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INTERRAD

International Association of Radiolarian Paleontologists *A Research Group of the International Paleontological Association*

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INTERRAD is an international non-profit organization for researchers interested in all aspects of radiolarian taxonomy, palaeobiology, morphology, biostratigraphy, biology, ecology and paleoecology. INTERRAD is a Research Group of the International Paleontological Association (IPA). Since 1978 members of INTERRAD meet every three years to present papers and exchange ideas and materials.

INTERRAD MEMBERSHIP: The international Association of Radiolarian Paleontologists is open to any one interested on receipt of subscription. The actual fee is US \$ 15 per year. Membership queries and subscription are sent to the Treasurer. Changes of address can be sent to the Secretary.

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Newsletter of the International Association of Radiolarian Paleontologists

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Editor: *Giuseppe Cortese*

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EDITOR'S NOTE

Giuseppe Cortese

This new issue of Radiolaria contains the reports by the chairmen of our working groups (Paleozoic/Mesozoic/Cenozoic/Recent), a few announcements, a report on InterRad11 and some info on the relative Proceedings volumes, a translation of a report on last InterRad appeared in a french magazine, an article (previously appeared in japanese only) on a radiolarian enrichment technique when working with sandy sediments, and the radiolarian bibliography for the 2005/2006 period.

Thanks to all of you who contributed material and information to this issue. Enjoy !

RECENT AND CENOZOIC WORKING GROUP

Annika Sanfilippo

During the past year the Combined Late Cretaceous-early Paleogene, Cenozoic and Recent Working Group had no specific working group projects to report on. References with abstracts to the published papers resulting from new and exciting work are included in the Bibliography.

Our thanks to Chris Hollis and the Organizing Committee for organizing the first International Radiolarian Conference in the Southern Hemisphere. It was a great success with a large number of participants, especially students, from many different countries, and many excellent field trips that combined other aspects of New Zealand natural history and culture. The opportunity for participants to meet the two radiolarian researchers, Bill Riedel and Emile Pessagno, who revolutionized Cenozoic and Mesozoic biostratigraphy made for a very special and memorable meeting.

During the INTERRAD Business meeting the Working Groups discussed a wide spectrum of interests. The participants agreed to address themes of common interest, primarily the various database efforts under way (see presentations and discussions on Radiolaria.org and Radfolks), and the joint efforts toward an integrated taxonomy for the purpose of radiolarian distributional patterns in studies of environmental change. There is an urgent need to coordinate these initiatives to avoid duplication and establish systems that can eventually be integrated. The Recent and Cenozoic Working Group agreed that the first step was to stabilize the species concepts, and to develop a consistent taxonomy through the use of web-based databases. If you are interested in contributing your effort toward this worthwhile project contact the persons responsible: Recent & Holocene – John Rogers; Neogene – Dave Lazarus; Paleogene – Chris Hollis.

The Haeckel and Ehrenberg project, led by the Japanese, to re-examine and re-describe type material held in collections in London, Berlin and Jena has the potential to resolve the lack of well defined holotypes that exist for many common radiolarian species and genera.

News from Dave Lazarus - as this developed quite recently:

A substantial number of original Haeckel radiolarian slides (ca. 70), primarily plankton slides made on-board the Challenger, has surfaced in Germany. The private owner initiated contacts this summer with the Natural History Museums in London and Berlin. This material had been in the family since it was given to one of Haeckel's nieces ca. 100 years ago. The owner has generously allowed the material to be loaned for a few months to the Museum in Berlin where it is now being systematically examined and the radiolarians imaged. As is true for all other known Haeckel Challenger materials no type specimens are specifically marked. However, as at least some of these are of Challenger plankton samples no longer known from anywhere else (e.g. there are no equivalent plankton slides at the Natural History Museum in London), this represents a valuable addition to our knowledge of original Haeckel radiolarian materials.

MESOZOIC WORKING GROUP

Luis O'Dogherty

Lower Jurassic Group (Leaders: Spela Gorican and Elizabeth S. Carter)

Participants: Patrick De Wever, Paulian Dumitrica, Jean Guex, Rie S. Hori, Atsushi Matsuoka, Luis O'Dogherty and Patricia A. Whalen

After five years of hard work, two meetings (Ljubljana 2001 and 2002) and many hours in front of the screen, the taxonomic project led by Spela Gorican and Beth Carter is finally done. This project involves a systematic revision and stratigraphy of Lower Jurassic Radiolaria. This work will be published in two parts: a first book devoted to the Taxonomy (published by the Scientific Research Centre of the Slovenian Academy of Sciences and Arts), and a second article entirely dedicated to the biostratigraphy (it will be published separately in an international journal).

The "*Catalogue and Systematics of Pliensbachian, Toarcian and Aalenian radiolarian genera and species*" is now camera ready (printing proof already done). The page setting of the taxonomy and plates is now done (410 pages) with an appendix of all the localities studied (18 pages). The palaeontological part includes a collection of 274 species, with revised synonymy and actualized taxonomy. 37 species are new formal descriptions. The locality data is presented in an appendix and they are provided only for specimens that are illustrated in the catalogue. The exact location, a short description of lithology and the overall stratigraphic range of the studied successions are given. Stratigraphically important co-occurring fossils are also indicated.

The biostratigraphy is based on the Unitary Associations method. A first draft was presented by Spela at the past InterRad congress in New Zealand. A second revision of this zonation was discussed in Granada (Spain) in early May. New samples of Aalenian mate-

rial from Spain were added, and revised data from Rie and Paulian were cleaned and included. This new version of the zonation has been discussed in Krakow (7th International **Congress on the Jurassic System**) while benefiting from the attendance of Atsushi, Jean, and Spela to this meeting. The range chart and correlation table will be discussed during early autumn and the final and definitive version will be included into the biochronological manuscript before December for its external review.

The "*Catalogue and Systematics of Pliensbachian, Toarcian and Aalenian radiolarian genera and species*" will be available at the end of 2006 (its final price is not yet available, but it will be really inexpensive, the high number of plates notwithstanding), whereas the biochronology is planned for mid 2007.

Mesozoic genera revision, Part 1 Triassic (Leader: Luis O'Dogherty)

Participants: Elizabeth S. Carter, Patrick De Wever, Paulian Dumitrica, Spela Gorican, Alex Hungerbueler, Yoshihito Kamata and Atsushi Takemura.

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 more than 800 genera are published, many as valid genera, but a considerable number of them as *nomina dubia*, junior synonyms or homonyms. 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.

This project was born in December 2005, when we (Patrick, Spela and me) were working on an article about radiolarian diversity. At that time, we discussed about the recurrent misclassification of many species, by a process comparable to those changes occurring in the oral transmission of knowledge, what the historians call "homeostasis": stories change imperceptibly over time. A striking case is, for example, the species successively assigned under the genus *Canutus*. The genus well illustrates how each new species included afterwards under the nominal genus shows a gradual displacement from the original type-species concept.

The reason is no other than the misconception acquired on the genus as an heritage of a wrong classification of the first species included under this genus, which, in some cases, acquires more value than the former type-species of the genus. In other words, there is a gradual drift in the generic concept, as the new species assigned to the genus are progressively diverging from the type-species.

Obviously, changes in oral knowledge cannot be undone, because there are no old copies to go back to. In our case something similar happens, however we have still the possibility to go back to the sources, that is, to revisit the type-species. In this sense, we believe highly necessary to get quickly a reference atlas of all type-species described for the Mesozoic genera.

During early May the group met in Granada to discuss on the taxonomic validity of 319 Triassic genera, revising which were synonyms, homonyms, and which have to be considered as *nomina dubia*. Their type-species were previously scanned and cleaned for publica-

tion (finely done by Alex) for helping in our taxonomic discussion. The stratigraphic ranges for all of them were also discussed at a substage level.

Finally we decided to produce a series of plates displaying nine genera-boxes per plate and arranged by orders and then by morphological affinity (rather than by family assignment), just to help the location of types for those radiolarists not familiar with Triassic names. For the specialist, or whoever would use this atlas, we have also assigned a number for each genus, which is indicated in an alphabetically-arranged list at the end of the 36 plates. Each image of the type-species is accompanied by: a) genus number; b) genus author, with indication of the date of publication and description page; c) type species' author, with indication of date of publication, page location, plate and figure of the holotype; d) the most accurate stratigraphic range known; and e) their family assignment.

In these plates we reproduced all the Triassic genera described, valid and invalid names (synonyms, homonyms and *dubia*). When an invalid name is illustrated, its taxonomic status is also stated with a link to the valid nominal genus.

The Triassic Atlas, as well as the second part of this project (Jurassic-Cretaceous) will be published separately in normal issues of *Geodiversitas*, a journal of the Muséum National d'Histoire Naturelle de Paris. Once both articles will be published, a special volume grouping both publications is planned. The manuscript is expected to be submitted by early December.

The next meeting is scheduled for early May 2007, again in Granada, to work on the second part of this project. For this meeting Alex Bandini, Atsushi Matsuoka and Chris Hollis will join the group.

InterRad Mesozoic Radiolaria Database - Online (Leaders: P.O. Baumgartner, Robin Liechti and Luis O'Dogherty)

The InterRad Mesozoic Radiolaria Database is a relational database that can be accessed now through a web interface. The whole contents are editable (images and text fields). The information is shared between 18 tables in a MySQL 4.0 database. The strict XHTML code is dynamically generated with PHP4 scripts and Javascript. The coherence is ensured by CSS2.1. For the moment, the database will contain the Inter Rad Jurassic-Cretaceous Working Group 1995 radiolarian database with the systematics, sample dataset, and the UAZ95 biochronology. We have also included the Mid-Cretaceous systematics and biochronology by O'Dogherty 1994 (the biochronological part is not yet available). The various datasets are related in a way to easily access and visualize ranges of selected taxa, ranges of all taxa of a sample, or taxa of a selected time interval. The base is designed for repeated update: new taxa can be introduced, old taxa can be edited, images can be withdrawn or moved to other taxa, and new ones can be uploaded. Revised data sets can be published or left in preview mode to be revised by other members of the working group before publishing. The published portions of this online database is available on the Web since April 2006 (username and password are assigned upon request), while the unpublished data sets are accessible via username/password by members of the working group with editing privileges. The database is located at the following address: <http://www3.unil.ch/interrad-mrd>

Check it and enjoy life!

PALEOZOIC WORKING GROUP

Patricia Whalen

News from Paula Noble:

I continue my work on Silurian (Wenlock and Ludlow) from the Canadian Arctic, focusing on the taxonomy and radiolarian response across graptolite extinctions. I have a manuscript in press on the Homerican ceratiokiscids and am finishing one on the Homerican sphaerellarians. Matt Jones successfully defended his MS in 2005 on the Sheinwoodian section in the Arctic and his taxonomy chapter will be published this fall in *Micropaleontology*. In March, I collected material with Barry Webby from the upper Ordovician Malongulli Formation and will be working it up in comparison with the Hanson Creek Material from Nevada. As the internal structures of the Hanson Creek sphaerellaria are seldom preserved, the comparative study will allow for a more definitive taxonomic determination of the higher level relationships of the Hanson Creek taxa. In 2005, I began work on the Permian Lamar Limestone in west Texas, looking at the paleoceanographic controls on faunal variation between spumellarian-dominated and albaillellid-dominated assemblages. My PhD student Ivy Jin will examine geochemical fluctuations in conjunction with changes in the assemblages to determine paleoecologic controls. My MS candidate Amy Smith will work on the faunas of the latest Guadalupian Reef Trail member, above the Lamar, which have not been described before.

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News from Masao Kametaka:

Masao Kametaka, researcher, Nagoya University Museum, sends information about his newest paper on Permian rads from Japan.

Kametaka, M., 2006, Early Permian radiolarians from mudstone at Hisage in the Dai area, Nagato Tectonic Zone, Southwest Japan. *Jour. Geol. Soc. Japan*, 112, 535-538. (in Japanese with English abstract)

Abstract: Early Permian radiolarian fossils were discovered from mudstone of the Nagato Tectonic Zone, at Hisage in the Dai area, Yamaguchi Prefecture, Southwest Japan. The mudstone consists of a broken formation of alternating beds of sandstone and mudstone. The radiolarian fauna, composed of *Albaillella sinuata*, *Pseudotormentus kamigoriensis*, *Raciditor gracilis* and others, indicates late Early Permian (Kungurian) age. This radiolaria-bearing broken formation does not correspond to the clastic rocks of the Akiyoshi terrane, but it corresponds to the formations of the Maizuru terrane or the Hida Gaien terrane.

Another paper has been accepted just now!!

Kametaka, M., in press, Permian radiolarians from felsic tuff at Soegasako in the Nishiichi area, Nagato Tectonic Zone, Southwest Japan. Jour. Geol. Soc. Japan. (in Japanese with English abstract)

Abstract: Permian radiolarian fossils were discovered from greenish gray felsic tuff of the Nagato Tectonic Zone, at Soegasako in the Nishiichi area, Yamaguchi Prefecture, Southwest Japan. The radiolarian fauna is composed of *Follicucullus* sp. cf. *F. porrectus*, *Pseudoalbaillella* sp. aff. *P. longicornis*, *Cauletella manica*, *Raciditor gracilis*, *Pseudotormentus kamigoriensis* and others. It indicates late Middle to Late Permian in age. The lithology of felsic tuff, age of radiolarian fauna and characteristics of sponge spicule fauna look similar to those of the clastic rocks of the Akiyoshi terrane. Therefore, Paleozoic formation in the Nagato Tectonic Zone of the Nishiichi area corresponds to the Akiyoshi terrane.

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MRC ANNOUNCEMENT & TMS MEETING

David Lazarus

The Micropaleontological Reference Centers have a new, completely redone website at: <http://iodp.tamu.edu/curation/mrc.html>. There are links to updated lists of holdings, maps etc as well. Consider using the MRCs in your research and teaching!

Meeting announcement: Microfossils and Climate Change.

An afternoon symposium in connection with the annual meeting of the TMS.

Venue: University College London, November 15th, 2006, Commencing 1.00PM, room to be announced. For further information see TMS website. The meeting will include presentation of society Awards and Honours, and will be followed by a wine reception. Attendance is free.

OFFICIAL INTERRAD 11 REPORT

Chris Hollis and Hamish Campbell

InterRad 11 and Triassic Stratigraphy Symposium: a joint conference hosted by the International Association of Radiolarian paleontologists, IGCP 467 and the Subcommittee on Triassic Stratigraphy. Wellington, New Zealand, March 19th to 24th, 2006

The first international radiolarian conference to be held in the Southern Hemisphere attracted record numbers of radiolarian researchers to Wellington, New Zealand, from March 19 to 24, 2006. The conference was held in conjunction with a meeting of IGCP Project 467, *Triassic time and trans-Panthalassan correlations*. The 120 participants came from 19 countries, with 35 participants from Japan alone and 32 students. Particularly pleasing was the large number of participants from eastern Europe, include eight from Russia. The 72 oral presentations included 17 plenary talks, nine of these open to public, which addressed the key themes of the conference: Triassic catastrophes and their consequences, biological indicators of oceanographic change, micropaleontological methodologies for the 21st century and radiolarian solutions to tectonic problems.



Most of the conference participants, March 20. Photo K. Whitley, GNS

A highlight for radiolarian researchers was the presence of two visionaries in radiolarian research: William R. Riedel, who revolutionised Cretaceous-Cenozoic radiolarian biostratigraphy through studies of cores collected in the course of the Deep Sea Drilling Project, and Emile A. Pessagno, who revolutionised Mesozoic radiolarian biostratigraphy

through perfection of the hydrofluoric acid rock-leaching method to retrieve radiolarians from indurated rocks and use of the scanning electron microscope for refined taxonomic discrimination.

In addition to the oral papers, 32 posters were presented. Student prizes were awarded for the best oral and poster presentations. Tomoko Yuasa of Tokyo Gakugei University won the best oral paper award for "*Phaeodarians found a home? Molecular phylogenetic study of Phaeodarea*". Two posters tied for best poster and so the award was shared between Susumi Shibutani, Ehime University, and Seiji Tanaka, Kyushu University, for their posters on "*Radiolarian assemblages and chemical compositions of lowest Jurassic (Hettangian/Sinemurian) black chert sequence from the Ikuno District, Tamba Terrane, Southwest Japan*" and "*Radiolarian distribution using vertical multiple plankton sampler and paleoceanography in the Bering Sea*", respectively. It was very pleasing to see the wide-ranging multidisciplinary research that is being undertaken by these young researchers.

Conference symposia

The conference comprised three symposia: Triassic stratigraphy, Nigrini and Biosilica. In the **Triassic Symposium** Dr Mike Orchard, Convenor of IGCP 467 and Chair of the Subcommittee on Triassic Stratigraphy drew attention to the deadline that IUG have set for determining appropriate GSSPs for all stage boundaries. This impacts on the Triassic Period in particular because as yet only two stage boundaries have been fixed: the base Induan (Permian-Triassic boundary) and the base Ladinian. Formal proposals for several others are almost ready for voting by members of the subcommittee, but others are far from being resolved. In a plenary session, Dr Ian Metcalfe reviewed the available evidence for discriminating between competing causes of the Permian-Triassic boundary crisis and in so doing explained the basis for the currently accepted age for the base of the Triassic (252.6 Ma). His thesis was supported by Dr Heinz Kozur, advocating very persuasively for a direct link with LIP volcanism and eruption of the Siberian Traps. Dr Martial Caridroit (and Patrick de Wever subsequently in the Biosilica symposium) provided a philosophical consideration of the fossil record and the much-vaunted magnitude of the extinction event at the end of the Permian. Their view was that the extinction rate may have been vastly over exaggerated.

New Zealand contributors Hamish Campbell, Ian Raine, Jack Grant-Mackie and Bruce Waterhouse drew attention to the status of New Zealand Triassic studies and especially the woeful lack of current research on aspects of paleontology and chronostratigraphy. Yet it was widely recognised during the conference that little-deformed and metamorphosed tuff-rich fossiliferous New Zealand Murihiku Supergroup sequences (Murihiku terrane) offer tremendous potential for establishing age control for much of Triassic time. Clearly this is a project waiting to happen. Many Triassic workers, and radiolarian workers alike, were attracted to the conference because of the opportunity to visit the Permian-Triassic boundary section at Arrow Rocks in Whangaroa Bay, Northland. Those who made it on Trip 1 were not disappointed! This is undoubtedly the most significant deep marine Permian-Triassic record for the Panthalassa Ocean in the Southern Hemisphere. A GNS Monograph presenting all available data will be published within the next three months.

The **Nigrini Symposium** on biological indicators of oceanographic change honoured our colleague Cathy Nigrini, who passed away in January 2005, and acknowledged her major contributions to Cenozoic radiolarian taxonomy, biostratigraphy and paleoceanography.

The symposium began with plenaries by local researchers Helen Neil, Scott Nodder and Chris Hollis, who outlined the oceanographic regime around New Zealand and showed how studies of plankton (including radiolarians) in sediment traps, surface sediments and sediment cores were contributing understanding the influence climate change has on ocean productivity offshore eastern New Zealand. The following papers spanned the full breadth of current radiolarian research from studies of living radiolaria to detailed core- and outcrop-based studies of faunal changes during episodes of significant climatic or environmental change. Atsushi Matsuoka spanned this range in a single talk, demonstrating how his laboratory studies of living radiolarian feeding strategies help to explain survivorship patterns across mass extinction horizons. The symposium finished with three public plenary talks: a retrospective on deep sea drilling from William Riedel, an introduction into the new phase of ocean drilling within the framework of the Integrated Ocean Drilling Program from Kozo Takahashi, and an overview of the contribution that radiolarian research has made to understanding the evolution of the Cenozoic ocean from David Lazarus.

The **Biosilica Symposium** includes oral papers on a wide range of themes, including biodiversity, taxonomic databases, phylogenetics and evolution, tectonics, petroleum exploration and biostratigraphy. Plenary talks by Patrick De Wever and James Crampton emphasised the serious problem of sampling bias in traditional paleo-diversity studies. However, they also pointed to solutions that will give new rigour to fossil-based studies of biodiversity and stratigraphy. That part of the solution comes as international database initiatives that will help paleontologists speak the same taxonomic language was highlighted in a series of talks on database projects: Paleobiology Database (David Lazarus), WoRaDD (Demetrio Boltovskoy), RadWorld (Jean-Pierre Caulet), Radiolarian Information System (Yuri Agarkov). This theme was continued in a databases workshop where participants recognised the urgent need to coordinate these initiatives to avoid duplication and establish systems that can eventually be integrated. Another initiative to be applauded is the Joint Haeckel and Ehrenberg Project, a Japanese-led project to re-examine and redescribe type material held in collections in London, Berlin and Jena. As explained by Noritoshi Suzuki, this work has the potential to resolve a problem that has thwarted radiolarian research for generations: the lack of well-defined or definitive holotypes for many common radiolarian species and genera. In the public plenary talks for the Biosilica Symposium Sergey Zhabrev, Jonathan Aitchison and Emile Pessagno gave a stimulating series of talks on the theme “radiolarian solutions to tectonic problems” with spectacularly illustrated examples from the Russian Far East, Tibet and Mexico.

Conference excursions

The conference included six field trips that covered almost every corner of New Zealand: from the Permian-Triassic boundary of Northland to the radiolarian-rich Cretaceous-Tertiary and Paleocene-Eocene boundary sections of Marlborough, and the New Zealand Triassic stage stratotypes of Southland. Combining geology with other aspects of New Zealand natural history and culture proved to be very popular with participants – most of whom were making their first visit to New Zealand. The main pre-conference excursion in Northland was led by Bernhard Spörli, Chris Hollis, Atsushi Takemura and Yoshiaki Aita. It focussed on the Permian-Triassic boundary sequence within Waipapa terrane and radiolarian-rich Paleogene limestone within the Northland Allochthon but included an introduction to New Zealand’s giant araucarian, the kauri tree, and the industries that exploited the kauri forests.



Field trip participants view the Permian-Triassic boundary succession at Arrow Rocks, Oruatemanu Island, Northland. Photo C. Hollis, GNS

Follow-on pre-conference trips delivered participants to the conference venue in Wellington by two routes. One excursion led by Chris Hollis and Murray Baker visited the geothermal fields and calc-alkaline volcanoes of the central North Island. The other excursion, led by Jack Grant-Mackie, Hamish Campbell and Rie Hori, visited key Triassic–Early Jurassic sections in Murihiku terrane on the North Island’s west coast. A mid-conference excursion, led by Hamish Campbell, Bernhard Spörli and John Simes, to examine Triassic rocks of Torlesse composite terrane exposed on Wellington’s south coast was a terrific introduction to local wet-weather field conditions. The terrible weather did not phase the 77 participants. One hardy soul even went for an *intentional* swim.

The post-conference excursion to Southland, led by Hamish Campbell, escaped the wet weather and participants enjoyed five sunshine-packed days viewing the key stratotype sections for six of the eight local Triassic stages. Participants on the other post-conference excursion to Marlborough and North Canterbury, led by Chris Hollis, Percy Strong and John Bradshaw, were less fortunate with the weather but had the compensation of spectacular geology, fine food and comfortable accommodation. The excursion visited four K/T boundary sections in Marlborough: Woodside Creek, Mead Stream, Chancet Rocks and Flaxbourne River. As well as being one of the first three sections shown to contain an iridium anomaly in the K/T boundary clay, the Woodside Creek section has a rich radiolarian record that shows almost 100% survival across the K/T boundary as well as progressive first appearances of important Cenozoic taxa – these events forming the basis of an early Paleocene radiolarian zonation.

The conference was hosted by InterRad, the International Association of Radiolarian Paleontologists, IGCP 467, the Subcommittee on Triassic Stratigraphy and GNS Science. It was sponsored by the Royal Society of New Zealand and the New Zealand Government

through the International Conference Fund, NIWA, Te Papa Tongarewa Museum of New Zealand, Wellington City Council, Zeiss Australasia, Webster Drilling and Clevedon Coast Oysters. The conference abstract volume can be downloaded from the GNS website: www.gns.cri.nz/interrad.

The next InterRad conference will be held in Nanjing in September 2009. The next sponsored meeting of STS/IGCP 467 will be held in Svalbard, Norway during August 2006, with a final meeting scheduled for Albuquerque, New Mexico in May 2007.

Chris Hollis & Hamish Campbell

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INTERRAD 11 AND TRIASSIC SYMPOSIUM PROCEEDINGS VOLUMES

Chris Hollis

The conference proceedings will be published as twin issues of *Micropaleontology* and *Stratigraphy* - peer-reviewed journals published by Micropaleontology Press. Both journals have the same formats and submission process, which can be viewed at: <http://micropress.org/>

For *Micropaleontology*, papers are requested on the theme: *radiolarian indicators of ocean change*. Other papers on radiolarians may also be submitted. Chris Hollis and Dave Lazarus will be guest editors of this volume.

For *Stratigraphy*, papers are sought on general Triassic themes and radiolarian stratigraphy. Hamish Campbell and Mike Orchard will be guest editors of this volume, with Emile Pessagno as chief editor. Short papers are preferred (no more than 10 journal pages).

If you wish to submit a conference proceedings paper, please consider the following time frame:

- Submit title by 28 April 2006 to interrad@gns.cri.nz
- Submit pre-reviewed manuscript by 24 November 2006
- Receive back reviewed manuscript with editorial comments by 16 March 2007
- Submit revised manuscript by 29 June 2007 Publication by 30 September 2007

We will only accept papers that have been pre-reviewed by two colleagues (pre-review forms can be downloaded from <http://micropress.org/>) and revised following the pre-review recommendations prior to the submission deadline of **24 November**.

For updates on progress with these twin volumes please visit the conference website: <http://www.gns.cri.nz/interrad/>

ARTICLE REPORTING ON INTERRAD

Patrick De Wever

The following is a translation of a contribution appeared on "Geochronique", 06/2006, p. 9

InterRad 11 : From one extreme to the other

The radiolarist community met for the first time in France (Lille, 1978). This group, initially european (EuroRad), is today an international association (InterRad), as well demonstrated by the location of last meeting of the association, held in March 2006 : one couldn't go farther from France, as it was hosted in New Zealand, on the other side of the globe. The meeting was held jointly together with IGCP 467 and the Subcommission on Triassic Stratigraphy. More than 110 participants from ca. 20 countries met). During the symposium some sessions were plenary, while other addressed specific topics. The pre- and post-meeting excursions took place at localities spanning from the extreme north to the extreme south of New Zealand, and visited triassic strata or radiolarian-bearing lithologies, without forgetting localities where some important stratigraphic boundaries are outcropping : The Permian/Triassic, the Triassic/Jurassic, and the Cretaceous/Tertiary.

