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CLASSIFICATION AND EVOLUTION OF THE RADIOLARIA

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In the 19th century the Radiolaria were initially classified as an order. After Haeckel’s studies, the taxonomic rank was raised to that of a class. In accordance with our investigation this rank should be regarded as phylum. The establishment of a separate phylum Radiolaria is based on: (1) molecular genetic studies of recent radiolarians, (2) advances in the study of the macrosystem of protists in the last three decades, (3) evolutionary morphological studies of Radiolaria, (4) evidence of the almost simultaneous appearance of five radiolarian classes in the Cambrian.

Phylum Radiolaria consists of two subphyla Phaeodaria and Polycystina. Polycystina includes six classes: Aculearia Afanasieva, emend. Afanasieva & Amon 2003: skeleton consists of spines or bunches of spines, which cross each other at one or more points; Sphaerellaria Haeckel, emend. Afanasieva & Amon 2005: globular porous skeleton; Spumellaria Ehrenberg, emend. Afanasieva & Amon 2005: spherical latticed, reticular, or spongy skeleton; the branching of apophyses on spines caused the appearance of spherical radiolarians; Stauraxonaria Afanasieva & Amon 2005: flattened, convex, or armed skeletons with various shape (discoid, polymorphous, subtriangular, pyramidal, spindellike, and bladed with three, four, five and more blades); Nassellaria Ehrenberg, emend. Afanasieva & Amon 2005: conical, pyramidal, bell-shaped, helmet-shaped, cap-shape or differently shaped external skeleton with pylome; Collodaria Haeckel 1881: large solitary and colonial Polycystina; mineral skeleton often absent, ectoplasm may include tangentially arranged spines or porous shell.

Radiolarians diverged from main protist stem on one of earliest stages of Protista adaptive radiation. In the phylogenesis of the Polycystina subphylum it could be clearly recognized the practically simultaneous occurrence in Cambrian of: (1) primary spiny skeleton of class Aculearia; (2) primary spherical porous skeleton of class Sphaerellaria, and spongy shells of Spumellaria; (3) the first nassellarians from order Pylomariata; (4) the first discoidal members of class Stauraxonaria. Analogously, in the phylogenesis of Phaeodaria subphylum the parallel occurrence of spiny, latticed, porous and lamellar skeletons also is marked.

The development of the skeleton in the extant radiolarians Polycystina and Phaeodaria may occur in various ways and passes several stages: (1) appearance of the skeleton occurs simultaneous on the polysaccharide plates over the entire volume of the organic matrix of the future shell; (2) primary development of the skeleton occurs in two ways: pellicular growth and bridge growth; (3) final stage of the skeletal development is finalized in two ways: bridge growth and rim growth. All types of the skeletal growth may be observed in the same individual at different ontogenetic stages, or one of the patterns may be dominant.

Such evidences as mentioned above, and also the presence in morphology of radiolarians of different classes the various types of primary internal skeleton (hollow sphere, spicule, microsphere) or it rudiments, can be evidence of polyphyletic origin of Radiolaria phylum.

The study was supported by the Program of the Presidium of the Russian Academy of Sciences "Origin and Evolution of the Biosphere" and the Russian Foundation for Basic Research (project no. 04-05-64103).
STAGES IN RADIOLARIAN EVOLUTION IN THE PHANEROZOIC

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Generally, evolution of radiolarian subphylum Polycystina showed periodical cyclical changes from origination to acme to extinction. In a general dynamic model of cyclic evolution of radiolarians in Phanerozoic, simple cycles (steps) are combined into nine cycles of a higher order (stages) characterizing four phases, which are cycles of major order (Fig. 1): Phase I, Early Paleozoic; Stage 1, Cambrian–Silurian; Phase II, Late Paleozoic; Stage 2, Devonian–Early Carboniferous; Stage 3, Middle Carboniferous–Permian; Phase III, Mesozoic; Stage 4, Triassic; Stage 5, Jurassic; Stage 6, Cretaceous; Phase IV, Cenozoic; Stage 7, Paleocene–Eocene; Stage 8, Oligocene–Pliocene; Stage 9, Quaternary. Each evolutionary stage was characterized by considerable changes in composition and number of dominant radiolarian groups.

In the Cambrian-Silurian, 223 radiolarian species appeared with average speciation rate of 1.4 species/Myrs; in the Devonian-Permian, 487 species appeared with average rate 2.9 species/Myrs. The Mesozoic is characterized by highest number of radiolarian species (3328 species) and by maximum speciation rate of 18.8 sp./Myrs. The Cenozoic (excluding recent radiolarians) differs by a sharp reduction in total species to 922 and a reduced speciation rate of 12.8 sp./Myrs. The transition from a cold Paleozoic climate to warm Mesozoic one was marked by an extraordinary extinction of radiolarians: 95.6 % of genera and 97.7 % of species. The transition from a warm Mesozoic climate to cold Cenozoic was accompanied with significant extinction of 96.6% of genera and 99.4 % of species of Mesozoic radiolarians. The beginning of the Holocene epoch was a time of new mass extinction, when 98.2% of genera and 99.2 % of species of Cenozoic radiolarians died out. Absence of high radiolarian biodiversity in the Holocene is distinctly shown as well.

Fig. 1. Change in radiolarian diversity and main events in geological evolution of the Earth: 1 – radiolarian mass extinction; 2 – number of genera (1, 3) and species (2, 4); 3 – marine eustatic events (1-11) and geocratic epochs (A-F); 4 – glaciation (I-IV). Supported by the Russian Foundation for Basic Research (no. 04-05-64103).
HOW RADIOLARIAN STUDIES HAVE HELPED TO EXPLAIN THE PERMIAN-JURASSIC STRATIGRAPHY OF NORTHLAND

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Waipapa Terrane is one of five major Mesozoic basement terranes in the northern and central part of North Island, New Zealand. Waipapa Terrane rocks are dominated by terrigenous greywackes, but include thin sequences of basaltic rocks with minor limestones, radiolarian cherts and hemipelagic green siliceous argillites. These units are part of an accretionary complex that formed along the margin of Gondwanaland during the Middle Triassic to Late Jurassic. A complete “ocean plate stratigraphy” of basaltic rocks, overlying radiolarian cherts and hemipelagic siliceous mudstones followed by trench-fill turbidites and/or sandstones is observed elsewhere in Waipapa Terrane. The terrane is subdivided into a northern, older segment where the oceanic rocks are Permian-Triassic and a southern Triassic-Jurassic complex. New stratigraphic and microfossil (radiolarian and conodont) data from the pelagic–hemipelagic successions in Waipapa Terrane provides basic information on geologic age, facies-age relationships, structure, paleobiogeography and timing of accretion.

In the north, Arrow Rocks and Mahinepua Peninsula in the Whangaroa area, have yielded an excellent Permian to Triassic radiolarian record. Arrow Rocks represents an uninterrupted pelagic-hemipelagic cherts and siliceous mudstone sequence of Late Permian to Middle Triassic age. At Mahinepua, the basal bedded red cherts have not yet yielded any datable radiolarian material but diverse, well-preserved radiolarian faunas in phosphatic concretions in the overlying green siliceous argillite and blue-grey mudstone are Middle to Late Triassic. Middle Triassic high-latitude radiolarian faunas are characterised by abundant species of the genus Glomeropyle (Alta & Bragin, 1999) in the lower green argillites, whereas in the upper green argillites, Late Triassic radiolarian faunas are dominated by spumellarians including many undescribed species of the genera, Capnuchosphaera, Fontinella, Sarla, Kahlerosphaera, Vinassaspongus, and Dumitricasphaera. Similar Late Triassic radiolarians are known from green siliceous argillite on Urupukapuka Island, Bay of Islands.

In the southern segment (Whangarei to Auckland), hemipelagic siliceous green argillites have yielded Mid- to Late Jurassic high-latitude radiolarians. These faunas are dominated by thick-walled multicystoid nassellarians associated with minor spumellarians. In contrast, Late Triassic–Early Jurassic radiolarians from bedded cherts indicate a Tethyan affinity. Overall, successions of the “oceanic plate stratigraphy” in the Waipapa Terrane clearly display a younging polarity from north to south. Paleobiogeographic affinities of the Waipapa green argillite radiolarians suggest that high-latitude conditions prevailed from Middle Triassic to Late Jurassic time along the Gondwanaland margin where accretion took place.
STABLE CARBON ISOTOPE STRATIGRAPHY OF THE TRIASSIC/JURASSIC BOUNDARY SEQUENCE IN MURIHIKU TERRANE AT KAWHIA AND AWAKINO, NEW ZEALAND

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We investigated stable carbon isotope compositions of marine organic matter (δ¹³Corg), the total carbon contents (TOC) and carbon/nitrogen ratios (C/N) of Upper Triassic to Lower Jurassic strata from Kawhia Coast and Awakino Gorge sections, Murihiku terrane, New Zealand. The data were obtained from carbonate nodules sampled (NA-1~34, n=32) in the Kawhia Coast section and siltstone samples (AWA3~20, n=18) in the Awakino Gorge section.

The Triassic/Jurassic (Tr/J) boundary of Kawhia Coast section as indicated by palynoflora (Zhang & Grant-Mackie, 2001) is located lower than that indicated by marine fauna, in the same way as the section at St. Audries Bay in Canada (e.g. Hesselbo et al., 2002). Within the interval the Tr/J boundary at St. Audries Bay is still not precisely fixed, but is at least 10m above a distinctive horizon of well-laminated strata containing small FeS₂ nodules. This same lithofacies is also recognized in the Tr/J boundary section from Awakino Gorge, and corresponds well stratigraphically.

In the Kawhia Coast section, δ¹³Corg values from Upper Triassic and Lower Jurassic strata fluctuate from -28.5 to -27 ‰, with an average value of δ¹³Corg = -27.7‰. However δ¹³Corg within the Tr/J boundary interval indicates large excursions. Above the Tr/J boundary as determined by palynoflora but below the laminated strata, a positive excursion (+1.8‰) is observed followed by a large negative excursion (-3.0‰) within the laminated strata. The former positive excursion has not been detected in the Awakino Gorge section but the later negative excursion is recognized in the same facies as a short-lived negative excursion (-2.8‰). C/N ratios of organic matter in carbonate nodules from Kawhia Coast show wide variation from 20 to 80. On the other hand, C/N ratios of siltstone samples from Awakino Gorge are approximately 7. These facts suggest that the organic carbon source is different from these two sections, which may reflect lithology (carbonate nodule vs siltstone).

Although absolute values are slightly different, the obtained carbon isotope patterns from the Tr/J boundary sequences at Kawhia Coast and Awakino Gorge are similar, and also well correlated to δ¹³Corg excursion patterns from other Tr/J boundary sections, such as St. Audrie’s Bay (Hesselbo et al., 2002), Queen Charlotte Islands, Canada (Ward et al., 2004) and Hungary (Pálfy et al., 2001). These observations suggest that stable carbon isotope stratigraphy around the Tr/J boundary is suitable for correlation on a global scale.
THE PERMO-TRIASSIC BOUNDARY AT NHI TAO, VIETNAM:
EVIDENCE FOR RECURRENT INFLUX OF SULFIDIC WATERMASSES
TO A SHALLOW-MARINE CARBONATE PLATFORM

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A high-resolution chemostratigraphic study of a Permo-Triassic boundary in Cao Bang Province, Vietnam, provides evidence of at least 7 discrete episodes of upwelling of sulfidic watermasses in the eastern Paleotethys during the latest Permian and earliest Triassic.

The 7.5-m-thick Nhi Tao section consists entirely of slightly argillaceous limestone representing oxic, shallow-marine facies of the Debao Platform, one of several carbonate platforms within the Nanpanjiang Basin, located on the southern margin of the South China craton. Upper Permian strata (beds 1-7) are mainly dark-gray, cherty fossiliferous packstones containing a diverse, open-marine fauna, whereas uppermost Permian and Lower Triassic strata (beds 9 and higher) are medium-gray calcimicrobial framestones lacking macrofossils. These facies are separated by a 12-cm-thick oolitic-pisolitic grainstone (bed 8), deposition of which coincided with a major “geochemical event” reflected in (1) an abrupt decline in TOC to <0.1%, (2) the onset of a sustained decline in carbonate δ¹³C, from +2‰ to -1‰ PDB some 3 meters higher in the section, and (3) the first of multiple concentration peaks in total sulfur (mainly pyrite-hosted). The total S record exhibits a total of 7 well-defined concentration peaks over ~5 meters of section, each of which coincides with the onset of a negative excursion in the carbonate δ¹³C record.

These chemostratigraphic patterns are consistent with multiple episodes of upwelling of sulfidic, ¹²C-enriched deep-ocean waters. The first upwelling event was the most intense and resulted in a drastic reduction in primary productivity and the demise of the Late Permian fauna at Nhi Tao; subsequent episodes were less intense but may have contributed to a delay in recovery of the Early Triassic marine ecosystem.

A ten-fold increase in magnetic susceptibility (MS) within bed 9 records an increase in the detrital sediment flux resulting from eustatic fall and consequent erosion. The fact that this “MS event” postdates chemical oceanographic changes recorded in bed 8 is an indication that the end-Permian mass extinction had fundamentally intrinsic causes, and that intensified upwelling and/or upward chemocline excursion preceded and most probably caused subsequent changes in global sea level and climate.

Correlation of the MS record with that from the Meishan D Permo-Triassic boundary GSSP (Zhejiang Province, China) provides the most reliable assessment of the position of the Permo-Triassic boundary in the Nhi Tao section, which is located in the upper half of bed 11. Sedimentation rates were approximately three times greater than at Meishan, and the enhanced stratigraphic resolution thus afforded may be essential to resolution of recurrent, short-duration chemical paleoceanographic events at Nhi Tao.
OCEANIC RECORD OF THE PERMIAN-TRIASSIC CRISIS: VIEW FROM TETHYS (HAWASINA, OMAN) AND COMPARISON WITH PANTHALASSA (ACCRETATE TERRANES)

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The Oman Mountains expose the middle Permian to lower Triassic Buday'ah section of oceanic sediments belonging to the South margin of the Tethys. The tectonically truncated Permian litho-units start with pillow basalts. Above, radiolarites and siliceous shales, 5 to 8 m thick, are dated from late Wordian to late Capitanian (Cordey in Baud et al., 2001). Within the overlying beige siliceous shales, Wuchiapingian in age at its base (Kozur in Richoz et al., 2005), we note the progressive loss of the radiolarian fauna and its replacement by calcareous shale near the boundary. The overlying basal Triassic sediments consist of thinly bedded platy limestones associated with beige shale, about 10 m thick. This unit is overlain by papery limestones (7 m, Smithian?) and olive shales (5 m, Spathian?). Radiolarian recovery forming radiolarites did not occur before Ladinian time on this Tethyan oceanic margin.

