isotope correlation ages of 231.5 ±0.1 Ma and 227.1 ±0.1 Ma; 2 $\varsigma$  intralaboratory error). These are interpreted as dating relatively rapid post-magmatic cooling at high crustal levels following pluton emplacement in the Middle-Late Triassic. The magmatic activity predated Early Jurassic rifting in the Eastern Carpathian orogen.

DAVIES, G.R., 1997. The Triassic of the Western Canada Sedimentary Basin: tectonic and stratigraphic framework, paleogeography, paleoclimate and biota. Bull. Can. Petrol. Geol., 45: 434-460.

The Triassic of the Western Canada Sedimentary Basin records the transition from carbonate-dominant facies of the Paleozoic to siliciclastic-dominant facies of the Jurassic-Cretaceous in a tectonic setting preceding the onset of extensive terrane accretion and formation of a foreland basin in western Canada. Triassic sedimentation in western Canada was centred on four basins or subbasins: the extensional or transtensional Peace River Basin, the transtensional Liard Basin, an unnamed continental margin sag basin. and the

Williston Basin. This paper covers only the Peace River Basin and its western extension into the continental margin sag basin. The Triassic basin occupied a midlatitudinal, west-facing position on the western margin of the Supercontinent Pangea. In this setting, climatic aridity, influence of prevailing northeast trade winds, offshore coastal upwelling, and other conditions resulted in Limited fluvial influx, dominantly fine-grained siliciclastic sedimentation, significant aeolian processes, low-productivity carbonate shelves and ramps, extensive evaporites, and early-diagenetic dolomitization. Underlying Devonian reefs, reactivation of graben fault systems in the Peace River area, localized Paleozoic highs, and other tectonic elements, exerted strong influence on Triassic basin topography and facies, including localization of sediment gravity flows and turbidites. Collectively, these tectonic, paleogeographic and paleoclimatic conditions in western Canada in Triassic time have left a relatively unique sedimentological record with a wide range of facies and reservoir types. Ongoing discoveries of gas in Upper Triassic carbonates in northeastern British Columbia, new discoveries and extensions of play trends in the Lower Triassic in Alberta, and ongoing exploration in Middle Triassic units in both areas, are contributing to the growing reserves of oil and gas in the Triassic of western Canada. An understanding of some of the unique or different sedimentological aspects of the Triassic, as reflected by its tectonic setting, paleogeography and paleoclimate, is a necessary step in evaluating its reservoir potential.

DAVIES, G.R., 1997. Aeolian sedimentation and bypass, Triassic of western Canada. Bull. Can. Petrol. Geol., 45: 624-642.

The Triassic succession in the Western Canada Sedimentary Basin contains extensive evidence, both direct and indirect, for an aeolian influence on sedimentation. Paleogeographic and paleoclimatic reconstructions for western Canada in Triassic time show that northeast trade winds would have been the expected prevailing wind system during the arid summer season. This is confirmed by southwesterly dip of crossbeds in dune sands in the Charlie Lake Formation, particularly when corrected for Triassic plate rotation. A west-flowing jetstream may also have influenced sediment transport, similar to northwest Africa today. Arid coastal and inland desert or semidesert conditions provided a source for "desert loess" (silt fines) and very fine sand. Specific evidence for aeolian processes in the Triassic of western Canada includes bimodal or coarse-grained deflation lags in the Montney, Charlie Lake, Baldonnel and Pardonet formations and crossbedded dune sands in the Artex Member and other members of the Charlie Lake Formation. In addition (and more conjecturally), thick accumulations of relatively well sorted siltstones in the Montney, Baldonnel and Pardonet formations, and probably in all other Triassic units, may have formed at least in part by fallout from aeolian suspension ("loessite" model). For the Montney at least, basinward aeolian sediment bypass is suggested by the presence of coarse-grained aeolian deflation lags at the tops of some lowstand coquinal units. By comparison with Quaternary analogues of aeolian-marine turbidite sands in the Atlantic Ocean off the west coast of northwest Africa (offshore Saharan Desert) and in at least two other west-facing continental margin settings, bypassed well sorted aeolian silts and sands may have contributed to the formation of turbidites and extensive fluidized/downslope-d isplaced sandstones and siltstones in the Montney. The limited fine grain size, high detrital dolomite and feldspar composition, and high degree of sorting of many very fine-grained sandstones and siltstones in the Montney and in other Triassic units, are all consistent with aeolian source and transport mechanisms and also have direct impact on reservoir quality and petrophysical log characteristics.

DAVIES, G.R., 1997. The Upper Triassic Baldonnel and Pardonet formations, Western Canada Sedimentary Basin. Bull. Can. Petrol. Geol., 45: 643-674.

The carbonate-dominant Upper Triassic Baldonnel and Pardonet formations were deposited in the west-facing extensional Peace River Basin, in a midlatitudinal setting on the northwestern margin of the supercontinent Pangea. Subsurface distribution of the Pardonet is restricted to NE British Columbia, but the Baldonnel extends into west-central Alberta. This paper describes the stratigraphic framework, internal subdivisions, composition, facies and depositional setting of the two units and discusses the relationship between the overlying uppermost Triassic Bocock Formation and the Pardonet. A number of unconformities and flooding surfaces in the underlying upper Charlie Lake Formation, and in the Baldonnel and Pardonet, are documented, including two newly defined unconformities. Facies maps for the Baldonnel and Pardoner north and south of the Peace River-Williston Lake area in northeastern British Columbia demonstrate the westward-deepening ramp setting of these units and the influence of paleostructure on facies. Facies changes and increase in thickness of both the Baldonnel and the Pardonet in the Foothills of northeastern British Columbia south of Williston Lake reflect the influence of the southwestern extension of the Fort St. John Graben. The structural low defined by this extension is designated the Hudson Hope Embayment in this paper. The Embayment lies north of the northern termination of the upper Paleozoic Sukunka Uplift, which is roughly parallel to and en echelon with the Permian Beatton High to the northeast. Although the influence of these two highs on Triassic sedimentation, if any, remains unclear, the Baldonnel is thinned and the Pardonet missing over a smaller structural high on trend with the western end of the Beatton High. The boundary between the underlying Upper Triassic Charlie Lake Formation and the Baldonnel Formation in northeastern British Columbia is diachronous. The trace of the Siphon unconformity demonstrates this diachroneity most clearly: in the type section well of the Charlie Lake and Baldonnel formations near Fort St. John in British Columbia, the Siphon unconformity lies about 50 m below the "type" boundary between the two units but farther westward, in the Foothills of British Columbia (Cypress-Sikanni area), the formation boundary lies at or a few metres above the Siphon unconformity. Sequence- stratigraphic interpretations of the uppermost Charlie Lake-Baldonnel transition suggest that it represents a retrogradational transgressive systems tract that extends through northeastern British Columbia into west-central Alberta, where it includes the Worsley Member of the upper Charlie Lake Formation. The Baldonnel and Pardonet formations are the youngest major carbonate reservoir facies (outside the Williston Basin) in western Canada.

DAVIES, G.R., MOSLOW, T.F. and SHERWIN, M.D., 1997. The Lower Triassic Montney Formation, west-central Alberta. Bull. Can. Petrol. Geol., 45: 474-505.

The Lower Triassic Montney Formation was deposited in a west-facing, arcuate extensional basin, designated the Peace River Basin, on the northwestern margin of the Supercontinent Pangea, centred at about 30°N paleolatitude. At least seasonally arid climatic conditions, dominance of northeast trade winds, minimum fluvial influx, offshore coastal upwelling, and north to south longshore sediment transport affected Montney sedimentation. Paleo-structure, particularly highs over underlying Upper Devonian Leduc reefs and lows associated with graben trends in the Peace River area, strongly influenced Montney depositional and downslope mass-wasting processes. A wide range of depositional environments in the Montney is recorded by facies ranging from mid to upper shoreface sandstones, to middle and lower shoreface HCS sandstones and coarse siltstones, to finely laminated lower shoreface sand and offshore siltstones. and to turbidites. Dolomitized coquinal facies occur at seven stratigraphic horizons in the Montney. Some coquinas are capped by karst breccias and coarse-grained aeolian deflation lag sand residues indicating subaerial exposure. The

Montney has been divided into three informal members that have been dated by palynology and compared with global Early Triassic sequences. The subdivisions are: the Lower member, of Griesbachian to Dienerian age, correlated with a third-order cycle; the Coquinal Dolomite Middle member, of mixed Dienerian and Smithian ages; and the Upper member, of Smithian to Spathian age, correlative with two, shorter-duration third-order cycles. A forced regressive wedge systems tract model is adopted for deposition of the Coquinal Dolomite Middle member and for turbidites in the Valhalla-La Glace area of west-central Alberta. With this model, coquinas and turbidites accumulated during falling base level to lowstand, with a basal surface of forced regression at the base of the coquina and a sequence boundary at the top of the coquinal member. This is supported by the evidence for subaerial exposure and maximum lowstand at the top of the coquina. Very limited grain size distribution in the Montney, dominantly siltstone to very fine-grained sandstone, but often very well sorted, is interpreted to reflect an aeolian influence on sediment source and transport, High detrital feldspar and detrital dolomite in the Montney are consistent with (but not proof of) aeolian source from an arid interior, as is high detrital mica content in finer size grades. Extensive and often pervasive dolomitization, and early anhydrite cementation within the Montney, are also consistent with an arid climatic imprint. As new exploratory drilling continues to reveal the wide range of facies in the Montney, it adds to both the complexity and potential of this relatively unique formation in western Canada.

DAVIES, G.R., MOSLOW, T.F. and SHERWIN, M.D., 1997. Ganoid fish *Albertonia* sp. from the Lower Triassic Montney Formation, Western Canada Sedimentary Basin. Bull. Can. Petrol. Geol., 45: 715-718.

A remarkable core example of the Early Triassic ganoid fish *Albertonia* sp. has been discovered on a bedding plane in core in the Lower Triassic Montney Formation of Alberta, It matches very closely examples of the same species of fish recovered from outcrop in the time- equivalent Vega-Phroso Siltstone Member of the Sulphur Mountain Formation near Wapiti Lake in British Columbia, Albertonia is a member of the ganoid fish family Parasemionotidae, which is amongst the most advanced and abundant of Triassic sub-holostean families of fish. These fish were planktonic or deep-water in habitat and, together with other fish species identified from Wapiti Lake, may have indicated that bottom water conditions were anoxic.

DILKES, D.W., 1998. The Early Triassic rhynchosaur *Mesosuchus browni* and the interrelationships of basal archosauromorph reptiles. Phil. Trans. Roy. Soc. London, B, 353: 501-541

Restudy of the unique diapsid reptile *Mesosuchus browni* Watson from the *Cynognathus* Assemblage Zone (late Early Triassic to early Middle Triassic) of the Burgersdorp Formation (Tarkastad Subgroup; Beaufort Group) of South Africa, confirms that it is the most plesiomorphic known member of the Rhynchosauria. A new phylogenetic analysis of basal taxa of Archosauromorpha indicates that Choristodera falls outside of the Sauria, Prolacertiformes is a paraphyletic taxon with Prolacerta sharing a more recent common ancestor with Archosauriformes than with any other clade, *Megalancosaurus* and *Drepanosaurus* are sister taxa in the clade Drepanosauridae within Archosauromorpha, and are the sister group to the clade Tanystropheidae composed of *Tanystropheus, Macrocnemus,* and *Langobardisaurus*. Combination of the phylogenetic relationships of basal archosauromorphs and their known stratigraphic ranges reveals significant gaps in the fossil records of Late Permian and Triassic diapsids. Extensions of the temporal ranges of several lineages of diapsids into the Late Permian suggests that more groups of terrestrial reptiles survived the end-Permian mass extinction than thought previously.

DITTRICH, D., BARTELS, L. and VOGEL, K., 1997. Neue Ergebnisse zur Geologie des Ferschweiler Plateaus und des Heiderückens (zentrale Trier-Bitburger Mulde) -Tektonik, Keuper- und Lias-Stratigraphie sowie ein Beitrag zur genetischen Deutung des Naturdenkmals "Irreler Wasserfälle". Mainzer geowiss. Mitt. 26: 55-98.

At present the geological mapping of the Southern Eifel-Region is being revised. Facies and isopach patterns of the Triassic-Liassic series were controlled by synsedimentary mobile tectonic structures which can be assigned to three direction systems. A modem detailed Keuper stratigraphy is applied. Here and then special features of an ardennic marginal facies can be observed. Liassic series are mostly eroded.

DONG, Y., 1997. Late Triassic-Middle Jurassic strata and their sedimentary environments of the Jingzhou area, Hubei. J. Stratigraphy, 21: 130-135.

The characteristics of the Late Triassic-Middle Jurassic strata suggest that the Jingzhou area was a foreland basin which was formed in the foreland south of the Qinling orogenic belt. The sedimentary features and the contact relationships show that they are a l-grade sequence. Based on different graded beddings and formations, the Triassic and Jurassic strata can be divided into two Il-grade sequences, composed of three and seven III- grade sequences respectively. The studies of the stratigraphic sequences and sedimentary features in this area suggest that the Jinzhou foreland basin underwent three evolutionary stages. The subsidence center and forebulge of the foreland basin are of longitudinal migration, the scale and subsidence range of the basin indicate a regular transforms in different stages.

DUFFIN, C.J., 1997. New shark remains from the British Rhaetian (latest Triassic). 1. The earliest basking shark. N. Jb. Geol. Palaont. Mh., 1998: 157-181.

New shark remains are described from the Late Triassic fissure fillings of Holwell in Somerset (England). The material was collected by the Victorian geologist, Charles Moore. *Pseudocetorhinus pickfordi* n.g. n.sp., is placed tentatively with the neoselachians since it has a single crystallise enameloid with a rudimentary parallel fibred enameloid developed at the cutting edges of the crown. *Pseudocetorhinus* oral teeth and gill rakers are both described; it was a pelagic, filter-feeding shark, the dentition showing remarkable similarity to one of the Tertiary cetorhinids.

DUFFIN, C.J., 1998. New shark remains from the British Rhaetian (latest Triassic). 2. Hybodonts and palaeospinacids. N. Jb. Geol. Palaont. Mh., 1998: 240-256.

New shark remains are described from the Late Triassic fissure fillings of Holwell in Somerset (England). The material was collected by the Victorian geologist, Charles Moore. *Palaeobates reticulatus* n.sp. is the latest record for the genus. *Polyacrodus holwellensis* n.sp. is a new hybodont shark, and the teeth of *Synechodus rhaeticus* Duffin, 1982 are described for the first time.

DUNLOP, D.J., SCHMIDT, P.W., OZDEMIR, O. and CLARK, D.A., 1997. Paleomagnetism and paleothermometry of the Sydney Basin. 1. Thermoviscous and chemical overprinting of the Milton Monzonite. J. Geophys. Res. Solid Earth, 102: 27271-27283.

The Early Triassic (- 245 Ma) Milton Monzonite of the Sydney Basin, Australia, has four distinct components of natural remanent magnetization (NRM) with only slightly overlapping ranges of unblocking temperatures. The low-temperature (LT) component, the first to be thermally demagnetized, is thought to be a Late Cretaceous (approximate to 100 Ma) thermoviscous overprint acquired in slow cooling during uplift. The high-temperature (HT) component, the second to be demagnetized, is probably the primary thermoremanent

magnetization (TRM) of the Milton intrusion but could possibly be a Jurassic overprint. LT and HT are usually carried by magnetite and occasionally by pyrrhotite. Samples from nine sites have a further NRM component which unblocks at higher temperatures than HT but below the magnetite Curie temperature of 580° C. This component is argued to be a chemical remanent magnetization (CRM) because of its discrete range of high unblocking temperatures, above those of the thermal components HT and LT, and is called CRM1. CRM1 has almost the same direction as LT and is likely carried by authigenic magnetite produced during uplift similar to 100 Ma. Samples from five sites have a fourth NRM component, with a direction resembling that of HT but carried by hematite. This fourth component could be a primary TRM but is more likely a CRM and is therefore called CRM2. The HT-CRM2 mean direction is D = 50°, I = 75.5°, defining a paleopole at 16° S, 172° E. The HT-CRM2 paleopole falls near 150 Ma on the Australian apparent polar wander path but is a considerable distance from paleopoles of Permian and Early Triassic age. There is no known tectonic or other remagnetizing event in the Sydney Basin around 150 Ma. For this reason, we propose that the HT-CRM2 paleopole defines a new Triassic segment of the Australian polar wander path. The LT-CRM1 mean direction is  $D = 348^{\circ}$ ,  $I = -79^{\circ}$ , with a paleopole falling at 56° S, 158° E, near 100 Ma on the polar wander path. This age is consistent with uplift and cooling related to initial rifting of the Tasman Sea.

DUTTA, P.K., 1998. Provenance of chert in the Permo-Triassic Sydney Basin, Australia: oxygen isotopic evidence. Sed. Geol., 117: 123-132.

Detrital chert in chert-rich Permo-Triassic sandstones in the Sydney Basin, Australia, has been previously thought to have been derived from marine bedded chert in the New England Fold Belt (NEFB). This marine bedded chert is associated with volcanic, sedimentary, and metasedimentary rocks. Though volcanic detritus is common in these chert-rich sandstones, sedimentary and metasedimentary rock fragments are rare. This rarity raises the question of whether the source of chert grains in these sandstones was, indeed, the marine bedded chert in the NEFB or whether there was an alternative source. Without confirming the origin of chert, the provenance interpretation seems equivocal. Since the conventional petrographic technique proved to be inadequate in determining the origin of chert, it is necessary to use a technique that can discriminate chert of one type from another. The oxygen isotopic composition of chert from different environments shows characteristic  $\delta^{\mbox{\tiny 18}}O$  values and, therefore, is used in this study to differentiate chert based on their isotopic signatures. The oxygen isotopic composition of chert grains in Permo-Triassic sandstones in the Sydney Basin was determined and the  $\delta^{18}$ O values range between 12.7 and 20.8‰ (SMOW). On the other hand, the isotopic composition of metamorphosed marine chert in the NEFB ranges between 23.0 and 25.2‰. Texturally, detrital chert shows volcanic relicts while the bedded marine cherts show foliated texture. Both isotopic composition and texture are consistent with the interpretation that the primary source of the detrital chert was not from the NEFB but from an alternative source: chemically weathered volcanic rock.

EMBRY, A.F., 1997. Global sequence boundaries of the Triassic and their identification in the Western Canada Sedimentary Basin. Bull. Can. Petrol. Geol., 45: 415-433.

Twelve 2nd- and 3rd-orderT-R (transgressive-regressive) sequence boundaries have been delineated in the Triassic succession of the Sverdrup Basin, Arctic Canada. Sequence stratigraphic data from six other localities throughout the world, including Svalbard and Barents Sea, Germany, Italy, eastern Siberia, northern Himalayas and the southwestern U.S.A. indicate that these boundaries are global in extent. The ages and orders of these global sequence boundaries are: (1) near Permian-Triassic boundary (2nd order), (2) late Dienerian (3rd order), (3) late Smithian (3rd order), (4) near Early-Middle Triassic boundary

(2nd order), 5) late Anisian (3rd order), (6) near Middle-Late Triassic boundary (2nd order), (7) early Carnian (3rd order), (8) mid-Carnian (3rd order), 9) near Carnian-Norian boundary (2nd order), (10) mid- Norian (3rd order), (11) near Norian-Rhaetian boundary (2nd order), and (12) near Triassic-Jurassic boundary (2nd order). All twelve of these high-order boundaries are also readily recognizable in the Triassic succession of the Western Canada Sedimentary Basin. A widespread unconformity is associated with each boundary on the basin margin with a conformable transgressive surface forming the boundary farther basinward. Various potential stratigraphic traps are associated with each boundary. At various localities, the global sequence boundaries commonly exhibit the effects of tectonic uplift and thus tectonics was a factor in the generation of these boundaries. To accommodate the combination of both tectonic and eustatic mechanisms in the generation of the global boundaries, it is proposed that they are a consequence of episodic, major plate tectonic reorganizations. During these episodes, changes in spreading rates and/or directions would induce changes in the horizontal stress regimes of the oceanic and continental portions of plates. This would in turn result in an initial eustatic fall and tectonic uplifts along basin margins. During the subsequent relaxation phase, eustatic rise and tectonic subsidence on basin margins would occur. These combined eustatic and tectonic movements would create sequence boundaries consisting of subaerial unconformities and conformable transgression surfaces as well as associated stratigraphic surfaces including ravinements, maximum flooding surfaces and regressive surfaces of marine erosion within stratigraphic successions in many areas throughout the world.