A perplexing element has emerged from this meeting : while most countries try to develop a coherent international stratigraphic scheme, New Zealand continues to develop national stratotypes (last one has been erected in 2003). They have, of course, arguments : endemic faunas, monotonous facies, but these arguments, along with others, could also be produced by any other country. The solution would be to define the units as « xxx fossil »-bearing strata, or denominations such as « unit 1, 2, etc », as it is done, by the way, in the north of New Zealand, where japanese researchers co-work with a newzealander of swiss descent (which would explain why this occurs).

Molecular biology made a strong display, with interesting contributions, which however sometimes appear to be divergent, and occasionally even contradictory. As an example, some classifications consider polycystine radiolarians as a monophyletic group, while others consider it as polyphyletic, and all classifications consider spumellarians as polyphyletic in origin. But what really struck me is that the presented works do not make an attempt to compare the results obtained by other research groups, and each group seems to limit itself to propose its own phyletic tree. Databases occupy an ever-increasing place in our field of research, even if the presentations focused more on how these databases were developed, and not on the possible scientific objectives. One could thus hear presentations of databases built on published information, but utilized without any critical spirit, or even with quite suprising conceptions, and therefore leading, as one may expect, to the presentation of results that seemed absurd rather than original.

One should bear in mind that databases are not a science in itself but just a tool and, as such, prone to be dangerous if wrongly handled. Taxonomic revisions and the preparation of taxonomic catalogues (Lower Jurassic species atlas, Triassic genera atlas, or the revision of the historical collections by Haeckel and Ehrenberg) also represent an important part of the activities of our community.

The meeting was masterfully and strong-handed led by our president, and the next one will be held in China in three years from now (Nankin, September 2009).

EXTRACTION TECHNIQUE ARTICLE

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Elutriation technique for extracting radiolarian skeletons from sandy sediments and its usefulness for faunal analysis

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Abstract. An elutriation technique is useful for extracting radiolarian fossils from sandy sediment samples. A 46 % (SD=16.4 %) of all radiolarians in the sample were separated during the first elutriation process. Through five elutriation repetitions 93 % (SD=5.5 %) of all radiolarian skeletons were extracted from the sample. The results coincide with theoretical estimates based on the sinking speed of radiolarian skeletons in water. Because artificial impact on the original assemblage during the elutriation process is small, this technique can be used for statistical faunal analysis.

Keywords: method; elutriation technique; radiolarians; sandy sediment; quantitative analysis.

1. Introduction

Have you ever experienced hardship to find radiolarian fossils in sandy sediment samples? Radiolarian fossils are usually well represented in pelagic and hemi-pelagic sediments; however, they are not easily found in sandy, terrigenous sediments. Therefore, any radiolarian researcher who encountered the sandy sediment sample had to go through a great hardship, or simply give up the effort to work with this kind of sample material.

Itaki (2003) proposed a technique for the efficient extraction of radiolarian skeletons from sandy sediments using different sinking speed between radiolarian skeletons and other particles. This technique, called the elutriation technique, is useful to remove mineral grains from the sample. Moreover, the elutriation technique can also be used in quantitative radiolarian analysis. It has not been confirmed that the faunal composition, when extracted by the proposed elutriation technique, has been significantly altered. The detailed description of the technique by Itaki (2003) was written in Japanese and is therefore not easily readable for most radiolarian researchers.

The elutriation technique is introduced in English herein. This paper is an extension of Itaki (2003), but new data and comments concerning its effect on the faunal composition have been added. The purpose of the experiments in this study is to propose the elutriation technique as a standard quantitative analysis for radiolarian fossils in coarse-grained sandy sediments. Therefore, three problems are focused on in these experiments: (a) how many percent of all radiolarians can be extracted from the sample in one elutriation process, (b) how many repetitions of the elutriation process do we need to extract almost all radiolari-

ans from the sample, and finally (c) does the elutriation process lead to any artificial bias of the faunal composition?

2. Experimental processes

Eight unconsolidated or semi-consolidated sediment samples, from the southeastern Pacific and Okhotsk Sea, of different Tertiary-Quaternary age, were used in this experiment (Table 1). Six samples (a-e) were soaked in HCl and H₂O₂ solutions to remove calcium carbonate and organic carbon, washed and sieved on a 63 µm screen. Two samples (g-h) were sieved on a 45 µm screen. Based on the remaining particles on the sieve, elutriation experiments were performed in the following steps (Fig 1):

STEP 1. All particles were transferred into a 500 ml beaker, filled with tap water till 9 cm above the bottom (= about 500 ml). The sample was well agitated by using a hand shower when filling the beaker with tap water. This way the particles will be mixed homogeneously in the beaker.

STEP 2. The beaker was placed in a horizontal position, and the particles were allowed to settle for 20 seconds.

STEP 3. The upper 6.5 cm (about 350 ml) were carefully decanted and sieved again. The remaining particles in the lower 2.5 cm (about 150 ml) were allowed to settle on the bottom, after 20 seconds. In this step some light mineral grains in the upper suspension are extracted from the beaker to the sieve, while the majority of the heavy mineral grains remain on the bottom of the beaker.

STEP 4. All extracted particles on the sieve are moved to a slide by a pipette. The samples a-f were mounted with Entellan New, while samples g-h were mounted with Canada balsam.

STEP 5. All remaining particle on the bottom of the beaker in STEP 3 were again subject for a new elutriation process and STEP 1 to STEP 3 were repeated from 3 and up to 7 times. For each elutriation process observation slides were made. For sample e the particles from the 2nd and 3rd elutriation were mounted together. Finally, a slide was made of all remaining beaker residue from each sample.

Observation: All radiolarian skeletons on each slide were counted under an optical microscope at 40X or 100X magnification. For samples g and h the extracted mineral particles and radiolarian species composition were examined for each repeated elutriation process. This was done in the order to see how the composition did change from one elutriation process to another. More than 200 particles were counted per slide, and all radiolarian specimens on each slide were identified.

3. Results

The extracted grains were a mixture of biogenic and minerogenic particles, and their composition changed for each elutriation repetition (Fig. 2). Biogenic opal grains, such as diatoms and radiolarians obviously decreased with repeating elutriation processes, and after the 6th elutriation process less than 10 % biogenic opal particles remained.

Total radiolarian concentrations in each sample ranged from 34 to 1191 individuals (Table 1). Whether the radiolarian concentration is large or small, the number of extracted individuals increased step by step with increasing elutriation repetitions (Fig. 3a).

The Cumulative Extraction Percent (CEP) is calculated as follows:

$$\text{CEP (\%)} = (\text{CRN}_i / \text{CRN}_r) * 100$$

Where CRN_i is the cumulative radiolarian number extracted through the 1st to the i^{th} elutriation, and CRN_r is the total radiolarian number in the sample (*i.e.* the CRN values in Table 1). Samples e and f, which show low CRN_r values, tend to show somewhat lower CEP values than the other samples (Fig. 3b). The CEP ranged from 22.2 to 66.7 % (46 % in average, SD = 16.4 %) at 1st elutriation, and converged to 100 % with increasing elutriation repetitions. The CEP at the 5th elutriation amounted between 85.3 and 99.2 % (93.1 % in average, SD = 5.5 %).

Although the extraction of radiolarians will be complete with increasing elutriation repetitions, the excessive repetition takes a great deal of time and causes hardship to observe radiolarians because of the very high amount of mineral grains in the slides, thus diluting and masking the radiolarian tests. To obtain 90 % of the radiolarian fauna in a sample it looks as if the elutriation technique must be applied from 5 to 7 times. Therefore, all sieve residues after 5 to 7 elutriations should be mounted on one slide.

Figure 4 shows the radiolarian faunal composition at each of the four elutriations performed on samples g and h. The counts from the 4th elutriation to the residue were added due to the very low specimen number. In Figure 4 it is clearly shown that 60 % of the total faunal assemblage is made up of 12 species. For the three first elutriations the faunal composition is quite stable, however, from the 4th, through the remaining elutriations, till the assemblage in the beaker residue, the faunal composition has been slightly modified. For example, *Antarctissa* sp. and *Plectacantha oikiskos* decreased in the assemblages of the 4th elutriation and in the beaker residue, while *Spongotrochus glacialis* and *Stylatractus* spp. increased. This is a result of hydrodynamic separation as the different species do have different sinking speed. The elutriation technique is very efficient in extracting the species with a low sinking speed, while the species with a higher sinking speed easily may remain in the residue at the bottom of the beaker.

Although the faunal composition changed artificially from the 4th elutriation, residue assemblage included, this change is only a little part of the total assemblage, counting for only 3.3 % and 5.2 % in samples g and h, respectively. As a result we can conclude that the elutriation technique give us a good first hand information of the commonest species in an assemblage, and do not significantly disturb the original faunal composition. However, in cases where the associations are represented with big, heavy, and fast sinking species/specimens (for example in provinces with strong dissolution where most of the small species/specimens are dissolved), the elutriation technique should be repeated several more times in order to obtain a better and more accurate estimate of the original faunal composition.

4. Discussion

Takahashi and Honjo (1983) have measured the sinking speed of radiolarian skeletons in a stable water column at 3°C, 10°C, and 20°C. In the elutriation experiment, the grain distribution in the beaker is affected by the convection created by the agitation. However, assuming that the grains are homogeneously distributed in the suspension in the beaker, their average sinking speed after agitation could be near the values for the stable water column experiment by Takahashi and Honjo (1983). The theoretical CEP estimates below are based on the sinking speed of polycystine radiolarian skeletons at 10°C, which also was the temperature of the tap water used in the herein described experiments, and compared with the results obtained from the elutriation experiments (Fig 3b).

The sinking speed for polycystine radiolarian skeletons varies between 18.7 and 184 m/day, depending on the species (Takahashi and Honjo, 1983). This does suggest that the

sinking speed of most radiolarian skeletons actually converge in this range. Based on these values the extraction percent (EP) at one elutriation process can be calculated as follows:

$$EP (\%) = (6.5 - SS) / 9 * 100$$

where 6.5 is the height in cm of the water level in the beaker that has been sieved (see STEP 3 in the Experimental procedures and Fig. 1 (2)), SS is the sinking speed of polycystine radiolarian skeletons (cm/20 sec) and 9 is the depth in cm of the 500 ml beaker (see STEP 1 and Fig. 1 (2)). Because SS of the faster sinking species is 4.2 cm/20 sec, its EP value is 25.5 %. Similarly, the EP value for the species with the slowest sinking speed (0.4 cm/20 sec) is 67.7 %. Therefore, the theoretical EP for the first elutriation will be somewhere between 25.5 and 67.7 %.

In Fig. 3b actual cumulative extraction percent values have been plotted, and most of these plots are within the range of the theoretical estimates. This means that the relative amount of the polycystine radiolarian skeletons extracted during the first elutriation are also supported by theoretical calculations.

5. Conclusion

In this paper the extraction efficiency of polycystine radiolarian skeletons from coarse-grained sandy sediments by the elutriation technique was examined. The experimental results show that about 20-70 % (46 % in average) of the total radiolarians in a sample are extracted during the first elutriation, while 85-99 % (93 % in average) are extracted after 5 elutriation repetitions. This experiment was undertaken on sample sizes between 1 and 3 g, using a 500 ml beaker, and a settling time of 20 sec.

The elutriation technique is a useful method for polysystine radiolarian skeleton extraction from coarse-grained sandy sediments, rich in terrigenous minerals, which formerly were excluded from quantitative radiolarian analysis. This technique may encourage other workers to perform quantitative radiolarian studies in provinces with low radiolarian numbers, especially in continental shelf areas and in high latitude areas with ice rafted material and a general low radiolarian production. These are areas that still need to be explored, and the elutriation technique may greatly improve the studies of radiolarians from these areas.

Acknowledgements

I am grateful to Kjell R. Bjørklund for his critical reading of the manuscript. I would like to also thank Isao Motoyama and Ken Ikehara for their useful advices.

References

- Itaki, T., 2003. Elutriation technique for the extraction of radiolarian skeletons from sandy sediment. *Fossils* (73), 38-41. (in Japanese).
- Takahashi, K., Honjo, S., 1983. Radiolarian skeletons: size, weight, sinking speed, and residence time in tropical pelagic oceans. *Deep-Sea Research* 30 (5A), 543-568.

Captions

Table 1. Samples for the elutriation technique, their dry weight, extracted radiolarian number (RN), cumulative RN (CRN), and cumulative extraction percent (CEP). S.D. indicates standard deviation for CEP.

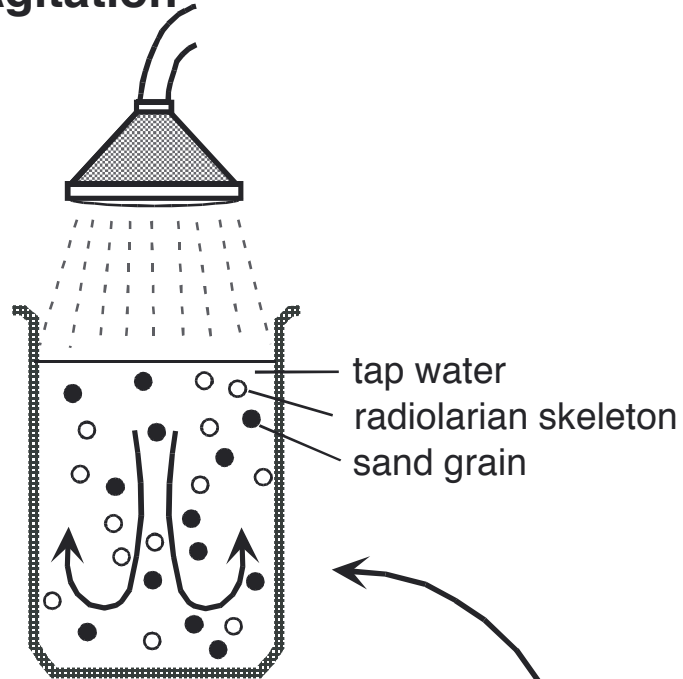
Figure 1. Experimental procedure for the elutriation technique.

Figure 2. Particle compositions in grains extracted by each elutriation for samples-g and -h.

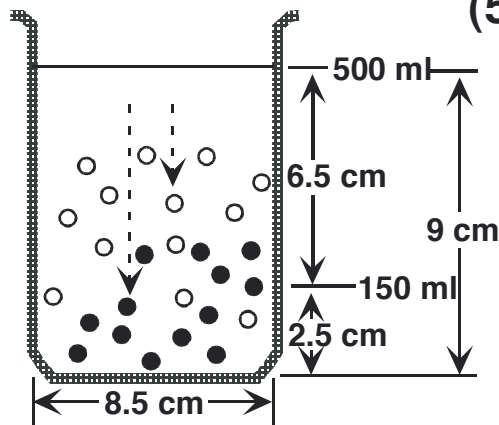
Figure 3. (a) CRN and (b) CEP for each decantation. Solid line indicates mean CEP values. Shaded zone shows the theoretical CEP range estimated based on sinking speed of radiolarian skeletons measured by Takahashi and Honjo (1983).

Figure 4. Faunal compositions of radiolarian species extracted by each elutriation for samples-g and -h.

(1) Agitation

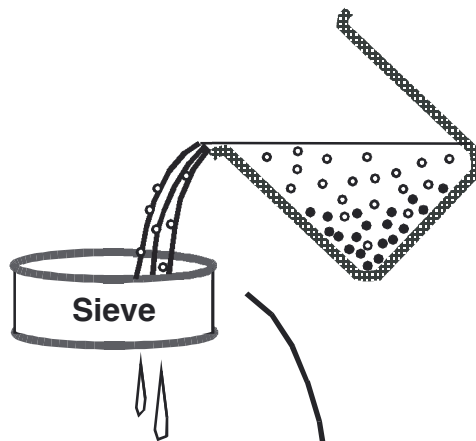


(2) Settling of sand grains for 20 seconds

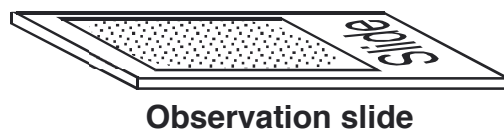


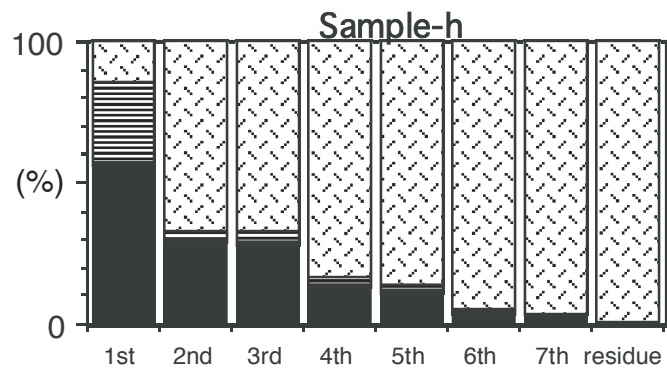
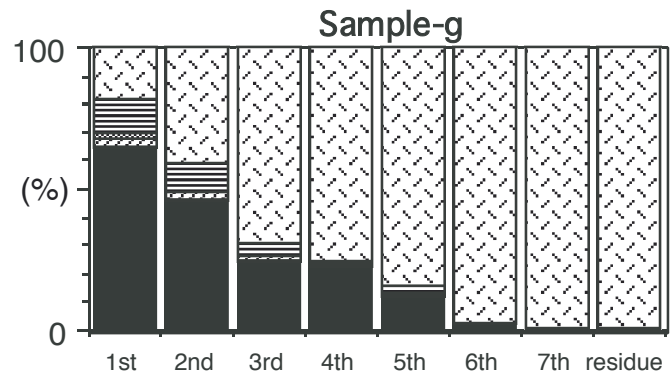
(5) Repetition

(3) Decantation and sieving of suspension (upper 350 ml)

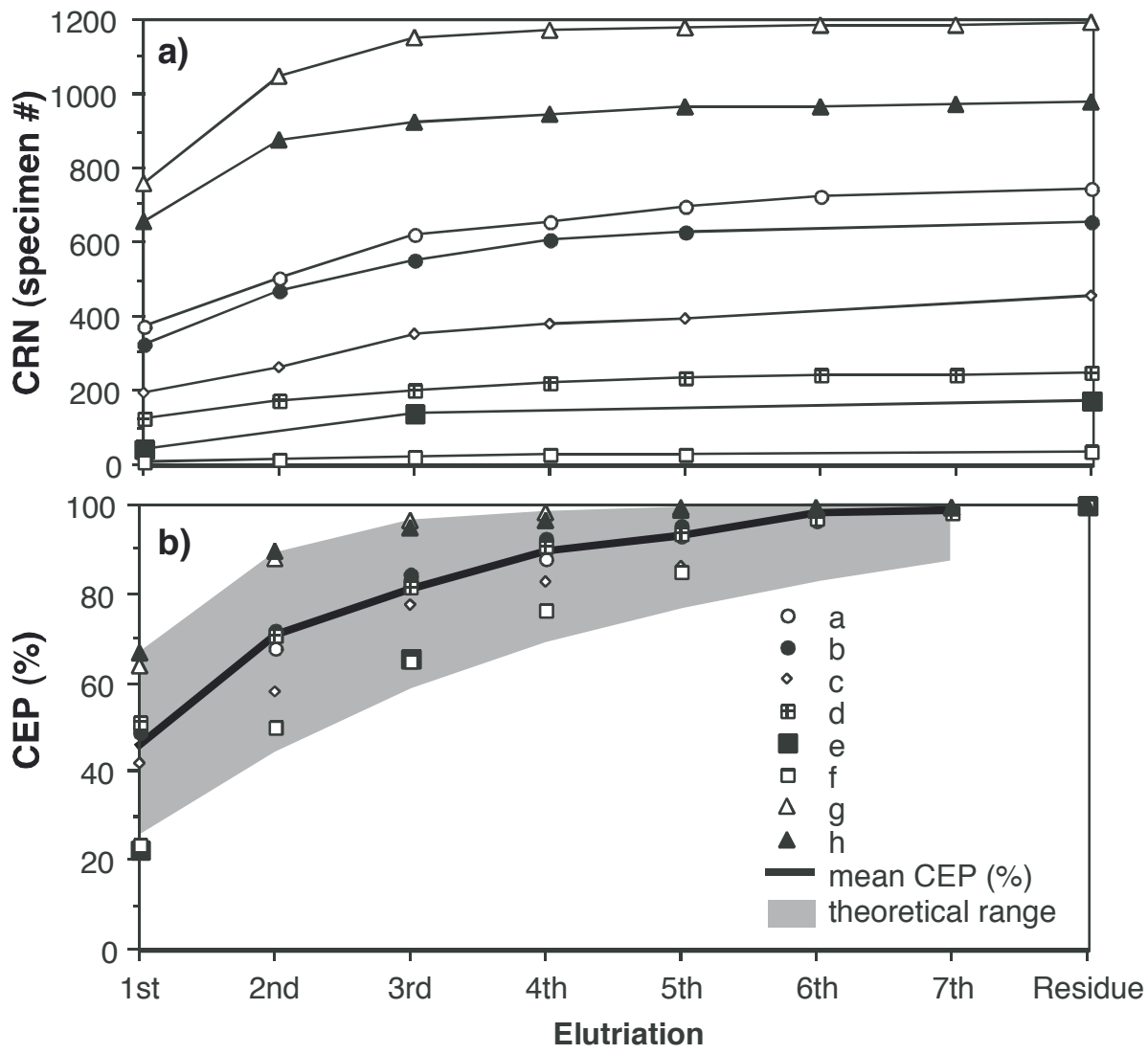


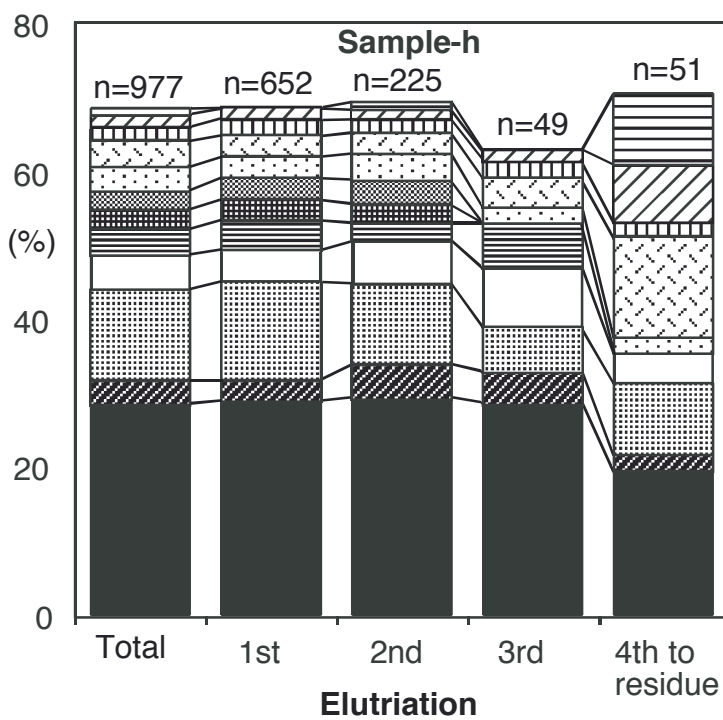
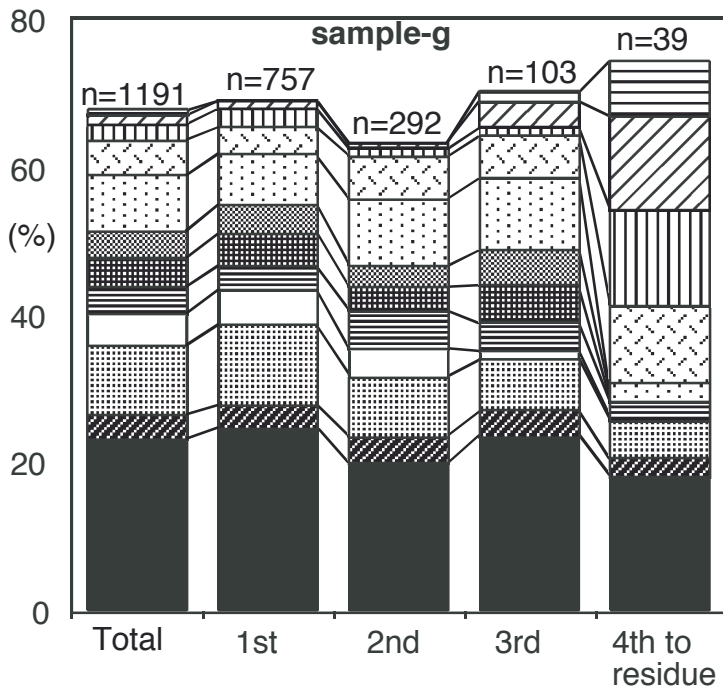
(4) Mounting





- minerals
- terrestrial organic fragments
- foraminifers
- radiolarians
- diatoms





- Stylatractus spp.
- Spongotorochus glacialis
- Sethoconus tablatus
- Ceratospyris borealis
- Rhizoplegma boreale
- Plectacantha oikiskos
- Antarctica sp.
- Zygocircus productus
- Pseudodictyophimus gracilipes
- Lithomelissa setosa
- Dictyophimus sp.
- Cycladophora davisiana

Table 1

Sample	Dry wt. (g)		1st	2nd	3rd	4th	5th	6th	7th	residue
a	2,55	RN (#/slide)	370	135	118	34	38	26		26
		CRN (#)	370	505	623	657	695	721		747
		CER (%)	49,5	67,6	83,4	88,0	93,0	96,5		100
b	2,30	RN (#/slide)	321	151	80	55	18			30
		CRN (#)	321	472	552	607	625			655
		CER (%)	49,0	72,1	84,3	92,7	95,4			100
c	2,63	RN (#/slide)	191	72	88	25	15			62
		CRN (#)	191	263	351	376	391			453
		CER (%)	42,2	58,1	77,5	83,0	86,3			100
d		RN (#/slide)	127	48	26	23	8	8	2	5
		CRN (#)	127	175	201	224	232	240	242	247
		CER (%)	51,4	70,9	81,4	90,7	93,9	97,2	98,0	100
e	1,29	RN (#/slide)	43		92					39
		CRN (#)	43		135					174
		CER (%)	22,2		65,7					100
f	2,83	RN (#/slide)	8	9	5	4	3			5
		CRN (#)	8	17	22	26	29			34
		CER (%)	23,5	50,0	64,7	76,5	85,3			100
g	1,53	RN (#/slide)	757	292	103	18	11	3	3	4
		CRN (#)	757	1049	1152	1170	1181	1184	1187	1191
		CER (%)	63,6	88,1	96,7	98,2	99,2	99,4	99,7	100
h	1,13	RN (#/slide)	652	225	49	20	18	4	2	7
		CRN (#)	652	877	926	946	964	968	970	977
		CER (%)	66,7	89,8	94,8	96,8	98,7	99,1	99,3	100
		Mean CER (%)	46,0	70,9	81,1	89,4	93,1	98,0	99,0	100
		S.D. of CER (%)	16,4	14,5	11,7	7,7	5,5	1,4	0,9	

RADIOLARIAN BIBLIOGRAPHY 2005-2006

Giuseppe Cortese

This list includes 164 references, the great majority of which come from the 2005-2006 period. The papers included in this list had the word radiolarian either in the title, in the abstract, or in the keywords. You will notice that several of the papers have a quite different focus than “simply” radiolarian studies, and many deal with tectonic interpretations of orogenic belts, ophiolites, and the like. Still, they may provide useful information to fellow radiolarists who are interested in those working areas. Although I did a detailed spelling check on the abstracts and titles, note that most of these references and abstracts are scanned copies, so spelling mistakes due to this procedure may still be in there. At least we will not have in this list a paper by the title “Progress and review of the studies on the end-Triassic ass extinction event”, as Web of Science likes to call it, probably entertaining reading, but the topic was just too hot for this newsletter. Thanks to all the colleagues who sent the references to their recently published papers.