The oceanic sediments of the Mino-Tamba terrane from Japan include the boundary within a 15 m interval of black shales intercalated within radiolarian cherts of respectively Late Permian (early Changhsingian) and Early Triassic (Olenekian) ages according to Isozaki (1997). This records an important decrease of siliceous bioproductivity in the Late Permian, within a major anoxia event and followed by a progressive recovery of siliceous planktic productivity in the early Triassic. In the Cache Creek terrane (British Columbia) similar lower Triassic black shales are intercalated between middle Permian and middle Triassic radiolarian cherts (Isozaki, 1997). The recent discovery of an unique, continuous, Permian to Triassic radiolarite sequence at Arrow Rocks, an islet in Northland, New Zealand (Waipapa terrane), indicates that there was no chert gap in the Southern Panthalassa ocean floor and that the mostly red cherts likely show an oxic environment (Takemura et al. 2002).

Comparing our Tethyan oceanic section with published Panthalassa sections shows that all localities display radiolarian cherts as the dominant type strata in the Middle Permian. Up section, successions grade into "boundary shales" and/or black shales of various thicknesses and this change occurs earlier in the Tethys (Wuchiapingian) than in Panthalassa oceanic sections, except in southern Panthalassa where the chert deposition is continuous. The chert gap is of a longer duration in the Tethys (20 My) than in Panthalassa Mino-Tamba terrane (8 My) or Cache Creek terrane (12 My). There is no chert gap in the Southern Panthalassa. During the Early Triassic, the Tethyan margin exports microbial carbonate up to the close oceanic realm (platy to papery limestones). The Panthalassa oceanic sections are devoid of carbonate and biogenic siliceous sedimentation reappears progressively up section.

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NEW ZEALAND'S TRIASSIC HERITAGE

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New Zealand and New Caledonia are best thought of as the emergent parts (about 10%) of a large sunken continent, Zealandia. Almost half the size of Australia, Zealandia rifted from the eastern margin of Gondwanaland for about 20 m.y. between 85 and 65 Ma, with formation of the Tasman Sea. This stretched and thinned Zealandia causing it to slowly sink for about 60 m.y. between 85 and 25 Ma. By this time (Late Oligocene) it was substantially if not totally submerged. The modern plate collision between the Australian and Pacific plates dates from about 45 Ma, and has resulted in uplift and emergence of New Zealand from about 25 Ma. It could be said that New Zealand exists only because of tectonism. Yet what of the basement? Surprisingly, much of it is Triassic!

The Triassic record preserved in New Zealand, and also that of New Caledonia, is that of Zealandia and is especially important in terms of the history of eastern Gondwanaland and the western Panthalassa Ocean. It is mainly a marine record, from marginal marine to abyssal, but there is also a terrestrial record based largely on palynology and paleobotany. Basement rocks of Zealandia comprise two major tectonostratigraphic groupings: an Eastern Province and a Western Province. They are separated by the Median Batholith a long-lived magmatic arc. All three entities have a Triassic record, and each province is comprised of terranes. The Western Province has an important record that is compatible with eastern Australian Gondwanaland foreland successions.

Eastern Province terranes are extensive and most significant in terms of the Triassic record, and include the classic New Zealand Murihiku Supergroup sequences (Murihiku terrane) that are the basis of the New Zealand regional stages (Nelsonian, Malakovian, Etalian, Kainikuan, Oretian, Otamitan, Warepan, Otapirian). Some terranes are accretionary complexes (Rakaia, Waipapa, Caples) and some are subduction related volcanic arc basin (fore arc and/or back arc) complexes (Dun Mountain – Maitai, Murihiku, Brook Street). All are elongate, attenuated and probably allochthonous yet can be traced through the length of the New Zealand landmass. Permian-Triassic and Triassic-Jurassic boundary sections are preserved in a number of sequences and are the focus of great interest.

In the past decade, there has been a review of New Zealand Triassic biodiversity, and a modern appraisal of New Zealand Triassic chronostratigraphy has also been addressed in light of the revised International Timescale, but the greatest advances in our knowledge of New Zealand’s Triassic have come from research on radiolarian and conodont faunas, and research on terrane provenance using radiogenic isotopes and zircon dating.
THE NEW ZEALAND TRIASSIC STAGES AND THEIR SIGNIFICANCE

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Given this background, this paper will consider the New Zealand Triassic in terms of the New Zealand local stages, their correlation, regional significance and potential. Of particular note is the widespread recognition of faunas attributable to the New Zealand stages: they can be applied across terranes within New Zealand’s Eastern Province, and are also recognised in more distant locations around the Pacific.
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Marine Triassic macrofossils from New Zealand were first collected and identified from the Nelson area by Hochstetter in 1859. He must have been amazed to recognise fossil shells that were familiar to him from the Austrian Alps, namely the bivalves Halobia and Monotis. To this day, his collections are prominently curated and displayed in the palatial splendour of the Natural History Museum in Vienna. Subsequent to Hochstetter’s visit, geological surveys and universities were quickly established in New Zealand and academic studies on New Zealand geology and paleontology began with a vengeance.

With formal European colonisation of New Zealand came provincial governments and the appointment of ‘provincial geologists’ in the early 1860s. These were finally scrapped in 1872 with the growth of centralised administrative government established in Wellington in 1865. It was also in 1865 that the New Zealand Geological Survey was established and it continues to this day as GNS Science (formed in 1992). The University of New Zealand with several institutions (Otago, Canterbury, Auckland) was also established in the early 1860s, and now there are at least eight universities in New Zealand, of which Otago, Canterbury, Auckland and Victoria have strong traditions in paleontological research, but Waikato, Massey and Auckland University of Technology also do.

Today, the National Paleontology Collection is housed at GNS Science and there are significant fossil collections housed at the universities of Auckland, Otago, Canterbury, Victoria and Waikato, as well as regional museums of Otago, Canterbury and Auckland. In this presentation, we track the history of collection and research on New Zealand and New Caledonian Triassic marine macrofossils, and appraise the present state of knowledge of all relevant fossil groups including: tube fossils, sponges, corals, conulariids, bryozoans, echinoids, crinoids, brachiopods, molluscs (bivalves, gastropods, nautiloids, ammonoids, scaphopods), vertebrates, trace fossils.

Early Triassic (Induan, Olenekian) macrofaunas are rare and of very low diversity (ammonoids, bivalves and tube fossils) but occur in three New Zealand terranes and one New Caledonian terrane. Middle Triassic (Anisian, Ladinian) macrofaunas are much more diverse, but are not especially widespread, occurring in three New Zealand and two New Caledonian terranes. Much of Ladinian time appears to be unrepresented. Late Triassic (Carnian, Norian, Rhetian) macrofaunas are even more diverse and there is an especially widespread record of Norian time in both New Zealand and New Caledonia. The Carnian is very poorly represented, but conversely, the Rhaetian is surprisingly well represented.
RADIOLARIANS AND THE P-T BOUNDARY: GEOCHEMISTRY, MAGNETIC SUSCEPTIBILITY AND DIVERSITY

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"A severe extinction during the latest Permian time, followed by a low diversity during the Lower Triassic, followed by a species bloom during the Middle Triassic" is an often adopted scheme to describe the response of the radiolarians during the perturbed P-T boundary times.

Firstly and mainly, continuous distal radiolarite series crossing the P-T boundary have been studied in Japan. Here, the Upper Permian is characterised by a facies change and radiolarian skeletons are not obtained or are poorly preserved around the supposed P-T boundary. The direct age dating of the boundary is not precise.

In South China, a continuous proximal series has been studied (e.g. Q. Shang & M. Caridroit, InterRad 9, 1999, USA; confirmed by the study of the same section by Q. Feng, InterRad 10, 2002, Switzerland) showing the surprising presence of "Triassic forms" in the last beds of the Upper Permian. This presence of "Lazare taxa" or "refugia taxa" demonstrated that the supposed "mass extinction" needs to be more investigated. In Northern Thailand, recent work (e.g. N. Wonganan, PhD Thesis, 2005, Lille) permits description of another distal radiolarite series crossing the P-T boundary. It is very similar to the Japanese ones but the youngest Permian assemblages are quite different from those from Japan, which are also different from those from South China.

From these results, several questions arise:

1. Are we comparing same age assemblages or are the differences between assemblages related to radiolarian provincialism around P-T boundary times?
2. Does the observed low diversity around the P-T boundary and during the lowest Triassic correspond to a true disaster, long-term refugia species or, simply, to a change of the preservation potential (in the water and/or in the sediments)?

Physical (magnetic susceptibility) and chemical (whole rock geochemistry, major and trace element) analysis has been done on 3 series (Japanese, Chinese and Thai). The correlation between them is reviewed, the relationship between sediments and diversity is discussed and an attempt on the productivity change has been done. It seems that the preservation conditions are an important factor to explain the diversity lost. In addition, a comparison between the taxonomic approaches in the Triassic and in the Permian shows that the Triassic radiolarian bloom is mainly related to choice of taxonomic criteria.
FIRST DISCOVERY OF MIDDLE TRIASSIC (ANISIAN) OSTRACODES FROM THE PHA KAN FORMATION, NORTHERN THAILAND

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The marine ostracodes described in this paper were collected from the micritic and oncolitic limestones of the Pha Kan Formation in the Lampang Province, northern Thailand. The Anisian age of the Pha Kan Formation is indicated by the occurrence of ammonoids e.g. \textit{Balatonites} sp. The ostracode fauna consists of 15 species belonging to 4 genera, all of which can be referable to the described species and one undetermined genus of Bairdiidae. \textit{Bairdia}, \textit{Acratia}, and \textit{Bairdiacypris} are the three dominant genera in this ostracode assemblage, associated with \textit{Baschkirina}. This ostracode fauna, mostly the Bairdiacea, suggests shallow marine conditions with normal salinity environment of deposition.
LATE TRIASSIC (NORIAN) STROMATOLITES AND OSTRACODES FROM THE HUAI HIN LAT FORMATION, NORTH-CENTRAL THAILAND

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Late Triassic (Norian) stromatolites and associated ostracode fauna are recorded for the first time from the Phetchabun Province, north-central Thailand. The dark-colored limestone of the Huai Hin Lat Formation contains the stromatolitic horizon, 10-30 cm. thick. The stromatolitic complex is characterised by three parts. The lower part or the pre-buildup sediment, about 5-10 cm. thick, consists of cross-stratified, flat laminated intraclastic and ostracode-bearing micritic limestone. The middle part, about 4-8 cm. thick, is made up of dome-shaped stromatolites. Domes are 2-5 cm. wide, with a 2-5 mm. space between them. The stromatolitic buildup is capped by, about 2-12 cm. thick, planar to cross-stratified argillaceous micrite. The whole stromatolitic complex is covered in turn by a thick black shale unit containing rich ostracode fauna. Five ostracode species belonging to two genera are identified. Darwinula is the dominant genus in this fauna and is associated with ? Eucypris. In north-central and north-eastern Thailand, cyanobacterial and ostracode communities thrived in many shallow fresh water lakes during Late Triassic (Norian) time.
BIODIVERSITY THROUGH TIME: SOME CONSIDERATIONS

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Born during the Rio’s meeting in the year 1972, the word biodiversity has become a vernacular word. There is no comprehensive news programme on TV or on the radio without this topic. Anybody knows it today or at least thinks he knows. But what does this word biodiversity mean more precisely? Dealing with the KT boundary and the disappearance of the dinosaurs, biodiversity is systematically mentioned and a curve is provided. Talking about whales, about bears, about corn, biodiversity is claimed. Evoking climate change, its influence on biodiversity is called: “imagine within one century, half of the biodiversity will have disappeared!”. Unfortunately, most of the time, nobody feels responsible to specify what this word is supposed to indicate: is it a counted biodiversity or is it an estimated biodiversity? This is true for present days, but it is even more true for the past! What is known and what is supposed to be known? What is the history of biodiversity as compared with the history of the Earth? Any scientific item has to be based on curves nowadays, even if people do not try to understand what these numbers or curves represent. Curves and numbers are either "disturbing" or "interesting" according to our ability to take distance with our own job. Obviously this work would also be applied to radiolarians as examples.
Upper Permian bedded cherts and siliceous claystones of the Tamba - Mino Terrane include sediments deposited just before the Permian-Triassic boundary when the biggest mass extinction event occurred. There are some attempts to solve the paleoceanographic fluctuation by means of radiolarian faunal analysis (Kuwahara and Yao, 1998). In morphological studies of radiolarians, assemblage and morphology are regarded to reflect the ocean paleoenvironment considering the relation between morphological changes and environmental changes. Shell size change of Late Permian radiolarians, Albaillella triangularis Ishiga, Kito and Imoto, Copiellintra ? sp.A, obtained from the Upper Permian bedded cherts and siliceous claystones of the Tamba - Mino Terrane are examined and discussed concerning ocean paleoenvironmental changes.

Samples are collected from the GC, R and Ubara sections of the Tamba - Mino Terrane. The shell size of A. triangularis (width×height) tends to increase to the upper horizons in the GC and R sections, and rather decreases in the Ubara section. In the GC section, the oscillation of shell size shows a pattern of rapid decrease after gradual increase. This pattern is repeated twice in the section and has an ~450 thousand-years cycle. The oscillation of shell size in the R section is similar to that in the GC section although the mean value of shell size and the thickness of corresponding bedded cherts of sections are different. At the upper part of the GC section mean shell size is largest, it is medium at the Ubara section and the lower part of the GC section, and it is smallest at the R section. The shell size of C. ? sp.A (long diameter×short diameter) tends to increase gradually to the upper horizons of sections and decreases rapidly in the uppermost part of sections within the GC and R sections. Oscillation of shell size of C. ? sp.A is partly similar to those of A. triangularis in each section.