ESCHARD, R., LEMOUZY, P., BACCHIANA, C., DESAUBLIAUX, G., PARPANT, J. and SMART, B., 1998. Combining sequence stratigraphy, geostatistical simulations, and production data for modelling a fluvial reservoir in the Chaunoy field (Triassic, France). AAPG Bull., 82: 545-568.

Reservoir modeling of the Chaunoy field was performed by combining a sedimentological study, a sequence stratigraphic analysis, geostatistical simulations, and the analysis of production data and fluid-flow simulations. The reservoir corresponds to the distal part of a Middle Triassic alluvial fan system in the Paris basin (France), and is extremely heterogeneous and layered. The reservoir mostly consists of small ribbon channel deposits interbedded with flood-plain and lacustrine mudstones. The channel amalgamation rate varied with cyclic lake-level variations, which directly controlled the reservoir geometry. Within a base-level cycle, during periods of low accommodation, channels were amalgamated, forming highly heterogeneous sand sheets. As the accommodation increased, channels became progressively isolated within flood-plain mudstones. Finally, a lacustrine transgression deposited lacustrine mudstones and induced thin but widespread vertical permeability barriers across the field. As accommodation started to decrease, considerable pedogenetic alteration occurred, as shown by dolocretes and groundwater dolomites. Five cycles that constituted the reservoir layering framework were identified. Geostatistical simulations of lithotype distribution within these units were computed using the truncated random Gaussian function method. Horizontal and vertical lithotype proportion curves and variograms were calculated from well data. Because of the wide well spacing, it was not possible to determine the range of horizontal experimental variograms. Three lithotype realizations were simulated within a high-resolution grid to compare short, medium, and long correlation lengths. After assigning petrophysical properties to the lithotypes and upscaling, fluid-flow simulations were performed for the three realizations. The three flow simulations were then compared to the 10-yr production history of the field. The simulations showed quite a good match regardless of the variogram range, except in the northern part of the field, indicating a problem in the reservoir layering in this area. This relative insensibility of the flow simulation to the correlation length probably is due to the high net pay within the amalgamated channel reservoir units and to the high number of conditioning wells; however, the flow simulation performed with the longest correlation length showed the best fit with the production history.

EVOY, R.W., 1997. Lowstand shorefaces in the Middle Triassic Doig Formation: implications for hydrocarbon exploration in the Fort St. John area, northeastern British Columbia. Bull. Can. Petrol. Geol., 45: 537-552.

Detailed examination of available core from a number of Middle Triassic Doig Formation sandstone reservoirs in the Fort St. John area of northeastern British Columbia (Buick Creek, Cache Creek, Fireweed and Stoddart-West) reveals a number of pronounced similarities with respect to sedimentologic characteristics, sandbody geometry and the nature of bounding surfaces. Sedimentary facies can be grouped into: (1) offshore/shelf, (2) shoreface acid (3) offshore transition facies associations. The shoreface sandstones are narrow, linear sand bodies oriented with their depositional axes elongate parallel to the paleoshoreline; net sand distribution defines a pronounced linear pattern exceeding 20 km in strike length in the Buick Creek field. Dip dimensions are limited to less than 2.0 km. Facies changes are abrupt, both vertically and laterally; the shoreface sandstones abruptly overlie offshore siltstones and shales across an erosive contact and represent development of the shoreface during a lowstand of sea level. The base of the sandstone is interpreted as a regressive surface of marine erosion (RSME) reflecting a fall in relative sea level. The shoreface sandstones, where the upper contact has been cored, are erosionally truncated by a transgressive surface of erosion/ravinement surface (TSE) and are overlain by a discontinuous coarse lag deposit which is abruptly overlain by finer grained sediments of offshore to offshore-transition affinities. The TSE and RSME merge in a paleolandward direction, removing any evidence of subaerial exposure. Recognition of these characteristics and their interpretation within a sequence stratigraphic framework, provides a powerful tool to guide exploration and constrain development decisions in the Doig Formation of northeastern British Columbia. The depositional history and orientation of these sandstones implies that exploration should emphasize strike continuity. The abrupt fluctuations in relative sea level, evidenced by the nature of the bounding surfaces, results in a fortuitous juxtaposition of reservoir, seal and potential source.

EZAKI, Y., 1998. Paleozoic scleractinia: progenitors or extinct experiments? Paleobiology, 24: 227-234

The Scleractinia, which are one of the most important builders of modern reefs, have been considered to have first appeared in the Middle Triassic. Recently, Paleozoic scleractiniamorphs have been reported from both the Ordovician and the Permian, suggesting that the scleractinian-like body plan was already established in the Paleozoic. Those Paleozoic scleractiniamorphs are considered either unsuccessful skeletonized offshoots (extinct experiments) or Paleozoic progenitors of the post-Paleozoic Scleractinia. Permian scleractiniamorphs are characterized by "ancestral" features and have no specific morphologies that deny scleractinian affinities. Molecular phylogenetics also indicate that extant scleractinians are monophyletic and originated long before their Triassic appearance. A Paleozoic origin for the Scleractinia is supported by morphological and molecular phylogenetic data. On the other hand, there is no positive evidence to show that different groups of scleractinians had separate soft-bodied precursors. The Paleozoic scleractinians evolved within the framework of their basic body plan, and a direct derivation of the Scleractinia from the Rugosa is not probable. The Anthozoa are characterized by a bilaterally symmetrical body plan, which is traditionally considered to have been derived from other radially symmetrical Cnidaria. The problem of the origin of scleractinian body plan may provide a key for deciphering the early

anthozoan radiation within the Bilateria. Other examples of Paleozoic Scleractinia and scleractiniamorphs will be found, probably in shallow-water reefal facies or deeper-water communities, bridging the stratigraphic gaps in occurrence and elucidating the origin of the Scleractinia and their body plan.

FANG, N.Q., FENG, Q.L., ZHANG, S.H. and WANG, X.L., 1998. Paleo-Tethys evolution recorded in the Changning-Menglian Belt, western Yunnan, China. C.R. Acad. Sci., Sér. II, 326: 275-282.

As a trunk part of the Paleo-Tethyan archipelago ocean, the Changning-Menglian belt of Western Yunnan, China, presents varied volcano-sedimentary records ranging in time from Early Devonian through Middle-Late Triassic. The typical pelagic sediments represented by radiolarites can not only signify a continuously evolved ocean but also constitute a complicated basin comprising different tectono-sedimentary units. It is likely that oceanic plateaus of diverse origins played a key role in constructing the pattern of eastern Tethys. The opening and closing of the Yunnan Tethys are discussed.

GALLEGO, O.F., 1997. Hallazgos de insectos Triásicos en la Argentina. Ameghiniana, 34: 511-516.

New findings of insects from the Middle to Upper Triassic, Potrerillos and Los Rastros Formations are listed. A survey of previous records by different authors, described and undescribed, is also presented. Familial faunal affinities with the Triassic from South Africa (Molteno Fm.), Brazil (Santa María Fm.) and Queensland (Ipswich Series) of Australia are briefly mentioned. The new combination *Palaeomantis acostai* (Marquat) is proposed.

GALL, J.C., GRAUVOGEL-STAMM, L., NEL, A. and PAPIER, F., 1998. The Permian mass extinction and the Triassic recovery. C.R. Acad. Sci., Sér. II., 326: 1-12.

The most severe mass extinction of the Phanerozoic occurred by stages in the Permian and spanned several millions of years. The marine environment suffered the most since their ecosystems greatly collapsed under the joint effects of a great drop in sea level and general anoxic conditions in the ocean. On the land, arid conditions and several brief episodes of climatic cooling led to a great loss in biodiversity of the vertrebrate fauna and flora and therefore in the ground cover by the plants. in contrast, the insects did not seem to be very much affected by the crisis. The recovery of the disturbed ecosystems at the beginning of the Triassic proceeded from refuges, such as the transitional environments between sea and emerged lands.

GALLET, Y., KRYSTYN, L. and BESSE, J., 1998. Upper Anisian to lower Carnian magnetostratigraphy from the northern Calcareous Alps (Austria). J. Geophys. Res. Solid Earth, 103: 605-621.

The authors present a magnetostratigraphic study of three pelagic limestone sections (Gamsstein, Mendlingbach and Mayerling) from the eastern part of the Northern Calcareous Alps. Together these sections, which contain a rich conodont fauna, yield a sedimentary record encompassing the uppermost Anisian, the Ladinian and the Lower Carnian. Thermal demagnetization and isothermal remanent magnetization experiments indicate that the magnetization is essentially carried by a mineral of the magnetite family. The high unblocking temperature components isolated from the three sections provide clear magnetic polarity zonations. Correlations between these results, based on the biostratigraphic data and tephrochronology, allow the construction of a composite magnetic polarity sequence from the Illyrian substage (Upper Anisian) to the Julian 2 zone (Lower Carnian). This sequence contains 17 well-defined polarity reversals, and eight more poorly defined intervals. Correlations can be suggested between the new data and other magnetostratigraphic

results previously obtained from marine sections. We estimate that the magnetic reversal frequency was 2.5 to 3.6 reversals per million years during the Ladinian.

GELETA, S. and WILLE, W., 1998. Middle Triassic palynomorphs from the Fincha-a River section, Horo Guduru, Western Central Ethiopia. - N. Jb. Geol. Paläont. Mh., 1998: 257-268.

Surface rock samples were collected from the southwestern cliff of the Fincha-a River valley in western central Ethiopia. The identified palynomorphs revealed the Middle Triassic age of the sequence. This paper reports for the first time the occurrence of Triassic rocks in the area. These sediments are coeval with the Karoo sequence known from subsurface studies in the Ogaden Basin of southeastern Ethiopia. Its location indicates that the Triassic sediments of the Fincha-a River may have been deposited in a NW-SE trending arm of the triradial Karoo rift.

GELUK, M.C. and ROHLING, H.G., 1997. High-resolution sequence stratigraphy of the Lower Triassic "Buntsandstein" in the Netherlands and northwestern Germany. Geologie en Mijnbouw, 76: 227-246.

Detailed log correlations of the largely fluvio-lacustrine Lower Triassic "Buntsandstein" (Late Permian-Early Anisian), carried out on 80 wells in the Dutch onshore and offshore areas, can be linked to northwest-German high-resolution sequence stratigraphy. The correlations show that cyclic sedimentation occurred in large parts of the basin. Seven 1st-order sequences are recognised, namely the Main Claystone, Rogenstein, Volpriehausen, Detfurth, Hardegsen, Selling and Lower Rot Sequences. They are overlain by the lower part of the Upper Rot-Lower Muschelkalk Sequence. Distinct sequence boundaries have been identified at the bases of four sequences: Volpriehausen, Detfurth, Selling and Upper Rot. The higher-order sequences consist of fining-upwards cycles with a thickness of up to tens of metres. The sequences are laterally persistent and have a characteristic expression on gamma-ray and sonic logs. In the Lower Buntsandstein, they display a uniform character throughout most of the area, with only minor differences in thickness or lithology. NNE-oriented lows and swells were formed during deposition of the Volpriehausen, Detfurth and Hardegsen Sequences. Uplift prior to the deposition of the Selling Sequence caused deep erosion on the swells in the basin and minor erosion in the lows. The high-resolution sequences probably represent alternating, relatively wet and dry climatic periods, with a periodicity of about 100,000 years. An analysis of the sequences suggests that their reduced thickness on the swells is mainly the effect of erosion. This is supported by analyses of the accumulation patterns and rates.

GERMANI, G., 1997. New data on ammonoids and biostratigraphy of the classical Spathian Kçira sections (Lower Triassic, Albania). Riv. Ital Paleont. Strat., 103: 267-292.

New bed-by-bed data on ammonoids and their stratigraphic position within three sections from the Lower and Middle Triassic Han-Bulog Limestone of Kçira (Northern Albania) are presented. Two of the sections studied are most likely from the classical localities described by Nopcsa in 1929. They have provided the only two ammonoid collections known from the Albanian Lower Trias, which are known as Arthaber's and Nopcsa's collections, now stored in Wien and London, respectively. The ammonoids from the two collections, although sampled discontinuously (not bed-by-bed), supplied the base of a substantial part of the Spathian taxonomy in the Western Tethys. The new sampling of the basal portion of the Han-Bulog Limestone of Koira provided the layers with the richest and most diversified faunas. Two marker levels recognized within the lowest 2.5 m of the succession are characterized by the acme of the genus *Subcolumbites*, that is practically absent in the middle-higher part of the formation. These basal faunas were assigned to the *Sub*-

columbites- Prohungarites Oppel zone, whose local revision is suggested with the introduction of the taxon range zone "Subcolumbites beds". The middle portion of the Han-Bulog Limestone provided only small long-ranging ammonoids belonging to the genera *Procarnites*, *Leiophyllites* and *Eophyllites*. Scant faunas with long-ranging Anisian forms (*Procladiscites*, *Sturia*, *Proarcestes*, *Monophyllites*) were found at the top of the succession within isolated blocks.

GNAEDINGER, S. and HERBST, R., 1998. La flora Triasica del Grupo El Tranquilo, Provincia de Santa Cruz, Patagonia. Parte IV. Pteridospermae. Ameghiniana, 35: 33-52.

The pteridosperms of the El Tranquilo Group (Upper Triassic of Patagonia) have been studied. Well known and widespread Gondwana species are only mentioned while less known taxa are described. The list of species comprises: *Dicroidium crassum* (Menéndez) Petriella, *D. dubium* (Feistmante) Gothan, *D. lancifolium* (Morris) Gothan, *D. dontopteroides* (Morris) Gothan, *D. townrovii* Retallack, *Dicroidium* sp. 1, *Dicroidium* sp. 2; *Diplasio-phyllum hughesi* (Feistmante) Frenguelli, *Xylopteris argentina* (Kurtz) Frenguelli, *X. rigida* (Dun) Jain y Delevoryas, *X. spinifolia* (Tenison-Woods) Frenguelli, *Zuberia zuberi* (Szajnocha) Frenguelli, *Lepidopteris madagascariensis* (Carpentier) Townrow, *L. stormbergensis* (Seward) Townrow; *Scytophyllum neuburgianum* Dobruskina. The taxonomic rank of variety in this group of plants is not accepted as it can be shown that most of them are transitional forms within species polymorphism.

GNAEDINGER, S. and HERBST, R., 1998. La flora Triasica del Grupo El Tranquilo, Provincia de Santa Cruz, Patagonia. Parte V. Pteridophylla. Ameghiniana, 35: 53-65.

The Pteridophylla of the El Tranquilo Group (Upper Triassic of Patagonia) have been studied. The list comprises: *Dejerseya lobata* (Jones & de Jersey) Herbst, *Linguifolium lillieanum* Arber, *L. steinmannii* (Solms-Laubach) Frenguelli, *L. tenisonwoodsii* (Jack & Etheridge) Retallack, *L. patagonicum* n.sp.; *Taeniopteris crassinervis* (Feistmantel) Walkom, *T. thomsoniana* Arber, *T. vittata* Brongniart, *Taeniopteris* sp. 1, *Taeniopteris* sp. 2., *Yabeiella mareyesiaca* (Geinitz) Oishi, *Y. wielandi* Oishi, *Santaecruzia hunickenii* n.gen. et sp. and *Santaecruzia* sp. *Santaecruzia* n.gen. is erected for big leaves with anastomosed lateral venation for which no previous name could be found in literature.

GODEFROIT, P. and CUNY, G., 1997. Archosauriform teeth from the Upper Triassic of Saint-Nicolas-de-Port (northeastern France). Palaeovertebrata, 26: 1-34.

The Late Triassic locality of Saint-Nicolas-de-Port (Meurthe-et-Moselle, France) has yielded numerous isolated teeth belonging to archosauriform reptiles. The following tooth groups can be identified: heterodont phytosaurs, the pterosaur *Eudimorphodon*, the prosauropod dinosaur *Plateosaurus*, three types of putative omithischian teeth and 13 types of carnivo-rous Archosauriformes indet. Apparent venom-conducting teeth belonging to a new taxon of ?Archosauriformes (*Graoullyodon hacheti* n.g. n.sp.) are also described. From a palaeo-geographical point of view, the ornithischian teeth from Saint-Nicolas-de-Port (if their attribution is confirmed) are the oldest fossils of this group in Europe. The biostratigraphic distribution of the tooth forms mostly suggests a Late Norian or Early Rhaetian (depending on current interpretations) age of the deposits, but do not provide more precisions than fossils previously described from the area. The dietary habits and, consequently, the palaeoecological relationships of the different vertebrate groups discovered at Saint-Nicolas-de-Port are tentatively established: the ornithischian and prosauropod teeth reflect a herbivorous diet, whereas the other archosauriform teeth are probably from carnivores or omnivores.

**GOGGIN, V., JACQUIN, T. and GAULIER, J.M.**, 1997. Three-dimensional accommodation analysis of the Triassic in the Paris Basin: a new approach in unravelling the basin evolution with time. Tectonophysics, 282: 205-222.

The mechanisms governing the development of the Paris Basin throughout the Triassic are regarded as being the result of superimposed and successive processes. In this study, the Triassic succession of the Paris Basin was re-interpreted in a sequence stratigraphic context, using essentially wireline log data. From this, a series of isopach maps, lithofacies maps and palaeobathymetric maps was produced for each sequence. Three-dimensional accommodation analysis was then carried out sequence by sequence, over the entire basin to produce a precise, detailed accommodation history for the entire Triassic succession. Previous studies have proposed that the Triassic was deposited during a rift period in a transtensional stress regime, with the formation of a trough superposed onto three fault systems derived from the Variscan structural framework. In this study, Scythian to Ladinian sediments (Buntsandstein and Muschelkalk) record the stress regime that prevailed over much of NW Europe. The basin architecture at this time is in continuity with the neighbouring Germanic Basin. Our three- dimensional accommodation modelling shows that the stress regime changed during the Carnian and the late Norian (Keuper). The Carnian events are marked by (1) the creation of a large depocentre infilled with halite, and (2) a northwest migration of this depocentre during the mid-late Carnian along with deposition of the Gres-a-Roseaux. an extensive fluvial deposit. This documents renewed strike-slip movement along the Bray fault. The Norian events involved major tectonic uplift on the basin margins, producing fan delta progradation into the basin. Rotation of the previous depocentre axis occurs on the downthrown side of the Bray fault. This may be viewed as a consequence of sinistral strike-slip displacement along the Bray fault, forming a local transpressive stress regime. The following Liassic cycle commenced with the Rhaetic sequences and illustrates a complete change in the stress regime. This corresponds with the new stress regime which prevailed over northwest Europe during the Liassic cycle. Accommodation curves from the basin complement this interpretation recognising two major accommodation phases which are separated by a significant unconformity. Both phases record periods of accelerating accommodation followed by a more uniform phase of decelerating accommodation. The accelerating phases correspond to periods of rapid accommodation space creation and result in thick evaporite deposits. They correspond to "rift pulses" which occurred in the remote North Atlantic and Tethyan domain. Each accommodation phase is proposed to correspond to lithospheric stretching pulses followed by a relaxation period. This study illustrates the importance of sequence stratigraphy coupled with three-dimensional accommodation analysis in refining important stages in the basin evolution with time.