ABBATE, E., FANUCCI, F., BENVENUTI, M., BRUNI, P., CIPRIANI, N., FALORNI, P., FAZZUOLI, M., MORELLI, D., PAPINI, M., PANDELI, E., SAGRI, M., REALE, V., VANNUCCHI, P., CHIARI, M., MORETTI, S. & VENTURI, F. 2005. Note illustrative della Carta Geologica d'Italia, alla scala 1:50.000. Foglio 248 - La Spezia.

ABELMANN, A., GERSONDE, R., CORTESE, G., KUHN, G. & SMETACEK, V. 2006. Extensive phytoplankton blooms in the Atlantic sector of the glacial Southern Ocean. *Paleoceanography* **21**(1), PA1013, doi:10.1029/2005PA001199.

The sources and sinks of atmospheric carbon dioxide over glacial/interglacial cycles are under debate. Variation in productivity of the Antarctic Circumpolar Current (ACC) could potentially play a significant role, but current interpretations of sedimentary geochemical proxies suggest that glacial productivity was not higher than today. We present areal and down-core distribution patterns of previously overlooked diatom resting spores that indicate the occurrence of extensive phytoplankton blooms across the entire Atlantic sector of the ACC, particularly in the seasonal ice zone (SIZ), linked to higher iron input during the last glacial. Sea ice acts as an effective transporter of iron and enhances its bioavailability. The dominance of the deep living radiolarian *Cycladophora davisiana* in glacial SIZ sediments indicates that organic carbon export to mesopelagic depths was at least tenfold higher than today.

ABELMANN, A. & NIMMERGUT, A. 2005. Radiolarians in the Sea of Okhotsk and their ecological implication for paleoenvironmental reconstructions. *Deep-Sea Research Part II-Topical Studies in Oceanography* **52**(16-18), 2302-2331.

To assess the relationship of radiolarian production, species distribution in water and surface sediment to water-mass characteristics, biological productivity and export regimes in the Sea of Okhotsk (SOk) we accomplished a quantitative analysis of radiolarian assemblages obtained from 35 surface-sediment samples and 115 plankton samples recording the radiolarian depth distribution in the upper 1000 m of the water column at 23 locations. This study augments the knowledge on the autecological demands of radiolarians dwelling in a specific hydrographic and biological environment, and extracts new information on the significance of radiolarians for the assessment of past oceanographic and climatic development in high latitudes. Highest radiolarian accumulation rates and seasonal radiolarian standing stocks are encountered in the western part of the SOk close to Sakhalin, marking the environmental conditions in this area as most favorable for radiolarian production. Maximum standing stocks occur during summer, indicating that the radiolarian signal preserved in the sediment record is mainly produced during this season when the mesopelagic biomass is at highest activity. We identified seven radiolarian species and groups related to specific water-mass characteristics, depth habitats, and productivity regimes. Of those, *Dictyophimus hirundo* and *Cycladophora davisiana* are most prominent in the Sea of Okhotsk Intermediate Water (200-1000m), the latter representing an indicator of the occurrence of cold and well ventilated intermediate/deep water and enhanced export of organic matter from a highly productive ocean surface. While *Antarctissa* (?) sp. I is typically related to the cold-water Sea of Okhotsk Dicotermal Layer (SODL), ranging between 50 and 150m water depth, the surface waters above the SODL affected by strong seasonal variability are inhabited predominantly by taxa belonging to the Spongodiscidae, having a broad environmental tolerance. Taxa only found in the sediment record show that the plankton study did not cover all assemblages occurring in the modern SOk. This accounts for an assemblage restricted to the western Kurile Basin and apparently related to

environmental conditions influenced by North Pacific and Japan Sea waters. Other important taxa include species of the Plagonidae group, representing the most prominent contributors to the SOk plankton and surface sediments. These radiolarians show a more opportunistic occurrence and are indicative of high nutrient supply in a hydrographic environment characterized by pronounced stratification enhancing heterotrophic activity and phytodetritus export.

ADL, S.M., SIMPSON, A.G.B., FARMER, M.A., ANDERSEN, R.A., ANDERSON, O.R., BARTA, J.R., BOWSER, S.S., BRUGEROLLE, G., FENSOME, R.A., FREDERICQ, S., JAMES, T.Y., KARPOV, S., KUGRENS, P., KRUG, J., LANE, C.E., LEWIS, L.A., LODGE, J., LYNN, D.H., MANN, D.G., MCCOURT, R.M., MENDOZA, L., MOESTRUP, O., MOZLEY-STANDRIDGE, S.E., NERAD, T.A., SHEARER, C.A., SMIRNOV, A.V., SPIEGEL, F.W. & TAYLOR, M.F.J.R. 2005. The new higher level classification of eukaryotes with emphasis on the taxonomy of protists. *Journal of Eukaryotic Microbiology* **52**(5), 399-451.

This revision of the classification of unicellular eukaryotes updates that of Levine et al. (1980) for the Protozoa and expands it to include other protists. Whereas the previous revision was primarily to incorporate the results of ultrastructural studies, this revision incorporates results from both ultrastructural research since 1980 and molecular phylogenetic studies. We propose a scheme that is based on nameless ranked systematics. The vocabulary of the taxonomy is updated, particularly to clarify the naming of groups that have been repositioned. We recognize six clusters of eukaryotes that may represent the basic groupings similar to traditional "kingdoms". The multicellular lineages emerged from within monophyletic protist lineages: animals and fungi from Opisthokonta, plants from Archaeplastida, and brown algae from Stramenopiles.

AFANASIEVA, M. 2006. Radiolarian Skeletons: Formation and Morphology of Skeletal Shells. *Paleontological Journal* **40**(5), 476-489.

A new scheme of successive stages in the formation of radiolarian skeletons is proposed. Successive complication of symmetry patterns is considered. The morphology and evolutionary changes of five types of skeletal shells, i.e., latticed, reticulate, spongy, porous, and lamellar, are analyzed

AFANASIEVA, M.S. & AMON, E.O. 2006. Biotic crises and stages of radiolarian evolution in the Phanerozoic. *Paleontological Journal* **40**(4), S453-S467.

The questions of ecology and taphonomy of radiolarians are reviewed and reexamined. In Recent oceans and seas, the major part of the "radiolarian rain" (dead individuals) comes from the layer of the water column which is not deeper than 500 m; therefore, the bottom radiolarian thanatocenoses and taphocenoses are formed in all oceanic zones, including the coastal and central oligotrophic regions of oceans. However, radiolarians should not be regarded as indicators of exclusively deepwater oceanic conditions. The crucial moments in the evolution of radiolarians at the major Phanerozoic boundaries are recognized. A dynamic model of cyclic development of radiolarians in the Phanerozoic is proposed and four phases and nine stages in their evolution are recognized. The absence of an outburst of radiolarian biodiversity in the Holocene is shown. Many great extinctions of radiolarians occurred at the boundaries between seasons of galactic years.

AKHMETIEV, M.A. & BENIAMOVSKI, V.N. 2004. Paleocene and Eocene of Western Eurasia

(Russian sector) - stratigraphy, palaeogeography, climate. *Neues Jahrbuch für Geologie und Paläontologie-Abhandlungen* **234**(1-3), 137-181.

The marine Paleocene and Eocene stratigraphic schemes of the European and West Siberian parts of Russia include the nannoplankton, planktonic foraminifera, dinocysts, radiolaria and diatom zonations. They are elaborated by the Russian specialists and summarize the achievements of the zonal stratigraphy worked out by the end of the last century. These schemes are a reliable stratigraphic base for different geological and palaeogeographic conclusions, are the base for the time scale for a variety of biotic and abiotic events, and reflect the evolution of biota and environment. The South European and West Siberian epicontinental seas are shown to represent a communication system of straits and internal seas (longitudinal and latitudinal seaways), which facilitated the exchange of water-masses and biotic elements between the Tethys, Atlantic, and Arctic paleo-oceans. Longitudinal and latitudinal communications were influenced by the action of tectonics, eustatic, and regional causes. The marine pathways widened, narrowed, or entirely closed. These events caused facies and biotic reorganization. The new data on the extensive area of the Early Paleogene of the Russian sector of Western Eurasia allow reconstructing the dynamics of paleoclimatic changes in the Early Paleogene of the North Hemisphere in the terminal phase of the transition from the warm to the cool biosphere.

ALLEN, A.P. & GILLOOLY, J.F. 2006. Assessing latitudinal gradients in speciation rates and biodiversity at the global scale. *Ecology Letters* **9**(8), 947-954.

The mechanisms responsible for latitudinal biodiversity gradients have fascinated and perplexed biologists since the time of Darwin. Ecological theory has yielded two general classes of mechanisms to account for variation in biodiversity: dispersal-assembly mechanisms that invoke differences in stochastic rates of speciation, extinction and dispersal; and niche-assembly mechanisms that invoke species differences, species interactions and environmental heterogeneity. Distinguishing between these two classes of mechanisms requires explicit consideration of macroevolutionary dynamics. Here, we assess the importance of dispersal-assembly mechanisms in the origin and maintenance of biodiversity using fossil data that encompass 30 million years of macroevolution for three distinct groups of ocean plankton: foraminifera, nannoplankton and radiolaria. Applying new methods of analysis to these fossil data, we show here for the first time that latitudinal biodiversity gradients exhibit strong positive correlations with speciation rates even after explicitly controlling for variation in sampling effort and for increases in habitat area towards the equator. These findings provide compelling evidence that geographical variation in macroevolutionary dynamics is a primary determinant of contemporary biodiversity gradients, as predicted by dispersal-assembly theory.

ALLEN, C.S., PIKE, J., PUDSEY, C.J. & LEVENTER, A. 2005. Submillennial variations in ocean conditions during deglaciation based on diatom assemblages from the southwest Atlantic. *Paleoceanography* **20**(2).

We present a high-resolution paleoceanographic record of deglaciation based on diatom assemblages from a core located just south of the Polar Front in the southwest Atlantic. Core KC073 is from a sediment drift at the mouth of the Falkland Trough and contains sediments from the Last Glacial Maximum (LGM) to present, dated using radiocarbon dates on bulk organic matter and radiolarian stratigraphy. The site lies along the path of the Antarctic Circumpolar Current (ACC) and immediately downstream of where North Atlantic Deep Water (NADW) is entrained into the ACC. Significant variations in ocean conditions are reflected in high-amplitude changes in diatom concentrations

and assemblage composition. The diatom assemblage at the LGM indicates that winter sea ice extent was at least 5 degrees farther north than present until at least 19.0 ka (calendar years) and summer sea ice may have occasionally extended over the site, but for the most part it lay to the south. During deglaciation, *Chaetoceros* resting spores (CRS) dominate the diatom assemblage with valve concentrations in excess of 500 x 10⁶ valves per gram. Submillennial-scale variations in the numbers of CRS and *Thalassiosira antarctica* occur throughout the late deglacial and dominate the changes in diatom concentration. We propose that the influx of CRS is controlled by the flow of NADW over the Falkland Plateau. As such our data provide unique evidence that NADW impacted on this sector of the Southern Ocean during deglaciation. During the Holocene the sedimentation rate dramatically reduced. We suggest that the ACC flow increased over the site and inhibited settling and winnowed the surface sediments.

AMLER, M.R.W. 2004. Bivalve biostratigraphy of the Kulm Facies (early Carboniferous, Mississippian) in central Europe. *Newsletters on Stratigraphy* **40**(3), 183-207.

Within the framework of the research project "Bivalve biostratigraphy of the Kulm Facies (Mississippian) of central Europe" a biostratigraphic subdivision is proposed for the marine upper Famennian to Serpukhovian/Bashkirian (Namurian) sequence of western and central Europe based on bivalve associations and index species. The bivalve zonation is intended to complement the traditional and revised zonations based on conodonts, goniatites, radiolarians and trilobites. The analysis of the vertical and horizontal occurrence of Kulm bivalves is derived from the systematic and taxonomic revision of late Palaeozoic bivalves carried out over the last decade. At the Devonian/Carboniferous boundary interval of Hercynian (basinal) Facies, members of the *Guerichia venusta* group (*Guerichia venusta* s. str., *Guerichia ratingensis* = *G. venustiformis* and *Guerichia mariannae*) are biostratigraphically important. In the Lower Carboniferous (Mississippian) Kulm Facies, members of the Eupteriomorpha (Pterioida, Aviculopectinoidea, Buchioldea) dominate above all other groups; biostratigraphically important taxa are Ptychopteria (Actinopteria) lepida, Ptychopteria (Actinopteria) sulcata, *Streblochondria praetenuis*, *Dunbarella mosensis*, *Dunbarella yatesae*, *Posidonia becheri*, *Posidonia kochi*, *Posidonia corrugata*, *Posidonia trapezoedra* and *Posidonia membranacea*. The upper Devonian to Mississippian sequence can be subdivided into nine zones, mostly characterized by the joint occurrence of at least two species: *Guerichia venusta* (s. str.) Zone, *Guerichia ratingensis* Zone, *Guerichia mariannae* Zone, *Chaenocardiola haliotoidea* Zone, *Posidonia becheri-Dunbarella mosensis* Zone, *Posidonia becheri-Posidonia kochi* Zone, *Posidonia corrugata Actinopteria sulcata* Zone, *Posidonia trapezoedra-Actinopteria lepida* Zone and *Dunbarella yatesae* Zone. Whereas the interval between the Mid-Tournaisian and the Mid-Visean reveals information gaps due to the scarce fossil content of the mostly siliceous rocks of that time, the subdivision of the Late Visean into five bivalve zones is comparatively dense. A correlation of the bivalve zones with the revised goniatite zonation is quite reliable, but yet no satisfying correlation is possible with the standard zonation by foraminifers of the Carboniferous Limestone shelf facies.

ASGAR-DEEN, M., RIEDIGER, C. & HALL, R. 2004. The Gordondale Member: designation of a new member in the Fernie Formation to replace the informal "Nordegg Member" nomenclature of the subsurface of west-central Alberta. *Bulletin of Canadian Petroleum Geology* **52**(3), 201-214.

New biostratigraphic data and revised lithostratigraphic correlations reveal that the current stratigraphic nomenclature for the Lower Jurassic portions of the Fernie Formation in the subsurface of west-central Alberta is inadequate. This paper introduces a new member, the Gordondale Member, for highly

radioactive, fine-grained strata previously referred to as either the lower Fernie Formation, the Lower Fernie shelf limestone and clastics, the Nordegg Member, or the "Nordegg Member". A new occurrence of a late Toarcian ammonite, which constrains the age of the top of the Gordondale Member, is also reported. The Hettangian to upper Toarcian Gordondale Member is an important hydrocarbon source rock and consists of dark brown, finely laminated, organic-rich, phosphatic and highly radioactive calcitic mudstones, calcilutites and fine-grained calcarenites. Fish fragments, pectinoid bivalves, *Ostrea*, belemnoids, ammonites, coccoliths and radiolarians are abundant. The Gordondale Member is laterally extensive and thins westward from a maximum thickness of approximately 50 m in the subsurface of west-central Alberta to 19 m at Pink Mountain in northeastern British Columbia.

ASHJIAN, C.J., GALLAGER, S.M. & PLOURDE, S. 2005. Transport of plankton and particles between the Chukchi and Beaufort Seas during summer 2002, described using a Video Plankton Recorder. *Deep-Sea Research Part II-Topical Studies in Oceanography* **52**(24-26), 3259-3280.

A key goal of the Western Arctic Shelf Basin Interactions program is to understand how physical and biological processes together impact shelf-basin exchange of biological, chemical, and physical properties. High-resolution vertical distributions of plankton and particles were obtained using an Auto Video Plankton Recorder from 29 locations on the Chukchi Shelf, in the deep Beaufort Sea, and across the Beaufort-Chukchi Shelf-break during a cruise on the USCGC Healy in July August, 2002. Coincident velocity estimates were collected using hull-mounted acoustic Doppler current profilers. Images of plankton and particles were extracted automatically and identified manually to taxa and type. Copepods, diatom chains, decaying diatoms, marine snow, and radiolarians were the most abundant categories observed. Distinct regional differences in abundance were observed that were associated with different oceanographic regimes and with the prevailing circulation in the region. Vertical distributions were closely associated with the physical structure of the water column. A sharp horizontal discontinuity in abundance of all categories between shelf and basin was observed, located over the shelf break and potentially established and maintained by transport of plankton and particles along-shelf to the east rather than northwards towards the basin. Barrow Canyon and the shelf and shelf-break east of Barrow Canyon had very high concentrations of plankton and particles, especially marine snow, that may have resulted from elevated production on the eastern Chukchi Shelf that subsequently was advected out of Barrow Canyon and to the east. Comparisons of downward flux, estimated from particle sinking rates based on individual marine snow particle size, and horizontal velocities suggested that much of the marine snow carbon was sinking to the benthos of the Chukchi Sea prior to being advected off-shelf. Velocities and plankton concentrations together indicated that little off-shelf flux of plankton or particles to the basin was occurring except in an eddy located off of the Beaufort Shelf.

BABAEI, A., BABAIE, H.A. & ARVIN, M. 2005. Tectonic evolution of the Neyriz ophiolite, Iran: An accretionary prism model. *Ophioliti* **30**(2), 65-74.

The Neyriz ophiolite complex in south central Iran is an assemblage of Upper Cretaceous crustal and mantle ophiolite sequences and related pelite, thinbedded limestone, chert, and melange with Permian-Cretaceous mega-clasts. The complex is thrust on shallow marine limestone of the Sarvak Formation to the southwest, and it is overthrust by arc-related volcanic and volcanoclastic rocks and forearc basin sediments from the northeast. The tectonic history of the ophiolite complex involved (i) rifting of the Afro-Arabian plate due to a late Carboniferous-early Permian uplift, which led to block-faulting along Precambrian basement faults and opening of the narrow Neo-Tethyan oceanic basin, (ii) sea-floor spreading, starting probably from Triassic, that

produced an oceanic crust, and (iii) SW-NE directed contraction and arc-related volcanism, in the Late Cretaceous, through which slivers of the Neo-Tethyan oceanic lithosphere and overlying sediments were accreted into an accretionary prism, and then thrust onto the passive, block-faulted northeastern margin of the Afro-Arabian plate, along a northeast-dipping subduction zone. The close correspondence between the cooling ages of the ophiolitic gabbro and plagiogranite, deposition of thin limestone interbedded with radiolarian chert, and metamorphism of mylonitic amphibolite along the sole detachment of the ophiolitic complex, suggests that the emplacement of the complex occurred in a relatively short period of time during which a segment of young rocks of a subducting mid-ocean ridge was thrust under accreted contemporaneous and older sedimentary cover. Continued contraction led to offscraping and/or underplating of pelagic, abyssal, and slope facies, deposited along the leading, passive margin of Afro-Arabian plate, under the crustal and mantle ophiolite sequences, forming an accretionary prism. Tholeiitic, arc-related basalt and volcanoclastic rocks covered the prism in the forearc region. The prism grew by incorporating slivers of Permian-Upper Cretaceous limestone, which capped normal-faulted blocks of the passive margin, and radiolarian chert and pelite which were deposited between the blocks, forming the Hajiabad melange. The final collision of the Eurasian and Arabian plates during the Miocene, which started when the Arabian plate separated from Africa, led to internal thrusting of the complex and the development of the cataclastic Zagros Crush zone immediately to the northeast of the ophiolite belt.

BAK, K. 2006. Sedimentological, geochemical and microfauunal responses to environmental changes around the Cenomanian-Turonian boundary in the Outer Carpathian Basin; a record from the Subsilesian Nappe, Poland. *Palaeogeography, Palaeoclimatology, Palaeoecology* **237**(2-4), 335-358.

Sedimentological, micropalaeontological and geochemical data from the upper Cenomanian-lower Turonian Zasan section (Outer Carpathians, Subsilesian Nappe, Poland) provide new insights into the sedimentary environment and its changes in a basin at the northern margin of the Western Tethys. A global oceanic event (OAE2) has been identified on the basis of lithology and radiolarian stratigraphic data. This event is marked by a series of organic-rich (TOC up to 5%) non-calcareous shales, practically devoid of benthic microfossils, indicative of bottom water anoxia. The marine type of organic matter and the occurrence of radiolarian-rich layers, with abundant small opportunistic forms, suggest that coastal upwelling was probably the main driving force for the accumulation of organic matter during the latest Cenomanian. The early diagenetic ferromanganese nodules followed by a 30 cm-thick series of manganese-rich non-calcareous variegated shales and bentonites, directly overlie the black facies of OAE2. The Fe-Mn nodules formed in two stages reflecting changes in bottom water dynamics across the C-T boundary. During the first stage, the Fe-Mn carbonate nodules were precipitated in presence of anoxic pore and/or bottom water that could be episodically oxygenated. Later, an increase in deep-water circulation led to strong oxygenation of the bottom and pore water, causing diagenetic modification of the nodule carbonate into ferromanganese oxides and hydroxides. The manganese-rich sediments recorded in the Zasan section represent an isochronous horizon within the Outer Carpathian Basin, probably concurrent with manganese enrichments in many other epicontinental seas and deep-water basins, coinciding with the end of the carbon isotope excursion close to the base of the Turonian. The manganese event may have been related to increased deep water circulation associated with the maximum flooding of the late Cenomanian-early Turonian transgression. The Mn event may have also been enhanced as a result of remobilization of Mn²⁺ dissolved in anoxic bottom and pore waters in the organic-rich sediments directly underlying the manganese sediments. The lower Turonian succession records increasing, but not completed, oxygenation of bottom water. The oxygenation was interrupted by periods of anoxia, marked by a few intervals of dark laminated

black shales, strongly enriched in organic matter (TOC up to 10%). Their marine origin and the occurrence of radiolarian-rich layers demonstrate enhanced primary productivity and a low clastic supply during the sea-level high-stand. Frequency of radiolarian-rich layers increases up section, reflecting an increase in upwelling circulation at the northern margin of the Carpathian Basin during the Early Turonian.

BAK, M. & BARWICZ-PISKORZ, W. 2006. Multivariate discrimination of *Buryella* species from the Lower Eocene of the Outer Flysch Carpathians, Poland. *Journal of Micropalaeontology* **25**, 45-54.

Variogated shales in the Lower Eocene hemipelagic deposits of the Subsilesian Series, Polish part of the Western Carpathians, have yielded rich radiolarians with common representatives of the genus *Buryella*. Two new radiolarian species, *Buryella spina* sp. nov. and *Buryella hanna* sp. nov., are described, and two other species have been recognized: *Buryella tetradica* Foreman and *Buryella clinata* Foreman. Specimens have been measured, grouped and interpreted using cluster analysis, principal component analysis (PCA) and canonical variates analysis (CVA). Species attributed to *Buryella* have three or four segments, a fusiform or lobate outline, and a constricted, rather than flared, aperture. The cephalis always possesses an apical horn of varying length with a distinct vertical pore at the collar stricture. All specimens possess a pronounced vertical tube, rounded or elongate, that might extend to the base of apical horn. Near the base of the cephalis the parallel ridges observed on the external wall of the cephalis are ridges from the horn that diverge and extend to the collar stricture except ventrally, where two ridges rejoin to enclose the vertical pore and form an upwardly directed tube. These structure might be evidence of the presence of arches (A-Vbl, A-Vbr) and bars (Vbl, Vbr), which form the vertical tube.

BALLENT, S., CONCHEYRO, A. & SAGASTI, G. 2006. Biostratigraphy and palaeoenvironment of the Agrio Formation (Lower Cretaceous), Mendoza Province, Neuquen Basin, Argentina. *Revista Geologica De Chile* **33**(1), 47-79.

A biostratigraphical and palaeoenvironmental study of the Agrio Formation, at the Cuesta del Chihuido section, southern Mendoza Province (35 degrees 45'S/69 degrees 34'W), Argentina, is presented. Thirty seven species of nannofossils, thirty four of foraminifers and six of ostracods have been recognized. Nannofossils association corresponding to Zones CC4A y CC4B indicates an Upper Valanginian-Upper Hauterivian age. At the base of the section, the presence of the benthonic foraminifer *Epistomina loncochensis* Ballent and radiolaria suggests eutrophic conditions of surface waters and oxygen depressed sea-bottom conditions. In the middle part of the section, diversity of lagenid foraminifers and nannofossils indicates a shelf and nearshore environment with clear and well-oxygenated waters.

BARASH, M.S., MATUL, A.G., KAZARINA, G.K., KHUSID, T.A., ABELMANN, A., BIEBOW, N., NÜRNBERG, D. & TIEDEMANN, R. 2006. Paleooceanography of the Central Sea of Okhotsk during the Middle Pleistocene (350-190 ka) as inferred from micropaleontological data. *Oceanology* **46**(4), 501.

The distribution of diatoms, radiolarians, planktonic and benthic foraminifers, and sediment components in the fraction >0.125 mm was analyzed in the core obtained from the central Sea of Okhotsk within the frameworks of the Russian-German KOMEX project. The core section characterizes the period 190-350ka, which corresponds to marine-isotopic stages (MIS) 7 to 10. During glacial MIS 10 and MIS 8, the basin accumulated terrigenous material lacking microfossils or containing them in low abundance, which reflects, along with their composition, heavy

sea-ice conditions, suppressed bioproductivity, and bottom environments aggressive toward calcium carbonate. Interglacial MIS 9 was characterized by elevated bioproductivity with accumulation of diatomaceous ooze during the climatic optimum (328 to 320 ka). The water exchange with the Pacific was maximal from 328 to 324 ka ago. Environments became moderate and close to the presentday ones at the end of the optimum exhibiting the possible existence of a dichothermal layer with substantial amounts of the surface Pacific water still flowing into the basin. Similar to interglacial MIS 5e and MIS 1, the "old" Pacific water determined near-bottom environments in the central Sea of Okhotsk during that period, although the influx of terrigenous material was higher, probably reflecting a more humid climate of the region. Slight warming marked the terminal MIS 8 (approximately 260 ka ago). The paleoceanographic situation during interglacial MIS 7 was highly variable: from warm-water to almost glacial. The main climatic optimum of MIS 7 occurred within 220-210 ka, when the subsurface stratification increased and the dichothermal layer developed. Bottom environments during the studied time interval, except for the optimum of interglacial MIS 9, resembled those characteristic of glacial periods: the actively formed "young" Okhotsk water displaced the "old" Pacific deep water.