In the GC and R sections, the similarity in oscillating pattern of shell size, lithological features and characters of specific composition of occurring radiolarian fossils may be used for biostratigraphic correlation among these sections. The difference in thickness of corresponding strata seems to be caused by difference in sedimentation rate and compaction process. Differences in mean shell size may reflect the difference of the ocean paleoenvironment among three sections. There are many possibilities that can be regarded as factors of morphological changes (Kuwahara, 1997). The closely similar oscillating pattern of each species from two sections, that tends to increase in shell size, is considered to be caused by evolutionary factors particular to each species. On the other hand, rather similarity in oscillating pattern between coexisting species in each section is considered to be caused by environmental factors influencing the two species. According to Granlund (1986,1990), low water temperature, low salinity and high dissolved oxygen are supposed regarding the results of shell size change tending to increase through the sections. These changes are estimated to occur over a period of ~1 million years. Features of shell size change in both, A. triangularis and C. ? sp.A, that decrease rapidly in the uppermost part of sections are supposed to be caused by sudden changes toward high water temperature, high salinity and low dissolved oxygen. These abrupt changes, estimated to take place in a short time at the end-Permian, may affect the shell forming of radiolarians.
CONSERVATISM AND INNOVATION AMONG TRIASSIC FORAMINIFERA FROM INTERIOR AND MARGINAL SEAS IN THE AUSTRALIAN REGION

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This study arises from recent discoveries in Timor Leste of Triassic foraminiferal assemblages belonging to three main faunal associations. The new collections allow a greater understanding of the Triassic benthic foraminifera from interior and marginal seas in eastern Gondwanaland and of faunal affinities with other continents. The Triassic foraminifera can now be compared with older Permian and later Mesozoic assemblages from similar basin settings in eastern Gondwanaland and elsewhere, and both conservative and innovative elements of the fauna identified.

Most of the known Triassic microfaunas from eastern Gondwanaland come from shallow-marine interior rift basins with flat uniform sea floors (the product of sediment infill of available accommodation). The basins were positioned on the continent at varying distances from the Triassic continent-ocean boundary. Depositional conditions within these interior basins may have been highly variable through time, resulting in periodic changes in faunal associations reflecting extensive faunal migrations in and out of the basins.

Mudstones in sand/shale sequences of the Middle to Upper Triassic in Timor Leste yield a faunal association similar to the Ammobaculites Association described from Australian Permian and Cretaceous interior basins. Organic-cemented siliceous agglutinated foraminifera are abundant and include species that show little difference from counterparts in the Permian and Cretaceous. Innovations in the Triassic not observed in the Permian include the presence of “neat” triserial chamber arrangements. The Order Lagenida is also abundant and diverse. Astacolus, Dentalina, Lenticulina, Marginulina and Pseudonodosaria are represented by morphotypes almost identical to those known in the Jurassic and Cretaceous. Ichthyolariid species are similar to those of the Permian. An abrupt innovation during the Middle Triassic was the appearance of rare trochospiral calcareous hyaline Duostominacea which combined an apparently aragonite wall with complex apertural arrangements.

A second faunal association is composed mainly of tests with fine microgranular calcareous walls, some containing agglutinated material. In Timor Leste, this association is found in Upper Triassic micritic limestones often associated with ooids. The apparently calcite-cemented agglutinated foraminifera include a diverse array of non-septate tubular species with “glomospire” and “milioline” chamber arrangements. Also prominent are trochospiral Duotaxis and related forms, including homeomorphs of the organic-cemented agglutinated Trochammina and the layered microgranular calcareous Tetrataxis.

Detrital algal-coral limestones of the Upper Triassic in Timor Leste contain an involutinid-dominated association with conspicuous large Aulotortus characterized by thick apparently aragonitic hyaline walls. Similar environments in the Permian and in the post Triassic may have been characterized by complex larger foraminifera.
DOUBLE OCEANIC ANOXIC EVENTS RECORDED IN LOWER TRIASSIC (INDUAN)
DEEP-SEA SEDIMENTS FROM ARROW ROCKS, NORTHLAND, NEW ZEALAND

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The Permian/Triassic (P/Tr) boundary is famous for the largest mass extinction of the Phanerozoic, in which most Paleozoic marine organisms died out. The Super Anoxic Ocean Hypothesis is one of the candidate causes for this event, which was proposed on the basis of data from deep-sea sediments in the Northern Hemisphere (Isozaki, 1996). We here present the first geochemical evidence of OAEs (Oceanic Anoxic Events) in lowermost Triassic deep-sea sedimentary rocks from the Southern Hemisphere, and discuss their relationship to faunal turnover of marine planktons from Paleozoic to Mesozoic types.

A geochemical study was performed on a continuous sequence of bedded chert spanning the P/Tr boundary at Arrow Rocks, Northland, New Zealand, the age of which is well constrained by conodont and radiolarian biostratigraphy (e.g., Takemura et al., 2003; Yamakita et al., 2003; Kamata et al., 2006). Based on concentration values normalized by Al contents on redox-sensitive trace elements (e.g. U, S, Cr, Ni, V, Zn, Mo, Pb, Co, Cu & As.), we detected two OAE levels in lowermost Triassic strata, namely OAEα at the P/Tr boundary and OAEβ in the upper Induan, separated by normal oxic conditions. This result is not in agreement with the Super Anoxia model. Considering the high variability of redox elements and their concentrations, it seems that OAEβ has higher redox potential than OAEα. In addition, OAEβ corresponds well with the radiolarian faunal turnover from Permian to Triassic forms studied by Takemura et al. (2003) and Kamata et al. (2003). This fact may suggest that peak time and magnitude of the OAEs around the P/Tr boundary and extinction events of marine fauna are not globally uniform.
TRIASSIC/JURASSIC BOUNDARY SEQUENCE OF BEDDED CHERT FROM PAKIHI ISLAND, WAIPAPA TERRANE, NORTHLAND, NEW ZEALAND

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We present the first discovery of the Triassic/Jurassic (Tr/J) boundary in deep-sea sedimentary rocks of New Zealand, from continuous sequences of bedded chert on Pakihi Island, Auckland, and describe their radiolarian fauna.

The basement rocks of Pakihi Island, part of the Waipapa terrane of northern New Zealand, are composed mainly of bedded red cherts and mélange of green argillite. The dominantly red chert sequences, with some brownish-red and manganese-rich intervals, contain abundant radiolarian fossils. We have collected and examined radiolarian samples from eight measured sections (Pak I to Pak VIII). Two continuous sequences (Pak II and Pak V), from Upper Triassic (Rhaetian) to Lower Jurassic (Hettangian/Sinemurian?), cross the Tr/J boundary.

The Pak II section consists of rhythmically interbedded muddy red cherts (2-15 cm thick) and red mudstones (1-30 mm) associated with yellowish white tuffaceous chert beds. Thirty-three samples (PakII-1 to PakII-33 in ascending order) were collected from this section and eleven of them contained identifiable radiolarian fossils. Rhaetian radiolarian assemblages including Livarella valida were obtained from PakII-1 to PakII-28. Above this level, PakII-32 contains Hettangian radiolarians such as Pantanellium tanuense, Tozerium sp., Bipedis sp. and Udalia sp. One characteristic taxon of latest Triassic time, Betraccium sp., was obtained together with the Jurassic Praehexasaturnalis tetraradiatus and Amuria impensa from PakII-31 level. Based on these radiolarian data, the Tr/J boundary is probably located near sample Pak II-31. The Pak V section shows similar radiolarian biostratigraphy, containing Rhaetian and Hettangian radiolarians, including Natoba sp. This radiolarian faunal turnover spanning the Tr/J boundary corresponds well with those from Queen Charlotte Islands, Canada and Inuyama, Japan. In the Rhaetian age interval, there is closer faunal affinity with Queen Charlotte Islands than Inuyama.
EARLY – LATE TRIASSIC MICROFAUNAS FROM THE BEDDED-CHERT AND ‘JURASSIC BASE-CONGLOMERATE' AT MAE-SOT, NW THAILAND: EVIDENCE FOR SHAN-THAI TERRANE AND END-TRIASSIC OROGENY

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Middle and Late Triassic radiolarian faunas were extracted from a vitric-tuff-rich laminated bedded-chert in the Mae-Sot and Umphang areas of NW Thailand. The radiolarian faunas from the bedded-chert succession are characterized by *Triassocampe postdeweveri* (Early Ladinian), *Pachus multinodosus* (Early Norian), *Sarla natividadensis* (Middle Norian) and *Canoptum rhaeticum* (Norian-Rhaetian), individually.

The Triassic chert-sequence is overlain by the ‘Jurassic base-conglomerate', an ill-sorted breccia in a reddish-silt matrix. The chert and limestone clasts in the conglomerate yield Middle - Late Triassic radiolarians and Early - Late Triassic conodonts, respectively. Chert clasts in the conglomerate yield among others Norian - Rhaetian radiolarians like *Pachus multinodosus* and *Canoptum rhaeticum*, while Early – Late Triassic conodonts as *Platyvilloides costatus*, *Cratognathodus cf. cuspidatus*, *Metapolygnathus polygonathiformis*, *M. carpathicus*, *Ancyrogondolella quadrata* and *A. spatulata* are found in limestone clasts.

The silici-pelagic origin of the clasts suggests the presence of an ocean before the end Triassic orogeny along the Mae Sariang Zone that amalgamated the parts of the Shan-Thai block. This first finding of Late Triassic (Norian - Rhaetian) radiolarians from bedded-cherts, next to the Middle Triassic and older radiolarian faunas, adds another element to the reconstruction of the sequence now comprised in the Mae Sariang Zone, W of the Nan-Uttaradit Suture.

The occurrence of Triassic limestone, similar to that of the Chaiburi Formation in the Phatthalung area of the Mae Sariang Zone or the Kodiang Limestone in the 'Western zones', may elucidate provenance of the Triassic conodont-bearing limestone clasts in the Jurassic base-conglomerate that seals the Mae-Sariang Zone. The newly dated Triassic sequence is further sealed by the continental-shelf deposits of the Toarcian - early Bajocian Hua Fai Group.
POST-ACCRETIONARY TRIASSIC SEALING OF THE KUROSEGAWA TERRANE IN EAST SHIKOKU, OUTER ZONE OF SW JAPAN

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The Late Permian accretion complex of the South Kurosegawa Terrane (Ishida & Kozai, 2003) is concealed by the Upper Triassic shallow-marine sedimentary cover of the Sabudani Formation (Lower Kochigatani Group) in East Shikoku. The boundary is known as the Sakashu Unconformity (Ichikawa et al., 1953). Consisting of an accretion mélange, dated by Late Permian radiolarians, the Hisone Group represents the basement of the unconformity. Stratigraphy and facies document the post-accretional environmental changes affecting the cover of the unconformity, from a view point of faunal provenance and reworking.

Sabudani Formation consists of three members. The lower member is characterized by the association of two types of debris flow, one consisting of blocks of pelagic chert, carbonate and greenstone, the origin of which is probably accreted pelagic sediments. The other being composed of mylonitized granitic breccias and fragments, probably derived from the Mitaki Granites (400+ Ma) of the Kurosegawa Tectonic Zone that form the substratum of the Silurian Haloisites limestone. The middle member is characterized by hummocky cross-stratified rather fine sandstone with lag deposits that indicate a lower off-shore facies. At the base, huge eroded blocks of alternating limestone and chert have yielded conodonts of late Early Permian M. bisseli - S. whitei Zone. Chert pebbles in the lag yield early Late Permian radiolarians e.g. Follicucullus monacanthus. These blocks and pebbles are probably derived from Permian accretionary complexes.

Triassic molluscs of the middle and upper members, e.g. Palaeopharus oblongatus and Oxytoma kashiwaiensis, are correlative with the Carnian (-Norian) Kochigatani bivalve-fauna in the clastic facies of the Kurosegawa Terrane (Outer Zone of SW Japan) as well as with the Mine and Nabae groups, Primorye, Zabaikal and NE Siberia (Tamura, 1990; Nakazawa, 1991). From a paleobiogeographic point of view, the bivalve-fauna of the clastic sand- and marlstone of the Kochigatani facies is regarded as different from that of the carbonate Tethyan facies in the South Chichibu Jurassic Accretionary Terrane (Tamura, 1992).
PRIMITIVE NASSELLARIANS FROM LOWER TRIASSIC SEQUENCES IN THE ARROW ROCKS, WAIPAPA TERRANE, NEW ZEALAND


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Detailed radiolarian biostratigraphy of Early Triassic chert sequences in the Arrow Rocks, North Island, New Zealand, has established that late Induan assemblages have Permian and Triassic affinities. ‘Permian-type’ radiolarians are similar to Permian genera such as Entactinia, Copicyntra and Kimagior, whereas ‘Triassic-type’ radiolarians are similar to species in the nassellarian families Poulpidae and Tripedurnulidae.

The radiolarian and conodont bearing sequence of Middle Permian to Middle Triassic age at Arrow Rocks consists mainly of basalt, limestone, tuff, mudstone, siliceous mudstone and chert. The sequence is divided into eight lithological units. Early Triassic (late early Induan to early Olenekian) conodont faunas have been obtained from Unit 2B to Unit 4. Moderately well-preserved radiolarians have also been obtained from several horizons within this interval. Late Induan (middle to late Dienerian) radiolarians have been obtained from three measured sections on Arrow Rocks (ARD, ARE and ARH), the interval from upper part of Unit 2B to lower part of Unit 3. This fauna is characterized by abundant spherical forms and Permian genera such as Entactinia, Copicyntra and Kimagior, and primitive nassellarians. These nassellarians have a small hemispherical cephalis and three basal feet and are best classified within the Poulpidae, Tripedumulidae and Spongolophophana, although internal structures are unclear due to the poor preservation. Genera of Hozmadia, Tripedocoris, Tripedocassis, Trisaaospongocyrtis and Zevius are identified. The form of their test (small cephalis, non bladed-basal feet) suggest an affinity with Spathian and Anisian Poulpidae and Tripedumulidae. Albaillellarians have never been obtained, although spherical and ‘Permian-type’ radiolarians are dominant in this fauna.