GRANT-MACKIE, J.A, CAMPBELL, H.J. and VU KHUC, D., 1997. *Torlessia* in Southeast Asia: A review of distributions and implications. Geol. Soc. New Zealand, Misc. Publ. 9SA: 68.

HAGDORN, H. and SANDY, M.R., 1998. Color banding in the Triassic terebratulid brachiopod Coenothyris from the Muschelkalk of Central Europe. J. Paleont., 72: 11-28.

The Triassic terebratulid brachiopod *Coenothyris* frequently displays preserved color patterns; such patterns have commonly been recorded from Paleozoic terebratulid brachiopods. Despite the frequency with which color patterns are preserved in *Coenothyris*, there has been no recent investigation of the cause and significance of this phenomenon. Shell material is well-preserved; energy-dispersive spectroscopy and microprobe analysis has been unable to detect compositional differences between colored and noncolored shell. This supports the organic origin of the color patterns as suggested for Devonian terebratulids by Richter (1919); color patterns originate from organic pigment in the primary shell layer.

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Three subtypes of radial color banding are identified: subtype A with a relatively large number (up to 80) of delicate color bands on each valve; subtype B with fewer and generally wider color bands (less than 20) on each valve of adult specimens; subtype C with faint to fairly wide but very short color bands along the anterior margin (ranging from a few to more than 50 in number). Serial sections prepared from subtypes A and B confirm their congeneric status. As shell form (length/width/ thickness ratio) and maximum size varies, color pattern types differ in various stratigraphic horizons and also in isochronous populations from different geographic localities, indicating different facies. However, the variation in color patterns is not due to systematic differences at the species or subspecies level but rather reflects a tendency among *Coenothyris vulgaris* to respond to different environmental parameters. This variation in color patterns is ecophenotypic.

HALLAM, A., 1998. Discussion on estimates of the amount and rate of sea-level change across the Rhaetian-Hettangian and Pliensbachian-Toarcian boundaries (latest Triassic to early Jurassic)-Reply. J. Geol. Soc., 155: : 421-422.

HAMIDI, E., COLIN, F. and BOULANGE, B., 1998. Evidence of early carbonate crust formation on Triassic basalt in the middle Atlas (Morocco). Bull. Soc. Géol. France, 169: 63-68.

The first stages of the basalt calcitization were studied along a weathering profile located near Elhajeb city, within the Moroccan Middle Atlas. This study allowed us to distinguish between smectitic weathering of basalt and its calcitization. The weathering front is up to 35 m deep. It is characterized by the transformation of primary minerals to smectites with a strong depletion of Ca. Calcitization is developed until 1.5 m deep and the lower limit of the calcitization front is marked by an increase of the Ca contents. LO to 15% of this Ca is inherited from basaltic material and is in situ incorporated in secondary products. The 85 to 90% remained are of external origin to the profile and attributed to either Quaternary carbonate (travertine) surrounding the profile or to Liassic carbonates outcropping above Elhajeb basin.

HE, H., CHEN, H., LI, J. and XIAO, W., 1997. A Permian and Triassic turbidite and its tectonic significance in northwestern Zhejiang. Acta Geol. Sinica, 71: 123-132.

Based on the sedimentary and bioecological characteristics, the Upper Permian Changxing and Dalong formations and the Lower Triassic Zhengtang Formation in northwestern Zhejiang Province are recognized as deep-water turbidites. They were violently deformed by the Indosinian Orogeny and show the characteristics of a foreland fold-thrust belt. Their sedimentary setting is passive continental margins tilting northeast. The geochemical data of rocks show that there may be some materials from the Late Paleozoic arc and Late Proterozoic orogenic belt during the deposition of the turbidite.

HE, Y., 1998. On occurrence of Triassic Oberhauserellidae (Foraminifera) from Yunnan. Acta Micropaleont. Sinica, 15: 30-35.

Although Fuchs (1967,1974) believed that Oberhauserellids of the Triassic are "*Globigerina*like" foraminifera related to the plankton forms of later geological ages, evidence in favour of his assertion remains so far meagre. In studying the fossil collection made by the Comprehensive Scientific Expedition to Qinghai-Xizang (Tibet) Plateau (Hengduan Shan part), Academia Sinica in 1981, the author found a number of specimens belonging to this interesting family, some of which afford a clue to clarification of its relations with globigerinas. The material was collected from the upper part of the Songgui Formation at Mitaojing, Yongsheng, NW Yunnan, belonging to the upper Norian (Rhaetian). HEDEGAARD, C., LINDBERG, D.R. and BANDEL, K., 1998. Shell microstructure of a Triassic patellogastropod limpet. Lethaia, 30: 331-335.

The St. Cassian formation of northern Italy contains an unsurpassed diversity of Triassic organisms, often with original or only slightly recrystallized shells. The shell microstructure of *Patella costulata* Münster, 1869, is examined and compared with the shell microstructures of 14 extant gastropod limpet taxa. The distribution of shell structure characters supports the assignment of *P. costulata* to the patellogastropod taxon Patellidae. St. Cassian facies also include near-shore environments that are consistent with the habitat of extant Patella species. The corroboration of *P. costulata* as a member of the Patellogastropoda reduces the hiatus between estimated origination and the previous unequivocal first occurrence by a minimum of 116 Ma.

HENDERSON, C.M., 1997. Uppermost Permian conodonts and the Permian-Triassic boundary in the Western Canada Sedimentary Basin. Bull. Can. Petrol. Geol., 45: 693-707.

The Permian-Triassic boundary interval was considered to be absent in many areas of the world, including western Canada, because of the unconformity associated with a global eustatic fall. This boundary is best recognized in strata of the paleo-Tethys Sea and, in particular, southern China, where the boundary will likely be defined. Age assignments discussed in this paper are based upon the assumption that the boundary will be defined by the first appearance of *Hindeodus parvus*. Biostratigraphic work presented herein indicate that the Permian-Triassic boundary interval is represented in western Canada within the basal black shale of the Sulphur Mountain, Montney and Grayling formations which were previously correlated exclusively with the Triassic. Uppermost Permian faunas have probably not been previously documented in the study area because the significance of considerable condensation within the basal parts of these formations was not recognized. The best section is at Opal Creek in Kananaskis Country where the Permian-Triassic boundary is identified at 1.5 metres above the top of the Ranger Canyon Formation. This suggests that a global eustatic fall, related essentially to the amalgamation of Pangea, occurred during a protracted Late Permian interval and that the subsequent transgression began during the latest Permian and continued into the Triassic. An anoxic depositional site is suggested for these basal shales as they are typically pyritic, lack bioturbation and current structures and have no benthic fossils. This anoxic episode may have been a contributing factor toward the Late Permian extinction event, the largest in geologic history, although extinctions largely occurred earlier in western Canada, since sponge spicules are the only Upper Permian macrofossils in the area. Conodonts, which were minimally affected by this extinction, provide valuable indices for high-resolution sequence biostratigraphic correlation in this interval. The age of the basal shales varies across the region; they are Changhsingian at Opal Creek, Griesbachian at several localities and possibly as young as Dienerian at Meiosin Mountain. This diachroneity can be attributed to the duration of the transgression, as well as paleotopography on the transgressed surface. New exploration insights may result from detailed correlation of Upper Permian and Lower Triassic conodont biozones and sequences/parasequences in the area.

HILLY, J., MARCHAL, C. and BUFFET, A., 1998. The Keuperian evaporitic series from Lorraine-Champagne (France). Analysis and genetic involvements of sedimentary discontinuities. C.R. Acad. Sci., Sér. II, 326: 427-432

In the Lorraine-Champagne basin, the Carnian salt deposit (similar to 150 m thick) presents numerous discontinuities located at the limit between successive "event sequences". Each sequence begins with the flooding of the basin and a shallow sedimentation of claystones and halite beds (maximum of a few metres thick). A trend towards a subaerial environment

announces the second phase marked by an emersion (tepees) and a long period of desiccation (giant polygonal fissures). The sediments (claystones and sulfates) laterally deposited in marginal flats show the same discontinuities. Similar features are known in the Permian, Triassic and Miocene evaporite basins of the U.S.A., West Europa and Morocco.

HUNT, A.P., LUCAS, S.G. and SPENCER, P., 1998. A reassessment of the taxonomic affinities of the enigmatic tetrapod *Anisodontosaurus greeri* Welles 1947 from the Middle Triassic of western North America. N. Jb. Geol. Palaont. Mh., 1998: 212-222.

Anisodontosaurus greeri Welles 1947 is a taxon of Middle Triassic reptile founded upon a left dentary from the Moenkopi Formation of Arizona (USA). The teeth of this taxon are transversely broadened and exhibit varying methods of implantation from acrodonty to protothecodonty. Protothecodont implantation indicates that this taxon is a diapsid, and this conclusion is supported by the presence of lingual resorption pits. Differing modes of tooth implantation suggest an affinity with Lepidosauromorpha. An unnamed taxon from the Middle Triassic of England appears to be closely related to Anisodontosaurus.

JOHNS, M.J., BARNES, C.R. and ORCHARD, M.J., 1997. Taxonomy and biostratigraphy of Middle and Late Triassic elasmobranch ichthyoliths from northeastern British Columbia. Geol. Survey Canada, Bull. 502.

Diverse and abundant Middle and Late Triassic elasmobranch ichthyoliths (microscopic shark teeth and scales) coexisting with conodonts, ammonoids, and bivalves were recovered from carbonates of the Pardonet, Baldonnel, Ludington, and Liard formations in the Peace River area of British Columbia. These faunas provide an excellent biostratigraphical framework for Triassic strata. Results from this study demonstrate that ichthyoliths can be used in basin analyses to date and correlate strata. The following summarizes the main achievements of this project. (1) Systematic description and illustration of Triassic elasmobranch ichthyoliths include seven species of teeth and nineteen new form genera and fiftythree new form species of scales. (2) Ichthyolith distributions consist of distinct faunal assemblages for the Ladinian, upper Carnian, and middle Norian. The Carnian/Norian boundary is marked by the disappearance of many Ladinian and Carnian elasmobranch species. In the Middle Norian, elasmobranch faunas reached a new peak of diversity and abundance. (3) A provisional ichthyolith zonation for the Middle and Upper Triassic, is proposed for the Peace River area. The sequence of coeval conodonts and (or) ammonoids indicate that the Coniunctio acquirugosa ichthyolith Zone is Ladinian, the Synechodus multinodosus ichthyolith Zone is upper Carnian, and the Synechodus incrementum ichthyolith Zone is lower and middle Norian. (4) New approaches to ichthyolith identification include recognizing diagnostic characteristics of scale and tooth bases, and using binomial, form, and utilitarian taxonomic systems. (5) Interpretations of histological and morphological features of elasmobranch teeth suggest that more derived neoselachian species than were originally known are present in the Triassic.

JOVANOVIĆ, R., 1996. Channel sequence of Lower Triassic sandpredominated braided rivers of Vuča (SW Serbia). Ann. Géol. Penins. Balk., 60: 129-136.

Investigated profiles are identified as single rnacroform-architectural element with characteristic association of lithofacies.

KAMATA, Y., 1997. Reconstruction of chert-clastic sequence of the Ashio Terrane in the Kuzu area, central Japan. J. Geol. Soc. Japan, 103: 343-356.

Sedimentary complex, widely distributed in the Kuzu area of the Ashio Mountains, central Japan, is characterized by tectonic repetition of coherent stratigraphic sequence of pelagic

to terrigenous sedimentary rocks with huge thrust bodies of limestone and greenstone. This complex is subdivided into three tectonostratigraphic units. Units 1 and 3 are composed of the Triassic to early Late Jurassic chert-clastic sequence which primarily consists of siliceous claystone, bedded chert, siliceous shale, and coarse clastic rocks in ascending order. The primary succession of the chert-clastic sequence was reconstructed by interrelationship of each type of rock and by radiolarian dating. Unit 2 is made up of Middle Permian greenstone and limestone which are attributed to part of seamounts capped by calcareous rocks. Reconstruction of the chert-clastic sequence contributed to recognition of imbricate structure which was formed by tectonic repetition of the sequences. Each slice does not include commonly all of the reconstructed secession and a part of the succession is excluded. The basal part of the slices commonly consists of siliceous claystone. It is suggested that the siliceous claystone functioned as tectonic discontinuous zone in formative process of the imbricate structure.

KHANCHUK ,A.I. and PANCHENKO, I.V., 1997. Permian and Triassic rocks in terranes of the southern Far East Russia. Mém. Géol. (Lausanne), 30: 1-4.

In the Burea-Khanka accretionary system, some assemblages, overlapping pre-Devonian terranes, consist of Permian and Triassic rocks. Permian volcanic and sedimentary deposits are characterized by a paleotectonic zonation: island arc and rifting back-arc basin. That epicontinental island-arc system formed near the tropical belt; in the very late Permian, it accreted to the Sino-Korean craton, forming the North China-Amur continent. Triassic rocks form predominantly clastic shallow-water and land deposits at the transform margin of the North China-Amur continent, shifted to the north, towards the Siberian Craton during Triassic time. In the Sikhote-Alin Area and Sakhalin Island, Jurassic and Cretaceous accretionary wedge terranes include Permian-Triassic cherts, Middle- to Upper Triassic cherts, interbedded with pelagic limestones, associated with oceanic basalt, and Permian and-Middle Triassic limestones in paleoguyot caps. Permian and Triassic rocks are, apparently, fragments of equatorial paleo-Pacific area, which experienced rearrangements in the very late Permian to early Triassic time and, possibly, abrupt shallowing.

KELBER, K.-P. and VAN KONIJNENBURG-VAN CITTERT, J.H.A., 1998. *Equisetites arenaceus* from the Upper Triassic of Germany with evidence for reproductive strategies. Rev. Palaeobot. Palynol., 100: 1-26.

In situ triplet groups of asymmetrical ellipsoidal strobili of *Equisetites arenaceus* in different stages of maturity, borne at the end of straight equisetalean branches, are described from the Keuper (Upper Triassic) of southern Germany. Apart from the organization of the strobili, spores in situ are also described. The strobili are compared to other equisetalean strobili with in situ spores and to extant *Equisetum* material. An additional mode of vegetative reproduction by shed twigs indicating adventitious roots is proven. In autochthonous situations, dense packages of shed twigs built up patches of newly sprouted rhizome layers. Moreover, we include *Equisetites elegans* Krāusel, 1959 in *E. arenaceus* (Jaeger) Schenk and give an emended diagnosis for the species.

KONSTANTINOV, A.G., SOBOLEV, E.S., KURUSHIN, N.I., KLETS, T.V. and YADRENKIN, A.V., 1997. Zonal subdivision of Triassic deposits of the Omulevka Uplift. Geol. Geofiz., 38: 1653-1669.

This paper describes the Triassic composite section in the Zyryanka basin (Omulevka Uplift). The Triassic deposits of the region are characterized paleontologically; the stratigraphy has been improved and detailed; the age has been justified by a complex of data. For the first time the Triassic in the Zyryanka basin was biostratigraphically subdivided at zonal level according to various faunistic groups. Under consideration is correlation between the local

biostratigraphic scheme of Triassic deposits and zonal schemes of the Triassic of Canada and Alpine region.

KÖPPEN, A., 1997. Faziesentwicklung in der frühen Obertrias Mitteleuropas ein sequenzstratigraphischer Vergleich. Gaea Heidelbergensis, 2: 1-233.

KRUCZYK, J., KADZIALKO-HOFMOKL, M., TUNYI, I., PAGAC, P. and MELLO, J., 1998. Paleomagnetic study of Triassic sediments from the Silica Nappe in the Slovak Karst, a new approach. Geol. Carpathica, 49: 33-43.

Intensive paleomagnetic and rock magnetic study were performed for Triassic limestones from the Silica Nappe in tile Slovak Karst. Five exposures situated on the eastern and western side of the Stitnik-Plesivec fault were sampled for this study. In all exposures a secondary component of remanence of normal polarity (N), carried by secondary PSD magnetite was found. In the Silicka Brezova exposure (SE) apart from the N component, another secondary component of reversed polarity (R), carried by hematite; was isolated. Both components were acquired after folding. The R component was acquired during the Odra reversal event in the Oligocene (Birkenmajer et al., 1977). Comparison of its direction with the reference data let us conclude that the area belonged during this time to the African affinity. The declination of the R component suggests that after this magnetization period the studied region rotated anticlockwise by about 90° around an intraplate vertical axis together with the whole Pelso megaunit, According to Marton et al. (1995) and Marton and Fodor (1995) the rotation took place in two phases, the first one by about 50° took place in the Early Miocene, the second one, by about 30° - in the Late Miocene. The N component, isolated by us, seems to have been acquired during the Middle Miocene after the first and before the second rotational phases: its declination agrees with a counterclockwise rotation of the Silica Nappe by about 30-40° during the Late Miocene, as postulated by the cited authors. The inclination of the N component is lower, than the expected for Miocene, but agrees with the Miocene results for the Bukk region also belonging to the Pelso block, confirming the idea about the Miocene "southern escape" of the Pelso block (Marton 1993). The final tectonic activity in the study area was connected with formation of the Stitnik-Plesivec fault (Late Tertiary-Quaternary). Our results suggest, that the fault is of rotational type and resulted in different tilting of beds situated on its eastern and western sides.

KUMAR, P., 1997. Almod Bed: a Permian-Triassic transition zone. Palaeobotanist, 46: 107-111. The Almod Bed located between the Bijori (Late Permian) and Pachmarhi Formations (Early Triassic) in Satpura Basin, has been palynologically analysed. The palynoassemblage is dominated by the Striatopodocarpites + Faunipollenites complex. Other characteristic palynofossils are Arcuatipollenites (= Lunatisporites), Chordasporites, Falcisporites, Goubinispora, Krempipollenites, Lundbladispora, Playfordiaspora, Podocarpidites, Satsangisaccites, etc. In its totality the palynological assemblage has a Late Permian aspect though the presence of the genera Goubinispora, Playfordiaspora and Lundbladispora in significant frequency indicates an Early Triassic influence.

LEHRMANN, D.J., WEI, J.Y. and ENOS, P., 1998. Controls on facies architecture of a large Triassic carbonate platform: The Great Bank of Guizhou, Nanpanjiang Basin, South China. J. Sed. Res., 68: 311-326.