BARASH, M.S., CHEKHOVSKAYA, M.P., BIEBOW, N., NURNBERG, D. & TIEDEMAN, R. 2005. On the Quaternary paleoceanology of the southeastern part of the Sea of Okhotsk from lithology and planktonic foraminifera. *Oceanology* **45**(2), 257-268.

In a 1116-cm-long sediment core from the Kamchatka continental slope (sea depth 684 m), the distribution of planktonic foraminifera and the proportions of the main components (terrigenous grains, volcanic ashes, siliceous microfossils (diatoms and radiolarians), planktonic and benthic foraminifera) in the grain-size fraction greater than 0.125 mm were studied. The section covers about 180 ky, from the end of the oxygen isotopic stage (OIS 6) up to present. Under the conditions of the penultimate (OIS 6) and the last (OIS 5d-2) continental glaciations, terrigenous sediments with coarse-grained ice-rafted matter, volcanic ashes, and insignificant contents of microfossils were accumulated. The sedimentation rates were 2.3-5.0 cm/ky. The temperatures of the surface water and their seasonal variability were minimum. The almost complete absence of microfossils suggests low biological productivity caused by the heavy ice conditions and weak mixing of the subsurface waters. Under the conditions of interglacials (OIS 5e and 1), layers of diatomaceous ooze with radiolarians and foraminifers were accumulated. The higher sedimentation rates (12.2 and 20-26 cm/ky, respectively) reflect the high biological productivity. The most warm-water conditions were characteristic of stage OIS 5e. The early stages of both interglacials were characterized by rather low seasonal temperature contrasts, poorly developed stratification, lower biological productivity, and increased concentrations of foraminifera in the deposits. The signs of the last deglaciation (reduction in the terrigenous matter supply and increase in the microfossil contents) are noted after oxygen isotope peak 2.2 (17 850 ky B.P.). About 6.7 ky B.P., with the growth in the summer temperatures and seasonal contrasts, a distinct vertical water structure was established, the thermocline sunk to greater depths, a dichothermal layer appeared, and the biological productivity increased. At OIS 5e, similar changes took place approximately 121 ky B.P. A certain cooling could probably have occurred 3.4 ky B.P.

BASS, D., MOREIRA, D., LOPEZ-GARCIA, P., POLET, S., CHAO, E.E., VON DER HEYDEN, S., PAWLOWSKI, J. & CAVALIER-SMITH, T. 2005. Polyubiquitin insertions and the phylogeny of Cercozoa and Rhizaria. *Protist* **156**(2), 149-161.

A single or double amino acid insertion at the monomer-monomer junction of the universal eukaryotic protein polyubiquitin is unique

to Cercozoa and Foraminifera, closely related 'core' phyla in the protozoan infrakingdom Rhizaria. We screened 11 other candidate rhizarians for this insertion: Radiozoa (polycystine and acantharean radiolaria), a 'microheliozoan', and Apusozoa; all lack it, supporting suggestions that Foraminifera are more closely related to Cercozoa than either is to other eukaryotes. The insertion's size was ascertained for 12 additional Cercozoa to help resolve their basal branching order. The earliest branching Cercozoa generally have a single amino acid insertion, like all Foraminifera, but a large derived clade consisting of all Monadofilosa except *Metopion*, *Helkesimastix*, and *Cercobodo agilis* has two amino acids, suggesting one doubling event and no reversions to a single amino acid. *Metromonas* and *Sainouron*, cercozoans of uncertain position, have a double insertion, suggesting that they belong in Monadofilosa. An alternative interpretation, suggested by the higher positions for *Metopion* and *Cercobodo* on Bayesian trees compared with most distance trees, cannot be ruled out, i.e. that the second insertion took place earlier, in the ancestral filosan, and was followed by three independent reversions to a single amino acid in *Chlorarachnea*, *Metopion* and *Cercobodo*.

BHATIA, S.B. & BHARGAVA, O.N. 2006. Biochronological continuity of the Paleogene sediments of the Himalayan Foreland Basin: paleontological and other evidences. *Journal of Asian Earth Sciences* **26**(5), 477-487.

The paleontological and field evidences presented in the paper demonstrate a biochronological continuity from the marine Subathu (Late Thanetian to Middle Lutetian) through the Passage Beds (Late Lutetian to Middle Bartonian) to the Dagshai and equivalent formations (Late Bartonian to Rupelian) of the Himalayan Foreland Basin, east of Hazara-Kashmir syntaxis. A similar continuity has also been demonstrated in the Sulaiman Range based on an assignment of Oligocene age to the Bugti vertebrate fauna, hitherto considered to be of Early Miocene age. Thus, the concept of a >10 Ma hiatus in the foreland basin based on Ar-40/Ar-39 dates of single detrital muscovite grains from the supposed basal Dagshai arenite is no longer tenable. While the occurrence of Cr-spinel and K-T boundary nannoplanktons in the Subathu Formation and Passage Beds indicate a westerly-northwesterly provenance, that of the radiolarian chert in the Dagshai and coeval formations indicates a northerly provenance from the Indus Suture Zone, coinciding with the first influx of the Himalayan detritus around 40 Ma.

BORTOLOTTI, V., CHIARI, M., KODRA, A., MARCUCCI, M., MUSTAFA, F., PRELA, M., PRINCIPI, G. & SACCANI, E. 2006. Triassic morib magmatism in the southern Mirdita zone ophiolites (Albania). *Ofioliti* **31**(1), 1-9.

In southern Albania the Mirdita Ophiolitic nappe is characterized by subophiolitic complexes in which remnants of volcanic ophiolite sequences of Triassic age have been identified, either as rare blocks of variable dimension in the Rubik Complex, or as a thin tectonic unit (the Porava Unit), sited immediately under the main ophiolitic masses of the Eastern Ophiolite Belt. In this paper the results of petrological investigations on basalts and biostratigraphical studies on associated radiolarian cherts included in these subophiolitic complexes units are presented. Biostratigraphical investigations indicate that cherts have ages ranging from Middle to Late Triassic. The associated basalts are represented by both high-Ti mid-ocean ridge basalts (MORB) and alkaline ocean island basalts (OIB). MORB rocks mainly consist of basalts and ferrobasalts with a mild enrichment in low field strength elements and flat rare earth element patterns and, subordinately, by basalts strongly depleted in incompatible elements and light rare earth elements. The chemistry of slightly enriched MORB is consistent with a generation in a mid-ocean ridge setting, from somewhat enriched sub-oceanic mantle source(s), whereas depleted MORB generated from a primitive MOR-type mantle source. The OIB rocks imply a generation in a

within-plate oceanic setting from a mantle source enriched by plume chemical components. Basalts and associated cherts from southern Albania subophiolitic mélanges represent remnants of a Triassic oceanic lithosphere, which testify for the existence, from northern Albania to southern Greece, of a Middle to Late Triassic oceanic basin located between the Adria and Eurasia plates. The occurrence in the Rubik Complex and Porava Unit of MOR basalts generated from differently enriched sources, as well as of alkaline OIBs, suggests that the early stage of oceanic spreading was variably associated with a plume activity.

BORTOLOTTI, V., CHIARI, M., MARCUCCI, M., PHOTIADES, A., PRINCIPI, G. & SACCANI, E. 2005. Triassic and Jurassic radiolarian assemblages from the cherts linked to the Mor basalts in the Othris area (Greece). *Ofioliti* **30**(2), 107.

BORTOLOTTI, V., MARRONI, M., PANDOLFI, L. & PRINCIPI, G. 2005. Mesozoic to Tertiary tectonic history of the Mirdita ophiolites, northern Albania. *Island Arc* **14**(4), 471-493.

In this paper, a summary of the tectonic history of the Mirdita ophiolitic nappe, northern Albania, is proposed by geological and structural data. The Mirdita ophiolitic nappe includes a subophiolite melange, the Rubik complex, overlain by two ophiolite units, referred to as the Western and Eastern units. Its history started in the Early Triassic with a rifting stage followed by a Middle to Late Triassic oceanic opening between the Adria and Eurasia continental margins. Subsequently, in Early Jurassic time, the oceanic basin was affected by convergence with the development of a subduction zone. The existence of this subduction zone is provided by the occurrence of the supra-subduction-zone-related magmatic sequences found in both the Western and Eastern units of the Mirdita ophiolitic nappe. During the Middle Jurassic, continuous convergence resulted in the obduction of the oceanic lithosphere, in two different stages—the intraoceanic and marginal stages. The intraoceanic stage is characterized by the westward thrusting of a young and still hot section of oceanic lithosphere leading to the development of a metamorphic sole. In the Late Jurassic, the marginal stage developed by the emplacement of the ophiolitic nappe onto the continental margin. During this second stage, the emplacement of the ophiolites resulted in the development of the Rubik complex. In the Early Cretaceous, the final emplacement of the ophiolites was followed by the unconformable sedimentation of the Barremian-Senonian platform carbonate. From the Late Cretaceous to the Middle Miocene, the Mirdita ophiolitic nappe was translated westward during the progressive migration of the deformation front toward the Adria Plate. In the Middle to Late Miocene, a thinning of the whole nappe pile was achieved by extensional tectonics, while the compression was still active in the westernmost areas of the Adria Plate. On the whole, the Miocene deformations resulted in the uplift and exposition of the Mirdita ophiolites as observed today.

BORTOLOTTI, V. & PRINCIPI, G. 2005. Tethyan ophiolites and Pangea break-up. *Island Arc* **14**(4), 442-470.

The break-up of Pangea began during the Triassic and was preceded by a generalized Permo-Triassic formation of continental rifts along the future margins between Africa and Europe, between Africa and North America, and between North and South America. During the Middle-Late Triassic, an ocean basin cutting the eastern equatorial portion of the Pangea opened as a prograding branch of the Paleotethys or as a new ocean (the Eastern Tethys); westwards, continental rift basins developed. The Western Tethys and Central Atlantic began to open only during the Middle Jurassic. The timing of the break-up can be hypothesized from data from the oceanic remnants of the peri-Mediterranean and peri-Caribbean regions (the Mesozoic ophiolites) and from the Atlantic ocean crust. In the Eastern Tethys, Middle-Late Triassic mid-

oceanic ridge basalt (MORB) ophiolites, Middle-Upper Jurassic MORB, island arc tholeiite (IAT) supra-subduction ophiolites and Middle-Upper Jurassic metamorphic soles occur, suggesting that the ocean drifting was active from the Triassic to the Middle Jurassic. The compressive phases, as early as during the Middle Jurassic, were when the drifting was still active and caused the ocean closure at the Jurassic-Cretaceous boundary and, successively, the formation of the orogenic belts. The present scattering of the ophiolites is a consequence of the orogenesis: once the tectonic disturbances are removed, the Eastern Tethys ophiolites constitute a single alignment. In the Western Tethys only Middle-Upper Jurassic MORB ophiolites are present—this was the drifting time. The closure began during the Late Cretaceous and was completed during the Eocene. Along the area linking the Western Tethys to the Central Atlantic, the break-up was realized through left lateral wrench movements. In the Central Atlantic—the link between the Western Tethys and the Caribbean Tethys—the drifting began at the same time and is still continuing. The Caribbean Tethys opened probably during the Late Jurassic—Early Cretaceous. The general picture rising from the previous data suggest a Pangea break-up rejuvenating from east to west, from the Middle-Late Triassic to the Late Jurassic—Early Cretaceous.

BOUMAN, C., ELLIOTT, T. & VROON, P.Z. 2004. Lithium inputs to subduction zones. *Chemical Geology* **212**(1-2), 59-79.

We have studied the sedimentary and basaltic inputs of lithium to subduction zones. Various sediments from DSDP and ODP drill cores in front of the Mariana, South Sandwich, Banda, East Sunda and Lesser Antilles island arcs have been analysed and show highly variable Li contents and $\delta(7)\text{Li}$ values. The sediment piles in front of the Mariana and South Sandwich arcs largely consist of pelagic sediments (clays and oozes). The pelagic clays have high Li contents (up to 57.3 ppm) and Li isotope compositions ranging from +1.3‰ to +4.1 parts per thousand. The oozes have lower Li contents (7.3-16 ppm) with $\delta(7)\text{Li}$ values of the diatom oozes from the South Sandwich lower (+2.8 parts per thousand to +3.2 parts per thousand) than those of the radiolarian oozes from the Mariana arc (+8.1 parts per thousand to +14.5 parts per thousand). Mariana sediment also contains a significant portion of volcanogenic material, which is characterised by a moderate Li content (14 ppm) and a relatively heavy isotope composition (+6.4 parts per thousand). Sediments from the Banda and Lesser Antilles contain considerable amounts of continental detritus, and have high Li contents (up to 74.3 ppm) and low $\delta(7)\text{Li}$ values (around 0 parts per thousand), caused by weathering of continental bedrock. East Sunda sediments largely consist of calcareous oozes. These carbonate sediments display intermediate to high Li contents (2.4-41.9 ppm) and highly variable $\delta(7)\text{Li}$ values (-1.6 parts per thousand to +12.8 parts per thousand). Basaltic oceanic crust samples from worldwide DSDP and ODP drill cores are characterised by enrichment of Li compared to fresh MORB (6.6-33.1 vs. 3.6-7.5 ppm, respectively), and show a large range in Li isotope compositions (+1.7 parts per thousand to +11.8 parts per thousand). The elemental and isotopic enrichment of Li in altered basalts is due to the uptake of isotopically heavy seawater Li during weathering. However, old oceanic crust samples from Sites 417/418 exhibit lighter Li isotope compositions compared to young basaltic crust samples from Sites 332B and 504B. This lighter Li isotope signature in old crust is unexpected and further research is needed to explore this issue.

BRAGIN, N.Y. 2005. Radiolarian Evolution and Diversity Dynamics in the Late Permian through to the Early Mesozoic. *Paleontological Journal* **39**(2), 117-132.

Available data on the distribution of radiolarian genera in the Upper Permian through to the Lower Jurassic are summarized, and their diversity dynamics, including the rates of appearance and extinction of genera and the general rate of diversification, are estimated. The results show a major extinction of Paleozoic taxa in the Late Permian, low taxonomic diversity in the Early Triassic, rapid diversification in the early Middle Triassic, stasis in the

Ladinian and Late Triassic, and a new major extinction at the Triassic-Jurassic boundary. This confirms previous assumptions that the Triassic Period was a unique stage in radiolarian evolution limited by two great extinction events

BRAUN, A., CHEN, Y.Y., WALOSZEK, D. & MAAS, A. 2005. Micropalaeontological studies in lower Cambrian rocks of the Yangtze Plate, China: methods and results. In: TYSZKA, J., OLIWKIEWICZ-MIKLASINSKA, M., GEDL, P. & KAMINSKI, M.A. (Eds.), *Methods and Applications in Micropalaeontology*. Studia Geologica Polonica - Series, pp. 11-20.

Deep water lowermost Cambrian sedimentary successions, Yangtze Plate, China, contain a variety of organic (acritarchs) and siliceous (sponge spicules, radiolarians) microfossils, representing oceanic both plankton and benthos. Predominant rock types are dark bedded cherts and black shales, with phosphorite concretions and phosphatic limestones. Specific methods used to separate microfossils from those rocks include surficial or whole-rock HF and HCl-etching, but also the acetate peel method. The latter method can be successfully applied to siliceous and clay-rich lithologies. Microfossil separation methods are described and their results are shown.

BREHM, U., GORBUSHINA, A. & MOTTERSHEAD, D. 2005. The role of microorganisms and biofilms in the breakdown and dissolution of quartz and glass. *Palaeogeography, Palaeoclimatology, Palaeoecology* **219**, 117-129.

Three different types of silica, (1) quartz sand, (2) crystalline (scepter) quartz, and (3) commercial glass, subjected to biological growth were investigated for evidence of biologically induced breakdown. The results of laboratory experiments with biofilms on quartz sand and glass were compared with material from the field. Microscopic (optical and SEM) analysis of quartz sand weathered in vitro by a microbial community of cyanobacteria, diatoms and heterotrophic bacteria demonstrate grain diminution of a sand fraction of North Sea sediment. The microbial community changes the minerals in the vicinity of the living cells, which leave their mark on the quartz surface in form of imprints, depressions and pits. Subsequently microbial growth on the surface brought about a general decrease of the grain size in the layer beneath a biofilm. Imprints of diatoms on glass surfaces colonized by diatoms and heterotrophic bacteria confirm the chemical etching activity of these organisms. Mixed cultures of diatoms and bacteria show depressions corresponding to the shape of individual cells. Our experiments confirm that diatoms, heterotrophic bacteria and cyanobacteria from natural biofilms can actively attack quartz and glass. Microscopic analysis of an idiomorphic scepter quartz crystal from a Tepui weathering environment reveals that the associated biofilms can create a local shift in the pH from 3.4 (pH of water on the Tepui) to evidently higher than 9 (necessary for quartz dissolution). The quartz covered with a biofilm is partially perforated to a depth of more than 4 mm. We conclude that biofilm growth in marine (sub-aquatic) and terrestrial (sub-aerial) conditions can significantly increase the breakdown of silica in the amorphous (glass), sub-crystalline (chert), crystalline and granular forms of quartz. Microbial growth may therefore substantially modify the processes of transformation of a major rock forming mineral of great chemical and physical resistance.

CECCA, F., GARIN, B.M., MARCHAND, D., LATHUILIERE, B. & BARTOLINI, A. 2005. Paleoclimatic control of biogeographic and sedimentary events in Tethyan and peri-Tethyan areas during the Oxfordian (Late Jurassic). *Palaeogeography Palaeoclimatology Palaeoecology* **222**(1-2), 10-32.

The paleobiogeographical distribution of Oxfordian ammonites and coral reefs in northern and Central Europe, the Mediterranean area, North and East Africa, and the Middle East and Central Asia is compared with the distribution in time and space of the most important lithofacies. Interest in the Oxfordian is focused on changes in facies and in biogeographical patterns that can be interpreted as the results of climatic events. Paleotemperature trends inferred from oxygen isotopes and paleoclimatic simulations are tested against fossil and facies data. A Late Callovian Early Oxfordian crisis in carbonate production is indicated by the widespread absence of Lower Oxfordian reefal formations. There is a gap (hiatus) in deposition on epicontinental platforms, with Middle Oxfordian deposits resting paraconformably on Upper Callovian, while shales accumulated in adjacent intracratonic basins. Simultaneously, in Mediterranean Tethys, radiolarites accumulated in deep troughs while Rosso Ammonitico facies formed on pelagic swells. However, deposition of oil swells was also discontinuous with numerous gaps (hiatuses) and sequences that are much reduced in thickness. Middle Callovian deposits are generally overlain by Middle Oxfordian limestones. The dearth of carbonates is consistent with a cooling event lasting about 1 My. By the middle Oxfordian a warming, leading to 'greenhouse' type conditions, is suggested on the basis of both biogeographical (mostly coral-reef distribution) and geochemical data. Carbonates spread onto an extensive European platform while radiolarites reached a maximum development in the Mediterranean Tethys. Two distinct latitudinal belts, with seemingly different accumulation regimes, are therefore inferred. Similar latitudinal belts were also present in the late Oxfordian, when carbonates were widespread. The distribution of reefal facies in the late Oxfordian-early Kimmeridgian fits relatively well with GCMs simulations that imply low rainfall in the Tethyan Mediterranean area and slightly higher precipitation in central and northern Europe. Local salinity variations, reflecting more arid or humid conditions, may bias the paleotemperature signal inferred from $\delta^{18}\text{O}$ values. Biogeographical and facies distributions, combined with $\delta^{18}\text{O}$ values, unravel the ambiguity and support a Late Callovian-Early Oxfordian cooling followed by warming in the later Oxfordian.

CHEN, Z.Q., SHI, G.R., YANG, F.Q., GAO, Y.Q., TONG, J.N. & PENG, Y.Q. 2006. An ecologically mixed brachiopod fauna from Changhsingian deep-water basin of South China: consequence of end-Permian global warming. *Lethaia* **39**(1), 79-90.

The Late Permian Shaiwa Group of the Ziyun area of Guizhou, South China is a deep-water facies succession characterized by deep-water assemblages of pelagic radiolarians, foraminifers, bivalves, ammonoids and brachiopods. Here we report 20 brachiopod species in 18 genera from the uppermost Shaiwa Group. This brachiopod fauna is latest Changhsingian in age and dominated by productides. The palaeoecologic and taphonomic analysis reveals that the brachiopod fauna is preserved in situ. The attachment modes and substratum preference demonstrate that the Shaiwa brachiopod fauna comprises admixed elements of deep-water and shallow-water assemblages. The presence of the shallow-water brachiopods in the Shaiwa faunas indicates the involuntary settlement of shallow-water brachiopods. The stressed ecologic pressure, triggered by warming surface waters, restricted ecospace and short food sources, may have forced some shallow-water elements to move to hospitable deep-water settings and others to modify their habiting behaviours and exploit new ecospace in deep-water environments. We infer that the end-Permian global warming and subsequent transgression event may have accounted for the stressed environmental pressure in the shallow-water communities prior to the end-Permian mass extinction.

CHENG, R.Y., WU, F.Y., GE, W.C., SUN, D.Y., LIU, X.M. & YANG, J.H. 2006. Emplacement age of the Raohe Complex in eastern Heilongjiang Province and the tectonic evolution of the eastern part of

Northeastern China. *Acta Petrologica Sinica* **22**(2), 353-376.

Raohe Complex, located in the eastern Heilongjiang Province and composed of deep oceanic sediments and mafic igneous rocks, was considered as slice of oceanic crust and intruded by Hamahe and Taipingcun granites. Zircon U-Pb dating indicated that both of plutons were emplaced in Early Cretaceous, with the Hamahe pluton formed at three individual stages (131Ma, 124Ma and 115Ma, respectively) and the Taipingcun pluton at 111 similar to 114Ma. However, the gabbro in Raohe Complex was formed at 166 +/- 1Ma, and the latest radiolarian in the deep oceanic sediments is about 160 similar to 150Ma. Therefore, it is concluded that the emplacement of the Raohe Complex took place at 150 similar to 131Ma of Late Jurassic-Early Cretaceous, indicating that there existed the Pacific plate subduction and striking-slip in this area before and during Late Jurassic-Early Cretaceous. Petrological studies indicate that both plutons contained magmatic cordierites and show peraluminous characteristics, suggesting their S-type affinity derived from partial melting of the sedimentary rocks. Hf isotopic analyses show that the zircons from plutons have high Hf-116/Hf-177 ratios and positive epsilon(Hf)(t) values, and the Hf isotope model age with the felsic crust rocks is 500 similar to 780Ma, which indicates that their protolith should be the juvenile crust formed in Neo Proterozoic-Phanerozoic. Therefore, it is suggested that there existed significant crust uplift and weathering before Late Jurassic-Early Cretaceous in the area.

CHRISTIDIS, G.E. 2006. Genesis and compositional heterogeneity of smectites. Part III: Alteration of basic pyroclastic rocks - A case study from the Troodos Ophiolite Complex, Cyprus. *American Mineralogist* **91**(4), 685-701.

Upper Cretaceous basic pyroclastic rocks, which overlie the Upper Pillow Lavas of the Troodos ophiolitic complex, Cyprus have been altered to bentonites. The resulting smectite is Fe-rich montmorillonite and Fe-rich beidellite, with moderate Mg contents. The smectite is trans-vacant and contains abundant exchangeable K. The presence of K is linked with hydrothermal alteration, which affected the higher members of the Troodos ophiolitic suite. The smectite displays significant compositional heterogeneity, which involves substitution of Fe for Al and to a lesser degree substitution of Mg for Al, and that reflects the influence of microenvironmental conditions on smectite formation. The layer charge of the smectite is controlled mainly by the tetrahedral charge, whereas the influence of octahedral charge is of lesser importance, because of Fe for Al substitutions, which does not create a charge deficit. Although the parent pyroclastic rocks were basic, the bentonites contain abundant Si-polymorphs and Si-rich zeolites, from dissolution of abundant radiolarian frustules, which increased the Si-activity of the pore waters, and also produced the partial replacement of smectite by palygorskite at a later stage. Dissolution of frustules was facilitated by the high heat flow from the ocean floor and by the circulation of hydrothermal fluids. The crystal chemistry of smectite and the bulk mineralogy of the bentonites influence the physical properties and industrial applications of the Cyprus bentonites, as well as their response to acid treatment.

CORTESE, G. 2005. Seawater temperature estimates in paleoceanography. In: LEHR, J.H. & KEELEY, J. (Eds.), *Water Encyclopedia*, Wiley Interscience, Hoboken, New Jersey, pp. 4112.

Temperature, together with salinity, determines the density of seawater, and therefore it strongly influences its circulation and sinking characteristics.

In turn, the important role oceanic circulation and deep-water formation play in past, present, and future climatic change lend a special significance to the estimate of past seawater temperature.

As the past values of this important climatic variable in the distant, geological past are impossible to measure directly, a variety of indirect methods, so called "proxies", have been developed. These methods are usually based on the fossil faunal/floral composition of sediment core samples, as there is a close link between species occurrences/abundances and environmental variables.

Semi-quantitative (e.g. faunal provinces indexes) and quantitative (e.g. transfer functions, neural networks) techniques are therefore applied to reconstruct past sea surface water variables, including temperature.

Additionally, several geochemical methods have been recently developed to estimate past ocean temperatures by measuring chemical elements (Mg/Ca, Sr/Ca) or organic compounds (alkenones), which are either incorporated in the organism shell, or produced during its life cycle.

DALY, K.L. 2004. Overwintering growth and development of larval *Euphausia superba*: an interannual comparison under varying environmental conditions west of the Antarctic Peninsula. *Deep-Sea Research Part II-Topical Studies in Oceanography* **51**(17-19), 2139-2168.