Kozur et al. (1996) described a late Induan (Dienerian) radiolarian assemblage and concluded from the absence of nassellarians that the group probably evolved within the late Scythian (late Olenekian = Spathian) from spicular Entactinaria. The occurrence of nassellarians in the Arrow Rocks sequence indicates that nassellarians must have appeared by the late Induan (Dienerian). Nassellarians obtained from Arrow Rocks are the oldest occurrence of Mesozoic-type nassellarians. Specimens of primitive nassellarians have not been obtained from the Griesbachian interval at Arrow Rocks. ‘Mesozoic’ nassellarians, were thought to have appeared in the late Olenekian (Spathian), but at Arrow Rocks they must have appeared by the late Induan (Dienerian). From the viewpoint of recovery after the end-Permian crisis and subsequent adaptive radiation, further study of Early Triassic primitive nassellarians at Arrow Rocks offers considerable potential.
BIOTIC AND ABIOTIC EVENTS AROUND THE PERMIAN-TRIASSIC BOUNDARY (PTB) IN MARINE AND CONTINENTAL BEDS AND THEIR POSSIBLE CAUSES

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A very detailed conodont zonation around the PTB has been established for open sea pelagic deposits from several sections in Iran. All biotic and abiotic events around the PTB have been well dated. By cross correlation with continuous continental lake deposits in the Germanic Basin with well recognisable Milankovitch cyclicity not only the numerical age of the events but also the duration of most of the conodont zones have been calculated. The unusual short duration of all conodont zones in the interval from the C. nodosa up to the H. parvus Zone indicates high ecologic stress. The following events can be observed close to the PTB in the Iranian sections: (1) A continuous drop of $\delta^{13}$C$_{carb}$ from values around 3 ‰ in the C. nodosa Zone to slightly below 0 ‰ at the base of the H. parvus Zone. (2) Short reversed horizon (duration according to cross correlation with continental beds ~ 110 000 years) in the upper C. changxingensis-C. deflecta Zone and in the largest part of the C. zhangi Zone. (3) Sudden facies change at the base of the Boundary Clay which is accompanied by a strong extinction event of the warm water fauna (and therefore related to a strong climatic change) which did not much affect the eurythermal benthos (small foraminifers, ostracods). Whereas the base of the Boundary Clay is a synchronous event which indicates rapid drop in biogenic carbonate production (most probably because of blocking of sunlight), the extinction of the warm water faunas is diachronous, and lies at the Tropic of Capricorn (Abadeh section) at the base of the C. hauschkei Zone, 1000 km closer to the palaeoequator themselves at the base of the C. meishanensis-H. praeparvus Zone. (4) Strong climatic change at the base of the Boundary Clay (see 3). (5) High energy event at the base of the Boundary Clay which can be also observed in the Bükk Mountains (Hungary) several 1000 km away. It is probably related to huge tsunamis. (6) Rapid, but stepwise extinction of the eurytherm benthos (which occurs in the southern sections earlier than in the northern sections closer to the palaeoequator) in the interval from the base of the M. ultima-S. ? mostleri Zone up to the very base of the H. parvus Zone. (7) Maximum of microbialites, in shallower sections also large stromatolite or thrombolite bodies in the H. parvus Zone which begins already in the M. ultima-S. ? mostleri Zone. (8) Presence of an c. 300 000 year interval with more frequent than average microsphaerules with a first maximum in the cool water horizon of the lower C. zhangi Zone (mostly volcanic microsphaerules) and a second strongest maximum in the lower but not lowermost Boundary Clay (cosmic and volcanic sphaerules). Most of these events can be traced also in other pelagic and shallow marine sections (except event 6) and continental successions (except events 5 and 6).

During the upper C. changxingensis-C. deflecta Zone and most of the C. zhangi Zone the warm water conodont fauna was replaced by a cool water fauna. This event within a short reversed horizon (see event 2) can be well correlated with a strong eruption of the Siberian Trap, which caused in the Nedubrovo Formation on the Russian Platform, several 1000 km away from the eruption centres, a fallout of mafic tuffs. In the Germanic Basin and more rare in Iran this horizon contains volcanic microsphaerules. As these faunal changes are the same as at the base of the Boundary Clay also for this horizon a short cooling event due to strong volcanism can be assumed. Additional influence by an impact cannot be excluded. Anoxia is not the reason for the extinction event. If anoxia is present, it only locally or regionally overprints the extinction event.
THE OCEANIC BASE OF SLOPE RECORD OF THE PERMIAN-TRIASSIC CRISIS: VIEW FROM TETHYS (OMAN)

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The Oman Mountains provide some of the best sections of Permian and Triassic sediments from ocean sea floor to base-of-slope environments related to the distal South Tethyan margin. The central part of the range exposes the Buday'ah section of oceanic sediments in the so-called "Hawasina allochtons".

The locality of Wadi Maqam in the north-western part of the Oman Mountains is among places where the thick Permian-Triassic base-of-slope sediments is exposed (Baud et al., 2001). Overlying 400 m of middle Permian limestones and dolomites, the upper Permian sediments consist of 50 m of ≈ 10 cm thick beds of cherts and dolomites rich in sponge spicules. The top of the Permian units is well bioturbated lime mudstone-wackestone, devoid of cherts and dated as late Changhsingian (Krystyn in Richoz et al., 2005). The boundary yellow shales are overlay by very thinly bedded, laminated microbial platy lime mudstone with *H. parvus*. The dramatic loss of the burrowing infauna indicates the appearance of oxygen-poor water. These Induan sediments are about 25 m thick and show at the top the first calcirudites, commonly clast-supported (edge-wise conglomerates), and are characterized by tabular clasts representing the sub- in situ reworking of the laminated, platy calcilutite. The very thick Smithian overlying litho-unit (up to 900 m) marks the onset on the base-of-slope of a deep-marine basin in which carbonate submarine fan deposits developed. This very thick unit consists essentially of platy limestones, calcarenites and calcirudites. It comprises mainly grey-beige calcilutite, laminated and flaggy, interbedded with sparse beds of fine-grained calcarenite in cm beds. Channelized beds of intraformational calcirudite are also part of this succession which constitutes the greater part of the outcrop available. During the Spathian to Anisian, the sedimentation changes to terrigenous mudstone and siltstone that ended with Ladinian radiolarites.

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SOUTHWESTERN LAURENTIA: TRIASSIC SEQUENCE STRATIGRAPHY, PALEOGEOGRAPHY, AND TECTONICS THROUGH POST-TRIASSIC TECTONIC OVERPRINT

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Cretaceous and Cenozoic tectonism has modified the distribution of Triassic - Jurassic stratigraphic assemblages, and tectonic and magmatic elements of southwestern Laurentian cratonal margin. Concurrent magmatism has further obliterated significant tracts of the modified distribution. The resulting overprint of Jurassic tectonics has further modified regional stratigraphic relations and paleogeography. Lower Mesozoic strata of the craton interior preserve a high-frequency record of early Mesozoic tectonic events along the margin. Tectonostratigraphy provides a link between the craton interior and the tectonically separated lower Mesozoic strata of the cratonal margin. Jurassic tectonosequences suggest tectonic models to explain present distribution of Triassic and Jurassic tectonostratigraphic assemblages. Tectonic models permit reconstruction of stratigraphic architecture and paleogeography for each of six tectonosequences (ts) recognized in southwestern North America. They include the Induan Dinwoody, Olenekian Moenkopi, Anisian Holbrook, Ladinian to early Carnian Panther Canyon, late Carnian to Norian Chinle, and Rhaetian to Hettangian Dinosaur Canyon. Along the cratonal margin, Triassic and Lower to Middle Jurassic tectonosequences are preserved in hanging walls of transtensional normal faults.

An extensional re-entrant in the center of the U.S. western cratonal margin was a sediment sink throughout the Triassic into the Early Jurassic. Boundaries of the re-entrant limited distribution of the Dinwoody ts to the central western part of the Western Interior. It and underlying Permian rocks form an overlap assemblage to the Sonoman orogeny. All six Triassic tectonosequences in Sonora, Mexico restore to the southern margin of the re-entrant in the western Sierra Nevada of eastern California. Shelf-break and slope strata of the Moenkopi ts east of the Sierra Nevada were obducted onto the shelf of the cratonal margin in the Jurassic. They restore to a location west of the Caborca terrane. Reconstruction of the Moenkopi ts suggests a passive-margin-like prism cut by extensional structures but with no volcanic arc. The prism comprises three T-R cycles, which preserve a Laurentian record of recovery from the Permo-Triassic-boundary event. In Sonora and western Nevada, the Holbrook ts comprises a nearly complete Anisian section of marine to paralic strata. Volcanogenic sediment of the Panther Canyon ts overlaps pericratonic terranes accreted in western Nevada during the early Ladinian. The Chinle ts records north and northwestward transport of voluminous volcanogenic sediment from a southern source to the re-entrant in the western craton margin. Upper Triassic volcanic rocks of the Sierran crest, assigned to the Chinle ts, are an island arc obducted onto the craton west of the Moenkopi prism. Coincidence of cessation of volcanism in the southern source and island-arc records the onset of a short duration plate rearrangement during deposition of the Dinosaur Canyon ts. Inability to identify a potential source for the Chinle tectonosequence sediments southward into Mexico suggests it was rifted from the southern margin of Laurentia. If rifted terranes were accreted to the Pacific Northwest in the Jurassic, then rifting must have preceded Early Jurassic transtensional faulting and associated right-lateral translation of pericratonic terranes outboard of the Panthalassan margin.
THE TRIASSIC STRATIGRAPHY OF TIMOR-LESTE AND ITS RELATIONSHIP TO NORTHEASTERN GONDWANA

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The Upper Paleozoic to Mesozoic strata of Timor, termed the Gondwana Sequence, were deposited in marine intracratonic basins close to the passive margin of northeastern Gondwana. Following the collision of the Australian continent and the Banda Arc, these strata were incorporated into a complex fold-thrust stack that today forms the outer Banda Arc of eastern Indonesia, including the island of Timor. Timor provides an excellent opportunity to study the Upper Paleozoic to Mesozoic strata of northeastern Gondwana in outcrop. Here we present the Triassic results of an ongoing study of the Gondwana Sequence in the eastern half of Timor, Timor-Leste. Our study commenced in 2004 and in this paper, we compare our initial results with the known Triassic stratigraphy of other outer Banda Arc islands, New Guinea and the North West Shelf of Australia.

In Timor, pervasive folding, thrusting, and faulting along with limited exposure of strata make the application of traditional stratigraphic field methods inherently difficult. In this study, coherent stratigraphic sections are located, logged and facies associations interpreted. Using biostratigraphy the relative ages of the facies associations are determined and a composite stratigraphic column constructed.

Following deposition of deltaic siliciclastic sediments during the Late Permian in Timor-Leste, mudstone-dominated deposition occurred during the Early Triassic. The Middle to lower Upper Triassic succession comprises mudstone deposits interbedded with sandstone, carbonate and conglomeratic beds with the latter becoming more common up-section. Upper Triassic limestone-dominated deposits conformably overlie the Middle Triassic succession. The Lower to lower Upper Triassic stratigraphic succession in Timor-Leste was controlled by regional sea-level fluctuations whereas regional tectonic events possibly had more control over the Upper Triassic succession.

In the western half of Timor, Lower Triassic strata have not been documented, however the Middle to Upper Triassic succession is very similar to that of Timor-Leste. The Triassic successions of other outer Banda Arc islands are similar to that in Timor-Leste but documented Lower Triassic strata are rare and siliciclastic sediments dominate the Upper Triassic of some localities. The Lower to Middle Triassic succession of the Bonaparte Basin is similar to that of Timor-Leste; however, differences are present in the Upper Triassic although similar limestones are present. The Lower Triassic stratigraphic succession of New Guinea is similar to Timor-Leste but siliciclastic and volcaniclastic strata dominate the Middle to Upper Triassic succession in New Guinea. However limestones, resembling those in Timor, are also present in the Upper Triassic of New Guinea.

Timor-Leste has a complete Triassic marine succession that provides outstanding reference sections for the Triassic in northeastern Gondwana. Because the succession can be studied in outcrop, stratigraphic information derived from these outcrops will be particularly useful in subsurface studies of coeval strata in adjacent basins.
The Triassic Period is bounded and historically recognised by two of the greatest mass extinctions of life in the Phanerozoic, the Permian-Triassic (P-T) “mother-of-all” mass extinction at its base, and the Triassic-Jurassic (T-J) mass extinction at its top. These mass extinctions, and the subsequent patterns of recovery of life and evolutionary radiation, are the consequences of globally significant catastrophic processes or events. The evidence that earth scientists unearth in the rocks tell us more about the consequences of causative processes and events than the processes and events themselves. Until today, the nature of the catastrophes that resulted in the observed immense changes in the earth's biota at the PT and T-J boundaries remain matters of hot debate and contention.

The Permian-Triassic transition marks the greatest mass extinction event in Earth's history. The loss of over 90% of all species brought an end to the Palaeozoic Era and shaped the subsequent course of evolution. It is arguably the single most significant event in Earth’s history for the past 600 million years. Biological diversity did not return to pre-extinction levels until 25 million years after the event. Our recent work on the P-T transition and mass extinction has dated this event at 252.6 +/− 0.2 Ma and demonstrated that the main pulse of extinction was extremely short, and in deep-time terms, catastrophic. Patterns of extinction in the latest Permian-earliest Triassic of both marine and terrestrial environments do however demonstrate a step-wise extinction pattern, with a more significant latest Permian extinction pulse rather than a single extinction event, and as such seems to preclude an extra-terrestrial impact as a sole or principal cause. Organic biomarker studies of marine sections in Australia, China and elsewhere suggest widespread photic-zone euxinic conditions and that sulphide toxicity was a major driver of extinction and the protracted Triassic recovery. Recent isotopic geochronological confirmation of the temporal coincidence of the Siberian Traps massive volcanism with the P-T mass extinction suggests a causative link. In continental environments, rapid swings in carbon isotope records, the presence of abnormal pollen and changes in sedimentary depositional regimes indicate major climatic perturbations at the extinction level consistent with protracted ecosystem disruption. The identification of a possible P-T major impact structure (Bedout structure), offshore Western Australia, has refuelled the impact vs. volcanism causative mechanism debate.