The Great Bank of Guizhou (GBG) is an exceptionally well exposed isolated Triassic platform in the Nanpanjiang Basin of South China, The platform is exhumed with its depositional profile preserved and is dissected by a faulted syncline that exposes a complete and uncomplicated cross section providing a unique opportunity to evaluate mechanisms involved in its birth, evolution, and demise. The GBG formed near the southern margin of the Yangtze Platform during a deepening event that expanded the Nanpanjiang Basin and drowned the region surrounding the GBG in the latest Permian, Initial accumulation of the GBG began in the latest Permian with small reef mounds and open-marine skeletal packstones. Following the end- Permian extinction, cyanobacterial boundstones grew over the bank top, During the Early Triassic the GBG developed a low-relief bank profile with mobile oolite shoals at the margin, shallow-subtidal and peritidal deposits in the interior, and gentle slopes dominated by pelagics, debris-flow deposits, and turbidites at the basin margin, In the Middle Triassic (Anisian) the GBG developed a progressively steepening profile rimmed with massive Tubiphytes reefs, The platform was hat topped with tidal-flat deposits across the interior, Basin-margin deposition was dominated by turbidites and debris flow deposits but eventually shifted to avalanche and rock-fall deposits as the slopes steepened to the angle of repose, In the Middle Triassic (Ladinian) an erosional escarpment up to 1700 m high developed at the margin, Platform- margin strata are bedded packstones similar to interior strata, whereas breccias at the basin margin contain coral-boundstone clasts suggesting erosion of reefs from the escarpment, A restricted subtidal lagoon formed in the interior, producing an atoll-like morphology, Later, a Bat-topped profile was restored as tidal Bats spread across the interior, In the beginning of the Late Triassic deepening contributed to termination of the GBG before siliciclastic turbidites end shales were deposited over the platform. In contrast with the well known platforms of the Dolomites of northern Italy, the GBG contains abundant muddy carbonates and a progressively steepening bank to reefrimmed and escarpment architecture, The Italian platforms contain little mud and have angle-of-repose, pinnacle geometries, The GBG's larger size increased mud production and protected it from extensive winnowing of mud, which in turn resulted in off-bank shedding of muddy sediments that were stable on relatively gentle, basin margin slopes which progressively steepened and ultimately led to avalanche deposits and a high- relief erosional escarpment, In contrast, the lesser mud content of the Dolomites platforms forced avalanche and talus deposition to dominate throughout deposition of basin margins, which in turn produced their angle-of-repose geometries.

LEMAIRE, M.M. WESTPHAL, M., GUREVITCH, E.L., NAZAROV, K., FEINBERG, H. and POZZI, J.P., 1997. How far between Iran and Eurasia was the Turan plate during Triassic-Jurassic times? Geologie en Mijnbouw, 76: 73-82.

Calc-alkaline volcanic deposits from the south-west of the Turan plate, near the city of Turkmenbasi (40°00' N, 52°58' E) in Turkmenistan, were studied paleomagnetically. These rocks have been affected by a greenschist-facies metamorphism, possibly of regional extent, that has been K/Ar-dated as 200 to 227 Ma old. A low-blocking-temperature component (D = 349°, I = 64°), close to the present field direction and probably of viscous or recent chemical origin, was isolated by a negative fold test at three sites. The mean direction of a high-blocking-temperature component isolated at 15 sites, mainly carried by magnetite, is scattered before and after tectonic correction and after tectonic correction was isolated. The mean inclination of these sites (31 ±8°), syn-folding or post-folding, corresponds to a paleolatitude of 17 ±8° which is lower than the conventional Eurasian paleolatitudes for post-Permian times. The paleomagnetic data from the Turan and Iran plates constrain this low paleolatitude to the Late Triassic and Jurassic period. This requires a shortening of at least 7° between the Turan plate and Eurasia during this time.

LEPVRIER, C., MALUSKI, H., VANVUONG, N., ROGUES, D., AXENTE, V. and RANGIN, C., 1997 Indosinian NW-trending shear zones within the Truong Son belt (Vietnam) <sup>40</sup>Ar/<sup>39</sup>Ar Triassic ages and Cretaceous to Cenozoic overprints. Tectonophysics, 283: 105-127.

Several NW-trending ductile and partly mylonitic shear zones cross the Truong Son belt of Central Vietnam, along the Song Ma and Song Ca valleys and, north of the Kontum block, from Da Nang to Aluoi and Khe Sanh. High-grade metamorphic rocks of amphibolite facies, showing a retrograde evolution and consisting of ortho-and paragneisses, metavolcanics, amphibolites, marbles and quartzites are exposed along these structures. They display a homogeneous deformation pattern characterized by a generally steeply dipping foliation and a near-horizontal to gently plunging mineral stretching lineation, indicating a strike-slip tectonic regime of deformation. Along the southernmost fault zone at least, various and consistent kinematic indicators, including S-C structures, asymmetric tails of porphyroclasts, prove that the strain and metamorphism have been generated by a phase of dominantly non-coaxial deformation with a dextral sense of shear. <sup>40</sup>Ar/<sup>39</sup>Ar dating, applied on the high-grade metamorphic rocks minerals occurring along these zones, provide plateau cooling ages, closely around 245 Ma, establishing that this event took place in the lowermost Triassic as an early phase of the Indosinian orogeny. The existence of Indosinian movements in Vietnam, as they have been defined by previous authors during the early century, is now accurately confirmed and this is the first insight in the occurrence of ductile strike-slip tectonics of Indosinian age along NW-SE fault zones. Well-expressed in Central Vietnam is a Cretaceous thermal and deformational overprint, marked by epimetamorphism, which took place between 90 and 120 Ma, as attested by low-temperature degassing ages, This Cretaceous event is not found further north in the Song Ma zone where younger ages appear as a result of the influence of Cenozoic shear movements along the Red River fault which displays 20-30 Ma ages. On the northern flank of Song Ca, in the Bu Khang-Phu Heat core complex, comparable Oligocene- Lower Miocene ages (20-35 Ma), yielded by biotite and phiogopite, reflect a strong overprinting and attest to a rapid uplift of the basement.

LE ROY, P., PIQUE, A., LE GALL, B. BRAHIM, L.A., MORABET, A.M and DEMNATI, A., 1997. The Triassic-Liassic basins of western Morocco and the diachronous intracontinental Central Atlantic rifting. Bull. Soc. Géol. France, 168: 637-648.

Interpretation of industrial seismic reflection profiles along the Atlantic Moroccan margin allows to reconstruct the geometry of the synrift basins and kinematics of the intracontinental Central Atlantic rifting. This extensive event was marked by a Triassic-Liassic horst and graben regional pattern. A first Carnian faulting phase, recorded in the eastern part of the Essaouira basin and the Souss basin, controlled deposition of coarse and sandy synrift sequences. A younger, pelitic-evaporitic synrift sequence is present over the entire margin. It registers a second, northward spreading fracturation episode developed from the Tarfaya southern basin to the Doukkala northern basin during the Norian-Hettangian times. From this structural regional point of view and at that scale, the Central Atlantic ocean opened diachronously.

LI, W., ZHOU, L., FU, J. and ZHAO, W., 1997. Turbidity current deposits and their significance for petroleum geology of Upper Triassic in the Kuqa Depression. Acta Sediment. Sinica, 15: 20-24.

A set of very typical turbidite sequence is developed in the middle of the Kuqa Depression. Among the rocks, mark structures showing turbidity features frequently occur and have characteristic Bouma sequence. As the Late Triassic is a stable subsiding stage of the depression and the landform of lakebed is smooth, turbidite sequence is relatively thinner and only D turbidite facies is developed. Turbidity deposits passing through the scarp zone of braid delta front in the northeast Kuqa Depression enter the center of the basin. Hydrocarbon source rocks of deep lake facies and reservoirs of braid deltas and cap rocks associated with turbidite are well developed. It has been proved that Mesozoic strata have good potentials for exploration of oil and gas in this region.

LIU, S., KE, A., WU, L. and HUANG, S., 1997. Sediment provenance analysis and its tectonic significance in the foreland basin of the Ordos southwestern margin. Acta Sediment. Sinica. 15: 156-160.

It is effective to determine thrust events of provenance, setting and provenance strata corresponding to basin sediments according to the clast dispersal style and the components of sediments in foreland basins. Testing and study on the Upper Triassic stratigraphic section of the Ankou region in the southwestern margin of Ordos show that the provenances of stratigraphy are a set of meta-clastics and meta-volcanics which are Chenjiahe Formation and Huluhe Formation contributed in the eastern Qilian fold-thrust belt.

LU ZONG-SHENG and CHEN BIN, 1998. Discovery of Late Triassic fish trails (Undichna) in Hengshan County, Shaanxi, China. Acta Palaeont. Sinica, 37: 76-84.

The fish trails (*Undichna*) described in this paper originated from the late Triassic Yanchang Group in the Hengshan County, Shaanxi Province (37°30'N, 109°30' E). Such a trail fossil is discovered for the first time in China, and this is also the initial report around the globe on the presence of the fish trails in the Mesozoic. Altogether three ichnospecies have been discovered in the research region namely, *U. bina, U. britannica,* and *U. tricosta* ichnosp. nov. The analysis on the morphology of these ichnofossils has been employed to reconstruct the body length of the fish trails ranging between 8 and 32 cm. All these fossils occurred in the low-energy environment of the relatively deep lakes.

MAHESHWARI, H.K., 1997. Permian-Triassic Boundary: a tyro's view. Palaeobotanist, 46: 63-74. The major stratigraphic divisions of the Phanerozoic are based on "Mass extinction events", a concept that is gradually loosing followers. These divisions are called as systems, and the boundaries between the different systems are often arbitrarily drawn. In continuous sequences it is usually possible to clearly draw the system boundaries, but in case of global stratigraphic gaps, as between the Permian and the Triassic, the placement of the system boundary becomes a difficult task. This paper discusses and analyses information available on the Permian-Triassic transition, both in marine and non-marine sequences, and brings out gaps in information. It has been suggested that the system boundaries are not natural boundaries, and hence instead of focusing on a static PTB, that is, on an abrupt change from Permian to Triassic, more emphasis should be placed on the transition from Permian to Triassic which may be referred to as the PTB Interval.

MAISCH, M.W. and MATZKE, A.T., 1997. Observations on Triassic ichthyosaurs. Part I: Structure of the palate and mode of tooth implantation in *Mixosaurus cornalianus* (Bassani, 1886). N. Jb. Geol. Palaont., Mh., 1997: 717-732.

For the first time a nearly completely preserved palate of *Mixosaurus cornalianus* (Bassani, 1886) from the Middle Triassic of Monte San Giorgio is described. *Mixosaurus* shows unique features, such as extremely broad palatines and narrow slit-like interpterygoid vacuities. It is suggested that the almost closed palate of *Mixosaurus* represents the primitive state for ichthyosaurs. The dentition is subthecodont in the premaxilla and maxilla.

MAISCH, M.W. and MATZKE, A.T., 1998. Observations on Triassic ichthyosaurs. Part II: A new ichthyosaur with palatal teeth from Monte San Giorgio. N. Jb. Geol. Palāont., Mh., 1998: 26-41. A new genus and species of Middle Triassic ichthyosaur, *Wimanius odontopalatus*, is described on the basis of an incomplete but well preserved cranium and mandible and compared to other European Middle Triassic ichthyosaurs. *Wimanius* shows some similarities to the skull of "*Mixosaurus atavus*" described by v. Huene 1916, but is more primitive in retaining a row of palatal teeth on the palatine. The new genus can not be confidently assigned to a known family.

MARFIL, R., HALL, A., GARCIA GIL, S. and STAMATAKIS, M.G., 1998. Petrology and geochemistry of diagenetically altered tuffaceous rocks from the Middle Triassic of Central Spain. J. Sed. Petrol., 68: 391-403.

Petrographical and geochemical analysis of altered tuffaceous rocks of the Middle Triassic from the Iberian Range in Central Spain shows that pedogenic processes and subsequent diagenesis have strongly modified the original mineralogy and textures. These rocks are related to a magmatic episode that occurred at the Buntsandstein-Muschelkalk unconformity in this region, during the evolution of the Iberian Trough. The tuffaceous rocks accumulated in saline ponds in an open and terminal hood-plain setting. Their alteration is typified by neoformation of K-feldspar and illite, Precipitation of chert and carbonate cements and replacements were also important processes, resulting in intercalated chert beds and nodules, Much of the silica appears to be derived from extensive devitrification and weathering of glassy volcanic ash, X-ray diffraction analysis, microscopic observations, and EDX microanalysis reveal that the chert consists of various types of chalcedony, tridymite, micro and megaguartz, illite, K- feldspar, and small amounts of albite, In some of the nodules dolomite-ankerite is also common, enclosing anhydrite and barite relicts, which are partially silicified. Different levels of ammonium enrichment have been found in each petrofacies type: tuffs and tuffaceous racks contain from 27 to 326 ppm (mean = 139) of NH4\*. Underlying arkosic sandstones with authigenic K-feldspar contain NH4\* ranging from 48 ppm to 191 ppm (mean = 124), The NH<sub>4</sub><sup> $\star$ </sup> was probably derived from decay of organic matter in the evaporitic environment of deposition and its incorporation into feldspar and illite as they formed from unstable volcanic glass, sanidine, plagioclase, and vitric volcanic fragments. This transformation could have occurred via the intermediate phases of smectite and zeolites. The tuffaceous racks also have a high content of B, ranging from 61 ppm to 170 ppm (mean = 101). However, high levels of B are not positively correlated with high levels of  $NH_4^+$  in the samples, Both B and  $NH_4^+$  can be contained in either K-feldspar or illite, but it is not possible to know how much is present in each mineral without separating the minerals. Comparison of spidergrams of the tuffaceous rocks with those in the underlying arkosic sandstones indicates similar patterns with positive anomalies in La, Sm, and Y, and negative in Nb, P, Ti, and Yb, although the tuffaceous rocks are slightly richer in total REE. These data suggest that the distribution of REE must also be controlled by weathering and diagenetic reactions, and cannot be used for discrimination between volcanic and nonvolcanic sandstones.

MARTINI, R., GIROD, F. and ZANINETTI, L., 1998. Découverte de foraminifères et confirmation de l'âge Norien et Rhétien du Trias des Préalpes Médianes Plastiques (Massif des Cornettes de Bise, Préalpes du Chablais, Suisse et France). Eclog. Geol. Helv., 91: 69-74.

Late Triassic (Norian to Rhaetian) foraminifers are recorded from the area of Cornettes de Bise, Préalpes Médianes plastiques, Préalpes du Chablais, Switzerland and France. They belong to *Agathammina austroalpina* Kristan-Tollmann & Tollmann, 1964, and *Hoyenella inconstans* (Michalik, Jendrejakova & Borza, 1979). This microfauna, typical of the NorianRhaetian alpine Neotethys, allows to confirm the age of the Dolomies blondes and Plan Falcon formations, which overlie the Carnian evaporates of the decollement surface of the Nappe des Préalpes Médianes plastiques.

MARTINI, R., ZANINETTI, L., CORNEE, J.J., VILLENEUVE, M., TRAN, N. and TA, T.T., 1998. Découverte de foraminifères du Trias dans les calcaires de la région de Ninh Binh (Nord-Vietnam). C.R. Acad. Sci., Sér. II, 326: 113-119.

Benthic foraminifers have been discovered in the limestones of the Dong Giao Formation, Ninh Binh area (Song Da Terrane, North Vietnam), deposited on a wide, subsident, shallow water carbonate platform. The foraminifers are of lower Triassic (?) to Anisian age; they show affinities to coeval microfaunas from North Malaysia and the South China Block suggesting connections during the Triassic between the different continental blocks of the Indochina Peninsula.

MASI, U., TUCCI, P., MENICHINI, G. and AZZARO, E., 1996. Chemostratigrafia e petrografia della parte superiore della formazione Dolomitica Triassica di Filettino (Monti Simbruini, Lazio). Geol. Romana, 32: 25-33.

MCINNES, S.J. and PUGH, P.J.A., 1998. Biogeography of limno-terrestrial Tardigrada, with particular reference to the Antarctic fauna. J. Biogeogr., 25: 31-36.

The Tardigrada is a cosmopolitan phylum of pre-Pangaean origin, yet tardigrade families and genera show distinct biogeographic components isolated by two major geological events. Separate Laurasian and Gondwanan familial clusters correlate with the Triassic disintegration of Pangaea, while discrete Antarctic. Australian and New Zealand familial/generic clusters relate to the subsequent Jurassic/Cretaceous disintegration of Gondwana.

MCLOUGHLIN, S. and DRINNAN, A.N., 1997. Fluvial sedimentology and revised stratigraphy of the Triassic Flagstone Bench Formation, northern Prince Charles Mountains, East Antarctica. Geol. Mag., 134: 781-806.

The Flagstone Bench Formation ranges in age from earliest Triassic to Norian (Late Triassic) and is exposed in the Beaver Lake area of the northern Prince Charles Mountains. This sandstone-dominated formation rests conformably on the Bainmedart Coal Measures and represents the upper part of the Permian-Triassic Amery Group. It is divisible into three members: the Ritchie, Jetty and McKelvey members (in ascending order). Nine sedimentary facies assignable to three facies associations (major channel, crevasse/fan and flood-basin deposits) are recognized within the formation. Ritchie Member sedimentation took place during a transition from consistently hygric to seasonally dry conditions and the unit comprises sandstone-dominated, sheet-like channel deposits interspersed with few, thin, mottled, haematiterich flood-basin siltstones. Deposition took place under fluctuating discharge conditions chiefly within the channel tracts of axially (NW/NE) flowing, lowsinuosity braided rivers. The Jetty Member shows a gross upward-fining profile dominated in the lower part by poorly sorted pebbly sandstones and in the upper part by ferruginous mudcracked siltstones, mottled palaeosols, calcrete and thin massive sandstone sheets. This unit reflects deposition of easterly directed alluvial fans and extensive flood-basin silt under a semi-arid climatic regime. The Upper Triassic sandstone-dominated McKelvey Member shows a return to axial drainage along the Lambert Graben with sedimentation occurring primarily within low-sinuosity braided channel tracts under wetter climatic conditions.

MCROBERTS, C.A., FURRER, H. and JONES, D.S., 1997. Palaeoenvironmental interpretation of a Triassic-Jurassic boundary section from Western Austria based on palaeoecological and geochemical data. Palaeogeogr. Palaeoclimatol. Palaeoecol., 136: 79-95.

A section spanning the Triassic-Jurassic boundary is described from near the village of Loruns in the Vorarlberg region of western Austria. At Loruns, the uppermost Triassic is characterised by bedded carbonates of the Kössen Formation supporting a stenotopic fauna indicative of a shallow sub-tidal environment of normal marine salinity. The Triassic-Jurassic boundary may be represented as a sequence boundary developed on top of a 1.1 m thick red mudstone of the lower Schattwald Shale, which is interpreted to have been deposited in a marginal marine environment, possibly a mud Rat. Above the boundary beds, the upper Schattwald Shale is characterised by thin-bedded marl and dark limestone beds with an earliest Hettangian macrofauna dominated by epifaunal filter-feeding bivalves, including ostreids, mytilids and oxytomids, which suggest a shallow, subtidal, salinity-controlled environment typical of an interplatform lagoon. Carbonate production rejuvenated in the later Early Hettangian with development of the Loruns oolite, a shallow subtidal oolitic and oncolitic unit bearing echinoderms indicative of normal marine conditions. Low Th/U ratios from the remainder of the section are a result of reduced thorium in carbonate-rich sediments and not from authigenic uranium in anoxic sediments. In the boundary beds evidence for marine anoxia (or dysoxia) is absent where Th/U values, determined by gamma-ray spectrometry, are above 5. The negative excursion in  $\delta^{13}C$  and positive excursion in  $\delta^{18}O$  in the boundary beds may be due to secondary geochemical effects, due to organic diagenesis or the precipitation of caliche during paleosol development. Alternatively, the excursions may reflect a primary geochemical signal recording short-term decline in primary productivity. Comparison in  $\delta^{10}$ O and  $\delta^{13}$ C values between the Kössen Formation and Lorfus oolite indicate no significant long-term geochemical changes are evident in the section and suggest that any environmental perturbations were restricted to the boundary beds and possible sequence boundary.

MEDLIN, L.K., KOOISTRA, W.H.C.F., POTTER, D., SAUNDERS, G.W. and ANDERSEN, R.A., 1997. Phylogenetic relationships of the "golden algae" (haptophytes, heterokont chromophytes) and their plastids. Plant Syst. Evol., Suppl. 11: 187-219.