Growth, molting, and development of larval Antarctic krill were investigated near Marguerite Bay during four cruises in austral autumn and winter 2001 and 2002, as part of the US Southern Ocean GLOBEC program. Overwintering survival of larvae has been linked to annual sea-ice formation and extent, as sea-ice biota may provide food when other sources are scarce in the water column. During autumn 2001, larvae were very abundant (1-19 individuals m⁻³), with younger stages dominant offshore and older stages dominant on-shelf. On-shelf larvae were in better condition than offshore larvae. During autumn 2002, larvae again were abundant offshore (0.01-110 m⁻³), whereas all stages were scarce on-shelf. Declining diatom and radiolarian blooms were present during autumn in both years. Average chlorophyll concentrations were low (0.10 vs. 0.22 mug l⁻¹) in autumn and an order of magnitude lower in winter. Carbon content of larvae during autumn 2001 and 2002 (41% vs. 38% C of DW) suggested that lipid storage was moderate. The median autumn larval growth rate (0.027 mm d⁻¹) was lower and the intermolt period (19 d) longer than reported summer values. During winter, larvae appeared to be food-limited based on the following observations: (1) the median growth rate decreased (0.00 mm d⁻¹) and the intermolt period increased (40 d), (2) larval length-specific dry weight (DW) and % carbon and nitrogen of DW decreased, and (3) 88 % of furcilia 6 did not develop to the juvenile stage, but remained at the same stage after molting. Experimental results demonstrated that some larvae could survive starvation for a month by combusting body reserves (ca. 1 % decrease in DW and body C and Nd-1), implying that a portion of the population was resilient to the suboptimal food supply. Although sea ice formed up to 2 months earlier in 2002, ice algae at the ice-water interface, where it is accessible to krill, was not an abundant food source in either year (0.05 vs. 0.07 mug chl l⁻¹). In winter 2001, furcilia were commonly observed near the undersurface of sea-ice, but only rarely in 2002 until mid-September, when ice algae began to accumulate. Low gut fluorescence values also indicate that little nutrition was derived from autotrophs in winter. Instead, larvae were likely opportunistic scavengers exploiting all available food sources, including microzooplankton, benthic larvae, detritus, scarce phytoplankton and sea-ice biota. In summary, larval krill exhibited several overwintering behaviors: (1) flexible feeding, (2) flexible morphology (i.e., delayed development), (3) flexible physiology (i.e., increased intermolt period, reduced growth), (4) moderate lipid storage, and (5) ability to withstand starvation by combusting body C and N. Because most larvae did not shrink in length, this measure may not be a good indicator of the body combustion strategy. At these high latitudes, sea-ice biota may not be a primary source of food during winter, but progressively more important in spring as irradiance levels increase. Winter survivors during 2001 resulted in a significant recruitment to the juvenile size class during spring.

DANELIAN, T., ROBERTSON, A.H.F., COLLINS,

A. & POISSON, A. 2006. Biochronology of Jurassic and Lower Cretaceous radiolarites from the Lycian Mélange (SW Turkey) and implications for the evolution of the northern Neotethyan ocean. *Journal of the Geological Society, London*.

New radiolarian ages for blocks of radiolarian cherts occurring in association with other blocks of distal pelagic facies and ophiolitic lithologies within the Lycian Mélange, SW Turkey, indicate deposition during the Middle Jurassic to Early Cretaceous. Radiolarites overlying pink pelagic limestones of an allochthonous carbonate unit accumulated during the Middle to Late Jurassic. On the basis of structural evidence the Lycian Mélange is inferred to have been rooted within the northern Neotethys to the north of the Tauride-Anatolide microcontinent. The Lycian radiolarites can be compared with other dated radiolarites from the Izmir-Ankara suture, the root zone of the northern Neotethys. Based on all available radiolarian data it is inferred that radiolarites accumulated within the northern Neotethys from Late Triassic (Mid-Carnian to Late Norian) to Mid Cretaceous (Cenomanian). Sometime after then, radiolarites were accreted from northward-subducting Neotethyan oceanic crust and emplaced southwards in the Late Cretaceous, together with continental margin and ophiolitic slices (Lycian thrust sheets) over the Tauride-Anatolide continental margin (Menderes Massif).

DENG, S.H., LU, Y.Z. & XU, D.Y. 2005. Progress and review of the studies on the end-Triassic mass extinction event. *Science in China Series D-Earth Sciences* **48**(12), 2049-2060.

The mass extinction at the end-Triassic is one of the five biggest in the Phanerozoic. However, it is the least well understood among these five events, and only till last decade it became a great academic interesting subject to geologists. The evidences for this event come obviously from bivalves, brachiopods, ammonites, corals, radiolaria, ostracods and foraminifera of marine habitats, and plants and tetrapods of terrestrial realm. By contrast, for some of other groups, such as marine gastropods and marine vertebrates, no mass extinction has been recognized yet. The extinction event is strongly marked at specific level but shown a complicated situation at generic and family levels. Dramatic changing of the environment, such as the temperature raise due to the greenhouse effect, the marine anoxic habitats caused by a sudden transgression after the regression at the end of Triassic, has been claimed to be the main cause of the extinction. Many hypotheses have been suggested to demonstrate the mechanisms of the environment changing, among which two popular ones are the bolide impact and volcanic eruption. The Triassic-Jurassic (Tr-J) boundary mass extinction event is still poorly understood because no enough data have been obtained from the Tr-J boundary successional sections of both marine and terrestrial sediments, and most of these studies were regionally restricted. The basic aspects of the event and its associated environmental conditions remain poorly characterized and the causal mechanism or mechanisms are equivocal. Some authors even doubt its occurrences. China has many successional developed terrestrial and marine Tr-J sections. Detailed studies of these sections may be important and significant for well understanding of the event.

DENYER, P. & BAUMGARTNER, P.O. 2006. Emplacement of Jurassic-Lower Cretaceous radiolarites of the Nicoya Complex (Costa Rica). *Geologica Acta* **4**(1-2), 203-218.

We present a new model to explain the origin, emplacement and stratigraphy of the Nicoya Complex in the NW part of the Nicoya Peninsula (Costa Rica) based on twenty-five years of field work, accompanied with the evolution of geochemical, vulcanological, petrological, sedimentological and paleontological paradigms. The igneous-sedimentary relation, together with radiolarian biochronology of the NW-Nicoya Peninsula is re-examined. We interpret the Nicoya Complex as a cross-section of a fragment of

the Late Cretaceous Caribbean Plateau, in which the deepest levels are exposed in the NW-Nicoya Peninsula. Over 50% of the igneous rocks are intrusive (gabbros and in less proportion plagiogranites) which have a single mantle source; the remainder are basalts with a similar geochemical signature. Ar39/Ar40 radioisotopic whole rock and plagioclase ages range throughout the area from 84 to 83 Ma (Santonian) for the intrusives, and from 139 to 88 Ma (Berriasian-Turonian) for the basalts. In contrast, Mn-radiolarites that crop out in the area are older in age, Bajocian (Middle Jurassic) to Albian (middle Cretaceous). These Mn-radiolaritic blocks are set in a "matrix" of multiple gabbros and diabases intrusions. Chilled margins of magmatites, and hydrothermal baking and leaching of the radiolarites confirm the Ar39/Ar40 dating of igneous rocks being consistently younger than most of the radiolarian cherts. No Jurassic magmatic basement has been identified on the Nicoya Peninsula. We interpret the Jurassic-Cretaceous chert sediment pile to have been disrupted and detached from its original basement by multiple magmatic events that occurred during the formation of the Caribbean Plateau. Coniacian-Santonian (Late Cretaceous), Fe-rich radiolarites are largely synchronous and associated with late phases of the Plateau.

DENYER, P. & BAUMGARTNER, P.O. 2006. Evidence for middle Cretaceous accretion at Santa Elena Peninsula (Santa Rosa Accretionary Complex), Costa Rica. *Geologica Acta* 4(1-2), 179-191.

An oceanic assemblage of alkaline basalts, radiolarites and polymictic breccias forms the tectonic substratum of the Santa Elena Nappe, which is constituted by extensive outcrops of ultramafic and mafic rocks of the Santa Elena Peninsula (NW Costa Rica). The undulating basal contact of this nappe defines several half-windows along the south shores of the Santa Elena Peninsula. Lithologically it is constituted by vesicular pillowed and massive alkaline basaltic flows, alkaline sills, ribbon-bedded and knobby radiolarites, muddy tuffaceous and detrital turbidites, debris flows and polymictic breccias and megabreccias. Sediments and basalt flows show predominant subvertical dips and occur in packages separated by roughly bed-parallel thrust planes. Individual packages reveal a coherent internal stratigraphy that records younging to the east in all packages and shows rapid coarsening upwards of the detrital facies. Alkaline basalt flows, pillow breccias and sills within radiolarite successions are genetically related to a mid-Cretaceous submarine seamount. Detrital sedimentary facies range from distal turbidites to proximal debris flows and culminate in megabreccias related to collapse and mass wasting in an accretionary prism. According to radiolarian dating, bedded radiolarites and soft-sediment-deformed clasts in the megabreccias formed in a short, late Aptian to Cenomanian time interval. Middle Jurassic to Lower Cretaceous radiolarian ages are found in clasts and blocks reworked from an older oceanic basement. We conclude that the oceanic assemblage beneath the Santa Elena Nappe does not represent a continuous stratigraphic succession. It is a pile of individual thrust sheets constituting an accretionary sequence, where intrusion and extrusion of alkaline basalts, sedimentation of radiolarites, turbidites and trench fill chaotic sediments occurred during the Aptian-Cenomanian. These thrust sheets formed shortly before the off-scraping and accretion of the complex. Here we define the Santa Rosa Accretionary Complex and propose a new hypothesis not considered in former interpretations. This hypothesis would be the basis for further research.

DUMOULIN, J.A., HARRIS, A.G., BLOME, C.D. & YOUNG, L.E. 2004. Depositional settings, correlation, and age of carboniferous rocks in the western Brooks Range, Alaska. *Economic Geology* 99(7), 1355-1384.

The Kuna Formation (Lisburne Group) in northwest Alaska hosts the Red Dog and other Zn-Pb-Ag massive sulfide deposits in the Red Dog district. New studies of the sedimentology and paleontology of the Lisburne Group constrain the setting, age, and

thermal history, of these deposits. In the western and west-central Brooks Range, the Lisburne Group includes both deep- and shallow-water sedimentary facies mid local volcanic rocks, that are exposed in a series of thrust sheets or allochthons. Deep-water facies in the Red Dog area (i.e. the Kuna Formation and related rocks) are found chiefly in the Endicott Mountains and structurally higher Picnic Creek allochthons. In the Red Door plate of the Endicott Mountains allochthon, the Kuna consists of at least 122 m of thinly interbedded calcareous shale, calcareous spiculite, and bioclastic supportstone (Kivalina unit) overlain by 30 to 240 m of siliceous shale, mudstone, calcareous radiolarite, and calcareous lithic turbidite (Ikalukrok unit). The Ikalukrok unit in the Red Dog plate hosts all massive sulfide deposits in the area. It is notably carbonaceous, is generally finely laminated, and contains siliceous sponge, spicules and radiolarians. The Kuna Formation in the Key Creek plate of the Endicott Mountains allochthon (60-110 m) resembles the Ikalukrok unit but is unmineralized and has thinner carbonate layers that are mainly organic-rich dolostone. Correlative strata in the Picnic Creek allochthon include less shale mid mudstone mid more carbonate (mostly calcareous spiculite). Conodonts and radiolarians indicate an age range of Osagean to early Chesterian (late Early to Late Mississippian) for the Kuna in the Red Dog area. Sedimentologic, faunal, and geochemical data imply that most of the Kuna formed in slope and basin settings characterized by anoxic or dysoxic bottom water and by local high productivity. Shallow-water facies of the Lisburne Group in the Red Dog area are present locally in the Endicott Mountains allochthon and throughout the Kelly River allochthon and consist of the Utukok and Kogruk Formations. The Utukok Formation is an impure limestone with disseminated and interbedded noncarbonate mud mid quartz-rich silt and sand. Clean carbonate predominates in the overlying Kogruk Formation but has been widely altered to dolostone and chert. Deep-water strata, similar to that in the Kuna Formation, overlie and grade laterally into shallow-water rocks in the Endicott Mountains allochthon mid compose the uppermost Lisburne in the Kelly River allochthon. The Utukok Formation is mainly Osagean but its base is Kinderhookian (early Early Mississippian) in the highest plates of the Kelly River allochthon. The Kogruk Formation is mostly Meramecian but partly Osagean and early Chesterian in some areas. We interpret inner to middle platform settings for most of the Utukok and Kogruk Formations. Deep-water, locally phosphatic facies of the uppermost Lisburne Group formed during a platform-drowning event of regional extent that began in the late Meramecian. In the Howard Pass area, similar to 120 to 250 km to the east, the Lisburne Group includes an array, of shallow- and deep-water facies that correspond well in age and general depositional environment to those in the Red Dog area but differ in some details. Deep-water strata are generally thinner, include less carbonate, and formed in settings that were deeper and/or had less detrital input. Shallow-water deposits are less extensive, contain less quartz silt mid sand, and formed chiefly in middle to outer platform settings. Paleogeographic reconstructions imply that carbonate platforms flanked the Kuna basin to the north and south in the west but flourished chiefly; north of the basin in the east. These platforms provided carbonate and perhaps some siliciclastic detritus to the basin; siliciclastic detritus could also have come from older strata underlying the platforms and/or from the Endicott delta to the north. Carbonate turbidite deposition in the Kuna basin occurred chiefly during middle Osagean and late Meramecian-early Chesterian times and ceased when adjacent platforms drowned. A combination of local mid eustatic factors probably controlled the timing of detrital input to the basin and the demise of the adjoining carbonate platforms. Platform inundation is roughly coeval with the onset of barite precipitation and sulfide mineralization, implying that regional extension was a significant component of all three events. High productivity, locally thick calcareous turbidite fill, and proximity to restricted, shallow-water carbonate platform environments are aspects of the Kuna basin that appear to have been important in forming the giant Red Dog deposits. Conodont color alteration indices of the Lisburne Group in the Red Dog area and much of the Howard Pass area are mostly 2.5 to 3.5 and indicate temperatures of 110 degrees to 200 degrees C. Such temperatures are typically produced by burial depths of 3,500 to 5,500 m. Because Pennsylvanian-Cretaceous strata above the Lisburne Group are less than 1,500 m thick, tectonic burial and/or an elevated geothermal gradient are needed

to explain the conodont color alteration index data.

DUNNINGTON, H.V. 2005. Generation, migration, accumulation, and dissipation of oil in Northern Iraq. *Geoarabia* **10**(2), 39-84.

Most of the known oil accumulations of Northern Iraq probably originated by upward migration from earlier, deeper accumulations which were initially housed in stratigraphic or long-established structural traps, and which are now largely depleted. The earlier concentrations had their source in basinal sediments, into which the porous, primary-reservoir limestones pass at modest distances east of the present fields. Development of the region favored lateral migration from different basinal areas of Upper Jurassic and Lower-Middle Cretaceous time into different areas of primary accumulation. Important factors affecting primary accumulation included: (1) early emergence and porosity improvement of the reservoir limestones, followed by burial under seal-capable sediments; (2) the timely imposition of heavy and increasing depositional loads on the source sediments, and the progressive marginward advance of such loads; (3) progressive steepening of gradients trending upward from source to accumulation area; (4) limitation of the reservoir formations on the up-dip margin by truncation or by porosity trap conditions. In late Tertiary time, large-scale folding caused adjustments within the primary reservoirs, and associated fracturing permitted eventual escape to higher limestone reservoirs, or to dissipation at surface. The sulfurous, non-commercial crudes of Miocene and Upper Cretaceous reservoirs in the Qaiyarah area are thought to stem from basinal radiolarian Upper Jurassic sediments, which lie down dip, a few tens of miles east of these fields. Upper Cretaceous oils of Ain Zalah and Butmah drained upward from primary accumulations in Middle Cretaceous limestones, which were filled from basinal sediments of Lower Cretaceous age situated in a localized trough a few miles northeast of these structures. The huge Kirkuk accumulation, now housed in Eocene-Oligocene limestones, ascended from a precedent accumulation in porous Middle-Lower Cretaceous limestones, which drew its oil from globigerinal-radiolarian shales and limestones of the contemporaneous basin, a short distance east of the present field limits. Eocene-Oligocene globigerinal sediments, considered by some the obvious source material for Kirkuk oil, seemingly provided little or no part of the present accumulation. The reservoir formation may have been filled from these sources, to lose its oil by surface dissipation during the erosional episode preceding Lower Fars deposition. Upper Cretaceous basinal sediments probably contributed nothing to known oil field accumulations, though they may have subscribed to the spectacular impregnations of some exposed, Upper Cretaceous reef-type limestones. Neither Miocene nor pre-Upper Jurassic sediments have played any discernible role in providing oil to any producing field. Indigenous oils are thought to be negligible in the limestone-reservoir formations considered.

DURAND-DELGA, M., ESTERAS, M., GARDIN, S. & PAQUET, H. 2005. The Tariquide domain (Gibraltar area, Spain-Morocco): sedimentary succession and hiatuses from Upper Jurassic to Palaeocene. *Comptes Rendus Geoscience* **337**(9), 849-860.

The originality of the Malm-Cretaceous series of the Tariquides (Gibraltar arc), as compared to those of the Rifian-Betic 'Dorsale' (Alboran domain), and especially with the Penibetic (Iberia) domain, is emphasized. In the Los Pastores Group, near Algeciras, Upper Tithonian nodular limestones directly lie on the Dogger and are followed by Aptychus-bearing limestones (Late Berriasian to Barremian). In the Musa Group, Rif, radiolarites are followed by siliceous limestones (Kimmeridgian-Tithonian), then by karst and massflow breccias connected to a Berriasian tectonics, by Aptychus-bearing marly limestones, then by karst filled by Turonian limestones, and finally by Maastrichtian-Palaeocene polychrome pelites, whose micropalaeontological and mineral compositions (clay minerals, Fe-Mn nodules) refer to a deep-sea,

probably infra-CCD, sedimentation.

FARYAD, S.W., SPISIAK, J., HORVATH, P., HOVORKA, D., DIANISKA, I. & JOZSA, S. 2005. Petrological and geochemical features of the Meliata mafic rocks from the sutured Triassic Oceanic Basin, Western Carpathians. *Ofioliti* **30**(1), 27-35.

Metabasites related to the Triassic Meliata oceanic basin occur along three tectonic zones in the Western Carpathians: (1) the Folkmar Zone, (2) the Roznava Zone (Meliata Unit, s.s.) and the (3) Bodva valley - Darnó Hill Zone. The first two zones form the northern and southern boundary of the Paleozoic of the Gemicum (south-eastern Slovakia), respectively, and the latter is located south of the Meliata Unit, NE Hungary. All three zones contain metabasites. The serpentinites, radiolarian shales and cherts are considered to be complementary members of an ancient oceanic crust. Geochemical characteristics of metabasites from the Folkmar Zone indicate a MORB affinity. Metabasites from the Roznava Zone have affinity between MORB and within plate basalts, but metagabbros comparable with alkaline basalts are also present. The Darnó Hill metabasites have MORB compositions and those from the Bodva valley are similar to the metabasites from the Roznava Zone. The geochemical and petrographic features of these metabasites suggest a continental rift volcanism, followed by spreading of the Triassic Meliata oceanic basin. During the Middle Jurassic, part of the oceanic crust and adjacent passive continental margin underwent a subduction-related blueschist facies metamorphism afterwards they were exhumed within a melange complex of the Meliata Unit in the southern part of Gemicum.

FENG, Q., HE, W., GU, S., JIN, Y. & MENG, Y. 2006. Latest Permian Spumellaria and Entactinaria (Radiolaria) from South China. *Revue de Micropaléontologie* **49**(1), 21-43.

A diverse and well-preserved latest Permian radiolarian fauna was obtained from bedded siliceous rocks and siliceous mudstones of the Dongpan Section, southwest Guangxi, China. All encountered specimens of the order Spumellaria and a few specimens of the order Entactinaria were selected for the taxonomic study of this paper. Thirty-three species, 15 of which are new species, were identified. They belong to 15 genera, three of which (*Paracopicyntra*, *Copiconulus*, and *Yujingella*) are new. The most interesting result of our study is that eight typical Middle Triassic spumellarian genera (*Paroertlispongus* Kozur and Mostler, *Tetrapaurinella* Kozur and Mostler, *Paurinella* Kozur and Mostler, *Lithelius* Haeckel, *Archaeospongoprimum* Pessagno, *Tamonella* Dumitrica, Kozur and Mostler, *Bistarkum* Yeh, and *Tetraspongodiscus* Kozur and Mostler) were discovered in the upper Changhsingian strata studied herein. Therefore, the most important and characteristic spumellarian families of the Middle Triassic were already present in the Late Permian of South China.

FENG, Q., HE, W., ZHANG, S. & GU, S. 2006. Taxonomy of order Latentifistularia (Radiolaria) from the Latest Permian in Southern Guangxi, China. *Journal of Paleontology* **80**(5), 826-848.

Caridroit, De Wever, and Dumitrica (1999) promoted *Stauraxon* (Radiolaria) to an order, order Latentifistularia, and De Wever et al. (2001) proposed a classification using family and genus levels. However, the taxonomy of this order in genus level is still problematic because some genera were named according to broken specimens. A radiolarian fauna with a high diversity was collected from the late Changhsingian in southern Guangxi, China. These specimens are very well preserved so that they are rare material for roundly describing the characters of some genera. They are identified as 42 species belonging to 16 genera and 5 families. Fifteen new species and one new genus are described, some genera are discussed, and some species are revised.

FENG, Q., MALILA, K., WONGANAN, N., CHONGLAKMANI, C., HELMCKE, D., INGAVAT-HELMCKE, R. & CARIDROIT, M. 2005. Permian and Triassic Radiolaria from Northwest Thailand: paleogeographical implications. *Revue de Micropaleontologie* **48**(4), 237-255.

Well-preserved radiolarians were recovered from seven sections in the Mae Hong Son-Mae Sariang area, northwestern Thailand. 51 species assigned to 34 genera are identified, including 1 new species (*Triassospongosphaera erici* Feng sp. nov.) and 19 unidentified species. They are divided into the Late Permian, late Ladinian and middle Carnian radiolarian assemblages. Newly identified radiolarian assemblages, together with the published radiolarian biostratigraphic data from this region, indicate that there was a pelagic basin during the Late Paleozoic and Triassic. This basin was joined to the Chiang Dao and Changning-Menglian oceanic basins, and they represent the main oceanic basin of the Paleotethyan Archipelago Ocean. This main oceanic basin was situated in the traditional "Shan-Thai Block". Therefore, "the Shan-Thai Block" was not a single block during that stage, but composed of the Paleotethyan Ocean and two continental terranes that were affiliated with the Gondwana and Cathaysian domains, respectively.

FERRANDO, S., BERNOULLI, D. & COMPAGNONI, R. 2004. The Canavese zone (internal Western Alps): a distal margin of Adria. *Schweizerische Mineralogische und Petrographische Mitteilungen* **84**(3), 237-256.

The Canavese zone is situated in the westernmost Southern Alps bordering the Austroalpine Sesia zone along the internal Western Alps. It represents the southwestern (in present-day coordinates) continuation of the northwestern distal continental margin of Adria whose relics are exposed in the Austroalpine-South Pennine boundary zone (Err nappe) of Graubünden (eastern Switzerland). Although the stratigraphic successions of the Canavese zone are badly exposed and have been dismembered by Alpine ductile shear zones and brittle faults, the signatures of Early to Middle Jurassic rifting are still preserved in the rock record. Two types of basement, separated by tectonic contacts, can be distinguished: (1) a migmatitic basement of gneisses associated with anatectic leucogranites and inclusions of mafic granulites similar to those of the nearby Ivrea zone; (2) an amphibolite-grade basement, composed of amphibolites, gneisses and micaschists with shallow intrusions of Permian granitoids, obviously representing a higher crustal level comparable to the Strona-Ceneri zone of the Southern Alps. A first phase of rifting is testified by tectono-sedimentary breccias (Macchia Vecchia) and neptunian dykes of Liassic age cutting across the Triassic pre-rift carbonate platform sediments. Further rifting during the Toarcian (?) to Middle Jurassic exposed Variscan basement rocks and Permian granitoids at the seafloor, providing clasts for matrix-poor or -free, non-fossiliferous, polymictic debris-flow breccias and for sandstone turbidites interbedded with black shales (late syn-rift sediments). The polymictic breccias are dominated by granite clasts; however, they contain also fragments derived not only from the upper but also from the lower crust, and clasts of fault-rocks (phyllonites and cataclases) most probably derived from exposed Jurassic fault planes. The occurrence of breccias and sandstone turbidites in the Radiolarite (Middle to Upper Jurassic) and Maiolica Formations (Lower Cretaceous) yielding clasts from the continental basement indicate the persistence of a submarine relief along the margin. The Middle Jurassic late syn-rift sediments of the Canavese zone are conspicuously similar in terms of facies association, sedimentary structures and elastic content to the analogous syn-rift sediments (Saluver Formation) of the lower Austroalpine Err nappe (Graubünden). The occurrence of clasts of upper and lower crustal rocks in the polymictic breccias shows that the two types of basement of the Canavese zone were juxtaposed and exposed to the sea floor already in Middle Jurassic times, most probably along low-angle extensional detachment faults as observed today along the present-day west-Iberian margin. This scenario would match

those developed for the ocean-continent transitions along the Austroalpine-South Pennine boundary zone of Graubünden, the southern prolongation of the Canavese zone in the external Apennines, and - last not least - the Cretaceous west-Iberian margin.

FOSTER, R.A., CARPENTER, E.J. & BERGMAN, B. 2006. Unicellular cyanobionts in open ocean dinoflagellates, radiolarians, and tintinnids: Ultrastructural characterization and immunolocalization of phycoerythrin and nitrogenase. *Journal of Phycology* **42**(2), 453-463.

Cyanobacterial symbionts (cyanobionts) have been identified forming associations with various open ocean eukaryotic host genera, including two dinophysoid genera, *Histioneis* sp. and *Ornithocercus* sp., two radiolarians, *Spongastaurus* and *Dictyocoryne truncatum*, sp., and a tintinnid, *Codonella* sp. The TEM analysis revealed that single individual hosts were closely associated with one to two different cyanobacterial morphotypes (cyanobionts) and two hosts had in addition to cyanobionts, one to two bacterial cell types. Eleven significantly ($P < 0.01$) different cell types were identified as cyanobionts, with cell diameters ranging 0.5 ± 0.38 - $3.7 \pm 0.66 \mu\text{m}$. Using immunogold-labeling techniques coupled to the TEM, four of the five cell types contained phycoerythrin (PE) at high levels ($> 71 \pm 28$ gold particles. μm^{-2}). Immunolabeling-TEM using nitrogenase antisera demonstrated a significant ($P < 0.01$) nitrogenase content in cell type four cyanobionts of *Histioneis* sp. host 1 (39 ± 34 gold particles. μm^{-2}). The cyanobionts of the radiolarians were of a cell diameter (0.5 - $0.8 \mu\text{m}$) and showed ultrastructural characters (peripheral thylakoids) reminiscent of *Prochlorococcus* sp. Also, an open ocean tintinnid, *Codonella* sp., was shown to contain cyanobacteria as symbionts for the first time. In all cyanobionts, glycogen storage was obvious, no cellular degradation was visible, cells were observed in the process of cellular division, and antisera localization was apparent. These observations suggest that the relationship between host eukaryote and cyanobacteria is an active one, and likely symbiotic.