The end-Triassic mass extinction comprises coupled Norian-Rhetian and Rhetian-Hettangian (T-J) extinctions. Isotopic excursions and other evidence suggest that again, impact as a sole causative mechanism for these extinctions is unlikely. Massive volcanism (Central Atlantic) is again found coincident with the end-Triassic extinction.

Whilst a range of causes, including bolide impact, massive volcanism, major climate change (cooling or warming), marine regression and global anoxia have been suggested for the P-T and T-J mass extinctions, massive volcanism seems to be the current front runner. It is here suggested that simplistic single cause mechanisms for the greatest mass extinctions of life are probably unrealistic, and serious consideration to multiple causes must be given. Continued studies of the dawn and dusk of the Triassic will provide vital insights on the consequences of Triassic catastrophes and the nature of these mass extinction causing events and processes.
OCCURRENCE OF TRIASSIC CONODONTS FROM THE META-BEDDED CHERT SUCCESSION IN WAZUKA UNIT, TAMBA TERRANE OF SW JAPAN

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The Tamba Terrane, consisting of Jurassic accretionary complexes, is distributed in the Inner Zone of Southwest Japan. In the Ujitawara area (ca. 30 km SE of Kyoto City), southern part of the Tamba Terrane, sedimentary rocks have been subjected to low-grade metamorphism. Thermal condition of this metamorphism is approximately 300 °C as determined from conodont color alteration index, quartz crystallinity and grain size of quartz of bedded chert (Mikami et al., 2002). In the area, the Tamba Group of the terrane is subdivided into three distinct suites (Obukugawa Unit, Ujitawara Unit, Wazuka Unit) of stratigraphic successions. The Wazuka Unit of the southernmost part is composed mainly of Triassic cherts and younger clastics. The sedimentary rocks have been deformed into tight folds within a deep trench. The slaty cleavages are well-developed in the sedimentary rocks. Even the radiolarians are too ill-preserved to identify; age is based on Triassic conodonts found within a 15 m thick bedded chert.

The 2 m thick studied part of the chert succession yields late Carnian to early Norian conodont faunas: Metapolygnathus cf. permicus – M. cf. lindae (late Carnian), Metapolygnathus cf. polygnathiformis (late Carnian), Metapolygnathus echinatus (late Carnian - early Norian), and Ancyrogondolella quadrata - A. spatulata (early Norian) assemblages in ascending order. The vertical occurrences of index species are characteristic of the nodosus zone (late Carnian) to quadrata zone (early Norian) in the Canadian Cordillera (Orchard, 1991); as well as correlative with the polygnathiformis zone (late Carnian) to the quadrata - spatulata zone (early Norian) in the Hisaidani Section of the South Chichibu Terrane (Ishida & Hirsch, 2001). Common occurrence of Ancyrogondolella quadrata and A. spatulata in the upper horizon is also comparable to the Hisaidani Section faunas that characterize the Izanami Plateau (Hirsch & Ishida, 2002). The lower part of the chert succession is characterized by dominant Neospathodus homerii, indicative of late Early Triassic (late Olenekian) age.

Southward younging of the sedimentary rocks has been determined by the relationship between cleavage and bedding. While studied chert beds are situated in the northern limb of the synform, the conodont succession within the upper horizon of the chert sequence faces northward.

This is the first report of an upper Carnian to lower Norian chert-sequence from the Ujitawara area as determined by conodont biostratigraphy. The biostratigraphic data also throws light on the detailed structure of this highly deformed and metamorphosed region of the Tamba Terrane.
New Zealand has a valuable igneous, stratigraphic and tectono-metamorphic record of the growth and deformation of Gondwanaland’s active southern margin in the Phanerozoic. The Cambrian to Early Cretaceous basement rocks comprise at least nine major volcano-sedimentary terranes, three composite regional batholiths, and three regional metamorphic-tectonic belts that overprint the terranes and batholiths.

No Precambrian rocks are exposed in onland New Zealand. The Early Paleozoic Buller and Takaka terranes are the westernmost terranes in New Zealand and are grouped into the Western Province. The Permian to Early Cretaceous Brook Street, Murihiku, Maitai, Caples, Bay of Islands (part of former Waipapa), Rakaia (older Torlesse) and Pahau (younger Torlesse) terranes, are grouped into the Eastern Province. Triassic rocks are particularly well represented throughout the Eastern Province. The Western Province terranes are intruded by three composite batholith sized belts of plutons: Karamea-Paparoa, Hohonu and Median, as well as numerous smaller plutons. Median Batholith (including the Median Tectonic Zone) is a recently-recognised Cordilleran batholith between the Eastern and Western Provinces that represents the site of subduction-related magmatism from c. 360-110 Ma. The basement rocks are variably metamorphosed and deformed into Devonian-Carboniferous and Cretaceous amphibolite-granulite facies gneisses, Jurassic-Cretaceous subgreenschist-amphibolite facies Haast Schist and Cretaceous subgreenschist facies melanges.

The continental shelf edge of greater New Zealand lies close to the 2000 m isobath. Basement schists, greywackes and granitoids are exposed on scattered islands and have been sparsely sampled in dredges on the Campbell Plateau, Chatham Rise, Challenger Plateau, Lord Howe Rise, Dampier Ridge and Norfolk Ridge. The term Zealandia is used to describe this mainly submerged continental mass, whose area is about one third that of Australia.

Zealandia is a rifted piece of Gondwanaland that, before 85-55 Ma sea floor spreading, was contiguous with Australia and Antarctica. On a Late Cretaceous reconstruction, orogenic trends in Queensland, New South Wales, Victoria and Tasmania strike along the Lord Howe Rise towards New Zealand and continue through into Marie Byrd Land.

In terms of basement rock types and belts, New Zealand is as geologically prospective for mineral deposits as eastern Australia. Additional geological events that have affected New Zealand’s, but not eastern Australia’s, prospectivity include more widespread 125-85 Ma magmatism and extensional exhumation, superposition of Neogene volcanic arcs in the North Island, and localised Neogene exhumation in the South Island.
CONODONT BIOSTRATIGRAPHY AND PALAEOGEOGRAPHY OF THE TRIASSIC ON THE WESTERN, NORTHWESTERN AND NORTHERN MARGINS OF THE AUSTRALIAN PLATE

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In the Triassic the northern margin of Gondwanan Pangea opened onto the Meso-Tethys Ocean. The then continental margin was formed by the Lhasa and West Burma Blocks and the New Guinea portion of the Australian Plate. Along what would become the margin of the Australian Plate were a series of cratonic basins, from the Perth Basin in the south, through the Bonaparte Basin to poorly defined Triassic basinal structures on islands of the Banda Arc. Only along the northern margin of present-day New Guinea and some of the islands of the Northern Banda Arc did continental margin shelf areas open directly onto the Meso-Tethys Ocean. Within this setting Triassic sediments were deposited in tectonically controlled basins. Conodonts and other fossils are beginning to allow high resolution correlation of sedimentary sequences and events within and between these basins.
A REVIEW OF TRIASSIC AND PERMIAN CONODONTS FROM NEW ZEALAND

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Triassic conodonts are known from the Waipapa and Rakaia Terranes and melanges of the North Island, and from the Dun Mountain – Maitai, Rakaia and Pahau terranes and Esk Head Melange of the South Island. The faunas range from Induan to Norian.

The Arrow Rocks locality in the Waipapa Terrane is Early, but not earliest, Triassic (Induan) in age. There is no indication of the earliest Triassic faunas of Hindeodus parvus and Isarcicella spp. Conodonts from the Arrow Rocks locality can be related to two conodont zones, the lower is the N. dieneri Zone (late Induan = Dienerian) and the upper is the N. waageni Zone (Early Olenekian = Smithian).

A single conodont element of uncertain identity has been recorded from a concretion in siltstone near Kaka Point, south Otago coast, within rocks mapped as Dun Mountain – Maitai Terrane. The age is probably early Anisian.

The conodonts from the Ruahine Range in southeastern North Island are from a single limestone block within melange. The age is latest Carnian to earliest Norian.

The conodont faunas of the Esk Head Melange of the South Island are of Norian age. Two low-diversity faunas have been reported, one from the Mount Mason Limestone containing Norigondolella navicula is Early Norian and a second from the Okuku Limestone contains Norigondolella steinbergensis and is of early Late Norian age.

Conodonts of presumed Permian age have been found at three localities in the Waipapa Terrane of the North Island, and the Caples and Rakaia Terranes in the South Island. Clarkina changxingensis has been recovered from Arrow Rocks section in the Waipapa Terrane and is of Changhsingian age. The identification of Mesogondolella idahoensis from the Nokomai locality in the Caples Terrane is confirmed, and the age is upper Kungurian (M. idahoensis Zone) to early Middle Permian (Roadian, basal Mesogondolella nankingensis Zone).

The specimens previously illustrated as Mesogondolella bisselli from the Meyers Pass locality in the Rakaia Terrane are almost certainly not this species, but probably a species of Gondolella with affinity to G. bella. Gondolella bella has a larger cusp, an irregular to nodose lateral margin, and is known to range in age from the Upper Carboniferous (Pennsylvanian, Missourian) to the upper Sakmarian (Lower Permian). Thus the fauna from the Meyers Pass locality could be either of Late Carboniferous (Pennsylvanian) or Early Permian (Asselian to Sakmarian) age.
In the framework of the InterRad Mesozoic Working Group, detailed revision of the taxonomy of Mesozoic radiolarians at the generic level is in progress. The aim is to compile and review all existing genera and establish a taxonomic basis for a refined Mesozoic radiolarian stratigraphy. A review of the entire Mesozoic indicates that approximately 800 genera are published, many as valid genera but a considerable number as nomen dubium or junior synonyms. We have separated this project into two homogeneous parts: the Triassic, and the Jurassic-Cretaceous. This is largely because only a few genera cross the Rhaetian-Hettangian boundary. The basic purpose is to provide the scientific community with a catalogue of type-species in hopes that it will clarify the generic assignment of many Mesozoic species.

Each atlas will be published in GEODIVERSITAS, a journal of the Muséum National d’Histoire Naturelle de Paris. The Triassic atlas contains the taxonomy of 340 Triassic genera, and will be submitted to the publisher in 2006. All genera have been reviewed and their type species re-illustrated. These are presented on 17 plates (20 genera per plate) and arranged morphologically for quick recognition (an alphabetic list is available also). Each genus (even those corresponding to a junior synonym) is illustrated (see Figure 1). The basic information contains: genus name, author, year of publication and page of description; family (when possible); image of type species with scale bar; binomial combination for the type species with indication of original source (year, page, and plate-figure for the holotype).

This revision also includes a brief stratigraphic synthesis and range chart. Presently, this is conceived empirically from the published literature. We hope that this tool will aid in the future assignation at species level and will also contribute to understanding possible evolutionary relationships among Mesozoic radiolarians. We further analyse diversity at the family and generic level with emphasis on major faunal turnovers and paleoenvironmental changes (i.e. Sr-C isotope, volcanism, sea-level changes, etc.) during the Triassic.
UPPER TRIASSIC PELAGIC CARBONATE FROM SAMBOSAN ACCRETIONARY COMPLEX, SOUTHWEST JAPAN, AND ITS PALEOCEANOGRAPHIC IMPLICATIONS

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This paper describes the stratigraphy and microscopic characteristics of the Upper Triassic siliceous micrite of southwest Japan, considered as having accumulated on the lower flank of a seamount in the Panthalassa Ocean. Biotic association and lithologic properties of the siliceous micrite are compared with those of Upper Triassic deep-water micritic limestone widespread in a pelagic realm of the Tethys Ocean. This correlation permits the interpretation of enormous production and accumulation of calcareous plankton in an open-ocean realm within both the Panthalassa and Tethys Oceans in Late Triassic time.

This idea is based on investigation of an upper Carnian to lower Norian siliceous micrite and radiolarian chert succession of the Sambosan accretionary complex, defined as a Late Jurassic to Early Cretaceous subduction-generated accretionary complex of southwest Japan. The examined succession comprises a lower radiolarian chert unit (ca. 30 m thick), middle siliceous micrite unit (ca. 30 m) with chert nodules, and upper radiolarian chert unit (ca. 15 m) with minor siliceous micrite. The siliceous micrite comprises radiolarian remains and filamentous shells of thin-shelled bivalves disseminated in a micritic matrix. The scanning electron microscopic examination recognized small (5-11 µm), globular calcitic particles embedded in a micritic matrix. These particles have an affinity most like that of calcareous nannoplankton described from Upper Triassic deep-water micritic limestone in Northern Alps, India, and northwestern Australia.

Occurrence of calcareous nannoplanktonic forms from the Sambosan siliceous micrite indicates that significant planktogenic carbonate accumulation occurred in the Panthalassa Ocean as well as the Tethys Ocean. The stratigraphic succession of siliceous micrite and radiolarian chert is most satisfactorily explained by a fluctuation of the carbonate compensation depth (CCD). The appearance of abundant calcareous nannoplankton might have resulted from a local, or even a global fluctuation of the CCD in late Carnian to early Norian time.
THE TRIASSIC TIME SCALE: STATUS AND PROGRESS

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The Triassic Time Scale consists of 7 internationally accepted stages: Induan, Olenekian, Anisian, Ladinian, Carnian, Norian, and Rhaetian. It forms part of a standard Phanerzoic Time Scale that the International Commission on Stratigraphy (ICS), under the auspices of the IUGS, has committed to complete by the next International Geological Congress in 2008. In turn, the Subcommission on Triassic Stratigraphy (STS) is responsible through its task groups for selecting a Global Stratigraphic Section and Point (GSSP) for each of the Triassic stages. To date, this has been accomplished for the base of the Induan (= base of the Triassic) and the base of the Ladinian; 5 more stages await definition.