The phylogenetic relationships of the "golden algae", like all algae, were rarely addressed before the advent of electron microscopy because, based upon light microscopy, each group was so distinct that shared characters were not apparent. Electron microscopy has provided many new characters that have initiated phylogenetic discussions about the relationships among the "golden algae". Consequently, new taxa have been described or old ones revised, many of which now include non-algal protists and fungi. The haptophytes were first placed in the class Chrysophyceae but ultrastructural data have provided evidence to classify them separately. Molecular studies have greatly enhanced phylogenetic analyses based on morpho-logy and have led to the description of additional new taxa. We took available nucleotide sequence data for the nuclear-encoded SSU rRNA, fucoxanthin/ chlorophyll photosystem I/II, and actin genes and the plastid-encoded SSU rRNA, tufA, and rbcL genes and analysed these to evaluate phylogenetic relationships among the "golden algae", viz., the Haptophyceae (= Prymnesiophyceae) and the heterokont chromophytes (also known as chromophytes, heterokont algae, autotrophic stramenopiles). Using molecular clock calculations, we estimated the average and earliest probable time of origin of these two groups and their plastids. The origin of the haptophyte host-cell lineages appears to be more ancient than the origin of its plastid, suggesting that an endosymbiotic origin of plastids occurred late in the evolutionary history of this group. The pigmented heterokonts (heterokont chromophytes) also arose later, following an endosymbiotic event

that led to the transfer of photosynthetic capacity to their heterotrophic ancestors. Photosynthetic haptophytes and heterokont chromophytes both appear to have arisen at or shortly before the Permian-Triassic boundary. Our data support the hypothesis that the haptophyte and heterokont chromophyte plastids have independent origins (i.e., two separate secondary endosymbioses) even though their plastids are similar in structure and pigmentation. Present evidence is insufficient to evaluate conclusively the possible monophyletic relationship of the haptophyte and heterokont protist host cells, even though haptophytes lack tripartite flagellar hairs. The molecular data, albeit weak, consistently fail to present the heterokont chromophytes and haptophytes as monophyletic. Phylogenetic resolution among all classes of heterokont chromophytes remains elusive even though molecular evidence has established the phylogenetic alliance of some classes (e.g., Phaeophyceae and Xanthophyceae).

MENNING, M. and JIN, Y.G., 1998. Permo-Triassic magnetostratigraphy in China: The type section near Taiyuan, Shanxi Province, North China - Comment. Geophys. J. Int., 133: 213-216.

MOSLOW, T.F. and DAVIES, G.R., 1997. Turbidite reservoir facies in the Lower Triassic Montney Formation, west-central Alberta. Bull. Can. Petrol. Geol., 45: 507-536.

The Lower Triassic Montney Formation in west-central Alberta is divided into two major third-order sequences separated by a sequence boundary that correlates to an Early Triassic (Smithian/Dienerian) global eustatic sea level fall. This drop in sea level enhanced masswasting processes responsible for the formation of a turbidite channel and lobe complex within the lowstand systems tract of the upper Montney sequence. This assemblage of facies constitutes the principal reservoir within the Valhalla-La Glace fields. Most of the turbidite reservoirs facies were derived from the reworking of a southwestward-prograding depositional thick, designated the "Cindy Lobe", of the lower Montney sequence that protrudes basinward from the western extension of the Cindy Graben trend. The Valhalla-La Glace reservoir facies are a complex of turbidite channels and downdip lobes deposited in the subaqueous platform of a prograding lowstand shoreline immediately seaward of a continental ramp slope break. The ramp "edge" trends NNW-SSE through the area, and defines the updip depositional limit of turbidite facies. The ramp-edge orientation is probably fault controlled and marks the onset of rapid and abrupt thickening of lowstand facies associations. The origin of these facies is attributed to mass-wasting and generation of sediment gravity flows due to substrate instability at the slope break. Individual turbidite channels likely have undergone headward retreat, moving upslope and creating their own supply of sediment for turbidity flows. Lateral facies relationships expressed by turbidite channel, channel margin and levee/overbank facies provide a predictive model for determining proximity to the turbidite channel axis. The turbidite channel facies association contains the highest quality reservoir in terms of porosity and permeability. Turbidite channels can be amalgamated or crosscut one another, thus inducing vertical and lateral permeability barriers and reservoir heterogeneity. However, there is a lateral continuity in lithofacies along depositional strike and dip, The reservoir facies are more continuous along depositional dip, Turbidite channel, turbidite channel margin, and turbidite lobe facies associations are recognized within the study area. The latter is found almost exclusively within the Glacier field. Facies associations and their lateral variability within the study area are analogous to turbidite channels and lobes from the subaqueous platform of the Fraser River delta, providing a process sedimentologic and geomorphic analogue for the Valhalla-La Glace field reservoir facies.

MOSSMAN, D.J., GRANTHAM, R.G. and LANGENHORST, F., 1998. A search for shocked quartz at the Triassic-Jurassic boundary in the Fundy and Newark basins of the Newark supergroup. Can. J. Earth Sci., 35: 101-109.

Triassic-Jurassic rift basins associated with the breakup of Pangea preserve key geological elements of a defining interval in Earth history. In eastern North America, the Fundy basin is the largest and deepest of nine major early Mesozoic basins of the Newark Supergroup. Overall, the stratigraphic succession is that of continental sediments, primarily fluvial, eolian, and playa lacustrine facies. In the Fundy basin, the Triassic-Jurassic boundary, as palynologically defined, is located within a few metres of the base of the North Mountain Basalt In the Jacksonwald Syncline of the Newark basin, the boundary is precisely correlated to a "fern spike" coincident with geologically rapid Late Triassic extinctions. If meteorite impact is held to account for extinctions at the Triassic-Jurassic boundary, then shocked quartz, the most important and unequivocal evidence of terrestrial impact, should be preserved in strata of the appropriate time interval. Quartz-bearing rocks below the North Mountain Basalt display in thin section up to five different sets of subparallel, subplanar features, which contain numerous tiny voids causing the optical contrast. Within error limits, universal-stage measurements reveal that the features seem to be oriented parallel to rhombohedral planes, which would favour their shock origin. Transmitted electron microscopic observations of the same grains show, however, that the optically visible features are subgrain boundaries. Many perfect dislocations present in the quartz grains clearly indicate tectonic origin. This microstructure is distinctly different from that of shocked quartz, which is free of dislocations and contains amorphous silica lamellae, the so-called planar deformation features. A catastrophic impact event at the Triassic-Jurassic boundary, however, cannot be excluded, because this boundary has not yet been comprehensively investigated.

MOTANI, R. and YOU, H.L., 1998. The forefin of *Chensaurus chaoxianensis* (Ichthyosauria) shows delayed mesopodial ossification. J. Paleont., 72: 133-136.

The hitherto poorly known forefin of *Chensaurus chaoxianensis* (Ichthyosauria) from the Lower Triassic (Spathian) is redescribed on the basis of the holotype and two new specimens. The humerus resembles that of *Utatsusaurus hataii* but is distinctive in having an emarginated anterior margin. The anteroproximal prominence of the radius is well developed, unlike that of other ichthyosaurs. All three specimens have five metacarpals and many phalanges, but only three carpals, which are identified as the ulnare, intermedium, and fourth distal carpal. These specimens show that delayed mesopodial ossification is common among diapsids and is unknown in Jurassic ichthyosaurs, it was lost during the evolution of the lotthyosauria. The osteogenic developmental axis appears to have continued into the fourth digit, as in other amniotes. The ossification of the fifth digit in Early Triassic ichthyosaurs is a metacarpal, rather than a carpal.

MOTANI, R., MINOURA, N. and ANDO, T., 1998. Ichthyosaurian relationships illuminated by new primitive skeletons from Japan. Nature, 393(6682): 255-257.

The Ichthyosauria is a group of reptiles with fish-shaped bodies from the Mesozoic (65-250 million years ago). Their secondary adaptations to aquatic life have obscured their ancestral features, and basal ichthyosaurs, which would be expected to retain these ancestral features (plesiomorphies), are poorly represented in the fossil record. As a result, their relationships to other amniotes have been controversial for over 180 years. New specimens of *Utatsusaurus hataii* from the Lower Triassic (240 Myr ago) of Japan are the first basal

ichthyosaurs to show detailed features for almost the entire skeleton, including previously unknown parts of the skull and pelvic girdle. Computer-assisted retrodeformation of fossil images shows that *Utatsusaurus* retained features of terrestrial amniotes in both the skull and the postcranial skeleton, such as the connection between the vertebral column and the pelvic girdle. Phylogenetic analyses indicate that ichthyosaurs belong in the Diapsida, but that, unlike the sauropterygians, they are not included with the Sauria (the crown group containing lizards, crocodiles, birds and Sphenodon). Recent studies have reported that the addition of ichthyosaurs to the amniote data altered the relationships among basal saurians, but no major clades were affected by the inclusion of ichthyosaurs in our analyses.

MOVSHOVICH, E.V., 1998. Correlation of the Middle Triassic deposits in the North Caspian and Germanic basins. Strat. Geol. Correlation, 6: 119-126.

The analyzed distribution ranges of tetrapods, ostracods, megaspores, and other fossils were used, with due regard for the facial dependence and phylomorphogenetic lineage, to resolve correlation problems concerning Triassic sections of the Germanic and North Caspian basins and southern Cis-Urals, and also to correlate them with the general stratigraphic scale of the Triassic. The Inder and Donguz formations of the North Caspian basin and Cis-Urals are proved to be early-middle Anisian in age. They correspond to the upper Rot (upper Buntsandstein) and lower Muschelkalk (lower-middle Wellenkalk) of the Germanic basin. The Sarpa and Masteksai formations of the North Caspian basin, along with the Yushatyr and Bukobai formations and a lower part of the Surakai Formation, are dated back to the late Anisian- Ladinian and correlated with the uppermost middle-upper Muschelkalk (its Anhydrite Group and Hauptmuschelkalk) and Lettenkeuper of the Germanic basin. A hiatus separating the Inder Formation from the Sarpa Formation and the Kill Formation from the Masteksai Formation in the North Caspian region is coeval with that separating the Donguz and Yushatyr formations of the southern Cis-Urals. It appears to be a consequence of regression also recorded in the middle Muschelkalk (middle Illyrian) of Germany. In the North Caspian basin and Cis-Urals, the hiatus ranges from the middle-terminal Pelsonian to the mid-Illyrian.

NAWROCKI, J., 1997. Permian to Early Triassic magnetostratigraphy from the Central European Basin in Poland: Implications on regional and worldwide correlations. Earth Sci. Planet. Lett., 152: 37-58.

Permian-Early Triassic rocks sampled in 15 outcrops (93 hand samples) and 11 unoriented boreholes (630 hand samples) from the Polish part of the Central European Basin were studied paleomagnetically. In spite of extensive remagnetization, affecting 50% of samples from the boreholes, a magnetic polarity sequence was compiled. The polarity pattern is not only common for many sections from the investigated area but also convergent with the global synthetic magnetostratigraphic scale. The Lower Rotliegend (Early Permian) rocks contain a reversed polarity record, while the Upper Rotliegend (Late Permian)-Early Triassic sediments are characterized by mixed polarity magnetization. Within the Buntsandstein part of that mixed megazone 14 magnetic zones were found. Buntsandstein sedimentation started with a normal polarity zone, which may be compared with that of Early Griesbachian defined in several places in the world. The polarity record noted in the Middle Buntsandstein sediments could indicate significant stratigraphic gaps or condensations near the Middle Buntsandstein polarity with the Early-Middle Triassic magnetostratigraphic data from other basins suggests that the majority or even all the Rot sediments should be included in the Anisian.
NIE, Y.H. and LI, S.G., 1998. Sm-Nd age of syncollisional mafic-ultramafic intrusions in the Dabie Mountains. Chin. Sci. Bull., 43: 160-163.

A Sm-Nd age of  $(228 \pm 42)$  Ma with initial epsilon(Nd) = -16.4 for the Renjiawan pyroxenite intrusion in the North Dabie terrane is reported. This agrees with another Sm-Nd age of  $(230 \pm 44)$  Ma for the Zhujiapu pyroxenite in the same terrane documents that the pyroxenite in the North Dabie terrane are formed during continental subduction time of the Yangtze craton in the Triassic.

NORGARD, G.T., 1997. Structural inversion of the Middle Triassic Halfway formation, Monias Field, northeast British Columbia. Bull. Can Petrol. Geol., 45: 614-623.

The Monias Field is the largest Halfway Formation gas field in northeast British Columbia. The field was discovered in 1975 by the re-entry of the 14-15-82-21W6M well. Monias is located 22 kilometres southwest of the city of Fort Saint John. The field is made up of a series of anticlinal structures, the result of Jurassic reactivation, of late Mississippian-aged faults with structural movement that continued into post-Albian time forming structural closure at the Triassic Halfway Formation level and also overlying Cretaceous reservoirs. Gas is trapped in the Halfway Formation sandstone and coquina reservoirs which were deposited in an upper shoreface setting that have an average porosity of 8.8% and average horizontal permeability of 5.2 md. Diagenetic overgrowths around detrital grains and fine pore-blocking dolomite and quartz crystals are the cause of low flows on drillstem tests during drilling operations. To date there are 33 producing gas wells in the Halfway Formation pools flowing 1239 E(3)m(3)/d (44 MMcf/d) with a cumulative production of 7184 E(6)m(3) (255 Bcf) to July 1, 1996.

NÜTZEL, A., 1998. Über die Stammnesgeschichte der Ptenogiossa (Gastropoda). Berliner Geowiss. Abh., E 26: 1-229.

The phylogeny of the order Ptenoglossa (Gastrapoda, Caenogastropoda) is traced back into the Paleozoic by studying 179 Recent and fossil species. The stem lines of sponge eaters and coelenterate eaters have been separated from each other at least since the Triassic.

OHBA, H., 1997. Mesozoic radiolarian fossils from Kamishima Island, Mie Prefecture, southwestern Japan. J. Geol. Soc. Japan, 103: 1085-1088.

ORCHARD, M.J. and TOZER, E.T., 1997. Triassic conodont biochronology, its calibration with the ammonoid standard, and a biostratigraphic summary for the Western Canada Sedimentary Basin. Bull. Can. Petrol. Geol., 45: 675-692.

A refined conodont biochronology is presented for the Triassic of Western Canada Sedimentary Basin (WCSB). This is supplemented with additional conodont data from Arctic and western Canada and from the western U.S.A. The conodont scale is intercalibrated with ammonoid zones and standard Triassic stages to produce a continental conodont standard with good potential for global application. Griesbachian conodont faunas from the Canadian Arctic are regarded as wholly Triassic rather than as partly Permian. Above the base of the Triassic, a significant change in the conodont fauna is recognized within the upper Griesbachian *Strigatus* Zone. *Neospathodus* species and divergent lineages of "*Neogondolella"* provide indices through Dienerian, Smithian and Spathian strata. *Neogondolella regale* characterizes strata of late Spathian through middle Anisian age and therefore did not develop from early Anisian *Chiosella timorensis*, which is reported for the first time from the *Neogondolella regale* group. Ladinian conodont fauna changes significantly within the Meginae Zone, with *Neogondolella* ex. gr. *constricta* (*N. aldae*) characterizing the early part and Paragondolella ex gr. foliata dominating the later part. Budurovignathus spp. are important hut occur sporadically through the Ladinian. The base of the Carnian is identified by the first appearance of Metapolygnathus. The Ladinian holdovers Paragondolella and Mosherella disappear within the Lower Carnian. In the Upper Carnian, rapid evolution of the Metapolygnathus nodosus group is represented by the M. samueli lineage and leads ultimately to M. primitius, the precursor of Norian Epigondolella. The latest Triassic conodont zonation is highly resolved on the basis of this genus, which ends with Rhaetian Epigondolella mosheri in WCSB.Biostratigraphic constraints are summarized for each of the formations for which conodont and molluscan data are available. Most of this data is from the outcrop belt of northeastern British Columbia where virtually all the present stratigraphic units have diachronous contacts. The Grayling Formation is Griesbachian-Smithian in age, the Toad Formation is Smithian-Ladinian, the Liard Formation is Ladinian, the Ludington Formation is late Ladinian-late Carnian, the Baldonnel Formation is Carnian, the Pardoner Formation is late Carnian-Rhaetian and the Bocock Limestone is Rhaetian. The Grayling-Toad formational boundary is younger in the south than in the north, the Toad-Liard formational boundary is younger in the west, and the base of the Pardonet Formation is younger in the east. On Williston Lake, a remarkable record of Smithian through Carnian conodonts occurs in the Toad and Ludington formations at Ursula Creel;. The top of the Ludington at this locality is the same age as the base of the Pardonet Formation at Black Bear Ridge to the east, which itself is age-equivalent to the top of the Baldonnel Formation farther east at Carbon Creek. At the top of the Triassic succession, the Pardonet Formation is locally equivalent to the Rhaetian Bocock Limestone.

OSETE, M.L., REY, D., VILLALAIN, J.J. and JUAREZ, M.T., 1997. The Late Carboniferous to Late Triassic segment of the apparent polar wander path of Iberia. Geologie en Mijnbouw, 76: 105-119.

A palaeomagnetic study has been carried out at 16 well-dated sites from four areas in central Spain (southeastern Iberian Massif and western Iberian Ranges) in order to constrain the Late Carboniferous to Late Triassic segment of the apparent polar wander path (APWP) of Iberia. 322 samples (218 with useful results) were collected from andesitic rocks at Atienza (287  $\pm$  12 Ma) and from Triassic continental red beds at Molina de Aragon (Anisian-Ladinian), Alcaraz (Ladinian-Carnian), Alcazar de San Juan (Ladinian-Carnian) and Cuevas de Ayllon (Carnian- Norian). Comparison of the palaeomagnetic results from the western Iberian Ranges and from the Iberian Massif indicates that the investigated area of the Iberian Ranges forms part of Stable Iberia. The palaeomagnetic poles obtained in this study and a revision of previous palaeomagnetic data, discarding poles obtained from areas of doubtful stability, show together a gradual and consistent change in latitude and longitude resulting in a coherent segment of the APWP for the Late Carboniferous to Late Triassic time span.

PAL, P.K. and GHOSH, A.K., 1997. Megafloral zonation of Permian-Triassic sequence in the Kamthi Formation, Talcher Coalfield, Orissa. Palaeobotanist, 46: 81-87.

The Kamthi Formation exposed in the west-central part of the Talcher Coalfield is divisible into a Lower and an uppermember. Megafloral assemblage (Assemblage Zone-I) of the Lower Member is dominated by *Glossopteris* in association with *Trizygia*, *Vertebraria* and *Pseudoctenis*. The Upper Member consists of two distinct sets of lithounits, viz., lower and upper beds. Assemblage Zone-II found in the lower beds of Upper Member is characterised by preponderance of *Glossopteris*, associated elements are *Cyclodendron*, *Phyllotheca*, *Stellotheca*, *Trizygia*, *Sphenophyllum*, *Raniganjia*, *Schizoneura*, *Dizeugotheca*, *Neomariopteris*, *Damudopteris*, *Surangephyllum*, *Handapaphyllum*, various glossopterid

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fructifications, scale leaves, etc. The Assemblage Zone-III also from the lower beds of upper Member is dominated by *Glossopteris*, associated elements are equisetaceous stems and *Neomariopteris*. However, the presence of *Lepidopteris* and *?Dicroidium* distinguishes Assemblage Zone-III. Assemblage Zone-IV from the upper beds of Upper Member is characterised by abundance of *Dicroidium*, in association with *Lepidopteris*, *Elatocladus*, *Yabiella* and *Desmiophyllum*. On the basis of megafloral assemblages it has been derived that the Permian-Triassic boundary in the Talcher Coalfield lies somewhere in the lower beds of the Upper Member of the Kamthi Formation.