FOSTER, R.A., COLLIER, J.L. & CARPENTER, E.J. 2006. Reverse transcription PCR amplification of cyanobacterial symbiont 16S rRNA sequences from single non-photosynthetic eukaryotic marine planktonic host cells. *Journal of Phycology* **42**(1), 243-250.

A reverse transcription-polymerase chain reaction (RT-PCR) method was developed for amplifying prokaryotic symbiont rRNA sequences from individual marine planktonic eukaryotic host cells belonging to the tintinnid genus *Codonella*, the spongioid radiolarian genus *Dictyocoryne*, and several Dinophysoid genera (*Amphisolenia*, *Citharistes*, *Dinophysis*, *Histioneis*, *Ornithocercus*). Of the 93 sequences obtained from 67 clone libraries, 26% were most similar to a variety of heterotrophic bacteria and 4% were most similar to plastids. Most (70%) of the sequences had the greatest similarity to cyanobacterial 16S rRNA sequences. Several (10%) of these had low sequence identity ($< 94\%$) to cyanobacteria in the database, suggesting that they represent novel cyanobacterial lineages. Fifty-three percent of the cyanobacterial sequences were most closely related ($> 96\%$ identical) to *Synechococcus* sp., and three were $> 99\%$ identical to *Prochlorococcus* sp. Subgroups of sequences most similar to *Synechococcus* sp. were derived from multiple host types, indicating that the same symbiont was capable of forming an association with a variety of host organisms. Sixteen libraries yielded two or three divergent (from 2% to 25% different) sequence types, indicating the presence of mixed assemblages in single host cells. This study provides the first insight into the phylogenetic diversity of the symbiotic cyanobacteria of open ocean protists.

FUJINAGA, K. & KATO, Y. 2005. Radiolarian age

of red chert from the Kunimiyama ferromanganese deposit in the Northern Chichibu Belt, central Shikoku, Japan. *Resource Geology* **55**(4), 353-356.

The radiolarian age of red chert from the Kunimiyama area of the Northern Chichibu Belt was determined in order to constrain the depositional age of the Kunimiyama deposit that is among the largest ferromanganese deposits in Japan. *Pseudoalbaillella* cf. *scalprata* Holdsworth and Jones, *Pseudoalbaillella* cf. *longicornis* Ishiga and Imoto and *Pseudoalbaillella* sp. belonging to the *Ps. lomentaria* Zone are found in the red chert, indicating an age of middle Early Permian (middle Wolfcampian). The red chert occurs immediately above the ferromanganese deposit, and the boundary between them is gradual. Based on their mode of occurrence and geochemical features, it is most likely that radiolarian chert and ferromanganese precipitate accumulated simultaneously to produce red chert during the waning stage of submarine hydrothermal activity that was responsible for the Kunimiyama deposit. Consequently, the age of Kunimiyama stratiform ferromanganese deposit is constrained as middle Early Permian (middle Wolfcampian).

FUNAKAWA, S., NISHI, H., MOORE, T.C. & NIGRINI, C.A. 2006. Radiolarian faunal turnover and paleoceanographic change around Eocene/Oligocene boundary in the central equatorial Pacific, ODP Leg 199, Holes 1218A, 1219A, and 1220A. *Palaeogeography Palaeoclimatology Palaeoecology* **230**(3-4), 183-203.

Continuous Eocene through Oligocene sedimentary sections were obtained at Holes 1218A, 1219A, and 1220A drilled during Leg 199 of the Ocean Drilling Program in the central equatorial Pacific. Quantitative analysis of radiolarian assemblages between the upper Eocene through lower Oligocene sedimentary successions revealed that major faunal changes of radiolarians occurred in the late Eocene (35.5-35.7 Ma; Subchron C16n1), around the Eocene/Oligocene boundary (33.7-33.8 Ma; upper Subchron C13r) and in the early Oligocene (30.9-31.3 Ma; uppermost Subchron C12r). The faunal change in the late Eocene is characterized by a stepwise decrease of tropical Eocene species and an increase in cosmopolitan, probably cool-water-tolerant, radiolarians; however, without a significant change in species diversity and radiolarian accumulation rates. The stratigraphic level of this late Eocene turnover came after the late Eocene impact event, and may have been more related to global cooling and associated oceanographic changes than to asteroid impact. The turnover around the Eocene/Oligocene boundary, corresponding to the Oi-1 event, is the most critical during the Eocene-Oligocene transition. Many biotic events such as a sudden drop of species diversity, an increase in the cosmopolitan radiolarian group, a large number of species turnovers, and a drop in radiolarian accumulation rates occurred at or just above this level. Together these indicators suggest a major restructuring of radiolarian assemblages from the high diversity Eocene fauna to a low diversity Oligocene one. The third turnover event within early Oligocene is represented by a replacement of dominant species with a sudden decrease in radiolarian accumulation rates. However, this Oligocene turnover is not consistent with other major $\delta^{18}O$ isotope events, such as Oi-1b and Oi-2.

GAST, R.J. 2006. Molecular phylogeny of a potentially parasitic dinoflagellate isolated from the solitary radiolarian, *Thalassicolla nucleata*. *Journal of Eukaryotic Microbiology* **53**(1), 43-45.

Thalassicolla nucleata, a solitary radiolarian, has been described as being parasitized by two dinoflagellates, *Solenodinium* (Syndiniales) and *Caryotoma* (Blastodinales). Several *T. nucleata* were stripped of their extracapsular material and allowed to regenerate their rhizopodial structures without symbionts. Within a week, two were observed to disintegrate, leaving behind non-

pigmented swimming dinoflagellate cells. Identical full-length ribosomal sequences were recovered from both samples. Upon alignment and phylogenetic analysis, it was determined that these putative parasite sequences were distinct from *Scrippsiella nutricula* (the dinoflagellate symbiont of the host), and also from all other dinoflagellate parasites sequenced to date.

GAUDIN, A., BUATIER, M.D., BEAUFORT, D., PETIT, S., GRAUBY, O. & DECARREAU, A. 2005. Characterization and origin of Fe³⁺-montmorillonite in deep-water calcareous sediments (Pacific Ocean, Costa Rica margin). *Clays and Clay Minerals* **53**(5), 452-465.

Millimetric to centimetric green grains widespread in pelagic calcareous sediments recovered at a water depth of 3000 m near the Costa Rica margin were studied by X-ray diffraction, scanning electron microscopy (SEM), transmission electron microscopy (TEM) and Fourier transform infrared spectroscopy. Samples were collected, during the Ticoflux H expedition, from the upper bioturbated part of four sedimentary cores (0.13-3.75 m below seafloor). The sediments are calcareous and siliceous nanofossil oozes (coccoliths, diatoms, radiolarians, etc.). Green grains show generally a concentric zoning with a green rim in which smectite largely predominates over pyrite and a black core in which pyrite is prevalent. Observations by SEM indicate that this zoning results from a progressive inward alteration and replacement of the accumulations of pyrites by smectites. The high-resolution TEM observations of the smectite-pyrite interfaces suggest that the replacement of pyrites by smectite occurs through a dissolution-precipitation process with the formation of a gel. The pyrite matrix is composed of a huge number of very small (0.5-2 μ m) pyrite octahedra, a typical texture resulting from the pyritization of organic material in early diagenetic environments. The accurate mineralogical and crystal chemical characterization of the smectites indicate that they are Fe³⁺-montmorillonites (Fe³⁺-rich smectite with a dominant octahedral charge, rarely recorded in the literature). The formation of such Fe³⁺-montmorillonites forming green grains could be explained by two successive diagenetic redox stages: (1) reducing stage: early pyritization of the organic matter by microbial reduction within reducing micro-environments; (2) oxidizing stage: Fe³⁺-montmorillonite crystallized in space liberated after dissolution of pyrite connected with the rebalancing of the redox conditions of the micro-environments with the oxidizing surrounding sediments.

GAWLICK, H.A., SUZUKI, H. & SCHLAGINTWEIT, F. 2006. The upper triassic and jurassic sedimentary rocks of the Sarsteinalm: evidence for the tectonic configuration of the Dachstein block (Salzkammergut region, Northern Calcareous Alps, Austria). *Neues Jahrbuch für Geologie und Paläontologie-Abhandlungen* **239**(1), 101-160.

The Jurassic sedimentary rocks in the Sarsteinalm area are so far poorly known with respect to facies and stratigraphy; also their attribution to certain formations is ambiguous. Rhaetian lagoonal Dachstein limestone overlies red nodular limestones of the ?Adnet and the Klaus formations (Liassic to ?Bathonian). These are followed by 1 m thick red radiolarites (Callovian to Oxfordian), thin black radiolarites (Callovian to Oxfordian), mass-flow deposits with components of Late Jurassic shallow water carbonates and finally, only preserved as small remnants, platform carbonates of the Plassen Formation. The latter can be assigned to slope, platform margin and occasionally also closed lagoonal facies of presumably Kimmeridgian age. The sedimentary succession shows that no mass-flow deposits with components of Hallstatt limestones occur in the study area. It can thus be excluded that slide masses of Hallstatt limestones were transported over this area during Callovian to Oxfordian times. Therefore, the Sarsteinalm area can be considered an isolated block from the Dachstein Block by an east-west striking fault.

GAWLICK, H.J. & SCHLAGINTWEIT, F. 2006. Berriasian drowning of the Plassen carbonate platform at the type-locality and its bearing on the early Eoalpine orogenic dynamics in the Northern Calcareous Alps (Austria). *International Journal of Earth Sciences* **95**(3), 451-462.

The Plassen carbonate platform (Kimmeridgian to Early Berriasian) developed above the Callovian to Tithonian carbonate clastic radiolaritic flysch basins of the Northern Calcareous Alps during a tectonically active period in a convergent regime. Remnants of the drowning sequence of the Plassen Formation have been discovered at Mount Plassen in the Austrian Salzkammergut. It is represented by calpionellid-radiolaria wacke- to packstones that, due to the occurrence of *Calpionellopsis oblonga* (Cadisch), are of Late Berriasian age (*oblonga* Subzone). Thus, the Plassen Formation at its type-locality shows the most complete profile presently known, documenting the carbonate platform evolution from the initial shallowing upward evolution in the Kimmeridgian until the final Berriasian drowning. The shift from neritic to pelagic sedimentation took place during Berriasian times. A siliciclastic-influenced drowning sequence sealed the highly differentiated Plassen carbonate platform. The former interpretation of a Late Jurassic carbonate platform formed under conditions of tectonic quiescence cannot be confirmed. The onset, evolution and drowning of the Plassen carbonate platform took place at an active continental margin. The tectonic evolution of the Northern Calcareous Alps during the Kimmeridgian to Berriasian time span and the reasons for the final drowning of the Plassen carbonate platform are to be seen in connection with further tectonic shortening after the closure of the Tethys Ocean.

GAWLICK, H.J., SCHLAGINTWEIT, F. & MISSONI, S. 2005. The type locality of the Barmstein limestones northwest of Hallein (late Tithonian to early Berriasian; Salzburg Calcareous Alps) - Sedimentology, microfacies, stratigraphy and micropaleontology: new aspects about the evolution of the Late Jurassic carbonate platform and the tectonic interpretation of the Hallstatt Zone of Hallein - Bad Durnberg. *Neues Jahrbuch für Geologie und Paläontologie-Abhandlungen* **236**(3), 351-421.

The type-locality of the Late Jurassic to Early Cretaceous Barmstein limestones east of the Hallstatt zone of Hallein - Bad Durnberg was reinvestigated. Main subjects were sedimentological and microfacies studies, stratigraphic dating of the clasts as well as their biogenic content. These data allow to reconstruct the source area of the Barmstein limestones during Late Tithonian to Early Berriasian times since older Late Jurassic clasts were not found. This excludes deep erosional processes on the platform. Triassic Hallstatt limestones or Permian Haselgebirge components were not detected. Moreover, the superposition of the Hallstatt limestones by the described sequence can be excluded, inferring a new interpretation of the Hallstatt zone of Hallein - Bad Durnberg. The Hallstatt rocks form slides in the Lammer/Sillenkopf basin, whereas the Oberalm Formation with the intercalated Barmstein limestones is overlying the cherty sediments of the Tauglboden basin further north. The actual neighborhood of both facies was caused by younger, presumably Miocene, lateral movements in the framework of lateral tectonic extrusion. In Late Jurassic times both basins were widely separated from each other. The Barmstein limestones do not consist of single, basin wide homogeneous mass-flow deposits, but represent various single flows, each with little varying component spectrum. These flows, partly containing clasts of radiolarites or *Saccocoma* limestones probably deriving from the channel flanks, show minor variations only with respect to grain size and component spectrum. For the genesis of the Barmstein limestones, tectonic control mechanisms as well as possible sequence stratigraphic cyclicity

are discussed. The evolution of the carbonate platform in Late Tithonian times is reconstructed in the framework of tectonic shortening.

GHAZI, A.M., HASSANIPAK, A.A., MAHONEY, J.J. & DUNCAN, R.A. 2004. Geochemical characteristics Ar-40-Ar-39 ages and original tectonic setting of the Band-e-Zeyarat/Dar Anar ophiolite, Makran accretionary prism, SE Iran. *Tectonophysics* **393**(1-4), 175-196.

The Makran accretionary prism in southeastern Iran contains extensive Mesozoic zones of melange and large intact ophiolites, representing remnants of the Tethys oceanic crust that was subducted beneath Eurasia. To the north of the Makran accretionary prism lies the Jaz Murian depression which is a subduction-related back-arc basin. The Band-e-Zeyarat/Dar Anar ophiolite is one of the ophiolite complexes; it is located on the west side of the Makran accretionary prism and Jaz Murian depression, and is bounded by two major fault systems. The principal rock units of this complex are a gabbro sequence which includes low- and high-level gabbros, an extensive sheeted diabase dike sequence, late intrusive rocks which consist largely of trondhjemites and diorites, and volcanic rocks which are largely pillow basalts interbedded with pelagic sedimentary rocks, including radiolarian chert. Chondrite- and primitive-mantle-normalized incompatible trace element data and age-corrected Nd, Pb, and Sr isotopic data indicate that the Band-e-Zeyarat/Dar Anar ophiolite was derived from a midocean ridge basalt-like mantle source. The isotopic data also reveal that the source for basalts was Indian-Ocean-type mantle. Based on the rare earth element (REE) data and small isotopic range, all the rocks from the Band-e-Zeyarat/Dar Anar ophiolite are cogenetic and were derived by fractionation from melts with a composition similar to average E-MORB; fractionation was controlled by the removal of clinopyroxene, hornblende and plagioclase. Three Ar-40-Ar-39 plateau ages of 140.7 \pm 2.2, 142.9 \pm 3.5 and 141.7 \pm 1.0 Ma. and five previously published K-Ar ages ranging from 121 \pm 4 to 146 \pm 5 Ma for the hornblende gabbros suggest that rocks from this ophiolite were formed during the Late Jurassic-Early Cretaceous. Plate reconstructions suggest that the rocks of this complex appear to be approximately contemporaneous with the Masirah ophiolite which has crystallization age of (similar to 150 Ma). Like Masirah, the rocks from the Band-e-Zeyarat/Dar Anar ophiolite complex represent southern Tethyan ocean crust that was formed distinctly earlier than crust preserved in the 90-100 Ma Bitlis-Zagros ophiolites (including the Samail ophiolite).

HADDOCK, S.H.D. 2005. Radiolarian diversity and morphology: Structural adaptations to the deep sea. *Integrative and Comparative Biology* **45**(6), 1006-1006.

HASLETT, S.K. & SMART, C.W. 2006. Late Quaternary upwelling off tropical NW Africa: new micropalaeontological evidence from ODP Hole 658C. *Journal of Quaternary Science* **21**(3), 259-269.

Planktonic foraminifera and radiolaria have been analysed in a Late Quaternary (40-0 ka) sediment sequence from Ocean Drilling Program (ODP) Hole 658C located under a coastal upwelling system near Cap Blanc, offshore northwest Africa, in order to document the palaeoceanographic history of the area. Temporal variations in species abundance and faunal assemblage analysis reveal a tripartite phased sequence of palaeoceanographic change through the Late Quaternary. Phase 1 spans 40-14.5 ka and is characterised by moderate Upwelling, but Heinrich event 2 is distinguished as a brief episode of strengthened upwelling. Phase 2 begins with a change in a number of variables at ca. 14.5 ka and extends to ca. 5.5 ka. This phase is characterised by a general strengthening of upwelling, but may be subdivided into three minor phases including (a) the recognition of the Younger Dryas,

marked by a temporary reduction in upwelling strength, followed by (b) an intensification of upwelling, and (c) upwelling and high productivity between 8 and 5.5 ka. This phase of Upwelling corresponds with maximum Holocene cooling, possibly triggered by the collapse of the Laurentide ice sheet. Phase 3 extends from 5.5 to 0 ka and is characterised by weak Upwelling and significant calcite dissolution. These phases are related to climatic events, particularly the African Humid Period (AHP), which is coincident with Phase 2. The AHP is characterised by increased precipitation, linked to an intensification of the African monsoon that enhances North East Trade Wind-driven coastal Upwelling and is associated with the expansion of continental vegetation across North Africa.

HE, W.-H. 2006. Changhsingian radiolarian fauna from the Meishan D section and sea-level changes. *Earth Science (Wuhan)* **31**(2), 19-164.

There is relatively less research for radiolarian fauna in the Meishan D Section of Changxing County, Zhejiang Province. The radiolarian species in each sample from the Meishan D Section were identified, and the individuals in 0.5 g dried samples (sieved through 300 meshes) were counted out. The research shows the abundance and diversity are closely related to sea level changes of Changhsingian age at the Meishan D Section. Where abundance and diversity reach higher values, the sea level would have peaked (e. g. maximum transgression surfaces). The abundance and diversity of radiolarians from the early Changhsingian is greater than that of the late Changhsingian age, which coincides with the opinion that the marine water was deeper in the early Changhsingian than in the late Changhsingian. This conclusion provides evidence that radiolarian abundance and diversity are indicators for investigating sea-level changes.

HE, W.H., SHEN, S.Z., FENG, Q.L. & GUI, S.Z. 2005. A late Changhsingian (Late Permian) deepwater brachiopod fauna from the Talung Formation at the Dongpan Section, southern Guangxi, South China. *Journal of Paleontology* **79**(5), 927-938.

This paper describes a unique deepwater brachiopod fauna from the upper part of the Talung Formation at the Dongpan Section, southern Guangxi, South China. This brachiopod fauna includes 10 species belonging to 10 genera. New taxa are *Anidanthus mucronata* n. sp., *Dongpanoproductus elegans* n. gen. and sp., *Costammulus dongpanensis* n. sp., and *Spinomarginifera semicircridge* n. sp. This fauna is characterized by small, thin-shelled species with high abundance and low diversity, and therefore is different in generic and species composition from the coeval faunas of the Late Permian limestone facies in South China. The brachiopod fauna can be safely assigned to the latest Changhsingian as indicated by the presence of abundant *Paracrurithyris pigmaea*, the immediately underlying radiolarian *Neoalibaillella optima* Zone of late Changhsingian age, and the overlying ammonoid *Ophiceras* sp. cf. *O. tingi* Tien of the lowest Triassic. This fauna is most likely to have lived in a deepwater environment as indicated by coexistence with the radiolarian *Latentifistularia*, small thin-shelled brachiopods, and the dominance of silica-bearing mudstone.

HEUSSER, L., HEUSSER, C. & PISIAS, N. 2006. Vegetation and climate dynamics of southern Chile during the past 50,000 years: results of ODP Site 1233 pollen analysis. *Quaternary Science Reviews* **25**(5-6), 474-485.

High-resolution pollen data from ODP Site 1233 (41 degrees 0.005S, 74 degrees 26.992W, 838m water depth) provide a continuous, chronostratigraphically controlled similar to 50,000-yr record of regional changes in vegetation from temperate South America. Deposited similar to 38 km west of the transition from northern, summer-green, lowland forest to southern evergreen rain

forest, the 135 m core documents the comparatively brief Holocene development of thermophilous vegetation (Lowland Deciduous Beech Forest and Valdivian Evergreen Forest), and the expansion of glacial, subantarctic vegetation (North Patagonian Evergreen Forest-Subantarctic Parkland) during Marine Isotope State (MIS) 2 and 3. Systematic variability in these terrestrial climate proxies that reflect latitudinal movement of the Southern westerlies is mirrored in co-eval ocean conditions inferred from radiolaria census data and in Antarctic climate records.

HILLENBRAND, C.-D. & CORTESE, G. 2006. Polar stratification: a critical view from the Southern Ocean. *Palaeogeography Palaeoclimatology Palaeoecology* **In press**.

Oceanic stratification represents an effective mechanism to reduce vertical mixing of the water column, thereby locking up carbon dioxide (CO₂) in the deep sea and preventing air-sea exchange of CO₂. It has been proposed that enhanced stratification of the upper water column in polar oceans during late Cenozoic cooling episodes limited the upwelling of CO₂-rich deep waters and thus CO₂-release to the atmosphere, resulting in a net global drawdown of atmospheric CO₂. Increased stratification in the Subarctic Northwest Pacific, during both the onset of Northern Hemisphere glaciation at 2.73 Ma and late Quaternary glacial periods, has been recently linked to enhanced ocean stratification south of the Antarctic Polar Front (APF) in the Pacific and Atlantic sectors of the Southern Ocean. Increased stratification of Southern Ocean surface waters was mainly deduced from a reduction of biological production during these cooling episodes, manifested by the decrease of geochemical proxies for productivity, such as biogenic opal and barium, in the marine sediment records. However, the records chosen from the Southern Ocean do not provide evidence for a more stratified upper water column, rather the observed decrease in biological productivity is likely to have resulted from an expansion of annual sea-ice coverage. The sediment records suggest that south of the APF in the Pacific and Atlantic sectors of the Southern Ocean, extensive sea ice may have contributed to the global CO₂-drawdown during glacial periods, with hypothetical glacial increase of stratification in today's permanent open-ocean zone merely being an "add on" caused by this expansion.

HOCK, V., SLACZKA, A., GASINSKI, M.A. & BAK, M. 2005. Konradsheim Limestone of the Gresten Klippen Zone (Austria): new insight into its stratigraphic and paleogeographic setting. *Geologica Carpathica* **56**(3), 237-244.

Biostratigraphic investigations of pelitic intercalations and pebbles within the Konradsheim Limestone (Gresten Unit, "Gresten Klippen Zone") in the area of Konradsheim and Pechgraben - Maria Neustift (Lower and Upper Austria) imply that at least a part of that limestone is Cretaceous and not only Jurassic in age. In marly intercalations Foraminifera assemblages with *Caudammina ovulum* were found, in addition some pebbles in conglomeratic limestones contain Radiolaria of Early Cretaceous age. Therefore, the sedimentation of the Konradsheim Limestone lasted at least to the Early Cretaceous. The provenance of the Cretaceous Radiolaria bearing limestones is interesting, as north from the anticipated paleogeographical position of the Gresten Unit (European Platform) there are no similar deposits; they are only known from the Alpine realm. Implications for the Alpine and Carpathian geodynamic evolution are discussed.

HOLLIS, C.J., FIELD, B.D., JONES, C.M., STRONG, C.P., WILSON, G.J. & DICKENS, G.R. 2005. Biostratigraphy and carbon isotope stratigraphy of uppermost Cretaceous-lower Cenozoic Muzzle Group in middle Clarence valley, New Zealand. *Journal of the Royal Society of New Zealand* **35**(3), 345-383.

Muzzle Group strata exposed along southeast-flowing tributaries of the Clarence River valley, Marlborough, record hemipelagic-pelagic sedimentation across a high latitude (c. 55 degrees S), terrigenous sediment-starved, continental margin from latest Cretaceous to middle Eocene times. Studies of dinoflagellates, foraminifera, calcareous nannofossils, and radiolarians have been integrated with bulk carbonate $\delta(13)C$ profiles to establish the chronostratigraphy for two stratigraphic sections along Bluff and Muzzle Streams, middle Clarence valley. The two sections comprise similar successions. Uppermost Cretaceous (upper Haumurian) micritic limestone of Mead Hill Formation is overlain unconformably by Teredo Limestone, a c. 0.25 m thick bed of highly glauconitic, calcareous sandstone. This unit, the basal member of Amuri Limestone, is overlain conformably by c. 15 m thick Lower Limestone, micritic limestone that is glauconitic at base and progressively more marl-rich in its upper part. Lower Limestone grades up into Lower Marl, a poorly exposed, 40-70 m thick unit of alternating marl and micritic limestone beds. Biostratigraphy indicates that the base of Amuri Limestone is younger at Bluff Stream (earliest Eocene, early Waipawan) than at Muzzle Stream (late Paleocene, late Teurian). In the condensed (12 m) upper Paleocene-lower Eocene Amuri Limestone sequence at Muzzle Stream, a trend in PC from high (≥ 2.4 parts per thousand) to low (≤ 1 parts per thousand) values is consistent with global records across three major climate or carbon cycle perturbations: the late Paleocene carbon isotope maximum (PCIM, 59-56 Ma), the initial Eocene thermal maximum (IETM, 55.5 Ma), and the early Eocene climatic optimum (EECO, 53-50 Ma). Probably only the upper PCIM is preserved in the 4 m thick siliceous limestone interval overlying Teredo Limestone. The IETM is well-defined by a 1 parts per thousand negative $\delta(13)C$ excursion at the base of a 0.8 m thick marl-rich unit (Dee Marl), 5 m above the base of Lower Limestone at Muzzle Stream, and the abrupt appearances of Eocene-restricted species or distinctly warm-water elements within dinoflagellate, foraminiferal, calcareous nannofossil, and radiolarian assemblages. The lithological expression of the IETM as a recessive marly unit has now been identified in three Clarence valley sections (Muzzle, Dee, and Mead Streams), representing a 20 km continental margin transect. Sedimentation rate trends across this margin indicate that the local effects of extreme global warming were increased supply of terrigenous mud, probably due to enhanced precipitation, weathering and erosion, and a decrease in pelagic sedimentation, reflecting a decrease in oceanic productivity. Bluff section lacks an IETM record but contains an expanded (20 m) early Eocene succession that records the onset of the EECO as a progressive increase in marl-rich units associated with consistently low $\delta(13)C$ (< 1 parts per thousand). Both Muzzle and Bluff sections indicate that local environmental changes associated with the EECO were a more gradual and extended version of those inferred for the IETM: an increase in terrigenous mud supply coupled with a decrease in oceanic productivity.