• The base of the Induan is defined at the first appearance (FAD) of the conodont Hindeodus parvus at the base of Bed 27c at Meishan section D, Changxing County, Zhejiang, S.China. A strong negative excursion of $\delta^{13}\text{C}$ occurs a little below the boundary in strata yielding a U/Pb zircon date of 252.4± 0.3 Ma. The boundary lies within a normal magnetostratigraphic chron.

• A GSSP for the base of the Olenekian has been proposed at Chaohu, Anhui Province, China based on the first appearance of the conodont 'Neospathodus' waageni. This datum lies 26 cm below the FAD of the flemingitid ammonoids, slightly prior to the top of the second Triassic normal magnetozone, and the peak of the first Triassic positive excursion of $\delta^{13}\text{C}$. An alternate candidate at Muth, Spiti, has a superior ammonoid record but lacks magnetostratigraphy.

• The FAD of the conodont Chiosella timorensis at Desli Caira, in Dobrogea, Romania has been favored as a GSSP for the base Anisian. This corresponds to a significant change in the ammonoid fauna and a negative peak in $\delta^{13}\text{C}$; it falls within a short reversed polarity interval situated between two short normal intervals that follow a longer reversal in the upper Olenekian. An alternative section is identified in Guandao, Guizhou Province, China where ash beds have dated this boundary as ~247 Ma.

• The GSSP for the base Ladinian is now defined at the top of "Chiesense groove", located about 5 m above the base of the Buchenstein Beds at Bagolino, northern Italy; the lower surface of the overlying thick limestone bed has the lowest occurrence of the ammonoid Eoprotrachyceras curionii. Secondary global markers in the uppermost Anisian include the lowest occurrence of conodont Budurovignathus praehungarica and a brief normal-polarity magnetic zone. The GSSP level is bracketed by U-Pb single zircon age data indicating that the boundary age is within the range 240-242Ma.

• For the base of the Carnian, the FAD of the ammonoid Daxatina at the Prati di Stuores section in the Italian Dolomites has been proposed as a GSSP. However, conodonts are poor in this section. In Spiti, where intercalibration of ammonoids, conodonts and bivalves is possible, the FAD of a possible alternate index, Metapolygnathus polygonathiformis, apparently predates the incoming of Daxatina by several meters. Work on a section in New Pass, Nevada, continues.

• Two sections provide important data for the base of the Norian: Black Bear Ridge in British Columbia, which has a superb conodont succession as well as macrofossil data, and Pizzo Mondello in Sicily where a magnetostratigraphic profile facilitates correlation with the nonmarine Triassic of the Newark group in the USA, and indirect dating through cyclostratigraphy. However, the age of the base Norian remains a contentious issue.

• The base of the Rhaetian is well displayed in the Zlambach Formation, Austria, where ammonoid, bivalve, conodont, radiolarian, and palynomorph data are calibrated by magnetostratigraphy. The FAD of Rhætognyaaulax rhaetica corresponds to a distinct and widely recognized dinoflagellate change midway through the section. This level corresponds to the FAD of the conodont Misikella posternsteini in Europe, and in North America with Epigondolella mosheri and radiolarians of the Proparvicingula moniliformis Zone.
Marine Triassic rocks are widely distributed in western and northern North America. Autochthonous successions in the Arctic, NE British Columbia, and the Great Basin/USA have long provided a basis for a latitudinally differentiated molluscan biochronology, and more recently an intercalibrated conodont zonation enhanced by a new multielement taxonomy. Application of this zonation in Cordilleran allochthonous terranes reveals a substantial, often contrasting Triassic rock record and points to significant transportation of some terranes.

Triassic conodonts are known from 14 displaced terranes in the western Canadian Cordillera, and several others in the USA. Within these terranes (T), lowermost Triassic strata (with [+]) *Hindeodus parvus* are known only from Cache Creek T, where thick carbonates (+*Hadroidontina, Pachycladina*) and local conglomerates flanked by cherty-argillites span the entire Lower Triassic, and represent deposition on isolated Panthalassan atolls far from the North American margin. In Stikine T, mixed clastic-carbonate rocks (+*Scythogondolella*) in an island-arc setting provide the only other evidence of Lower Triassic sedimentation.

Radiolarian ribbon cherts predominate in the Middle Triassic of the oceanic Cache Creek and Bridge River T and occur also interbedded with tuff and carbonates in Stikine and Harrison Lake T. In Quesnel T, a volcano-sedimentary facies appears at the base of the Anisian (+*Chiosella timorensis*), and in Taku T contemporaneous conodonts occurs in limestone associated with siliceous slate. A major episode of volcanism began in Quesnel and Stikine T during the late Ladinian (+*Budurovignathus mungoensis*) and continued through the early Carnian (+*Mosharella newpassensis*).

The oldest Triassic strata in Cadwallader, Chilliwack, and Pacific Rim T are Upper Carnian volcanogenics (+*Metapolygnathus nodosus*), by which time volcanism was widespread throughout the Intermontane belt. To the east, impure clastic sediments accumulated on pericratonic Kootenay and Slide Mountain T, whereas no sign of volcanism is evident in autochthonous successions near the cratonic margin. On the coast, Wrangel and Alexander T contain a spotty pre-late Carnian record, but are locally no older than Norian above an unconformity. In Wrangel T, extensive platformal carbonates were deposited on a basement of tholeiitic lavas during the late Carnian and then overtaken by slope and basin deposits in the north; in the south, platform sedimentation continued and local patch reefs developed in the early Norian (+*Epigondolella triangularis*). M-Norian strata is scarce possibly due to intra-Norian erosion such as in evident in reworked clasts in Cadwallader and Stikine T. Radiolarian chert deposition persisted in Cache Creek and Bridge River T through the Norian.

Upper Norian strata with *Monotis* (+*E. bidentata*) is widespread but the species vary between terranes. Rhaetian strata (+*Misikella posthermsteini*) are diverse: slope turbidites and local coral bioherms in Wrangel T; nearshore clastics in Cadwallader T; megalodont reefs in Stikine T; and radiolarian chert in Cache Creek T. Tethyan conodont species (*Epigondolella spatulata, Gladigondolella tethydis, Neocavitella sp., Paragondolella? hallstattensis*) occur in Wrangel, Bridge River, Cache Creek, Baker (US), and Wallowa (US) terranes.
TRIASSIC AND JURASSIC RADIOLARIANS FROM THE NORTHERN AND SOUTHERN EDGE OF VARDAR ZONE: GEODYNAMIC IMPLICATIONS FOR MESOZOIC PALEOGEOGRAPHY

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The primary aim of this study was the bio- and lithostratigraphic correlation between Northern Hungary (Aggtelek-Rudabánya Unit) and Greece (Subpelagonian Terrane and Outer Hellenids) by Middle Triassic and Middle Jurassic radiolarian faunas. A further aim of the project was to investigate the age-dating capabilities of Middle Triassic radiolarians in Vardar zone, which mainly contains oceanic basement fragments (MORB-type) and deep water sediments (mainly radiolarians). The northernmost outcrops of Vardar s.l. (Meliata-Melléte) Oceanic Branch could be found in Aggtelek-Rudabánya Mountains, which is the most complicated area in Hungary.

The Aggtelek-Rudabánya Unit consists of three nappes of different origin. The lower nappe, the Tornaikum Unit is made up of anchi- and epimetamorphosed Mesozoic sequences. The topmost nappe, the Silicicum Unit is made up of non-metamorphosed sequences. The middle nappe, the anchi-metamorphosed Meliata Unit preserved as thicker chips in the basal evaporitic complex of Silicicum Unit. The Silicicum Unit is made up of three subunit of different facies: Aggtelek nappe (carbonate platform facies – Wetterstein Limestone), Szőlősardó Unit (slope and periplatform basin facies – Reifling Limestone) and Bődva nappe (deep, pelagic basin facies – Bődvalenke Limestone). The Meliata Unit consists of two nappes: Bődvarárkó Unit (deep, pelagic basin facies) and Tornakápolna Unit (ophiolite complex). The Tornaikum Unit consists of mainly pelagic sediments. In the Bődva Nappe the Middle Anisian to Carnian interval is a deep pelagic facies, the consequence of attenuation of the continental crust following initial Meliata Ocean (Vardar s.l.) opening. The Upper Anisian-Upper Carnian sequence is made up of an alternation of pinkish thin-bedded limestone and pelagic bivalve coquinite with thin, red clay and red chert interlayers. This red, condensed carbonate formation (Bődvalenke Limestone) was deposited in a well-oxygenated pelagic basin. The Tornakápolna Unit is made up of ophiolite sequences (ultrabasic rocks, gabbro, and basalts) and radiolarite. Spilitised metabasalts shows pillow structure, frequently. In basalt complex radiolarite and claystone ontercalations occur. Based on radiolarians found in these layers, they are Ladinian. In addition, the Jurassic pelagic series (Telekesvölgy complex and Telekesoldal complex) of the Aggtelek-Rudabánya Unit and the Darnó-Szarvaskő Unit which was overthrusted onto the Bükk parautochthonous unit belong also to Meliaticum. Very similar Triassic sequences are much better exposed and preserved conditions in Northern Pindos (Outer Hellenids, Vardar zone) and in Othrys Mountains, where they are preserved as slivers in ophiolite complex. The pelagic sediments are red “Hallstatt”-type limestones lying over pillo lavas occurred in Outer Hellenids as early as in the Late Scythian and Early Anisian, whereas in North-Eastern part of Hungary in the Middle Anisian. Very similar and important link between Northern Hungary and Greece was recently found in the Dinarides (Vardar Zone s.s), where the presence of Late Scythian and Early Anisian pelagic sediments was also recorded. The radiolarians in both regions and also in the Inner Dinarides were deposited from Early Ladinian to Carnian, possibly linked to a Tethyan-wide event.
TERRESTRIAL FLORAS FROM THE NEW ZEALAND TRIASSIC

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New Zealand Triassic plant macrofossils are best known from several localities in the Rakaia Terrane of South Island. These mainly nonmarine Kaihikuan (Ladinian) localities contain diverse assemblages in which prominent taxa include species of Dicroidium, Johnstonia, Pachydermophyllum, Ginkgophytopsis, Neocalamites, Linguifolium, and Heidiphyllum, and were incorporated by Retallack (1977) in his "ecostratigraphic" zonation of Gondwanaland Triassic floras. Leaf fossil assemblages from Triassic Murihiku Terrane rocks are mostly limited to fragmentary remains. These have generally been of little stratigraphic value, however Etalian (Anisian) marine sediments are characterised by dispersed leaves of Taeniopteris lentriculiformis, paralleling a similar acme in eastern Australia.

Triassic palynofloras have been recovered from only two New Zealand terranes, other terranes generally being of too high a metamorphic rank for their preservation. In the Western Province, Triassic miospores occur in Topfer Formation, a small outlier of terrestrial sediments which represents the continental "Beacon" facies of the southern Gondwanaland margin. In the Murihiku Terrane of the Eastern Province, well-preserved mixed terrestrial-marine palynofloras occur in Triassic and Jurassic shallow marine sediments of the Murihiku Supergroup, correlated with the global timescale by ammonoids and other marine fauna. Late Permian palynofloras are also known from this terrane. A miospore zonation was developed for the Triassic to Middle Jurassic by de Jersey & Raine (see Campbell & Raine 2004). In this zonation the Triassic is divided into five zones: an informal "pre-clematisi" interval (Makarewan to Etalian; Induan to Anisian), Apiculatisporis clematisi Zone (Etalian-Kaihikuan; Anisian-Ladinian) with Triplexisporites playfordii Subzone (Anisian), Annulispora folliculosa Zone (Kaihikuan-Oretian; Carnian-Norian) with A. microannulata Subzone (Norian) Polycingulatisporites crenulatus Zone (Otamitan-Otapirian; Norian), and Foveosporites moretonensis Zone (Otapirian; Rhaetian).

Broad similarities in the palynofloral successions of NZ and Queensland assist global correlation of the wholly terrestrial eastern Australian sequence. The miospore assemblages conform to the Ipswich biogeographic province, which was situated south of paleolatitude 35°S during the Triassic. This austral paleoflora was characterized by relatively abundant pteridophyte, lycophyte and bryophyte spores, with distinctive species such as A. clematisi, A. microannulata and F. moretonensis, in contrast to the lower latitude Onslow province paleoflora with its distinctive gymnosperm taxa. The Rhaetian saw a short-term acme in the lycophyte Densoisporites psilatus, but also a breakdown in provinciality, with appearance of new cosmopolitan elements. The Triassic-Jurassic boundary is marked by considerable floral turnover. Features include a decline in abundance of D. psilatus; first appearance of Retitriletes austroclavatidites, R. semimuris, and Zebrasporites interscriptus; and (a little higher) the first common occurrence of Corollina cf. chateaunovi.

REFERENCES:
LOWER TRIASSIC PERITIDAL CARBONATES OF CACHE CREEK COMPLEX
IN JESMOND, SOUTHERN BRITISH COLUMBIA

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We report the field relationships of the Smithian to Spathian carbonates of the Cache Creek Complex in the northern Marble Range, southern British Columbia. The Early Triassic carbonates are underlain by Upper Permian shallow-marine carbonates. Both carbonate units are integrated as an atoll-type buildup on the top of a seamount in a mid-oceanic realm of the Panthalassa ocean.

The Lower Triassic carbonate succession (>80 m thick) predominantly comprises bedded, light gray dolomitic lime-mudstone (dolomicrite) of an intertidal facies. Dolomicrite is rich in fenestral voids and contains mm-scale, wavy and parallel faint laminae, most presumably referable to as microbial mats. The lower part (>35 m thick) of the succession has frequent interbeds (< 0.5 m thick beds) of flat-pebble breccia and intraclastic limestone both best interpreted as storm-generated sediments. The middle part (ca. 25 m) contains carbonaceous, fenestrae-laminated, carbonaceous, stromatolitic bindstone (< 0.8 m thick) at two levels. This facies is lithologically comparable with the Griesbachian microbialite described in atoll-type carbonates in Japan. Fenestral void-rich, siliceous limestone and microbial lumpy particles and oncoids characterize the upper part (>20 m).