PANTIĆ-PRODANOVIĆ, S., 1996. Micropaleontologic and biostratigrapiiic characters of Upper Permian and Lower Triassic deposits of northwestern Serbia, Yugoslavia - III, Mt. Vlašić region: localities Panića Cave and Gaj. Ann. Géol. Penins. Balk., 60: 195-218.

The evolution and characteristics of Upper Permian and Lower Triassic sedimentary deposits of Mount Vlašić region, northwestern Serbia, are described. The description is based on the study of geologic columns in the localities of Panića cave, southwestern slope of Vlašić, and Gaj village in the Tamnava valley on northeastern hills of Vlašić.

PAULL, R.K., PAULL, R.A. and LAUDON, T.S., 1997. Conodont biostratigraphy of the Lower Triassic Mackenzie Dolomite Lentil, Sulphur Mountain Formation in the Cadomin area, Alberta. Bull. Can. Petrol. Geol., 45: 708-714.

A Lower Triassic stage boundary (Dienerian-Smithian), defined by conodonts in two adjacent samples, occurs within the Mackenzie Dolomite Lentil of the Sulphur Mountain Formation 5 km south of Cadomin, Alberta, A sparse lower Dienerian (upper Induan) conodont fauna including Neogondolella carinata and Neospathodus kummeli occurs low in the exposed carbonate. An abundant, lower Smithian (lower Olenekian) fauna, 2.1 m higher in the section, consists primarily of Neospathodus pakistanensis and N. waageni. These two species are associated with a major episode of transgression that is recorded worldwide. In North America, both faunas are best represented in the Lower Triassic depocentre of southeast Idaho in the western United States. The apparent absence of upper Dienerian conodonts suggests the Mackenzie Lentil, a complex of offshore shell banks, may contain an interval of slow deposition or an episode of erosion. As a byproduct of this study, a modest revision of stratigraphic nomenclature is proposed. We recommend establishing the lower and upper boundaries of the Mackenzie Dolomite Lentil in its depositional area, respectively, as the upper boundary of the Phroso Siltstone Member and the lower boundary of the Vega Siltstone Member, thus establishing this carbonate lentil as a member of the Sulphur Mountain Formation.

PERTHUISOT, V., AOUDJEHANE, M., BOUZENOUNE, A., HATIRA, N., LAATAR, E., MANSOURI, A., ROUVIER, H., SMATI, A. and THIBIEROZ, J., 1998. Are the Triassic bodies of the "Monts du Mellegue" region (Algero-Tunisian border) diapirs or salt-glaciers? Bull. Soc. Géol. France, 169; 53-61.

The Triassic outcropping in the eastern Maghreb are generally considered to be the visible parts of diapiric structures of halokinetic origin. The interpretation of some of them, located on the Algero-Tunisian border (Monts du Mellegue), as old submarine salt glaciers passively set up during the Albian is neither consistent with the real geometric patterns nor with the rheologic characteristics of the model proposed.

PILLEVUIT, A., MARCOUX, J., STAMPFLI, G. and BAUD, A., 1997. The Oman exotics: A key to the understanding of the Neotethyan geodynamic evolution. Geodin. Acta, 10: 209-238.

The study of the exotic blocks of the Hawasina Nappes (Sultanate of Oman) leads to give apposit data that allow us to propose a new paleogeographic evolution of the Oman margin in: time and space. A revised classification of exotic blocks into different paleogeographical units is presented. Two newly introduced stratigraphic groups, the Ramaq Group (Ordovician to Triassic) and the Al Buda'ah Group (upper Permian to Jurassic) are interpreted as tilted blocks related to the Oman continental mar in. The Kawr Group (middle Triassic to Cretaceous) is redefined and interpreted as an atoll-type seamount. The paleogeography and paleoenvironments of these units are integrated into a new scheme of the Neotethyan rifting history. Brecciae and olistoliths of the Hawasina series are interpreted to have originated from tectonic movements affecting the Oman margin and the Neotethyan ocean floor: The breccias of late Permian age were generated by the extension processes affecting the margin, and by the creation of the Neotethyan oceanic floor. The breccias of late Jurassic and Cretaceous age are interpreted as resulting to the creation of a new oceanic crust (Serail) off the Oman margin.

PUNINA, T.A., 1997. Stratigraphic levels of Triassic limestones of the south Sikhote-Alin (on the basis of coral study). Mém. Géol. (Lausanne), 30: 155-163.

Six stratigraphical units, *Coryphyllia moiseevi*, *Volzeia badiotica, Margarosmilia melnikovae*, *Gablonzeria kipa-risovae*, *Meandrostylis tener*, and *Retiophyllia buonamici* Beds, are suggested for Ladinian-Rhaetian limestones of the South Sikhote-Alin.

PUNINA, A.T., 1997. Stages of the development of Triassic biogenic buildups in Sikhote-Alin. Mém. Géol. (Lausanne), 30: 165-173.

The study of the structure and composition of Triassic invertebrate communities in the Dalnegorsk region of Sikhote-Alin allows the determination of some stages (banks - biostromes - bioherm massifs - reefs) in this region.

RADZINSKI, K.-H., 1997. Das Typusprofil der Calvörde-Folge (Unterer Buntsandstein). Mitt. Geol. Sachsen-Anhalt, 3: 5-16.

The lower succession of the Lower Bunter in the sense of Boigk (1959) is now called "Calvörde-Folge" (= formation) because of its typical character in the region of the Calvörde block (resolution of the Subkommission Perm-Trias 1992). The author presents the lithological profile of the core drilling Mieste 3/61 as a type locality and the geophysical well-logging of the borehole Mieste 21/77, which is situated in a distance of 1,1 kilometers, as a standard log. The lithological sequence can be compared with the indications of the geophysical measurements. The Calvörde-Folge can be subdivided by the oolitic horizons of Schulze (1969). These horizons are the arenaceous oolitic basal beds of ten cycles which fining upwards into more argillaceous sediments. The correlation with the profile Remlingen 5 (Asse-Salt-anticline, Lower Saxony) and other profiles in the southern part of Saxony-Anhalt is discussed.

RAM-AWATAR, 1996. Palynological succession through Gondwana India. Geophytology, 26: 33-38.

On the basis of relative abundance in association with the other characteristic palynotaxa, 9 palynological zones have been identified from Talchir to Pali-Tiki formations in the Gondwana sediments of South Rewa Basin, Madhya Pradesh. The occurrence of a Karharbari palynoflora in the older part of the Berakar Formation suggests the existence of Karbarbari

sediments in the basin. Pali Formation is palynologically cornsidered to be a time-transgressive unit ranging in age from Late Permian to Early-Middle Triassic since the Middle Member contains Raniganj and the Upper Member shows Panchet (= Scythian-Anisian) equivalent palynofloras. The Tiki Formation contains a Late Triassic (Carnic-Noric) palynoflora and is thus younger than the Pali Formation. The earlier suggestion to merge the two as Pali-Tiki Formation is negated here since the two units are lithologically as well as floristically different.

RAM-AWATAR, 1997. Palynological evidence for the Permian-Triassic Boundary in Sohagpur Coalfield, India. Palaeobotanist, 46: 101-106.

The palynological analysis of the Upper Pali sediments exposed along the Chundi River Section is been discussed. The palynotaxa recovered from the above sediments reveal the presence of non-striate disaccate pollen in dominance along with the striate disaccate pollen. Besides, the other significant taxa recorded in the assemblage are *Goubinispora*, *Playfordiaspora*, *Densoisporites*, *Lundbladispora*, *Nidipollenites*, *Satsangisaccites*, *Brachy-saccus*, *Foveosporites*, *Staurosaccites*, *Todisporites*, *Convertuocsisporites* and *Kamthisaccites*. The overall palynoassemblages (I, II) decipher that the Sediments of Chundi River Section have been deposited during Late Permian to Early-Middle Triassic period. Correlation of the palynofloral assemblages suggests that the sediments of the Chundi River Section lie between Nidpur bed and Tiki Formation of the South Rewa Basin.

RAMPINO, M.R. and ADLER, A.C., 1998. Evidence for abrupt latest Permian mass extinction of foraminifera: Results of tests for the Signor-Lipps effect. Geology, 26: 415-418.

The authors used published biostratigraphic data on ranges of fusulinids and other foraminifera from Permian-Triassic boundary sections in the southern Alps, Italy, to test the effects of sampling and species abundance on the record of the timing of the latest Permian extinction, The number of last occurrences of taxa reaches a maximum close to the local base of the Tesero horizon of the Werfen Formation. Taxa that have less than or equal to 15% stratigraphic abundance (percent of sample intervals in which a taxon occurs) show last occurrences well before that level, whereas taxa with more complete records tend to disappear at or close to that level. These results are in agreement with simulations for abrupt extinctions, as opposed to gradual or steplike extinction scenarios, and support predictions of the Signor-Lipps effect, that errors in the end points of biostratigraphic ranges can produce range truncations and apparent gradual decline preceding a sudden extinction boundary. On the basis of estimated sedimentation rates for the Italian sections, the end-Permian extinctions could have been very sudden (less than or equal to 30 ky), and the disappearance of most latest Permian foraminifers was most likely coincident with a world wide ecological stress event, identified by a global negative  $\delta^{13}C$  anomaly that occurs in Italy near the base or within the time-transgressive Tesero horizon.

RENESTO, S. and PAGANONI, A., 1998. A Phytosaur skull from the Norian (Late Triassic) of Lombardy (northern Italy). Riv. Ital Strat. Paleont., 104: 115-122.

An isolated phytosaur skull found in the Calcare di Zorzino (Norian, Late Triassic), near the locality of Endenna (Bergamo Prealps, Lombardy, Northern Italy), is described. The skull lacks the mandible and is severely compressed and distorted in its posterior portion. Nevertheless it is possible to ascribe it to the genus *Mystriosuchus*, likely to *Mystriosuchus planirostris*, already known on the basis of excellent specimens from the Stubensandstein Formation in Germany. This finding represents one of the rare large reptile specimens found in the Norian fossil-bearing localities of Lombardy, along with a new phytosaur yet to be prepared and a nearly two meters long specimen of the placodont *Psephoderma alpinum*.

RETALLACK, G.J. and ALONSO-ZARZA, A.M., 1998. Middle Triassic paleosols and paleoclimate of Antarctica. J. Sed. Res., 68: 169-184.

The Lashly Formation in the Allan Hills of southern Victoria Land, Antarctica, is now at a latitude of 76° S and during the Middle Triassic was at least 70° S. The combined evidence of fossil roots and soils indicates a paleoclimate unusual for such a high latitude. Temperate paleotemperature is indicated by roots, logs, and leaves of woody plants and the degree of chemical weathering and clay formation within the paleosols, Paleosols of the Lashly Formation are more like soils of southern Sweden than those of either Finland or southern Europe. Silt infiltration structures around root traces and in cracks within the paleosols are evidence for a seasonally snowy climate, but there is no evidence of ice wedges or other permafrost features in the paleosols. Other evidence of climatic seasonality includes well-defined growth rings in fossil wood, and abscission scars at the base of fossil leaves. Diverse broadleaf plants, and noncalcareous paleosols, indicate a humid climate with mean annual precipitation of about 1200 mm. Such a wet climate is anomalous for the interior of the supercontinent of Pangea, and such a warm and mildly seasonal climate is anomalous for such high latitudes. This paleoclimatic anomaly may be a lingering effect of global greenhouse initiated at the Permian-Triassic boundary. Paleoclimatic variables calculated here may be useful for recalibrating global paleoclimatic models for the middle Triassic.

RICKEN, W., AIGNER, TH. and JACOBSEN, B., 1998. Levee-crevasse deposits from the German Schilfsandstein. N. Jb. Geol. Paläont. Mh., 1998: 77-94.

Widely-distributed levee-crevasse deposits in the mid Carnian Schilfsandstein of SW-Germany suggest that the established depositional model requires revision. Most of the well-known Schilfsandstein strings represent incised valley-fills, while others are largely non-incised and related to avulsion and crevasse aggradation. The levee-crevasse deposits were found to accompany major sandstone strings of the Schilfsandstein. A dominantly fluvial origin is therefore suggested. Individual flood-event beds are composed of graded sandstone-shale couplets. An idealized sequence stratigraphic model for the Schilfsandstein includes baselevel fall, paleovalley incision and initial fluvial infilling. Rising baselevel in the study area overfilled paleovalleys, causing aggradation of widely-distributed levees. Further case studies are needed to fully decipher the depositional history of the Schilfsandstein.

RIEPPEL, O., MAZIN, J.M. and TCHERNOV, E., 1997. Speciation along rifting continental margins: a new Nothosaur from the Negev (Israel). C.R. Acad. Sci., Sér. II, 325: 991-997.

Middle Triassic Muschelkalk deposits in the Negev (Israel) yielded two endemic species of the sauropterygian reptile genus *Nothosaurus*, one of which is new. These two species of notho-saurs from the Nahal Ramon Basin provide evidence for cladogenesis in a newly opened habitat with resource partitioning between the daughter species. The two Nahal Ramon species are sister-taxa, and jointly they form the sister-clade of *Nothosaurus mirabilis* from the Germanic Muschelkalk. Cladistic analysis of nothosaur interrelationships supports the hypothesis of a Burgundy Gate, linking the Germanic Basin with the developing Neotethys during late Anisian and Ladinian times.

RONIEWICZ, E. and STANLEY, G.D., 1998. Middle Triassic cnidarians from the New Pass Range, Central Nevada. J. Paleont., 72: 246-256.

The authors describe three scleractinian corals and one species of hydrozoan from the New Pass Range, central Nevada, which together constitute the oldest Triassic cnidarian assemblage from North America. They occur in carbonate rocks tentatively correlated with the Augusta Mountain Formation, Star Peak Group. At generic and higher levels, these cnidarians seem representative of early Mesozoic Tethyan faunas and carbonate lithofacies,

but they indicate some endemism. Although the original aragonitic skeletons and microstructure are destroyed by recrystallization, the corals still yield important details allowing their correct taxonomic assignment. They contain the minitrabecular cerioid coral, *Ceriastella variabilis* n.gen., n.sp., the thick-trabecular, thamnasteroid coral *Mesomorpha newpassensis* n.sp., and an undeterminable cuifastreid coral tentatively assigned to *Cuifastraea*. The discovery of *Mesomorpha*, the first occurrence of this genus outside the Jurassic and Cretaceous seas. Also discovered is a remarkably coral-like hydrozoan, *Cassianastraea reussi* (Laube), already known from the Carnian stage of the western Tethys. This is the first occurrence of this species outside the western Tethys.

Ross, G.M., GEHRELS, G.E. and PATCHETT, P.J., 1997. Provenance of Triassic strata in the Cordilleran miogeocline, western Canada. Bull. Can. Petrol. Geol., 45: 461-473.

Siliciclastic strata of Triassic age that are exposed in the Rocky Mountains have been sampled for isotopic studies in order to determine their provenance. Sm-Nd analyses of whole rock shale and sandstone samples from northeast British Columbia and the Bow Corridor of western Alberta are isotopically homogeneous with epsilon Nd values of -6.7 to -10.5 at the time of deposition. These values are part of a distinct isotopic provenance signature that characterizes the Devonian through Jurassic of the miogeocline of western Canada and thus the sources of Triassic sediments are part of a larger provenance signature within the miogeocline. These isotopic data do not support sediment derivation from the exposed Canadian Shield and our present working model is that most of the sediment is detrital material reworked from the Innuitian (Ellesmerian) elastic wedge, No evidence has been found in the Nd data to suggest that magmatic are rocks of Triassic age to the west of the miogeocline (e.g., Quesnellia) made any contribution to the sediment record. U-Pb geochronology of detrital zircons from Triassic sandstones in the Pine Pass and Kananaskis areas are dominated by Precambrian grains with only a few Silurian grains. Comparison with detrital zircons dated from the Devonian Ellesmerian elastic wedge of Arctic Canada show a similar pattern and strengthen the contention that sedimentary strata of the western miggeocline were derived from reworking of Innuitian elastic strata which must have been formerly more widespread and covered the Canadian Shield.

ROUVIER, H., HENRY, B., LE GOFF, M., HATIRA, N., LAATAR, E., MANSOURI, A., PERTHUISOT, V. and SMATI, A., 1998. Paleomagnetic evidence for non-interbedding of the Triassic evaporites within the Albian strata in eastern Maghreb. C.R. Acad. Sci., Sér. II, 326: 363-368.

In northwestern Tunisia, a paleomagnetic study was carried out on Albian levels, objects of controversy. They are considered to be either overturned strata on the limb of diapirs, or in their upright position as the floor of a salt glacier. After correction for the apparent dip, the polarity of the primary magnetization is always reversed, and the magnetization directions are relatively scattered. The Earth's magnetic field was always of normal polarity during the Albian, so that these levels are overturned. The scattering of the magnetization direction points out moreover that the tilting occurred around axes of various orientations. All these observations show that the evaporitic bodies were emplaced in diapirs, and that the notion of a salt glacier interbedded within the Albian sediments has to be given up.

RUSSELL, A.P. and WU, X.C., 1997. The Crocodylomorpha at and between geological boundaries: the Baden-Powell approach to change? Zool. Anal. Compl. Syst., 100: 164-182.

Although the Crocodylomorpha spans a time period of over 200 million years, none of its notable morphological transitions appear to coincide with major geological boundaries. The Crocodylomorpha originated before the extinction event at the end of the Carnian Stage (Late Triassic), concomitant with a shift of locomotor pattern from bipedal erect posture to

quadrupedal erect posture. With the successive divergence of the Sphenosuchia and Protosuchia the majority of features of the extant Crocodylia became established before the end of the Triassic. The Mesoeucrocodylia may have arisen in the early part of the Early Jurassic. The adoption of a more sprawling posture in the Longirostrine Taxa of the Mesoeucrocodylia was associated with a change of way of life from terrestrial to aquatic, probably immediately after the extinction event at the end of the Pliensbachian Stage (Jurassic). The Eusuchia arose in the Early Cretaceous, being characterized mainly by a complete bony secondary palate and the proceely of all vertebrae. The three extant clades most probably all arose before the Cretaceous-Tertiary boundary. Thus, the patterns of cladogenesis and diversification within the Crocodylomorpha indicate that, at least as currently understood, these taxa were prepared for the major environmental and biotic events that occurred during their history. Baden-Powell's motto of "be prepared" (Maynard 1946), taken from his own initials, appears to be an adequate descriptor of the history of the Crocodylomorpha,

SAIDI, A., BRUNET, M.F. and RICOU, L.E., 1997. Continental accretion of the Iran block to Eurasia as seen from late Paleozoic to early Cretaceous subsidence curves. Geodin. Acta, 10: 189-208.

Subsidence analysis is used here to get a better understanding of the Eo-Cimmerian continental accretion to Eurasia of a block (the Iran Block) of Gondwanian origin. The drift of the block from Gondwana to Eurasia is classically considered as a late Triassic event but the lack of unquestionable age evidence leads to investigate the whole Permian to Jurassic history. Indeed, the subsequent Alpine deformation along the proposed suture that should mark the Eo-Cimmerian collision forbids to characterize the collisional event without ambiguity, Moreover, the Iran block is presently represented by different continental slivers that are disconnected from each other, being in places separated by Cretaceous ophiolites, and it makes unclear if one or several blocks should be taken into account. Subsidence analysis is introduced to solve the problem, in the hope that the sedimentary history in any part of the slivers has registered important crustal events such as breakup and collision and that the few well- preserved stratigraphic sections bear the corresponding subsidence signals. Subsidence analysis is thus applied to logically disconnected objects in a manner that departs from its traditional use in basin analysis. However, as it introduces quantified data on the behaviour of the crust in response to tectonics, it was shown to be an efficient tool in sorting out the major events amongst various local evidences for crustal unstability. Major results are: - dating the breakup as Early Permian and collision as Middle Triassic; showing that the accretion of the Iran Block to Eurasia was accompanied by a new breakup that formed a passive margin in Nayband to the Southeast, in contrast to the new active margin that was established along the Abadeh, south-western side; - emphasising the tectonic instability that controlled the continental Jurassic deposits upon the new continent before stabilisation was reached during Late Jurassic-Early Cretaceous times.