HORI, N. 2005. Paleozoic and Mesozoic radiolarians from the Chichibu Belt in the Iragomisaki District, Atsumi Peninsula, Aichi Prefecture, southwest Japan. *Bulletin of the Geological Survey of Japan* **56**(1-2), 37-83.

Paleozoic and Mesozoic radiolarians were recovered from the Jurassic accretionary complex of the Chichibu Belt in the Iragomisaki district, Atsumi Peninsula, Aichi Prefecture, Southwest Japan. Permian and Triassic radiolarians were detected from 7 and 23 samples of chert, respectively. Jurassic radiolarians were obtained from 10, 6 and 11 samples of chert, siliceous mudstone and mudstone, respectively. 108 species belonging to 54 genera are identified, and are shown in plates with undescribed morphotypes as a database for further study. Based on Permian, Triassic and Jurassic radiolarian biostratigraphic schemes, the geologic ages of the examined chert, siliceous mudstone and mudstone samples range from Middle Permian to late Middle Jurassic, early Middle Jurassic to middle Middle Jurassic and early Middle Jurassic to late Middle Jurassic, respectively.

HORI, N. & WAKITA, K. 2006. Early Middle

Jurassic (late Aalenian) radiolarian assemblage in a manganese nodule from the Northern Chichibu Belt in the Ino area, Kochi Prefecture, Southwest Japan. *Journal of Asian Earth Sciences* **27**(1), 45-60.

Well-preserved radiolarians were obtained from a manganese nodule collected from the Northern Chichibu Belt in the Ino area, Kochi Prefecture, Southwestern Japan. This is the first discovery of manganese nodules containing radiolarians in the Chichibu Belt. The radiolarian assemblage in the manganese nodule consists of 111 nassellarians and 110 spumellarians. The assemblage contains 38 described species and 43 unknown morphotypes as shown by Yao [Yao, A., 1997. Faunal change of Early-Middle Jurassic radiolarians. *News of Osaka Micropaleontologists*, Special Volume, no. 10, 155-182 (in Japanese with English abstract)]. The assemblage suggests the late Aalenian age based on the biostratigraphic data in Japan and the Western Pacific. It shows a low diversity of ring and disc shaped spumellarians like the genera *Hexasaturnalis*, *Parasaturnalis* and *Orbiculiforma*. The genera *Paronaella*, *Parvicingula* and *Parahsuum* are highly diversified. Faunal composition of the examined assemblage in the Chichibu Belt is different from the contemporaneous assemblages in the Mino and Kuzumaki-Kamaishi Belts. This difference seems to indicate that the depositional regions of manganese nodules are different among the Chichibu, Mino and Kuzumaki-Kamaishi Belts. The examined manganese nodule may have been deposited during late Aalenian time in a higher latitudinal area than its present location in the Kuzumaki-Kamaishi Belt judging by the number of species belonging to *Parvicingula*.

HORI, R.S., CAMPBELL, J.D. & GRANT-MACKIE, J.A. 2003. Triassic Radiolaria from Kaka Point Structural Belt, Otago, New Zealand. *Journal of the Royal Society of New Zealand* **33**(1), 39-55.

HU, X., WANG, C., LI, X. & JANSKA, L. 2006. Upper Cretaceous oceanic red beds in southern Tibet: Lithofacies, environments and colour origin. *Science in China Series D: Earth Sciences* **49**(8), 785-795.

Application of mineralogy, geochemistry, sedimentary petrology, and sedimentology methods result in better understanding of the genesis and paleoenvironments of the Upper Cretaceous oceanic red beds exposed in southern Tibet. The red beds comprise the Chungde Formation. Nine lithofacies recognized within this formation are: red foraminiferal packstone/grainstone, red microfossils wackestone, red marlstone with microfossils, red marlstone, red to variegated floatstone and rudstone (debris flow), red shale, red radiolarite, red chert with radiolaria, and red chert. Sedimentary structures and textures, microfossils, and carbonate content show that the Chuangde Fm was deposited near the base of a continental slope in a deep oceanic basin environment, with the basin floor below the carbonate compensation depth (CCD). Red marlstones and limestones intercalated within red shales represent slides and slumps from the upper part of the continental margin. Debris flow and turbidity deposits consist of volcanoclastic, fossiliferous rudstone and floatstone, and very thin calcareous mudstone, intercalated with red shales.

The Upper Cretaceous oceanic red beds in southern Tibet are characterized by high Fe_2O_3 , low FeO , which indicates an oxic diagenetic environment, resulting in precipitation of hematite. The latter occurs as finely, disseminated ferric oxide giving the red color to the rocks. It is concluded that the red beds in southern Tibet were deposited under highly oxygenated bottom conditions in the deep ocean basin. Such conditions not only occurred in a deep ocean basin as indicated by the occurrence of pelagic red shale deposited below the CCD, but also extended up the continental margin as indicated by the presence of red colored marlstones and limestones embedded in the Chuangde Fm. The latter were deposited above CCD, most probably on the continental slope. The oxic bottom conditions are interpreted to be a result of a combination of climate cooling, active bottom ocean circulation, and change in the ocean-atmosphere oxygen budget.

ISHIDA, N. & MURATA, M. 2006. Mixed radiolarian assemblages from the Middle Jurassic chert and siliceous mudstone in the Southern Chichibu terrane, southeastern part of the Kanto Mountains. *Journal of the Geological Society of Japan* **112**(3), 197-209.

Mixed radiolarian assemblages, comprising fossils of different ages, were detected from the Unazawa Formation of the Southern Chichibu terrane, in the southeastern part of the Kanto Mountains. The Unazawa Formation composed of chert, siliceous mudstone and coarse clastic rocks in ascending order, represents a chert-clastic sequence. The mixed assemblages found in four samples from the Middle Jurassic (Aalenian to Bathonian) chert and siliceous mudstone, contain a few reworked radiolarians. The reworked components include six genera and twelve species, and their age assignments range from late Early Permian to Middle Triassic, but lack any Early Triassic representatives. Mode of occurrences of the reworked fossils and textural properties of their host sediments suggest that the reworked components redeposited individually from source sediments in pelagic and hemipelagic environments. Considering the reworking-features of pelagic sediments in the Central Pacific, it is suggested that plausible sources of the reworked radiolarians were the sediments on the flanks of submarine highs, like seamounts.

ITURRALDE-VINENT, M.A., DIAZ-OTERO, C., RODRIGUEZ-VEGA, A. & DIAZ-MARTINEZ, R. 2006. Tectonic implications of paleontologic dating of Cretaceous-Danian sections of Eastern Cuba. *Geologica Acta* **4**, 89-102.

The sedimentary rocks intercalated in volcanic and metavolcanic sections of Mayarí-Baracoa and Sierra del Purial Mountains (Eastern Cuba), yielded Cretaceous through Danian microfossils. In the Mayarí Mountains the Téneme Fm consists of basalts and hyaloclastites with minor intercalations of well-bedded foliated limestone and shaly limestone that in the type area contain a Turonian or early Coniacian planktonic foraminifera assemblage. In the Morel area (Moa-Baracoa massif), back-arc pillow basalts with ribbon cherts include a late Turonian or Coniacian limestone bed intercalated with interbedded organic-rich calcareous shales near the top. The upper part of the Coniacian (?)–Campanian Santo Domingo Fm crops out west of Moa and it consists of finegrained well-bedded volcanoclastic rocks with two intercalated lenses of coarse-grained impure biocalcirudites to biocalcarenes. These rocks yielded a mixed penecontemporaneous planktonic and benthonic microfossil assemblage attributed to the lower part of the late Campanian (Globotruncanita calcarata Zone). At Sierra del Purial, crystalline limestones embedded within the metavolcano-sedimentary Rio Baracoa section (Purial metamorphic complex) yielded Campanian microfossils. The Maastrichtian Yaguaneque (=Cañas) limestones crop out extensively in both Mayarí-Baracoa and Purial Mountains. All the formations previously mentioned unconformably overlie and tectonically intermingle with the late Maastrichtian-early Danian clastic rocks of the Micara and La Picota Fms. Our new dates demonstrate that in the Greater Antilles the PIA (Primitive Island Arc-tholeiite) recorded by the Téneme Fm would be Late Cretaceous in age in opposition to the Lower Cretaceous age proposed for the PIA basalts. The protolith of the Purial metamorphic complex is probably Maastrichtian-early Danian, but certainly Campanian and older in age. This fact suggests that the metamorphism that affected the Purial rocks took place probably in the late Maastrichtian and was coeval with the detachment, exhumation and emplacement of mafic-ultramafic thrust-sheet bodies. This event recorded in Eastern Cuba/Western Hispaniola and Guatemala might have been related to the insertion of thick oceanic ridges into the subduction zone.

KAMETAKA, M. 2006. Early Permian radiolarians from mudstone at Hisage in the Dai area, Nagato Tectonic Zone, Southwest Japan. *Jour. Geol. Soc.*

Japan (in Japanese with English abstract) **112**, 535-538.

Early Permian radiolarian fossils were discovered from mudstone of the Na-gato Tectonic Zone, at Hisage in the Dai area, Yamaguchi Prefecture, Southwest Japan. The mudstone consists of a broken formation of alternating beds of sandstone and mudstone. The radiolarian fauna, composed of *Albaillella sinuata*, *Pseudotormentus kamigoriensis*, *Raciditor gracilis* and others, indicates late Early Permian (Kungurian) age. This radiolaria-bearing broken formation does not correspond to the clastic rocks of the Akiyo-shi terrane, but it corresponds to the formations of the Maizuru terrane or the Hida Gaien terrane

KAMETAKA, M. in Press. Permian radiolarians from felsic tuff at Soegasako in the Ni-shiichi area, Nagato Tectonic Zone, Southwest Japan. *Jour. Geol. Soc. Japan. (in Japanese with English abstract)*.

Permian radiolarian fossils were discovered from greenish gray felsic tuff of the Nagato Tectonic Zone, at Soegasako in the Nishiichi area, Yamaguchi Prefecture, Southwest Japan. The radiolarian fauna is composed of *Follicucullus* sp. cf. *F. porrectus*, *Pseudoalbaillella* sp. aff. *P. longicornis*, *Cauletella manica*, *Raciditor gracilis*, *Pseudo-tormentus kamigoriensis* and others. It indicates late Middle to Late Permian in age. The lithology of felsic tuff, age of radiolarian fauna and characteristics of sponge spicule fauna look similar to those of the clastic rocks of the Akiyoshi terrane. Therefore, Paleozoic formation in the Nagato Tectonic Zone of the Nishiichi area corresponds to the Akiyoshi terrane

KAMETAKA, M., NAKAE, S. & KAMADA, K. 2005. Early Permian radiolarians from siliceous mudstone in the Rikuchu-Seki District, North Kitakami Terrane. *Bulletin of the geological Survey of Japan* **56**(7-8), 237-243.

Permian radiolarian fossils were discovered from red siliceous mudstone of the North Kitakami Terrane, in the Rikuchu-Seki District, Iwate Prefecture, Japan. This is the first report of Paleozoic radiolarians from the North Kitakami Terrane. Preservation of the radiolarian fossils are bad, because the accretionary complex in the district has been affected by contact metamorphism of Cretaceous granitic rocks. The radiolarian fauna, composed of *Pseudoalbaillella* sp. cf. *Ps. elegans*, *Ps.* sp. cf. *Ps. simplex*, *Ps.* sp. cf. *Ps. sakmarensis* and others, indicates early Early Permian (Asselian - early Sakmarian) in age. It is considered that this radiolaria-bearing red siliceous mudstone was originally overlain by chert and underlain by basaltic rocks in the reconstructed oceanic plate stratigraphy of the Jurassic accretionary complex in Japan.

KAMIKURI, S.I., NISHI, H., MOORE, T.C., NIGRINI, C.A. & MOTOYAMA, I. 2005. Radiolarian faunal turnover across the Oligocene/Miocene boundary in the equatorial Pacific Ocean. *Marine Micropaleontology* **57**(3-4), 74-96.

The global warming trend of the latest Oligocene was interrupted by several cooling events associated with Antarctic glaciations. These cooling events affected surface water productivity and plankton assemblages. Well-preserved radiolarians were obtained from upper Oligocene to lower Miocene sediments at Ocean Drilling Program (ODP) Leg 199 Sites 1218 and 1219 in the equatorial Pacific, and 110 radiolarian species were identified. Four episodes of significant radiolarian faunal changes were identified: middle late Oligocene (27.5 to 27.3 Ma), latest Oligocene (24.4 Ma), earliest Miocene (23.3 Ma), and middle early Miocene (21.6 Ma). These four episodes approximately coincide with increases and decreases of biogenic silica

accumulation rates and increases in 6180 values coded as "Oi" and "Mi" events. These data indicate that Antarctic glaciations were associated with change of siliceous sedimentation patterns and faunal changes in the equatorial Pacific. Radiolarian fauna was divided into three assemblages based on variations in radiolarian productivity, species richness and the composition of dominant species: a late Oligocene assemblage (27.6 to 24.4 Ma), a transitional assemblage (24.4 to 23.3 Ma) and an early Miocene assemblage (23.3 to 21.2 Ma). The late Oligocene assemblage is characterized by relatively high productivity, low species richness and four dominant species of *Tholospyris anthophora*, *Stichocorys subligata*, *Lophocyrtis nomas* and *Lithelius* spp. The transitional assemblage represents relatively low values of productivity and species richness, and consists of three dominant species of *T. anthophora*, *S. subligata* and *L. nomas*. The characteristics of the early Miocene assemblage are relatively low productivity, but high species richness. The two dominant species present in this assemblage are *T. anthophora* and *Cyrtocapsella tetrapera*. The most significant faunal turnover of radiolarians is marked at the boundary between the transitional/early Miocene assemblages. We also reviewed changes in other microfossil assemblages in the low latitudes during the late Oligocene through early Miocene. The microfossil assemblages of major groups show sequential changes near the Oligocene/Miocene (O/M) boundary (23.8 Ma). Many extinction events and some first occurrences of calcareous nanofossils and many occurrences of radiolarians are found from about 24.8 to 23.3 Ma, and first occurrences of planktic foraminifers and diatoms followed from 23.2 through 22 Ma. Hence, the ON boundary is identified as a significant level for microfossil evolutions.

KASHIWAGI, K., TSUKADA, K., NIWA, M., NIWA, K. & MIYAKOSHI, N. 2006 (in press). Radiolarians of the *Stylocapsa* (?) *spiralis* Zone (uppermost Middle to lower Upper Jurassic) extracted from a borehole core sample in the Chichibu Composite Belt, Hamakita City, Shizuoka Prefecture, Southwest Japan. *Memoir of the Fukui Prefectural Dinosaur Museum* 5 (in Japanese with English abstract).

Age-determinable radiolarian assemblage was extracted from a borehole core in Hamakita City, east of Lake Hamana-ko, Shizuoka Prefecture, Southwest Japan. Rocks of the borehole core are derived from a melange belonging to the accretionary complex of the Chichibu Composite Belt. The core includes blocks of mafic volcanic rocks, limestone, chert, sandstone and so on in a scaly mudstone matrix. The radiolaria-bearing sample is the alternation of thin beds of sandstone and siltstone which occurs as a block in a scaly mudstone matrix. Radiolarian assemblage from the sample belongs to the *Stylocapsa* (?) *spiralis* Zone, which indicates latest Middle to early Late Jurassic age (latest Callovian to Oxfordian) due to the radiolarian zonation in Japan and the western Pacific of Matsuoka (1995). On the basis of the radiolarian age of the alternation, we conclude that the formative age of the melange is the latest Middle to early Late Jurassic or later.

KELLEY, K.D., DUMOULIN, J.A. & JENNINGS, S. 2004. The Anarraq Zn-Pb-Ag and barite deposit, northern Alaska: Evidence for replacement of carbonate by barite and sulfides. *Economic Geology* 99(7), 1577-1591.

The Anarraq deposit in northern Alaska consists of a barite body, estimated to be as much as 1 billion metric tons, and a Zn-Pb-Ag massive sulfide zone with an estimated resource of about 18 Mt at 18 percent Zn, 5.4 percent Pb, and 85 g/t Ag. The barite and sulfide minerals are hosted by the uppermost part of the Mississippian Kuna Formation (Ikalukrok unit) that consists of carbonaceous and siliceous mudstone or shale interbedded with carbonate. The amount of interbedded carbonate in the Anarraq deposit is atypical of the district as a whole, comprising as much as

one third of the section. The total thickness of the Ikalukrok unit is considerably greater in the area of the deposit (210 to almost 350 m) than to the north mid south (maximum of 164 m). The mineralized zone at Anarraq is lens shaped and has a relatively flat top mid a convex base, it also ranges greatly in thickness, from a few meters to more than 100 m. Textures of some of the carbonate layers are distinctive, consisting of nodules, within siliceous mudstone or layers interbedded with shale. Many of the layers contain calcitized sponge spicules or radiolarians in a carbonate matrix. Textures of barite and sulfide minerals mimic those of carbonate mid provide unequivocal evidence that replacement of precursor carbonate was an important process. Barite and sulfide textures include either nodular, bladed grains of various sizes that resemble spicules (observed only with iron sulfides) or well-rounded forms that are replaced radiolarians. Mineralization at Anarraq probably occurred in a fault-bounded Carboniferous basin during early diagenesis in the shallow subsurface. The shape and size of the mineralized body suggest that barite and sulfides replaced calcareous mass flow deposits in a submarine channel. The distribution of biogenic and/or early diagenetic silica may have served as impermeable barriers to the fluids, thereby focusing and controlling fluid flow through unreplaced carbonate layers.

KOUDUKA, M., MATSUOKA, A. & NISHIGAKI, K. 2006. Acquisition of genome information from single-celled unculturable organisms (radiolaria) by exploiting genome profiling (GP). *Bmc Genomics* 7(135), 1-10.

Background: There is no effective method to obtain genome information from single-celled unculturable organisms such as radiolarians. Even worse, such organisms are often very difficult to collect. Sequence analysis of 18S rDNA has been carried out, but obtaining the data has been difficult and it has provided a rather limited amount of genome information. In this paper, we have developed a method which provides a sufficient amount of data from an unculturable organism. The effectiveness of this method was demonstrated by applying it to the provisional classification of a set of unculturable organisms (radiolarians). Results: Dendrogram was drawn regarding the single-celled unculturable species based on the similarity score termed PaSS, offering a consistent result with the conventional taxonomy of them built up based on phenotypes. This fact has shown that genome profiling-based technology developed here can obtain genome information being sufficient for identifying and classifying species from a single-celled organism. Conclusion: Since this method is so simple, general, and yet powerful, it can be applied to various organisms and cells, especially single-celled, unculturable ones, for their genome analysis.

KOZAI, T., ISHIDA, K., HIRSCH, F., PARK, S.O. & CHANG, K.H. 2005. Early Cretaceous non-marine mollusc faunas of Japan and Korea. *Cretaceous Research* 26(1), 97-112.

A biostratigraphic correlation of Early Cretaceous marine and non-marine mollusc faunas of south-west Japan and exclusively freshwater faunas of Korea is proposed. The material originates from the Inner Zone of central Japan (Tetori, Sanchu), the Outer Zone of south-west Japan (Kyushu, Shikoku, Kii Peninsula), and the Kyongsang Basin of south-west Korea. It includes new collections of freshwater Molluscs from the Monobegawa Group (Shikoku). The alternation of well-dated marine strata with nonmarine beds in Kyushu, Shikoku and central Honshu (Sanchu area) provides accurate age constraints to the well-studied nonmarine faunas. In the Inner and Outer Zones of Japan, four non-marine bivalve associations alternate with marine faunas: (1) Hauterivian: brackish-freshwater *Hayamina naumanni-Unio ogamigoensis* Assemblage of the Tatsukawa faunal association; (2) Hauterivian: brackish *Hayamina carinata-Isodomella matsumotoi* Assemblage of the Shobu faunal association; (3) Barremian: marine *Yabea shinanoensis*, *Pterotrignia kawaguchiensis* and *Nanonavis yokoyamai*, with the ammonite *Shastrioceras*

nipponicum and radiolarians (*Archaeodictyomitra pseudoscalaris* assemblage); (4) Late Barremian: brackish *Hayamina matsukawai*, *Costocyrena radiostriata*, and *Pulsidis tashiroi* of the non-marine Sebayashi faunal association, with *Nippononaia ryosekiana* in Sanchu, passing upwards to marine deposits with ammonites; (5) Early Aptian: brackish *Costocyrena minor*, and *Pulsidis rostratus* of the non-marine Hibihara faunal association, passing upwards to marine *Pterotrignia pocilliformis* and *Goshoraia minor*, with the ammonite *Chelonicerus* sp.; (6) Middle Albian: marine *Inoceramus anglicus*, and *Parvamussium tosaense*, with ammonites, radiolarians and calcareous nannoplankton. *Viviparus onogoensis* (gastropod) in the Hauterivian Tatsukawa association enables correlation of the Ryoseki and Tatsukawa formations (Monobegawa Group) with the Izuki, Kuwajima, and Okurodani formations (Tetori Group) and the Myogog Formation (Korea). *Plicatounio nakongensis* links the Kitadani Formation (Tetori Group) and Sengoku Formation (Kanmon Group) directly with the Hasandon Formation (Korea). The Kitadani and Sengoku faunas share components with the Sebayashi fauna (Central Honshu), define the Late Barremian Hibihara faunal association, and correlate with the Yunoki-Hiura fauna (Monobegawa Group). The faunas are controlled by salinity and temperature. Relationships between the environmental conditions indicate a geographic continuity between the Early Cretaceous deposits of Japan and Korea that accumulated on the continental side of Asia.

KREMER, B. 2006. Mat-forming coccoid cyanobacteria from early Silurian marine deposits of Sudetes, Poland. *Acta Palaeontologica Polonica* **51**(1), 143-154.

Mass occurrence of mats comprised of benthic coccoid cyanobacteria is reported from early Silurian black radiolarian cherts exposed at Zdanow village (Bardzkie Mountains, Sudetes, southwestern Poland). The cherts contain laminated organic matter representing degraded benthic coccoid cyanobacterial mats. The remains of cyanobacteria occur as laminated agglomerations of variously preserved subglobular colonies composed of spherical cells of variable size and numbers. The morphology of remnants of cells and their mucilaginous envelopes, structure of colonies, and particularly the presence of small granular structures resembling reproductive cells known in extant coccoid cyanobacteria as baeocytes, permit to compare the Silurian microbiota with modern cyanobacteria assigned to the genera *Stanieria* or *Chroococciidiopsis*.

KREMER, B. & KAZMIERCZAK, J. 2005. Cyanobacterial mats from silurian black radiolarian cherts: Phototrophic life at the edge of darkness? *Journal of Sedimentary Research* **75**(5), 897-906.

Remains of silicified microbial mats composed of benthic colonial coccoid cyanobacteria similar to modern entophysalidaceans and/or pleurocapsaleans have been identified in Lower Silurian black radiolarian cherts from central and southwestern Poland. Contrary to widespread views ascribing the genesis of such deposits to permanently anoxic deep-water marine environments, the abundance of benthic mats of phototrophic cyanobacteria suggests that the water-mat interface must have been located at moderate depth, most probably close to the limit of light penetration (dysphotic zone). Depending on ambient sulfide levels, the mats could intermittently perform anoxygenic (PSI) or oxygenic (PSII) photosynthesis, thriving under anoxic, oxic, or dysoxic (microaerophilic) conditions. The open marine (offshore) character of these cherts is consistent with their paleoceanographic location and with the presence of remains of such planktonic organisms as acritarchs, radiolarians, chitinozoans, and graptolites, entrapped by the cyanobacterial mats.

KUNITOMO, Y., SARASHINA, I., IJIMA, M., ENDO, K. & SASHIDA, K. 2006. Molecular phylogeny of acantharian and polycystine radiolarians based on ribosomal DNA sequences, and

some comparisons with data from the fossil record. *European Journal of Protistology* **42**(2), 143-153.

Polycystines (spumellarians, nassellarians, and collodarians), phaeodarians, and acantharians are marine planktonic protists that have been conventionally and collectively called "radiolaria". Recent molecular phylogenetic studies revealed radiolarian polyphyly with phaeodarians being a separate offshoot. Collodarians and nassellarians are also shown to form a monophyletic group, but other aspects of radiolarian phylogeny, such as interrelations among polycystines and acantharians, remained uncertain. Here, we present molecular phylogenetic analyses including new ribosomal RNA sequences from ten spumellarians and nine nassellarians, based on Bayesian and maximum-likelihood methods. Results indicate that the Polycystinea is a paraphyletic group, with Bayesian analysis suggesting that spumellarians form a clade with acantharians. The heliozoan-like protist *Sticholonche* appears as a sister to the spumellarian clade. The nassellarian *Eucyrtidium* is located outside the clade including the other nassellarians and collodarians. The mineralogy of the test of extant radiolarians and the tree topology obtained in this work suggest that acantharians and spumellarians evolved from an ancestor with a siliceous skeleton. Collodarians and nassellarians form a well-supported clade and one might infer from the fossil record that they may have diverged between the Jurassic and the Eocene.

KUWAHARA, K., YAO, A., YAO, J. & LI, J. 2005. Permian radiolarians from the Global boundary Stratotype Section and Point for the Guadalupian-Lopingian boundary in the Laibin area, Guanxi, China. *Journal of Geosciences, Osaka City University* **48**(Art. 6), 95-107.

LAZARUS, D. 2006 (in press). Radiolarians and Silicoflagellates. In: ELSEVIER (Ed.), *Encyclopedia of Quaternary Sciences*.

LAZARUS, D., BITTNIOK, B., DIESTER-HAASS, L., MEYERS, P. & BILLUPS, K. 2006 (in press). Comparison of radiolarian and sedimentologic paleoproductivity proxies in the latest Miocene-Recent Benguela Upwelling System. *Marine Micropaleontology*.

Estimating past ocean productivity from ocean sediments often gives different results depending on the measurement used. We have examined a suite of paleoproductivity proxies in latest Miocene-Recent sediments from DSDP Site 532 and ODP Site 1084, two deep-sea sections underlying the Benguela Upwelling System off the Atlantic coast of southern Africa. The productivity history of this system has been previously established via organic carbon concentration, diatom floras and alkenone based estimates of surface water temperature, and shows a change from low productivity in the early Pliocene to sustain high productivity in the late Pliocene-Recent. Each of our samples was split and simultaneously analysed for several proxies of ocean productivity, including organic carbon (TOC%), carbonate, abundance of opaline radiolarians, accumulation rate of benthic foraminifera (BFAR); the radiolarian faunal composition indices Upwelling Radiolarian Index (URI) and the Water Depth Ecology index (WADE); other proxies for opal and carbonate dissolution, plus stable isotopes of benthic foraminifera. Comparisons between proxies in the same measured samples, between sites in downcore plots and to the published productivity record for this region suggest that TOC and radiolarian faunal composition, particularly the WADE index, are good indicators of past productivity, albeit with different sensitivities (log-linear correlation WADE-TOC% $r=0.78$, $n=65$, $p<0.01$). In contrast, carbonate, and carbonatebased proxies such as BFAR primarily reflect changes in dissolution. Radiolarian faunal composition indices do not appear to be affected by bulk opal accumulation or changes in opal

preservation. WADE analysis of radiolarian faunas and TOC% measurements appear to be useful proxies for productivity in late Neogene sediments, particularly for sections where opal or carbonate dissolution is significant.