The examined carbonates are poor in calcitic skeletal debris. Discerned in the lower part are only scattered, tiny, opportunistic gastropods. In the middle part, sporadic and minute crinoid and bivalve debris first appear.

We tentatively interpret the Smithian-Spathian carbonates as sediments deposited in a lagoonal tidal flat under arid and warm climatic conditions, where the ecosystem of the benthic community was still devastated in the aftermath of the end-Permian crisis.

Comparison with the comparable atoll-type carbonates in Japan suggests a delayed biotic recovery in the Jesmond buildup. The occurrence of crinoids and bivalves in the middle part implies an initiation of the biotic recovery during Smithian-Spathian time in Jesmond, whereas explosive accumulation of thick-shelled bivalves are recorded as early as Dienerian in the Japanese atoll-type carbonates.
CONODONTS OF DIENERIAN AGE (EARLY TRIASSIC) FROM NORTHERN THAILAND

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A conodont fauna from a 40 cm interval of an unnamed Lower Triassic unit west of Phrao, northern Thailand, comprises several thousand well-preserved elements that appear to represent the full apparatuses of several species of the Neospathodus dieneri Sweet 1970 group. This group includes the first true species of Neospathodus to emerge from Neogondolella ancestors in the early Induan and furthermore represents a major root stock for many Olenekian conodonts.

The apparatus of Neogondolella is rather conservative in nature changing little from the Upper Permian to the Upper Triassic (Orchard & Rieber, 1999). On the other hand, Olenekian ‘Neospathodus’ species have at least nine different apparatuses (Orchard, 2005). During the late Induan, conodont apparatuses appear to have undergone a profound metamorphosis yet the details of these changes are virtually unknown. The Thailand material contributes important data to our understanding of the evolving apparatuses of the Triassic. We present several possible reconstructions of the material and speculate how they fit into the explosive radiation of conodonts evident in the Early Triassic.

REFERENCES:
RADIOLARIAN ASSEMBLAGES AND CHEMICAL COMPOSITION OF LOWEST JURASSIC (HETTANGIAN / SINEMURIAN) BLACK CHERT SEQUENCES FROM THE IKUNO DISTRICT, TAMBA TERRANE, SOUTHWEST JAPAN

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Triassic-Jurassic accretionary complexes of the Tamba Terrane are widely distributed in the Ikuno district, Hyogo Prefecture, SW Japan. The Wakai Complex which is distributed in the north part of the Ikuno district contains well-preserved Upper Triassic-Lower Jurassic radiolarian fossils. It is considered, the Wakai accretionary complex formed in the Earliest Jurassic time. It mainly consists of blocks of greenstone, bedded chert, bedded acidic tuff, siliceous shale, shale and sandstone with melange matrix. Hori & Goto (1994) and Hori et al (2004) have briefly documented the characteristic Lowest Jurassic (Hettangian) radiolarian fauna which includes a considerable high variety of \textit{Canoptum}. In this study, we investigated detailed faunal composition of radiolarian assemblages and their vertical change up section. We also performed geochemical analysis on the host rocks of these radiolarian fossils in order to clarify the nature of their oceanic environments.

\textbf{Characteristic radiolarian assemblages} were obtained from a continuous sequence of black, bedded, \textasciitilde 4 m thick chert. The lower part of the sequence yielded \textit{Crucella hettangica}, \textit{Pantanellium cf. browni}, \textit{Saitoum cf. triamphense}, \textit{Parahsuum} spp. (primitive form), \textit{Natoba} spp., \textit{Canoptum} spp., and \textit{Udalia} spp. of late Hettangian age. Species of the genus \textit{Natoba} resemble \textit{Natoba} sp. A which has been documented as a primitive form of \textit{Natoba minuta} by Kashiwagi (2003). He suggested that \textit{Natoba} sp. A ranges into the Upper Hettangian-Lower Sinemurian. Our results support his suggestion.

\textbf{Composition of radiolarian faunas} from the sequence were examined and produced the following result: 1) a high content of spumellarians (90%), which had already been reported by Hori et al (2004), 2) a considerable variety of nassellarians, 3) among nassellarians, the presence of \textit{Natoba} spp. is relatively high, (max 30%), compared with other correlative samples, such as those from the Inuyama bed cherts in SW Japan. Nassellarian fauna from the Ikuno area includes \textit{Natoba} spp. and a primitive form of \textit{Parahsuum} spp. High abundance of \textit{Natoba} is a distinctive feature of the Ikuno fauna, as the occurrence of \textit{Natoba} is quite limited in Lower Jurassic strata from Japan (e.g. Suzuki 1995, Kashiwagi 2003), and may strongly relate to the \textit{Canoptum} assemblage. Previous studies have suggested that the \textit{Canoptum} assemblage is endemic and is related to fertility of the ocean (Hori et al., 2004). It is possible that the genus \textit{Natoba} is particularly sensitive to change of oceanic environment. Chemical studies on host rocks of the Ikuno fauna have revealed the following facts: 1) detrital materials derived from continental sources are different for the Ikuno and Inuyama areas, 2) content of nutrients are different for these two areas. The results indicate that the oceanic environment where the Ikuno Lower Jurassic cherts accumulated is different from that of the Inuyama chert, as reflected in their distinctive radiolarian assemblages.
THE WAIPAPA TERRANE OF NEW ZEALAND: GEOLOGY OF A TREASURE TROVE OF PERMIAN - MESOZOIC OCEAN FLOOR FAUNAS

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A number of terranes (from west to east: Caples, Waipapa, Torlesse and Waioeka / Te Kaha) containing ocean-floor-rock-to-terrigenous-clastics stratigraphic sections were accreted onto the New Zealand Gondwana margin in the Mesozoic. Of these, the Waipapa Terrane has yielded the largest number of ocean floor faunas and hosts the only open-ocean section of the Permian / Triassic boundary in New Zealand.

The reasons for this richness are 1) environmental / lithological (abundance of red chert and green argillites and relatively low grade of metamorphism), 2) structural (moderate dips compared to those in the other terranes combined with low thicknesses of individual accretionary slices) and 3) geographical (extensive exposures on a highly indented coast). Waipapa Terrane occupies a wide belt in the north but tapers southward. Thin continuations in the South Island (Marlborough and Crystals Beach) have only been recently identified.

Definition of the Waipapa Terrane has evolved from a ‘carpet bag’ term through near-abolition into the present, narrower, delimitation due to the recognition of the Caples Terrane in Northland. In the North Island, the terrane consists of a proximal, southern, Morrinsville facies and a distal, northern, Hunua facies. The Hunua facies can be in turn divided into a northern and a southern sub-unit, based on their ocean floor rocks. A typical stratigraphic section in the Waipapa Terrane starts with spilitic basalts, either of mid-ocean ridge (in the south) or ocean island derivation (in the north), followed by red cherts, then green hemipelagic mudstones which grade into the terrigenous clastics (alternating volcanic/lithic sandstones and mudstones). The famous fusulinid-bearing limestones of Marble Bay are closely interleaved with basalts and indicate Tethyan (low latitude) derivation of the oceanic sequence (from the Phoenix plate?), in stark contrast to the very high latitude at which the terrane was eventually accreted onto Gondwanaland.

Such long distance travel by seafloor spreading is also indicated by radiolarian faunas. The subsequently deposited terrigenous clastics must have experienced lesser distances of displacement. Major thrusts within the Waipapa accretionary prism are marked by mélanges at the base of the oceanic sequence, but broken formation extends into most terrigenous sections. ‘Red melanges’ of the northern Waipapa Terrane indicate tectonic reworking of debris derived from collapse of large ocean floor volcanoes. Structures in the Waipapa Terrane are dominated by westerly dips of bedding, in accordance with accretion from the east. Mélanges and broken formation fabrics indicate a strong strike-parallel component of movement during accretion, mostly dextral in the north but dominantly sinistral in the south. These structures are postdated by subhorizontal eastwards-verging folds which in turn have been rotated on steeply plunging axes. During these deformations, the rocks were in a ‘weak rock’ state, with little formation of cleavages. All these structures are compatible with accretion of the Waipapa Terrane in an oblique-slip subduction system. Some late extensional faults represent subsequent uplift and collapse of the accretionary prism.
The Paleozoic and Mesozoic in the Kyoto Nishiyama area are divided into the Takatsuki Formation, the Hirose Formation and the Tamba Terrane. The Tamba Terrane is subdivided into the Honzanji and Izuriha complexes tectonically in descending order.

The Takatsuki Formation is a Late Permian clastic formation composed of sandstone, mudstone, siliceous mudstone and felsic tuff.

The Hirose Formation consists of sandstone, mudstone and greenstone, and includes both coherent and mixed facies. Middle Triassic radiolarians (Oertlispongus diacanthus, Eptinguim nakasekoi, Pseudostylosphaera compacta, Plafkerium sp., etc.) are reported from mudstone and mudstone clast of this formation.

The Honzanji Complex is subdivided into two parts: upper and lower. The former is of mixed facies which consists of sandstone, mudstone (early Late Triassic?), siliceous mudstone (Middle Triassic: Pseudostylosphaera japonica and Triassocampe deweveri), chert (Late Permian to Middle Triassic), and greenstone. The latter is of coherent facies and consists of clastics (early Late Triassic) and chert blocks.

The Izuriha Complex is of mixed facies and is composed of sandstone, mudstone (Late Triassic), siliceous mudstone (Late Triassic: hagiastrid gen. sp. indet.), chert (Late Permian to middle Late Triassic: Canesium cf. lentum, Canoptum laxum, etc.), limestone (Late Permian to Late Triassic) and greenstone.

These formations and complexes are involved in a fold structure named the Sakurai synform gently plunging to W-WNW. The Takatsuki Formation tectonically overlies the Tamba Terrane. The Hirose Formation appears to be interleaved with the Takatsuki Formation. These are in fault (high angle) contact with each other. The original relationships between the Takatsuki Formation and the Hirose Formation are unknown.

The Tamba Terrane in the study area is a Late Triassic to Earliest Jurassic accretionary complex. There is a possibility that the Takatsuki and Hirose formations are an accretionary complex or not, respectively.

In this paper I will report mainly on Triassic radiolarians from the Hirose formation, the Honzanji Complex, and Izuriha Complex, and discuss the implications for Late Paleozoic-Mesozoic tectonics of the Inner Zone, SW Japan.
PERMIAN AND TRIASSIC RADIOLARIANS FROM ARROW ROCKS, NORTHLAND, NEW ZEALAND

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Many Permian and Triassic radiolarians had been obtained from Arrow Rocks, a small island off Marble Bay in Whanganui area, Northland. They provide important information of not only the radiolarian faunas in the southern hemisphere but also the faunal evolution across the Permian/Triassic boundary. We present here the outline of geology of Arrow Rocks sequence and radiolarian occurrences.

The Arrow Rocks sequence is composed of massive basalt with lenses of limestone and red shale with volcanic sandstone, bedded chert, bedded siliceous mudstone, and maroon and green siliceous mudstone in ascending order. We had once regarded it as an almost continuous section and had divided into 8 lithologic units (Takemura et al., 1998). However, it is clarified that the basalt of Unit 1 is a sill and intruded into the poorly consolidated Permian pelagic sequence (Sakakibara et al., 2003).

The lowermost part of the Arrow Rocks sequence crops out at ARG section, the southern base of the eastern hill. This section consists of volcaniclastic rock, red bedded chert, red bedded siliceous mudstone and thin-bedded green-grey chert in ascending order (Takemura, S. et al., 2004) and we named this interval as Unit 2a. Middle to Late Permian radiolarians occur in many horizons of red bedded cherts and one siliceous mudstone layer. Late Permian conodonts were also obtained. Other than Unit 2a, one limestone lens within basalt yields well preserved Permian pelagic radiolarians (Takemura et al., 1999).

Black chert and red and grey bedded cherts overlie Unit 2a with a fault contact. These cherts (Unit 2b) and black and grey cherts of Unit 3 are Induan (Earliest Triassic) in age according to conodonts. Permian-type radiolarians occur in several horizons within the lower part of this interval, while primitive nassellarians are obtained from the late Induan bedded cherts (Kamata et al., this conference).

No well-preserved radiolarians occur in the Olenekian interval of Units 4 and 5, which are composed of red bedded chert and siliceous mudstone. Middle Triassic radiolarians were obtained from 2 horizons of bedded siliceous mudstones in Units 6 and 7 (Takemura et al., 2002), as well as manganese carbonate nodules within Unit 6. As yet we have not obtained any identifiable radiolarians or conodonts from green siliceous mudstone of Unit 8, the uppermost unit of the Arrow Rocks sequence.
MIDDLE TRIASSIC RADIOLARIANS FROM CHIANG DAO, CHIANG MAI NORTHERN THAILAND

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On the 1: 250,000 geological map of Thailand, an obvious zone of granites and metamorphic rocks occurs in the central part of northern Thailand. Extensive Carboniferous and few Permian strata crop out between this zone and the Cenozoic Chiang Mai basin. The Carboniferous strata mainly consist of greywackes, arkosic protoquartzites and orthoquartzites, quartzites and shales with quartz-veinlets. The Lower Permian includes phyllites, sandstones and siltstones, quartzites, quartzitic schists, agglomerates, and tuffs (Charoenprawat et al., 1994). Feng et al. (2002) discovered a Middle Triassic radiolarian assemblage from the Lower Permian strata, which is situated in the south of Chiang Mai, northern Thailand.

Recently, an Anisian radiolarian assemblage was recovered from bedded chert sequence northwest of Chiang Mai province, northern Thailand. The outcrop locality is located in northwest of Chiang Dao district on the left side of the road number 1322 between km 1 and km 2. More than 300 samples in a 13 m continuous succession were collected. The radiolarian-bearing cherts are mostly light grey in colour, well bedded and varied in several centimetres of thickness. These cherts are intercalated with a few millimetres in thickness of siliceous shale and claystone partings. Based on Baum et al. (1981), this area was mapped as Carboniferous in age.