SALAJ, J. and PEVNÝ, J., 1998. Fasanian ichthyoliths from the locality Zakázane in the Slovak Karst of the western Carpathians. Zemní plyn a nafta, 42: 269-281.

An abundant assemblage of ichthyolites, dermal denticles and fish teeth is found in Illyrian-Fassanian limestones at the locality Zakázané. In the Fassanian part of the Schreyeralm Limestones also several new species and subspecies are found: *Acodina ovalis* n.sp., *A. triassica depressa* n.ssp., *A. triassica polymorpha* n.ssp. and *A. triassica silicica* n.ssp. *"Mandibula"* multidentata n.sp. could represent a remnant of cephalopod mouth apparatus.

SANDY, M.R., 1998. Loop ontogeny of the Late Triassic (Norian) terebratulid brachiopod *Pseudorhaetina antimoniensis* Sandy from Sonora, Mexico and its taxonomic significance. J. Paleont., 72: 28-35.

Juvenile specimens of the short-looped terebratulid brachiopod genus *Pseudorhaetina* Sandy have been investigated by the use of transverse serial sections. Internal structures indicate a simple brachidium (loop) is present with long flanges in adult specimens; the brachidium is approximately half the length of the dorsal valve; there is no complex loop metamorphosis in the central cavity of the brachiopod (i.e., no median septum). This combination of characters presents a taxonomic problem - *Pseudorhaetina* can neither be referred with confidence to superfamily Terebratuloidea, nor superfamily Loboidothyridoidea. Consequently *Pseudorhaetina* is, for the time being, assigned to a new and as yet unnamed superfamily representing a previously unrecognized part of the post-Paleozoic recovery and reradiation of Mesozoic articulate brachiopods (Rhynchonellata of Williams et al., 1996).

SCHÄFER, P. and GRANT-MACKIE, J.A., 1998. Revised systematics and palaeobiogeography of some Late Triassic colonial invertebrates from the Pacific region. Alcheringa, 22: 87-122.

Revision of type and additional material of Upper Triassic colonial organisms from New Zealand, New Caledonia, Timor, Siberia, Canada and Chile, previously interpreted as Bryozoa or Cnidaria, provides new insights into their palaeobiology, systematic affinity and palaeobiogeography. Heterastridium conglobatum Reuss remains of uncertain hydrozoan affinity, and could be spheractinoidean, hydroidean, or even milleporine. H. conglobatum disciforme n. subsp. (= "forma" disciforme sensu Gerth) is described from New Zealand. The distribution of Heterastridium in the Murihiku and Todesse terranes of New Zealand-New Caledonia is documented, and it is recorded as ranging through the Middle and Late Norian (Rutherfordi, Columbianus, and Cordilleranus Zones). Its extreme rarity in the Torlesse terrane is thought to be the result of unsuitable facies. "Monotrypella" timorica Vinassa de Regny, described as a bryozoan, is a calcareous demposponge of uncertain family and genus. "M" maorica Wilckens is shown to be the senior synonym of Eoheteropora katzi Morozova. Echeteropora is considered to be a tabulate coral, and is a shown to be of circum-Pacific distribution from Late Triassic to Early Jurassic time. The genus includes the Norian E. maorica (New Zealand-New Caledonian Murihiku terrane, and Kolymskij massif, Siberia), Rhaetian E. caledonica n.sp. (New Caledonia), Toarcian E. tipperi (Henderson & Perry) (British Columbia, Canada), and possibly also an undescribed form from the Early Jurassic of Chile.

SCHWEIGL, J. and NEUBAUER, F., 1997. Semiductile deformation in pelagic limestones at diagenetic conditions. Geol. Carpathica, 48: 361-370.

Semiductile to ductile deformation phenomena within unmetamorphic, fine-grained, pelagic limestones of the Northern Calcareous Alps in the Eastern Alps were studied. The investigated pelagic limestones include the Triassic Hallstatt Limestone, the Liassic Adnet Limestone, the Middle Jurassic Strubberg Marl and the Upper Jurassic Oberalm Limestone. These pelagic limestones and marls display structures related to semiductile to ductile deformation, including shear planes, solution seams, stylolites and dynamic recrystallization similar to structures in protomylonites due to strata-parallel simple shear. The structures preferentially developed along clay-rich layers and along boundaries between more competent marry limestones showing a protomylonitic appearence due to disjunctive anastomosing foliation. Along the boundaries aragonite and fine-grained calcite were dissolved and insoluble clay minerals were concentrated. Increasing strain resulted in the development of a penetrative foliation, generating S-C fabrics even within competent limestone layers. Furthermore, mesoscale out-of- sequence shear planes caused decomposition of competent limestone layers into clasts and nodules. These clasts acted as rigid objects within a more viscous, argillaceous matrix. When ideally oriented, asymmetric pressure shadows were generated around these nodules and a-clasts were developed. The transition from massive limestone beds to nodular layers depends on silt and clay contents. While limestones with low clay content were structurally resistant to deformation, clay-rich limestones were easily deformed. The Adnet and Hallstatt limestones formed decollement horizons accommodating high strain during Cretaceous nappe stacking and thrusting within the Northern Calcareous Alps, while the Strubberg and Oberalm limestones were involved during Tertiary transpressive overprint in large strike-slip faults and thrusting within an associated triangle structure.

SENOWBARI-DARYAN, B. and STANLEY, G.D., 1998. Neoguadalupia oregonensis new species: Reappearance of a Permian sponge genus in the Upper Triassic Wallowa Terrane, Oregon. J. Paleont., 72: 221-224.

The sponge *Neoguadalupia oregonensis* n.sp. is described rom the Upper Triassic Martin Bridge Formation in the southern Wallowa Mountains, Oregon. It is the first authenticated Triassic occurrence of the genus *Neoguadalupia*, previously known from the Permian of South China and suspected to occur in Upper Triassic of Nevada. This discovery provides evidence at the generic level of survival of a Lazarus taxon in an island-are terrane of western North America.

SENOWBARI-DARYAN, B., SEYED-EMAMI, K. and AGHANABATI, A., 1997. Some inozoid sponges from Upper Triassic (Norian-Rhaetian) nayband formation of central Iran. Riv. Ital Paleont. Strat., 103: 293-321.

Some small-scaled Norian-Rhaetian reefs and reef mounds are imbedded within the shales, siltstones and siliciclastic-carbonate deposits of the Nayband Formation in central Iran. These deposits belong to the central Iranian plate as part of the Cimmerian Continent. Most of the biogenic rocks have a biostromal geometry, biohermal constructions are rare. Inozoid, sphinctozoid, and chaetetid sponges are, beside of corals and other reef builders, the most important reef organisms within these bioconstructions. In some reefs a variety of hexactinellid sponges also occur. The following inozoid sponges are described in this paper: *Radioifibra norica* n.sp., *Permocorynella maxima* n.sp., *? Sestrostomella robusta, Marawandia iranica* n.gen., n.sp. and *Enaulofungia ? triassica* n.sp. The first four taxa are among the most abundant sponges have never been reported from the Triassic deposits of this region. *Radiofibra*, until now known only from the Upper Permian of Djebel Tebaga (Tunisia), is reported here for the first time from Triassic rocks. The stratigraphic as well as the paleogeographic distribution of all the genera are discussed.

SHOROKHOVA, S.A., 1997. Late Triassic floras in the Primorye region, Russia. Mém. Géol. (Lausanne), 30: 107-119.

In the Primorye Region, the age of the Triassic plant-bearing deposits is determined by under- and overlying marine layers. The Carnian flora of Primorye is characterized by abundant *Neocalamites, Cladophlebis, Czekanowskia, Phoenicopsis, Pityophyllum, Podozamites, Taeniopteris,* and few ferns Dipteridaceae (only *Clathropteris* and *Hausmannia).* The Norian flora of Primorye is characterized by a dominance of Dipteridaceae (*Clathropteris, Dictyophyllum,* and *Camptopteris*), *Pterophyllum,* significant numbers of *Todites, Sphenobaiera, Baiera, Ginkgoites,* and *Podozamites,* and few *Thinnfeldia, Imania,* and *Tudovakia.* In Primorye, major Upper Triassic nonmarine and near-shore deposits with fossil plants are

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known in the south and southwest, predominantly in the basin of the Razdolnaya River, at the western coast of the Amur Gulf, in the basins of the Barabashevka and Philippovka Rivers, and in the northern Murav'ev-Amursky Peninsula. In the rest of Primorye they occur sporadically.

SMALL, B.J., 1997. A new procolophonid from the Upper Triassic of Texas, with a description of tooth replacement and implantation. J. Vert. Paleont., 17: 674-678.

A new procolophonid, *Libognathus sheddi*, g. et sp.nov. is reported from the Cooper Canyon Formation (Dockum Group; Upper Triassic: lower Norian) near Post, Texas. This is the first published description of an unequivocal procolophonid from the Upper Triassic of the southwestern United States. Some of the distinctive characters of *Libognathus* are the deep dentary, large anteriorly directed foramen on the lateral dentary surface, and the forward projecting coronoid. *Libognathus* provides a good example of tooth replacement and implantation, which are poorly known in procolophonids. The implantation is proto-thecodont, with the teeth set in sockets and firmly anchored by spongy hone of attachment. The stages of replacement are of the typical reptilian pattern. *Libognathus* is closely related to *Hypsognathus* from the Passaic Formation (Norian) of New Jersey, and correlative strata in Connecticut and Nova Scotia.

SMALL, B.J., 1998. The occurrence of *Aētosaurus* in the Chinle Formation (Late Triassic, USA) and its biostratigraphic significance. N. Jb. Geol. Paläont. Mh., 1998: 285-296.

The Aetosaur genus *Aētosaurus* O. Fraas is reported for the first time from the Chinle Formation (Upper Triassic: Norian) of Colorado, USA. The Colorado specimens are closely allied to *A. ferratus* from Germany based upon many diagnostic characters. These include paramedian armor plates with a low longitudinal keel and a radiating pitting pattern, and lateral plates with a more medially situated longitudinal keel. This find extends the known geographic range of this cosmopolitan aetosaur, and can possibly be used as an important biostratigraphic marker for Norian age continental deposits.

SOPEÑA, A. and SANCHEZ-MOYA, Y., 1997. Tectonic systems tract and depositional architecture of the western border of the Triassic Iberian Trough (central Spain). Sed. Geol., 113: 245-267.

During the Permian and Triassic, a sedimentary wedge developed overlying a listric normal fault on the western border of the Iberian Trough, central Spain. An area was selected for study that provides optimal conditions for a detailed analysis to be made of relationships between geometric strata arrangements, tectonic control and sedimentary responses. The excellent quality of the outcrops allows the observed patterns of strata to be related to fault growth and development of the basin. The recognition and mapping of local discontinuities throughout the study area were possible. Packages of similar strata with different angularity can be discerned between the two main discontinuities. Geometrical relationships can be established for depositional unit boundaries. The architectural style and sediment dispersal patterns, interpreted as the result of interactions between sedimentation and tectonics, are integrated into a three-dimensional tectono-sedimentary facies model to explain the basin's stratigraphic successions. As the basic control over the spatial distribution and temporal evolution of the basin's infilling is interpreted to be tectonic, the rift-related, three-dimensionally linked depositional systems recognized might be defined as tectonic systems tract. Five such tracts are recognized and related to specific phases of tectonic development.

SPRAY, J.G., KELLEY, S.P. and ROWLEY, D.B., 1998. Evidence for a late Triassic multiple impact event on Earth. Nature, 392: 171-173.

Evidence for the collision of fragmented comets or asteroids with some of the larger (jovian) planets and their moons is now well established following the dramatic impact of the disrupted comet Shoemaker-Levy 9 with Jupiter in 1994. Collisions by fragmented objects result in multiple impacts that can lead to the formation of linear crater chains, or catenae, on planetary surfaces. Here we present evidence for a multiple impact event that occurred on Earth. Five terrestrial impact structures have been found to possess comparable ages (~214 Myr), coincident with the Norian stage of the Triassic period These craters are Rochechouart (France), Manicouagan and Saint Martin (Canada), Obolon' (Ukraine) and Red Wing (USA). When these impact structures are plotted on a tectonic reconstruction of the North American and Eurasian plates for 214 Myr before present, the three largest structures (Rochechouart, Manicouagan and Saint Martin) are co-latitudinal at 22.8° (within 1.2°, ~110 km), and span  $43.5^{\circ}$  of palaeolongitude. These structures may thus represent the remains of a crater chain at least 4,462 km long. The Obolon' and Red Wing craters, on the other hand, lie on great circles of identical declination with Rochechouart and Saint Martin, respectively. We therefore suggest that the five impact structures were formed at the same time (within hours) during a multiple impact event caused by a fragmented comet or asteroid colliding with Earth.

SRIVASTAVA, S.C. and MANIK, S.R., 1996. Reconsideration of *Savitrispermum* from Triassic of Gondwanas. Geophytology 26: 1-11.

Study of additional specimens of *Savitrispermum crateriformis* has furnished new data to interpret the structural organisation of the seed. On the basis of details of the cutinized membranes of this seed-genus, a reconstruction has been suggested. The distribution of the taxon throughout the gondwanic continent has been dealt with. The botanical affinities have been ascertained with the pteridosperms on the relationship of *Savitrispermum* with that of *Umkomasia* a seed frucfification quite frequent in *Dicroidium* flora and its biostratigraphical significance has been discussed.

SRIVASTAVA SURESH, C. and JHA, N., 1997. Status of Kamthi Formation: biological and palaeobotanical evidences. Palaeobotanist 46: 88-96.

On the basis of lithological, palynological and megafloral data the status of Kamthi Formation has been reviewed. Hitherto known Kamthi Formation which was said to be a timetransgressive, unit (Permian-Triassic) actually represents a Triassic sequence overlying Permian sediments equivalent to Raniganj Formation. Presence of Permian taxa, viz., *Glossopteris, Vertebraria* and *Phyllotheca* in red claystone, ferruginous sandstone/shale unit (= Upper Member, Kamthi Formation) represent only the continuations of Permian taxa into the Triassic.

STRECKEISEN, A., AMSTUTZ, G.C. and DESMONS, J., 1998. The metabasites of Col Saflisch, Monte Leone cover (lower Penninic nappes, Valais): island arc andesitic basalts? Schweiz. Min. Petr. Mitt., 78: 147-155.

A basic bloc, a few tens of meters in length, from the Monte Leone cover (lower Penninic Alps) contains prasinites-ovardites and breccias often rich in varioles or bubbles. The stratigraphic age of the block is considered to be Triassic. The chemical composition is that of are tholeiite.

TRIPATHI, A., 1996. Early and Late Triassic palynoassemblages from subsurface Supra-Barakar sequence in Talcher Coalfield, Orissa, India. Geophytology 26: 109-118.

Lithologically the bore hole TP-8 from the northeastern region of Talcher Coalfield, Orissa intersects the Talchir, Karharbari, Barakar and Supra-Barakar formations. The contact between Barakar and Supra-Barakar has been marked at 368.00 m depth. The palynoflora (Assemblage-I) recovered from the lithologically classified Barakar Formation has shown the presence of a distinct Late Permian affiliation when compared to the Late Permian Raniganj assemblages of the Raniganj Coalfield. A distinct and sharp palynofloral break is recorded at the commencement of the Supra-Barakar sequence. The quantitative representation of characteristic palynotaxa and totality of the palynoassemblage reveal the presence of three distinct assemblages in the Supra-Barakar sediments. The Assemblage II and III at 350.00 and 334.00 to 307.30 meters respectively represent Early Triassic while Assemblage IV at 238.30 to 151.30 meter depth reveals Late Triassic age connotation. The presence of acritarchs in appreciable frequencies in Triassic assemblage is recorded for the first time from India.

TRIPATHI, A., 1997. Representation of acritarchs across the Permian-Triassic Boundary in India. Palaeobotanist, 46: 112-117.

The paper deals with the review of published as well as new data on acritarchs from the Late Permian and Early Triassic sediments of peninsular India. Acritarch representation in terms of form diversity and quantitative acme phase is assessed. From the present state of knowledge the Acritarcha Group shows high form diversity during latest Permian with high quantity in South Rewa and Rajmahal basins and Godavari Graben. During Early Triassic low to medium form diversity is observed in Damodar and South Rewa Gondwana basins. During late Early Triassic high form diversity and high quantity is represented in Talcher Coalfield. The record of *Micrhystridium, Cymatiosphaera* and *Veryhachium* in the Late Permian and *Muraticavea* in Early Triassic sediments significantly points towards transgression of sea during Late Permian and late Early Triassic in India although no physical data is available.

URLICHS, M., 1997. Die Gattung *Ceratites* (Ammonoidea) aus dem Muschelkalk der Provence (Mitteltrias, Südost-Frankreich). Stuttgarter Beitr. Naturk., Ser.B (Geol. Palāont.), 252, 22 pp.

*Ceratites (Austroceratites) toulonensis* from the Muschelkalk of the Provence (SE France), known since a long time, is revised. Furthermore, from the same beds *Ceratites (Cycloceratites) cf. laevigatus,* characteristic of the *enodis* Zone in the Germanic Basin, is described. Therefore, the *Ceratites-bearing* beds of the Provence and the *enodis* Zone are correlated. The occurrence of the conodont *Budurovignathus truempyi* in these beds indicates a Lower Ladinian age (Middle Triassic).

URLICHS, M. and KURZWEIL, W., 1997. Erstnachweis von *Flexoptychites* (Ammonoidea) aus dem Oberen Muschelkalk (Mitteltrias) Nordwürttembergs. Stuttgarter Beitr. Naturkunde, Ser. B (Geol. Paläont.), 253, 8 pp.

*Flexoptychites angustoumbilicatus* is described for the first time from the *spinosus* Zone of Gundelsheim/Northern Württemberg. In the Alps the genus *Flexoptychites* has a range as far as the top of the Nevadites-(= Secedensis)-Zone. At the top of this standard zone the Anisian/Ladinian boundary should be fixed according to the proposal of Brack & Rieber (1993) und Brack et al. (1995).

VAVILOV, M.N. and ARKADIEV, V.V., 1998 Ammonoid Remains in the Body Chambers of the Late Carnian Ammonoid *Proarcestes* from Kotel'nyi Island (New Siberian Islands). Paleont. Zhurn., 1998(2): 34-39.

The ontogeny of the Late Carnian ammonoid genera *Neosirenites, Proarcestes*, and *Discophyllites* has been studied. A five-lobed primary suture was noted in the genus *Proarcestes*, and consequently it was referred to the Ammonitida, rather than to the Ceratitida.

VECSEI, A., 1998. A sandy tidal coast in the uppermost Muschelkalk and the origin of the Muschelkalk/ Keuper boundary in the southwestern Germanic basin. Geol. Rundsch., 86: 835-851.

A tidal coast is documented in mixed siliciclastic and carbonate sands of the uppermost Muschelkalk (Middle Triassic) along the southwestern margin of the Germanic basin in Luxembourg. The coastal sediments are vertically and laterally stacked channel fills, interpreted to have formed in a tidal flat environment. The channel fills overlie carbonates of a shallow subtidal ramp. The strong progradation of the tidal flat indicates deposition during a late stage of sea-level highstand, but before sea-level fall. In their upper part, the channel fills are overprinted by a thick paleosol, which resulted from subaerial exposure around the time of the Muschelkalk/Keuper boundary. The exposure and formation of the paleosol in the subtidal coastal sediments and, in basinward sections, the deposition of dolomicrites above the Muschelkalk/Keuper boundary in the lowermost Keuper both indicate a sea-level fall.