The radiolarian assemblage includes Triassocampe diordinis Bradin, Triassocampe coronata coronata Bradin, Triassocampe coronata inflate Feng, Zhang and Ye, Triassocampe scalaris Dumitrica, Kozur and Mostler, Yeharaia sp., Striatotriassocampe yini (Feng), Pseudostylosphaera compacta (Nakaseko and Nishimura), Archaeospungoporprunum liui (Feng), Paroertlispongus hermi (Lahm), Cryptostephanidium cornigerum Dumitrica, Eptingium nakasekoi Kozur and Mostler, and other species. It can be well correlated with the Triassocampe coronata zone from the Mino terrane, Central Japan (Yao, 1982; Sugiyama, 1997) and the Triassocampe coronata coronata zone from the Changning-Menglian belt, Southwestern Yunnan (Feng et al., 2001). Those zones are correlated to middle Anisian.

The age of the described radiolarian fauna is important because the stratigraphic units in this area were formerly dated on the basis of a few fossil locations and petrological similarities. However, strata in the studied area are possibly not continuous in stratigraphic sequence, but consist of some stratigraphic slices. Fossil age from any stratigraphic slice indicates only the geological age of this slice, and adjacent stratigraphic slices are often different in geological age. Some parts of the strata formerly mapped as Carboniferous and Permian stratigraphic units should be younger. In other words, except Carboniferous-Permian clastic rocks, shales and siliceous rock sequences there are early-middle Triassic fine-grain clastic rocks and siliceous rock sequences distributed in the studied area.

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NEW DATA ON TRIASSIC AND JURASSIC TO CRETACEOUS RADIOLARIA OF BOSNIA AND SERBIA

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The presence of Late Cretaceous radiolarians in the Vardar Ocean is recorded. We have discovered two locations: first, in Bosnia near Kozara (Cema reka–Krovavac) with the Campanian zonal species Amphipyndax enessefi and numerous planktonic foraminifera such as Globotruncanca arca (Cushman), G. stuarti (De Lapparent) and others (Karamata et al., 2005), second, in Serbia (Struganik) with the Coniacian zonal species Alievium superbum. The richest locations of Early Cretaceous and Mid-Late Jurassic (Callovian-Oxfordian and Kimmeridgian-Tithonian) radiolarians were discovered in the Jezeračka reka, Maslovare, Jotanovići districts and Ivanska quarry of North Bosnia (Dinaridic Ocean).

The Berriasian-Valanginian radiolarians Acanthocircus minispineus Yang, Sethocapsa cetia Foreman Sethocapsa testata Jud, Pseudodictyomitra depressa Baumgartner, Xitus channelli Jud, Crolanium cf. pythiae SchAAF occur together with a few planktonic foraminifera that provide control. The Tithonian radiolarian assemblage includes Alievium helenaе Schaaf, Podocapsa amphitrepterа Foreman, Hsuum brevico стatum Ozvoldova, Obesacapsula ruscoensis Baumgartner, Obesacapsula ruscoensis umbriensis Jud, Spongocapsa palmerae Pessagno, Tethysetta dhimenaensis (Baumgartner). The Oxfordian-Kimmeridgian radiolarian assemblage is represented by the following species: Homоеoparanеlla argoldidensis Baumgartner, Archaeodictyomitra apiara (Rust), Cinguloturris carpatica Dumitrіca, Eucyrtidiellum ptyctum (Riedel et Sanfilippo), Hsuum maxwelli Pessagno, Podobursa spinosa Ozvoldova, Diboloachras chandrika Kocher. The uppermost Callovian- lower Oxfordian assemblage comprises Pantanellium meraceibaence Pessagno et MacLeod, Archaeosp ogrunun imlayi Pessagno, Triactoma blakei Pessagno, Tritrabs ewingi Pessagno, Podobursa helvetica Rust, Stichocapsa robusta Matsuoka, Eucyrtidiellum nodosum Wakita. The uppermost Bajocian-Bathonian assemblage is characterized by Tetradicryma pseudoplena Baumgartner, Staurosphaera antiquа (Rust), Emiluvia splendidа Carter, Triactoma jonesi Pessagno, Canoptum. dixoni Pessagno et Whalen, Hsuum mirabundum Pessagno et Whalen, Palinandromeda praepodieuleusс Baum., Cyrtocapsа mastoidеa Yao, Praewilliriedellum spinosum Kozur. The Aalenian-early Bajocian radiolarians include Hexasaturealis hexagonus (Yao), Transhssum hisui kyoenе (Isozaki et Matsuda), Minifusus proavus Tonielli, Luperhiум officerense Pessagno et Whalen, L. nitidum Pessagno et Whalen. A coeval assemblage also has been found in Serbia (8 km south of Sjenica). A Late Triassic (Norian-Rhaetian) radiolarian association with Kahlesphaera kemerensis from Serbia (west of Sjenica) has been found together with conodonts Grodella cf. delieulata (Mostler), Middle Triassic (Ladinian) assemblages, Muelleriritors cochleata, widespread in Serbia (Rzav River Basin, Dinaride Zone; Kablar gorge, Vardar Zone).

Radiolarian data permit precise age control of the Vardar Ocean (it was closed only in the Maastrichtian) and to reconstruct paleoprofiles of the Dinar and Vardar Oceans.

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Triassic rocks which make up the so-called “Torlesse terrane” of the Southern Alps and mountains extending almost to the east coast of the South Island, New Zealand, are analysed from extensive geological mapping in south and central Canterbury. Sequences are not simple, but detailed mapping and discoveries of scattered mostly macro-fossils allow unravelling of nappe formation during the Cretaceous Rangitata Orogeny, and extensive compression during the Kaikoura Orogeny.

From the Alpine Fault to the main divide and sometimes a little east are thick argillite- and less commonly sandstone-dominated turbidites of a former trough that developed largely in Late Triassic time, followed to the east by more sandstone-dominated turbidite and sandstones of continental slope, referred to the Early (?) to Late Triassic Malte Brun Group. Eastwards lies transitional or submarginal facies, mostly the Anisian-Ladinian Acolyte Formation of some 6-9 units of highstand systems tracts of sandstone alternating principally with shallow-water black shale representing maximum flooding levels. These are overlain close to the continental slope bypass-deposits of the Late Triassic Onslow and Baker Formations, and south of the Rakaia River, plant fossils and detached coal blocks, as at Tank Gully, Clyde River, followed by shallow-marine Mt Potts Group, which point to extensive uplift and tectonic uplift during Acolyte deposition.

Still further east, the Otematata and Balmacaan Groups and Fingers Formation are partly estuarine and subdeltaic, judged from plant remains, coal, conglomerate and marine fossils, and close the basin along the east side. The Jurassic substantially non-marine Clent Hills Group follows south of the Rakaia River. A second basin is newly recognised to the east in south Canterbury, with thick Early to Middle Triassic (?) clastics overlying extensive Permian and some Carboniferous. The interbasinal divide was later lost through Cretaceous subduction, leading to the development of mostly Late Cretaceous acidic flows and intrusions of the Mt Somers Group, and extensive development of schist bands along and close to the suture.

In recent years one favoured source for the Torlesse Triassic was accumulation as a basin offshore from northeast Queensland, another that the Torlesse was derived from rocks like those now exposed in west Antarctica. The present mapping study shows that the Alpine and associated rocks were derived from the east, from uplands of the interbasinal divide beyond the deltas and fans, and not from cannibalisation of easterly Permian. Mapping so far strongly suggests that the Triassic sediments east of the fans and deltas were derived from the same upland, on its eastern side. Thus it appears that the Torlesse s.l. came from an upland, perhaps split earlier from either northeast Queensland or Antarctica, but from fossil paleolatitudinal distributions, more likely west Antarctica, with a position, judged from faunal distributions and sea-floor spreading record, not far from the northeast coast of Queensland.
RECORDS OF STABLE ORGANIC CARBON ISOTOPES AND BIOMARKERS FROM THE TRIASSIC-JURASSIC BOUNDARY

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New lithologic, stable organic carbon isotope, and biomarker data are presented from Triassic-Jurassic boundary sections at Marokopa, New Zealand, Muller Canyon, Nevada, USA, and the Queen Charlotte Islands, British Columbia, Canada. The Marokopa stable carbon isotope record shows two negative excursions in close association with fossil turnover shown by MacFarlan (1998). A negative excursion at the boundary and a positive excursion just after the boundary are reported from the Muller Canyon GSSP candidate section in Nevada, USA. From Kennecott Point in the Queen Charlotte Islands, British Columbia, Canada, the previously reported Late Norian to Earliest Hettangian record is extended by over 130 m, and two new isotopic features are revealed. The Kennecott record now shows a negative trend in baseline carbon isotope values from approximately –29‰ in the Late Norian to –31‰ in the Hettangian. This trend is interrupted by the previously reported 2‰ negative excursion at the Triassic-Jurassic boundary and a 5‰ positive excursion in the early Hettangian. We suggest that changes in microbial ecology as well as changes in the inorganic carbon cycle due to a decline in biocalcification associated with the Triassic-Jurassic extinctions may have played a role in the great perturbations to the carbon cycle that would have been required to produce the isotopic changes that have been discovered in Triassic-Jurassic boundary sections around the world. Preliminary GC-MS analyses of Norian to Hettangian siltstones and black shales from Kennecott Point show fundamental changes in the source of the organic matter, supporting the idea that major microbial change may have accompanied the long recognized changes among macroflora and macrofauna during the Triassic-Jurassic transition.

REFERENCE:
PALAEOZOIC AND MESOZOIC RADIOLARIAN FAUNAS FROM NORTHERN THAILAND; A CONTRIBUTION TO A NEW GEODYNAMIC MODEL FOR THE SE ASIAN REGION

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The pre-Jurassic geology of the SE Asian region, including mainland Thailand, is generally known as a complex assembly of continental to distal oceanic series, continent and arc fragments, accretionary prisms and suture zones (e.g. Metcalfe 1996, 2002). The reconstruction of its history is fundamental to any understanding of the Palaeo-Tethys, evolution, and the structures inferred by one or more collisions (and/or subductions).

Owing to the poor exposure, few micropalaeontological investigations and a limited number of radiometric dates, the regional geologic history is still not well known and is also controversial.

Here we report on three years of intensive work, focused on the study of radiolarites and radiolarians preserved in oceanic rocks, that outcrop in Northern Thailand. Over forty sections have been studied. Taxonomy of the extracted radiolarians (Middle Devonian to Late Triassic) has been fully investigated. Several species are new.

The resultant radiolarian succession provides the basis of a regional radiolarian biostratigraphic scale with a half stage precision. Study of changes in biodiversity and assemblage comparisons allow palaeobiogeographic interpretation. These new age determinations and field observations permit a new tectonostratigraphic interpretation of northern Thailand and also a new geodynamic model.

This work clearly proves the fundamental importance of dating sedimentary rocks (the distal oceanic radiolarites and carbonates). Such data is essential in order to build models and to better understand the geological structures of Thailand as well as the wider SE Asian region. Radiolarian biostratigraphy is a very important tool.

REFERENCES:
TRIASSIC SCLERACTINIAN CORAL REEFS ON THE NORTH AMERICAN CRATON: PALAEO-TECTONIC & ENVIRONMENTAL IMPLICATIONS

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Small bioclastic mounds (~100 to 500 m³) composed of anthozoans (spongiomorphs and scleractinian corals), molluscs (bivalves, gastropods and rare nautiloids), echinoderms (crinoid and echinoid skeletal debris) and brachiopods (terebritulids and spiriferids) occur within Upper Triassic strata of the lower Baldonnel Formation at Pardonet Hill in northeastern British Columbia Canada. Many of the anthozoan fossils are preserved in growth position. These bioclastic mounds exhibit rigid, wave-resistant structure with appreciable relief above the surrounding sea floor and are interpreted as true, ecologic patch reefs. The patch reefs are composed of packstone, bioclastic floatstone / rudstone and carbonate breccia intercalated with mixed siliciclastic carbonate sediments deposited in a shallow subtidal setting (i.e. above fair-weather wave base). Amalgamated hummocky cross-stratified to current ripple-laminated, quartz-dominated sandstone beds and numerous sharp-based, normally graded, bioclastic (commonly encrinitic) packstone / grainstone - quartz-sandstone couplets characterize inter-reef lithologies which are typified by moderately diverse Cruziana-Skolithos trace fossil assemblages.

Conodont biostratigraphy indicates that the Pardonet Hill patch reefs occur within strata dated as earliest Upper Carnian (lower nodosus zone). The Pardonet Hill patch reefs originated and developed during an interval of regional sea level lowstand. Strata within which these patch reefs occur represent the westmost migration of the Triassic shoreline in western Canada. Disappearance of coral reefs in the study area may be the result of rapid marine transgression and failure of reef faunas to recolonize the new shore zone further to the east.

The Pardonet Hill patch reefs are the first and only coral-spongiomorph reefs reported from the North American cratonic margin. Prior to discovery of the Pardonet Hill coral patch reefs, Triassic reefs on the western margin of North America were limited to isolated features on allochthonous terranes that now comprise part of the North American Cordillera. The Pardonet Hill patch reefs are the only exception, documenting certain occurrence of Triassic corals on the North American craton margin at ~30° N paleolatitude. The presence of benthic faunas characteristic of low-paleolatitude settings on the northwestern coast of Pangea has significant implications for palaeotectonic and palaeoenvironmental reconstructions.

Most terrane coral/reef occurrences in the Canadian Cordillera are younger than the Pardonet Hill locality (i.e. lower to upper Norian) suggesting that the path of faunal migration from the Tethys region to the eastern Panthalassa was more complex than has previously been suggested. Regional sea-level flux, resulting in abrupt (and brief) westward migration of the shoreline (and concomitant deflection of regional oceanic circulation patterns), is interpreted to have played a germinal role in both the appearance and disappearance of coral reefs on the eastern margin of the Panthalassa Ocean.