VISSER, J.N.J. and PRAEKELT, H.E., 1998. Late Palaeozoic crustal block rotations within the Gondwana sector of Pangea. Tectonophysics, 287: 201-212.

From the Late Carboniferous to the onset of the Triassic, Gondwana was transected by several major shear systems the location of which was controlled by weak zones joining the ancient cratons. These shear systems subdivided Gondwana into mega-blocks each of which experienced rotational motions at different angular speeds. Collisions between Gondwana and Laurussia in the north and between Gondwana and the palaeo-Pacific Plate in the west resulted in a counterclockwise rotation for the Gondwana mega-blocks during the latest Carboniferous and Early Permian. These rotational motions led to the opening of fault- controlled basins along shear zones in the interior of Gondwana and a 10,000 km long transtensional basin system partly inboard of the convergent margin of the supercontinent. Southward propagation of the collision zone between Gondwana and the palaeo-Pacific Plate during the Late Permian and Early Triassic caused the mega-blocks within Gondwana to rotate clockwise. Except for the Tethys Sea margin of Gondwana, these motions increased the compressional stresses within the interior of the supercontinent resulting in crustal uplift and the formation of the Gondwanan and New England fold belts. The primary driving mechanism of the rotational plate motions was collisional tectonics during periods of plate-boundary reorganisation. Temporal changes in the motions of the mega-blocks are believed to be linked to the greater relevance of the mantle convection system during the Mesozoic and which culminated in the breakup of the supercontinent.

WANG, W-P. And GRANT-MACKIE, J.A., 1997. The sporo-pollen assemblages of the Late Triassic and Early Jurassic in New Zealnd and their correlation between China and New Zealnd. In: Zhang, W.-P., Grant-Mackie, J.A. and Yao, H.Z., Late Triassic-Early Jurassic stratigraphy of the Circum-Pacific Region, China and New Zealnd, 2: 1-70. Seismological Press, Beijing. WARREN, A., 1998. *Laidleria* uncovered: a redescription of *Laidleria gracilis* Kitching (1957), a temnospondyl from the Cynognathus zone of South Africa. Zool. J. Linn. Soc., 122: 167-185.

The holotype skull of *Laidleria gracilis* Kitching has been prepared from the dorsal surface, and the skull disarticulated from the vertebral column to repose the occiput. Unexpected features of the dorsal skull roof are the absence of an otic notch and tabular horn. The occiput has reduced paroccipital processes with extremely small or absent posttemporal fenestrae as a consequence of the lack of the tabular horns. Both stapes are in place with their distal ends anterior to an exceptionally deep occipital flange formed by ventral processes from the postparietals, tabulars, squamosals and quadratojugals. They thus abut the ventral surface of the skull roof rather than a tympanum. The vertebrae have well ossified, almost spool-shaped, intercentra associated with small, paired, pleurocentra. It is concluded that *L. gracilis* should be left in its own family, the Laidleriidae, which may prove the sister group to the Rhytidosteidae.

WIGNALL, P.B., MORANTE, R. and NEWTON, R., 1998. The Permo-Triassic transition in Spitsbergen:  $\delta^{13}C_{erg}$  chemostratigraphy, Fe and S geochemistry, facies, fauna and trace fossils. Geol. Mag., 135: 47-62.

New  $\delta^{13}C_{\mbox{\scriptsize org}}$  analyses of two boundary sections between the late Permian Kapp Starostin Formation and the early Triassic Vardebukta Formation of western Spitsbergen confirm field evidence that their contact is a conformable one. Thus, contrary to previous reports, some Spitsbergen sections contain a complete record of the environmental and faunal changes during the crisis interval of the end Permian mass extinction. No environmental deterioration is recorded in the late Permian until near the end of the terminal Changxingian Stage, whereupon the abundant siliceous sponge fauna of the Kapp Starostin Formation disappears along with the deep-burrowing fauna responsible for the Zoophycus trace fossil. A low diversity dysaerobic trace fossil assemblage is briefly developed before a transition to finely laminated, pyritic facies immediately beneath the Permo-Triassic boundary. Analysis of the S/C ratios from the laminated strata suggests that free H<sub>2</sub>S was present in the water column (euxinic conditions) even in relatively nearshore settings subject to storm sandstone deposition. The mass extinction crisis in Spitsbergen is therefore coincident with the extensive development of oxygen-poor conditions in the water column and compares closely, both in timing and nature, with the crisis seen in lower latitude Tethyan settings. However, the subsequent aftermath and recovery in the Boreal sections of Spitsbergen was more rapid than in Tethys. Thus, a shoreface sandstone body within the Dienerian Stage contains an appreciable diversity of fauna (by the standards of the early Triassic), including bryozoans, calcareous algae and deep infaunal bivalves, that suggests the marine ecosystem recovery began earliest in higher palaeolatitudes.

WITHJACK, M.O., SCHLISCHE, R.W. and OLSEN, P.E., 1998. Diachronous rifting, drifting, and inversion on the passive margin of central eastern North America: An analog for other passive margins. AAPG Bull. 82: 817-835

Integration of new data with existing information indicates that the tectonic development of the passive margin of eastern North America between the Carolina Trough and Scotian Basin was considerably more complex than the classic two-stage, rift-drift model. First, the transition from rifting to drifting was diachronous, in the southeastern United States, the rift-drift transition occurred after the Late Triassic synrift deposition and before eastern North America magmatism in the earliest Jurassic (200 Ma). In maritime Canada, the rift-drift transition occurred after eastern North America magmatic activity and synrift deposition in the Early Jurassic and before postrift deposition in the early Middle Jurassic (185 Ma). Second, the deformational regime changed substantially after rifting on both the southern and northern segments of the margin. Generally, northwest-southeast postrift shortening replaced northwest-southeast synrift extension. Northeast-striking reverse faults formed, and many of the rift-basin boundary faults had reverse displacements. In the southeastern U.S., the change in the deformational regime occurred in the Late Triassic-Early Jurassic during the rift-drift transition, Simultaneously, diabase sills and dikes, many striking nearly perpendicular to the trend of the rift basins, intruded the continental crust; and a massive wedge of volcanic or volcaniclastic rocks developed near the continent-ocean boundary. In maritime Canada, the change in the deformational regime occurred during or after the Early Jurassic and before or during the Early Cretaceous; that is, during the rift-drift transition or early stages of sea-floor spreading.

XIAO, C., LI, W. and HU, M., 1997. Early Triassic ecostratigraphy and paleogeographic character of Jianghan Basin. Acta Sediment. Sinica, 15: 85-91.

The Early Triassic evolution of sea level and paleogeography are discussed based on the analysis of the habitat type of twenty of the early Triassic communities of Jianghan Basin and the crosswise extent of communities of every age, furthermore the Early Triassic ecosystem is divided into six evolution stages. Based on the study of the Early Triassic ecostratigraphy of Jianghan Basin, the authors have firstly established the Early Triassic ecostratigraphic system of Jianghan Basin, which contains twenty community zones, ten community formations and three community groups. Their distributions, compositions, ecologic environment evolutions as well as top and bottom boundary lines are expounded in this paper.

YANG, R., 1997. New advances in the study of the Triassic strata in central Guizhou. J. Stratigraphy. 21: 141-145.

During the investigation in the central Guizhou area, a series of rhythmic layers were found in the Permian-Triassic transitional bed. Based on lithofacies, mineralogy, geochemistry, stratigraphy and paleontology, these rhythmic layers are regarded to be the products of deposition of a distant volcaniclastic gravitational flow, and are placed in the basal Triassic, based on the study of paleontology, sedimentology and stratigraphy. Abundant conodonts were found above and below the "Dawan Member" of the Anshun Formation. Based on lithological and paleontological characteristics, the "Dawan Member" is placed at the top of the Daye Formation in this paper. The Triassic terrigenous clastics came from the Jiangnan Old Land. The beds containing ammonoids and bivalves are the event sedimentary beds of turbidity currents.

YIN, H.F., 1997. The subsidence history of the northern Hyblean plateau margin, southeastern Sicily - Final report of IGCP project 359 (Correlation of Tethyan, Circum-Pacific and marginal Gondwanan Permo-Triassic). Episodes, 20: 204-206.

YOUNG, F.G., 1997. Iconoclastic view of mid-Triassic stratigraphy, Umbach-Wargen area, British Columbia. Bull. Can. Petrol. Geol., 45: 577-594.

The dominant view of Middle Triassic stratigraphy in western Alberta and northeastern British Columbia includes westward regression, via offlapping parasequences, continuously from the Doig Formation upward through the Halfway and the lower part of the Charlie Lake Formation to the Coplin Unconformity. The Doig-Halfway contact is arbitrarily picked within a succession of stacked parasequences. Some writers portray the Charlie Lake Formation as mildly unconformable above the Halfway; others depict the contact as conformable and time-transgressive, as the Charlie Lake is interpreted as a mainly nonmarine sabhka facies overlying regressive Halfway beach sands. In the Umbach-Wargen area of British Columbia,

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few of these entrenched models seem to apply; instead, the Halfway appears to overlie unconformably a truncated Doig Formation, forming a succession of stacked retrogradational and/or transgressive parasequences, which onlap progressively towards the northeast a structural high on the Doig. In addition, the Charlie Lake Formation forms a succession of widespread, correlatable parasequences, more akin to those deposited in shallow marine conditions rather than nonmarine. These strata overlie the beach sands of the Halfway Formation as its coeval, marine offshore equivalent. If the Charlie Lake Formation is an offshore, basinward equivalent to some of the Halfway shoreline sands, then depositional models have to be re-examined.

ZAKHAROV, YU.D., 1997. Ammonoid evolution and the problem of the stage and substage division of the Lower Triassic. Mém. Géol. (Lausanne), 30: 121-136.

The most popular stage scheme of the Lower Triassic proposed by Kiparisova and Popov may be significantly improved by division of the uppermost stage into two fundamentally different substages. The binomial composition of the Lower Triassic, with a single substage (stage) in the lower member, but with two sharply pronounced substages within the uppermost one, reflects more or less satisfactorily the triphasic character of evolution of the Early Triasic biota.

ZAKHAROV, YU.D., 1997. Carnian and Norian *sirenitid* ammonoids of the north-western circumpacific and their role in the Late Triassic faunal successions. Mém. Géol. (Lausanne), 30: 137-144.

Information on distribution of the Late Triassic sirenitid ammonoids and their associations in North East Russia, Trans-Baikal, Khabarovsk and Primorye regions, and Japan, some data on correlation of the Upper Triassic and geographical differentiation of the Triassic ammonoids and bivalves in the Far East are given. *Monotis ochotica* (Keyserling) and some other Norian bivalve and brachiopod species can not be always used, apparently, as indicator of faunistic associations of Boreal type in north-western circum-Pacific.

ZHAI, X.M., DAY, H.W., HACKER, B.R. and YOU, Z.D., 1998. Paleozoic metamorphism in the Oinling orogen, Tongbai Mountains, central China. Geology, 26: 371-374.

The collision of the Sino-Korean and Yangtze blocks to form a significant part of China is recorded in the Qinling, Tongbai, and Dabie Mountains. Radiometric ages of the ultrahighpressure metamorphic rocks in the South Qinling orogenic belt suggest that subduction and collision took place during the Triassic Period. Our new <sup>40</sup>Ar/<sup>38</sup>Ar geochronology of units in the North Qinling orogenic belt confirms that high-grade metamorphism and deformation took place also during the Silurian-Devonian and Carboniferous Periods. These results imply that the amalgamation of eastern China was a multistage process extending over at least 200 m.y.

ZHANG, W.Z., HUANG, Y.M. & SONG, G.C. and ZAN, C.L., 1997. Discovery and geologic significance of organic-biogenic secondary freshwater calcite in the Upper Triassic of Shaan-Gan-Ning Basin. Chin. Sci. Bull., 42: 1297-1300.

ZHIDOVINOV, S.N., GROSHEV, V.G., VOLOZH, Y.A. and LIPATOVA, V.V., 1997. Stratigraphy and formation environments of the Upper Permian-Triassic sequence in the Aksu-Kendyrli flexure area (Southern Mangyshlak). Strat. Geol. Correl., 5: 449-457.

Based on complex and voluminous geologic-geophysical data, relationships of pre-Jurassic sedimentary sections in the southern flank of the Southern Mangyshlak depression are outlined. Regional unconformities were established in the section, the main one of which

(pre-late Olenekian) divides Upper Permian-Triassic deposits into two structural stages. It is shown that the Aksy-Kendyrli flexure comprises three carbonate members of different age (Early, Middle, and Late Triassic), every one of which is of interest for oil and gas prospecting. Description and correlation of local stratigraphic units are given and their formation environments are characterized.

ZOLOTUKHIN, V.V., 1997. Permo-Triassic trap magmatism on the Siberian platform: Some problems of age and maximum intensity. Geol. Geofiz., 38: 1773-1781.

Using the available literature data and his own K-Ar datings, the author estimates the general duration of the platform magmatism of basic rocks on the Siberian Platform, including the trap magmatism. Its repeated occurrence is confirmed in a wide range from Late Proterozoic to Late Mesozoic. The bulk of the Siberian traps are, however, of certainly Late Paleozoic-Early Mesozoic age. Upon plotting histograms of K-Ar datings with various subdivision classes, a probable activity duration (few tens of Ma) was estimated for four large regions of the platform as well as the maximum total duration. The maximum activity of trap magmatism of lavas, tuffs, and subvolcanic intrusions approaches the Permian-Triassic boundary. According to new Ar-Ar datings, the minimum duration of activity is about 1-3 Ma for the Siberian traps. The maximum and minimum estimates of the Permo-Triassic magmatism duration suggest one or more volcanic catastrophes, though the minimum duration estimate remains to be confirmed additionally.

ZONNEVELD, J.P., MOSLOW, T.F. and HENDERSON, C.M., 1997. Lithofacies associations and depositional environments in a mixed siliciclastic-carbonate coastal depositional system, upper Liard Formation, Triassic, northeastern British Columbia. Bull. Can. Petrol. Geol., 45: 553-575.

The upper Liard Formation (Middle Triassic, Upper Ladinian) in the Peace River Foothills of northeastern British Columbia comprises a progradational succession of at least eleven parasequences deposited within a mixed siliciclastic-carbonate depositional system on the western margin of the North American craton. Sediments accumulated along a low gradient shoreface-continental ramp within an embayed/restricted portion of the northwestern Pangean continental margin. Thirteen sedimentary facies are recognized within the following three lithofacies successions: (A) progradational elastic offshore/shoreface, (B) progradational mixed-siliclastic carbonate shoreface and (C) mixed siliciclastic-carbonate marginal marine. Lithofacies association A is a coarsening-upwards offshore/lower shoreface succession, locally incised by tidal channels. Lithofacies association B consists of a coarsening-upwards, mixed siliciclastic-carbonate shoreface. Thick bioclastic accumulations within this unit are interpreted as terebratulid brachiopod-echinoid dominated reef mounds. Lithofacies association C consists of a mixed siliciclastic-carbonate intertidal-supratidal succession of mud flats, algal mats, evaporites and minor tidal channels. The terebratulidechinoid reef mounds were initiated by allogenic taphonomic feedback, Storm-generated skeletal concentrations provided "islands" of comparably stable substrate, These islands provided a locus for colonization by rocky substrate-preferring organisms such as terebratulid brachiopods, cidaroid echinoids and articulate crinoids, The Liard reef mounds accumulated during periods of comparably low siliciclastic input to the shoreface, likely during the later stages of a highstand systems tract.

Triassic workers are kindly requested to send reprints or xerox copies of the titles and abstracts (including journal name, volume and page numbers) of their recently published paper to the editor for the "Annotated Triassic Literature". E-mails with all relevant information are also most welcome.

## **GUIDELINES FOR THE SUBMISSION OF MANUSCRIPTS TO ALBERTIANA**

From 1993 onwards ALBERTIANA is published twice a year. Contributions should be sent to the editor. In order to facilitate the production of this newsletter and reduce typing errors, authors are kindly requested to submit their contributions on 3½ inch MS-DOS formatted floppy discs together with a printed hard copy.

Text files should preferably be in WordPerfect 5.1, 6.1, 7.0 or any other kind of word-processing program that can be converted into WordPerfect 6.1 (e.g. Word 6.0 or 7.0); no higher versions! Authors are kindly requested to follow the layout instructions! *If you think that this is too much work, do not expect that the editor does it for you! Manuscripts not prepared according to these guidelines can be rejected.* 

The normal type face is univers 10-point with line spacing 1. The layout of contributions should be in accordance with that of those in the present issue. Titles and author's names are set in univers 14-point bold; paragraph headings are set in univers 10-point bold and centered. References should be cited following the examples in this issue. Reference lists are set in univers 9-point with line spacing 0.9. Do not capitalise authors' names (except for the first letter and the initials) but either use 'small capitals' or the normal typeface. Do not use 'tabs' or extra spaces in reference lists but 'indent + margin release'. Journal titles should be abbreviated.

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Because the mailing costs of floppy discs are now six times higher than the costs of the discs themselves (at least in Germany), floppies cannot be returned. Files can also be submitted as attachments with e-mails. E-mails can be sent to the editor: *kerp@uni-muenster.de*. Sorry, but BinHex-encoded files (MacIntosh) can not be read! Those who do not have the possibility to submit a manuscript in electronic format, are kindly requested to send smooth and clearly typed manuscripts in a 12-point typeface (sans serif) with single line spacing.

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Special attention should be paid to grammar and syntax. Because the editor's administrative assistance has been reduced to virtually zero, linguistic corrections will be minimal. In case of doubt, send your manuscript to a colleague for proof reading. References should be in the format used in the 'Annotated Triassic Literature'. The use of names of biostratigraphic units should be in accordance with the International Stratigraphic Guide:

- "The formal name of a biostratigraphic unit should be formed from the names of one, or preferably no
  more than two, appropriate fossils combined with the appropriate term for the kind of unit in question."
- The writing and printing of fossil names for stratigraphic units should be guided by the rules laid down in the International Code of Zoological Nomenclature and in the International Code of Botanical Nomenclature. The initial letter of generic names should be capitalized; the initial letter of the specific epithets should be in lowercase; taxonomic names of genera and species should be in italics. The initial letter of the unit-term (Biozone, Zone, Assemblage Zone) should be capitalized; for example, Exus albus Assemblage Zone."
- The name of the fossil or fossils chosen to designate a biozone should include the genus name plus the specific epithet and also the subspecies name, if there is one. Thus *Exus albus* Assemblage Zone is correct. After the first mention, the genus name may be abbreviated to its initial letter if there is no danger of confusion with some other genus beginning with the same letter; for example, *Exus albus* may

be shortened to *E. albus*. On the other hand, the use of the specific epithet alone, in lowercase or capitalized, in italics or not (*albus* Assemblage zone, *Albus* Assemblage zone, albus Assemblage zone, or Albus Assemblage zone), is inadvisable because it can lead to confusion in the case of frequently used species names. However, once the complete name has been cited, and if the use of the specific epithet alone does not cause ambiguous communication, it may be used, in italics and lowercase, in the designation of a biozone; for example, *uniformis* Zone."

From: SALVADOR, A. (ed.), 1994. International Stratigraphic Guide. Second Edition. International Commission on Stratigraphic Classification of IUGS International Commission on Stratigraphy. IUGS/GSA, Boulder, Co, p. 66.



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