LEE, Y.I. & KIM, J.Y. 2005. Provenance of the Hayang Group (Early Cretaceous) in the Yeongyang Sub-basin, SE Korea and its bearing on the Cretaceous palaeogeography of SW Japan. *Palaeogeography Palaeoclimatology Palaeoecology* **228**(3-4), 278-295.

The Lower Cretaceous Hayang Group in the Yeongyang Subbasin, SE Korea, was deposited in a forearc basin formed by the subduction of the Palaeo-Pacific (Izanagi) Plate underneath the East Asian continent. It is characterized by an alternating sequence of reddish sandstones and mudstones deposited in fluvial plain environments. Sandstone compositions upsequence reveal that the tectonic regimes of source terrains evolved successively from basement uplift to recycled orogen, to magmatic arc, and back to recycled orogen. Characteristically, sandstones contain abundant plagioclases but rare K-feldspars, except for sandstones derived from basement sources. Sandstones derived from recycled orogens are rich in sedimentary rock fragments, especially chert fragments, which contain radiolarian faunas similar to those of the Jurassic accretionary complex located in Southwest Japan. Minor continental arc volcanism contributed volcanic materials to the basin during the middle stage of the basin filling. During the deposition of the Hayang Group strike-slip fault movements were active due to the oblique subduction of the Izanagi Plate and caused strong pulsed uplift of the trench slope break areas, resulting in supply of accretionary complex-derived sediments. Considering a direct drainage connection between the uplifted accretionary complex in Southwest Japan and the Yeongyang Subbasin, current Cretaceous palaeogeographic reconstructions of the East Asian continental margin need to be reconsidered and it is suggested that the collage of tectonic blocks in Southwest Japan assembled in post-Early Cretaceous time.

LENZ, A.C., NOBLE, P.J., MASIAK, M., POULSON, S.R. & KOZLOWSKA, A. 2006. The *lundgreni* Extinction Event: integration of paleontological and geochemical data from Arctic Canada. *GFF* **128**(2), 153-158.

The *lundgreni* Extinction Event (LEE) in Arctic Canada, as in other regions globally, exhibited an apparently abrupt and catastrophic reduction of graptolite and radiolarian taxa, followed by a short period of extremely low diversity, the *dubius-nassa* Biozone, followed in the subsequent *praedeubeli-deubeli* Biochron by the rapid evolutionary diversification of new taxa. The extinction event was very close to, or coincided with, a regression, as well as with a moderately strong positive $\delta C-13$ (organic) excursion. The excursion is bifurcated with the lower fork occurring at or near the LEE and the upper fork occurring in about the lower part of the *praedeubeli-deubeli* Biozone, possibly coinciding with a modest transgression. Radiolarians are diverse and abundant throughout the *lundgreni* Biozone, sparse to absent directly following the LEE (i.e., in the *dubius-nassa* Biozone), and found only sporadically within the *praedeubeli-deubeli* Biozone. Acritarch frequency throughout the entire investigated interval is extremely low, and only in one level in the *lundgreni* Biozone so-called "giant acritarchs" were observed. Sphaeromorph acritarchs and amorphous organic matter are moderately common in the *lundgreni* Biozone, extremely abundant in the brief time interval of the *dubius-nassa* Biozone at Rookery Creek, and only moderately common in higher strata. The presence of dark yellow and light brown-colored organic matter indicates that the absence of acritarchs is not due to reworking or thermal degradation but is, instead, suggestive of paleoecological control. Proximity to a shallower water shelf may have strongly influenced palynomorph/organic content

LI, W.Q., XIA, B., WU, G.G., WANG, H. & WANG, R. 2005. Kangguertage ophiolite and tectonic significance, Shanshan, Xinjiang China. *Acta Petrologica Sinica* **21**(6), 1617-1632.

The rock association of Kangguertage ophiolite includes metaperidotite-cumulus peridotite-gabbro-plagiogranite-diabase-basalt. The characters of harzburgite (ophite), ophiyroxenite and erosive gabbro are similar to the type of Troodos. The low-K (for all rocks), $MgO/(MgO + TFeO) = 0.834$ similar to 0.866 and TiO_2 (wt%) = 0.02% (for metaperidotite) show the metaperidotite belongs to the type of SSZ ophiolite. In the light of tectonic discrimination diagrams of basalt, the SSZ ophiolite is formed in subduction plate margin of ocean basin. The average $Al_2O_3/(Al_2O_3 + Fe_2O_3) = 0.047$, average $MnO/TiO_2 = 0.93$, Ce negative anomaly, $Ce/Ce^* = 0.548$ and $La-n/Ce-n = 1.661$ (all for radiolarian silicalite), show that the formation of radiolarian silicalite bear affinitive relation on the ocean ridge or opened ocean. The ophiolite lies to the suture line of Talimu plate and Kazakhstan-Aibi Lake in Zhungeer plate-Kangguertage, which represents out-of-order formed relict fragments of ancient north Tianshan ocean lithosphere on late palaeozoic.

LIN, H.X., CUI, K., YAO, Y.W., CAI, Q., FENG, Q.L. & LI, H.D. 2005. A simple route for preparing radiolarian-like mesoporous silica from water-diethyl ether binary solvent system. *Chemistry Letters* **34**(7), 918-919.

An interesting radiolarian-like silica sphere has been prepared from a water-diethyl ether binary solvent system, which is characterized by SEM, TEM, XRD, and adsorption experiments. The results indicate its particular morphology and hierarchical structure, i.e., hollow interior and a crust wherein two types of mesopores with radial orientation are located. This silica product embodies a novel morphosynthesis involving unstable water-oil interface.

LIU, Z.F., STEWART, G., COCHRAN, J.K., LEE, C., ARMSTRONG, R.A., HIRSCHBERG, D.J., GASSER, B. & MIQUEL, J.C. 2005. Why do POC concentrations measured using Niskin bottle collections sometimes differ from those using in-situ pumps? *Deep-Sea Research Part I-Oceanographic Research Papers* **52**(7), 1324-1344.

Systematic discrepancies between concentrations of particulate organic carbon (POC) measured using bottles (small volume) versus in-situ pumps (large volume) have long been of concern to oceanographers. Usually bottle samples yield higher values of POC than pump samples taken concurrently. Several factors, including pressure effects during filtration, particle formation during handling, contamination, and adsorption of dissolved organic carbon (DOC) onto filters, have been suggested as responsible for these differences. As part of a larger study of particles and particle fluxes in the Mediterranean Sea (MedFlux), we systematically and contemporaneously measured various factors that could allow comparison of particle types. The comparison of chlorophyll (Chl-a) and POC immediately suggested a disconnection between concentrations of carbon and Chl-a: bottle and pump estimates of Chl-a concentrations agreed at all depths, while POC and particulate organic nitrogen (PON) measurements did not, especially in the upper 50 m of the water column. These observations suggest that pumps and bottles are equally adept at capturing Chl-a, but that Chl-a:C and Chl-a:N are collected in different proportions by the two methods. Additional experiments using samples collected from the coastal waters of Long Island Sound and in the open Mediterranean, and using algal cultures of both non-fragile *Thalassiosira pseudonana* 3H and fragile *Isochrysis galbana* cells, showed no effects of filtration pressure on POC, PN, or Chl-a concentrations over the pressure range of 0.2-0.9 atm. In addition, shaking experiments using bottle

samples from the Mediterranean did not show particle formation during handling. Corrections for DOC adsorption on the filters were made and cannot account for the discrepancy between pump and bottle POC. One possible explanation for the pump-bottle POC discrepancy is that bottle samples capture zooplankton that can evade pumps but not bottles. In support of this hypothesis, comparisons of zooplankton caught in Niskin bottles with those retained on > 70 µm in situ pump filters, showed greater abundances in bottle relative to pump samples. In addition, non-swimming zooplankton (radiolaria) were under-collected by pumps, suggesting that washout of particles off the 70 µm mesh of in situ pumps during use or recovery may also cause lower POC values. This possibility needs to be further investigated. This study does not address whether zooplankton should or should not be included as POC, but only suggests constraints on the difference between the two methods.

LOVEJOY, C., MASSANA, R. & PEDROS-ALIO, C. 2006. Diversity and distribution of marine microbial eukaryotes in the Arctic Ocean and adjacent seas. *Applied and Environmental Microbiology* **72**(5), 3085-3095.

We analyzed microbial eukaryote diversity in perennially cold arctic marine waters by using 18S rRNA gene clone libraries. Samples were collected during concurrent oceanographic missions to opposite sides of the Arctic Ocean Basin and encompassed five distinct water masses. Two deep water Arctic Ocean sites and the convergence of the Greenland, Norwegian, and Barents Seas were sampled from 28 August to 2 September 2002. An additional sample was obtained from the Beaufort Sea (Canada) in early October 2002. The ribotypes were diverse, with different communities among sites and between the upper mixed layer and just below the halocline. Eukaryotes from the remote Canada Basin contained new phylotypes belonging to the radiolarian orders Acantharea, Polycystinea, and Taxopodida. A novel group within the photosynthetic stramenopiles was also identified. One sample closest to the interior of the Canada Basin yielded only four major taxa, and all but two of the sequences recovered belonged to the polar diatom *Fragilariopsis* and a radiolarian. Overall, 42% of the sequences were < 98% similar to any sequences in GenBank. Moreover, 15% of these were < 95% similar to previously recovered sequences, which is indicative of endemic or undersampled taxa in the North Polar environment. The cold, stable Arctic Ocean is a threatened environment, and climate change could result in significant loss of global microbial biodiversity.

LUO, H. 2005. Radiolarian from Upper Cretaceous oceanic red beds in Sinop Basin, northern Turkey. *Dixue Qianyan* **12**(2), 45-50.

Well-preserved radiolarians were found in the red chert samples taken from the upper Cretaceous oceanic redbeds of the Kapanbogazi Formation, near Kayadibi village, south Sinop basin, Turkey. This radiolarian assemblage is represented by: *Crucella cachensis*, *Alievum superbum?*, *Patellula verteoensis*, *Patellula eclipica*, *Stichomitra mediocris*, *Stichomitra stocki*, *Dictyomitra multicostata*, *Pseudodictyomitra pseudomacrocephala*, *Diacanthocapsa ovoidea*, *Halesium triacanthum*, *Pessagnobranchia fabianii*, *Cavaspongiae* cf. *uganea*, and *Pseudoaulophacus putahensis*. Based on the co-occurrence of the typical Turonian species such as *Crucella cachensis*, *Alievum superbum?*, *Pseudoaulophacus putahensis*, *Patellula eclipica*, *Dictyomitra multicostata*, etc., this fauna is correlative to the *Alievum superbum* zone in western Tethys, north American and Crimea, Russia as established by O'Dogherty (1994), Pessagno (1976, 1977) and Bragina (1997). This evidence confirms a Turonian age. These new radiolarian data provide a precision biostratigraphic age constraint on the timing of the redbeds in the Sinop basin.

MACDONALD, E.W. 2006. Haplotaeniidae and Inaniguttidae (Radiolaria) from the lower Silurian of the Cape Phillips Formation, Cornwallis

Island, Nunavut, Canada. *Journal of Paleontology* **80**(1), 19-37.

Radiolaria of the families Haplotaeniidae Won, Blodgett, and Nestor, 2002 and Inaniguttidae Nazarov and Ormiston, 1984 were recovered from the Llandoverly and lower Wenlock of the Cape Phillips Formation on Cornwallis Island, Nunavut, Canada. Three new species of haplotaeniids are described. *Haplotaeniium fissura* n. sp. is diagnosed by a densely constructed outer layer around a less dense interior; *Haplotaeniium nunavutensis* n. sp. has small, circular pores separated by wide lattice bars; and *Orbiculopylorum granti* n. sp. possesses robust external spines. Haplotaeniids described in open nomenclature are *Haplotaeniium labyrinthum?*, *Haplotaeniium* aff. *cathenatum*, *Haplotaeniium* cf. *raneatela*, *Haplotaeniium* species A, *Orbiculopylorum* aff. *adobensis*, *Orbiculopylorum* cf. *marginatum* and *Orbiculopylorum* species A. *Gyrosphaera* Noble and Maletz, 2000 is synonymized with *Haplotaeniium*. The Inaniguttidae are assigned to *Phussatispila* n. gen. The genus is diagnosed by two, well-spaced lattice shells and at least seven main spines; additional shells may be present. *Phussatispila magnilimax* n. sp. has a total of four shells, and *P. corn-wallisensis* n. sp. a total of three. *Phussatispila delicata* n. sp. has only the two fundamental shells of the genus and is slightly more delicate than the other inaniguttids. *Phussatispila pellicia* n. sp. possesses weakly developed spines and may have additional irregular layers.

MACDONALD, E.W. 2006. A preliminary radiolarian biozonation for the Lower Silurian of the Cape Phillips Formation, Nunavut, Canada. *Canadian Journal of Earth Sciences* **43**(2), 205-211.

Radiolaria from the Lower Silurian of the Cape Phillips Formation, Nunavut, Canada allow the definition of four biostratigraphic assemblages. The *Haplotaeniium* assemblage extends from the basal Llandoverly to topmost *Coronograptus cyphus* graptolite Biozone. The base is taken as the first occurrence of *Haplotaeniium nunavutensis*; no samples were collected below the Ordovician-Silurian boundary. The top of the assemblage is defined by the first Occurrence of *Orbiculopylorum*. The *Orbiculopylorum* assemblage is marked by the first occurrence of *Orbiculopylorum*. The boundary between this assemblage and the overlying *Phussatispila* assemblage is unclear because of a break in stratigraphy (upper *Spirograptus turriculatus* through *Monograptus crispus* graptolite biozones). The last Occurrence of *Orbiculopylorum* defines the top of the assemblage. The base of the *Phussatispila* assemblage is defined by the last occurrence of *Orbiculopylorum*. A barren interval (*Cyrtograptus insectus* to lower *Monograptus instrenuus* - *Cyrtograptus kolobus* graptolite biozones) separates the *Phussatispila* assemblage and subsequent *Ceratoikiscum* assemblage. The first Occurrence of *Ceratoikiscum* is taken as the boundary between these assemblages. The top of the *Ceratoikiscum* assemblage is not established, but is taken as the first occurrence of *Inanihella tarangulica* Group radiolarians. This zonation is comparable to, and a modification from, the global radiolarian biozonation of Noble and Aitchison (2000).

MALDONADO, M., CARMONA, C., VELASQUEZ, Z., PUIG, A., CRUZADO, A., LOPEZ, A. & YOUNG, C.M. 2005. Siliceous sponges as a silicon sink: An overlooked aspect of benthopelagic coupling in the marine silicon cycle. *Limnology and Oceanography* **50**(3), 799-809.

Our current understanding of the silicon (Si) cycle in the ocean assumes that diatoms dominate not only the uptake of silicic acid, but also the production and recycling of biogenic silica (BSi), and that other organisms with siliceous skeletons, including sponges, radiolarians, and silicoflagellates, play a negligible role. In this study, we reexamine some aspects of the potential contribution by sponges and present in vitro evidence that BSi in the form of sponge spicules redissolves into silicic acid at far slower rates than those known for diatom frustules. We also show that the retention

of Si by siliceous sponges in some sublittoral and bathyal environments is substantial and that sponge populations function as Si sinks. Additionally, by reanalyzing published information on sponge growth and BSi content, we estimate that BSi production rates by sublittoral sponges in Si-poor and Si-rich marine areas fall quite close to values known for diatom assemblages. Therefore, sponges may affect Si cycling dynamics and Si availability for diatoms, particularly in Si-depleted environments. Altogether, our data strongly suggest that the role of sponges in the benthopelagic coupling of the Si cycle is significant.

MALETZ, J. & BRUTON, D.L. 2005. *Beothuka terranova* (Radiolaria) assemblage and its importance for the understanding of early Ordovician radiolarian evolution. *Geological Magazine* **142**(6), 711-721.

The radiolarian *Beothuka terranova* occurs in the Arenigian *Didymograptellus bifidus* Biozone (uppermost Lower Ordovician) of Spitsbergen (Svalbard), associated with a diverse and well-preserved radiolarian fauna. The presence of typical Cambrian Spicular radiolarians associated with derived spherical forms shows a gradational faunal change from the Cambrian to the Ordovician. The genus and species *Antyopora ordovicica* n. gen. et n. sp. is described.

MASCARENHAS-PEREIRA, M.B.L., NATH, B.N., BOROLE, D.V. & GUPTA, S.M. 2006. Nature, source and composition of volcanic ash in sediments from a fracture zone trace of Rodriguez Triple Junction in the Central Indian Basin. *Marine Geology* **229**(1-2), 79-90.

Volcanic glasses associated with pumice, micronodules and palagonite like lithic fragments were recovered from a volcanic terrain in a fracture zone defined as Rodriguez Triple Junction trace in the Central Indian Basin. Morphologically, the tephra consist predominantly of bubble wall shards with the co-occurrence of platy and blocky types. Rarity of vesicles in the shards suggests that they are formed in depths deeper than 4000 m, below the volatile fragmentation depth (VFD). Energy dispersive spectrometer (EDS) analyses have shown that the tephra have SiO₂ contents ranging from similar to 74% to 77% suggesting that they are mainly rhyolitic and formed from melts of siliceous composition. The depositional age of the tephra layers determined by radiolarian assemblages and excess Th-230 decay profile corresponds to an age older than 180 kyr. The tephra are rare in sediments younger than similar to 239 kyr. The beginning of the volcanic eruption contributing this volcanic ash however, cannot be estimated. Occurrence of large sized tephra suggests proximal source, probably from a local volcanic source. Compositional and morphological contrasts, age constraints, occurrence of large sized tephra, and tectonic setting of the cored site/location suggest an intraplate volcanism, triggered by reactivation of tectonic activity in the fracture zone trace of the Indian Ocean Triple Junction during the Late Pleistocene.

MATSUOKA, A., YANG, Q. & TAKEI, M. 2005. Latest Jurassic-earliest Cretaceous radiolarian fauna from the Xialu chert in the Yarlung Zangbo suture zone, southern Tibet: Comparison with coeval western Pacific radiolarian faunas and paleoceanographic implications. *Island Arc* **14**(4), 338-345.

The Xialu chert radiolarian fauna is latest Jurassic - earliest Cretaceous in age (*Pseudodictyomitra carpatica* zone) and contains many taxa in common with coeval northern hemisphere middle-latitude (temperate) radiolarian faunas represented by the Torinosu fauna in southwest Japan. Common elements include *Eucyrtidiellum pyramis* (Aita), *Protunuma japonicus* Matsuoka & Yao, *Sethocapsa pseudouterculus* Aita, *Sethocapsa* (?)

subcrassitesta Aita, *Archaeodictyomitra minoensis* (Mizutani), *Stichocapsa praepulchella* Hori and *Xitus gifuensis* (Mizutani). The Xialu fauna is less similar to low-latitude (tropical) assemblages represented by the Mariana fauna. For this reason, the Xialu fauna is regarded as representative of a southern hemisphere middle-latitude (temperate) fauna. A mirror-image bi-temperate provincialism to the equator in radiolarian faunas is reconstructed for the Ceno-Tethys and Pacific Ocean in latest Jurassic - earliest Cretaceous time.

MATUL, A. & ABELMANN, A. 2005. Pleistocene and Holocene distribution of the radiolarian *Amphimelissa setosa* Cleve in the North Pacific and North Atlantic: Evidence for water mass movement. *Deep-Sea Research Part II-Topical Studies in Oceanography* **52**(16-18), 2351-2364.

The radiolarian *Amphimelissa setosa* is one of the prominent species of the Pleistocene radiolarian assemblages in the Sea of Okhotsk below the marine isotope stage (MIS) boundary 5/4, and it represents one of the most abundant radiolarian species in Holocene and modern environments of the Nordic Seas. We studied the *A. setosa* distribution in six cores from the Sea of Okhotsk and established morphometric measurements on *A. setosa* specimens from two cores of the Sea of Okhotsk and one core from the Labrador Sea. We further compared our data with other available studies from the Subarctic Pacific, the Labrador Sea, the North Atlantic, the Norwegian Sea, and the Iceland/Greenland Seas in order to discuss the possible settling of the species from the North Pacific via the Arctic Ocean into the Iceland/Greenland Seas. *A. setosa* exhibits a stable abundant population in the Sea of Okhotsk during most of the last ca. 0.7 m.y. and might repeatedly extend its population into the North Atlantic through the Arctic Ocean during the Pleistocene interglacial optima. The species declines from the Sea of Okhotsk and from the Subarctic Pacific at the end of MIS 5. Its final documented settling into the North Atlantic is during MIS 5, when *A. setosa* appears in low numbers in sediments of the Labrador Sea, however reaching significant percentages at the boundary of MIS 5/4. Based on the available information, we propose that *A. setosa* could migrate from the North Pacific into the Arctic Ocean during the interglacial optimum MIS 5e and then through the channels of the Canadian Arctic Archipelago into the Baffin Bay and Labrador Sea. A further migration step of *A. setosa* occurs at the boundary of MIS 5/4, when *A. setosa* migrated from the Labrador Sea into the North Atlantic, probably related to a southward expansion of cold waters at the end of the MIS 5. During the warming at Termination 1, *A. setosa* moved from the North Atlantic into the Nordic Seas. The abundant occurrence of *A. setosa* in sediments south of Iceland, the Norwegian and North Seas within the Younger Dryas period points to a marked cooling and a southward movement of polar water masses restricted to this time interval.

MUSAVU-MOUSSAVOU, B. & DANELIAN, T. 2006. The Radiolarian biotic response to Oceanic Anoxic Event 2 in the southern part of the Northern proto-Atlantic (Demerara Rise, ODP Leg 207). In: ERBACHER J., et al. (Eds.), *Demerara Rise (Leg 207): Equatorial Cretaceous and Paleogene Stratigraphy and Palaeoceanography*. *Revue de Micropaléontologie*.

Rare Radiolaria occur in the Upper Cenomanian - Lower Turonian part of finely laminated black shales recovered from Sites 1258 and 1261 of Demerara Rise (Ocean Drilling Program Leg 207, western tropical Atlantic, off Surinam). The observed fauna are of a low diversity, with up to 12 species co-occurring in a single sample and 49 species identified in total in both sites. Assemblages are equally represented by Nassellarians and "Spumellarians". Diverse species of *Stichomitra* and *Theocampe* are particularly common, including the two new species described herein: *Theocampe costata* and *T. demeraraense*. Radiolarian preservation is on average moderate to poor, suggesting substantial influence of

diagenetic alterations to species diversity. The rare well-preserved assemblages can potentially provide better information about Cenomanian-Turonian Radiolarian biodiversity, but given their low abundance in the processed sediment samples, the diversity sampled during this study is considered an underestimate of the original Radiolarian diversity at Demerara. However, the abundance and diversity of *Theocampe* in Upper Cenomanian levels is noteworthy. Given the earliest known occurrence of the genus from Upper Albian sediments of the Deep Ivorian Basin it is likely that it originated and diversified in the opening Equatorial Atlantic Gateway. Based on the stable carbon isotope curve the OAE-2 interval is clearly identified in the sedimentary sequence of both studied sites and helps to specify the known age range of two species (*Acanthocircus hueyi* and *Rhopalosyringium hispidum*). The most intriguing result of this study is the paucity of Radiolaria within the OAE-2 interval of the deeper site (1258) and the total absence of this micro-zooplankton group in the OAE-2 interval of the proximal site (1261). Radiolaria are the most abundant and diverse at the distal Site 1258, below OAE-2, while the proximal Site 1261 contains very rare Radiolaria. The opposite pattern is observed above OAE-2 (very rare Radiolaria at site 1258, more abundant at site 1261). The paucity or absence of Radiolaria within the OAE-2 interval may be due to the upward excursion of the chemocline in the southern part of the Northern proto-Atlantic. Upwelling of deep warm waters may have fuelled primary productivity (sulphate-reducing bacteria) but upheld at the same time micro-zooplankton survival and proliferation after accentuation of euxinic conditions in the surface waters.

NAKAE, S. & KOMURO, K. 2005. Radiolarian age of chert-hosted bedded manganese deposits from the Gen-otani mine in the Tamba district, northern Kyoto City, Japan. *Resource Geology* **55**(4), 311-320.

Numerous bedded manganese deposits sporadically distributed throughout the Tamba district, southwestern Japan are intercalated within chert sequence. It is well known that radiolarian remains are commonly included in both bedded manganese deposits and host cherts. The Gen-otani mine, one of these deposits, is located at Otani, Keihoku-Shimonaka, northern Kyoto City. Chemical composition and age of the chert sequence at the mine were examined. Mainly according to SiO₂ and MnO contents together with lithology, the chert sequence is divided into three sections; lower massive chert, middle bedded manganese deposit and upper bedded chert sections. Radiolarian faunas consisting of middle Jurassic species such as *Eucyrtidellum unumaense*, *Dictyomitrella(?) kamoensis*, *Parvicingula dhimenaensis*, *Sethocapsa aitai*, *Sethocapsa kodrai*, *Transsuum brevicostatum*, *Tricolocapsa plicarum*, *Unuma echinatus* and others were extracted from both the middle manganese section and overlying bedded chert of the Upper section. This examination reveals that the bedded manganese deposit at the Gen-otani mine formed until Bajocian to early Bathonian (middle Middle Jurassic) in age.

NAKATO, A., MOTOYAMA, I. & KAWAHATA, H. 2005. Seasonal and latitudinal changes of radiolarian sinking population in sediment trap samples from the central North Pacific. *Bulletin of the geological Survey of Japan* **56**(5-6), 225-236.

Fluxes of polycystine Radiolaria were examined to clarify temporal and regional variations in production and percentage assemblages in relation to hydrographic conditions. Three time-series sediment traps were deployed in the central North Pacific along 175°E for about one year, beginning in June 1993. The trap sites were located in the subarctic, the transitional, and the subtropical water masses.

Temporal fluxes of polycystines showed large variations during the experiment. In the subarctic water mass, high polycystine fluxes were observed during summer to fall, while in the transitional and subtropical regions any relationship was not seen between the polycystine fluxes and sea surface temperature. High polycystine fluxes observed from the subarctic and transition zones can probably be ascribed to high food availability. The

polycystine annual mean flux through the experiment was highest at the subarctic site, while that of the transition site was lower than that of the subtropical site. This pattern does not parallel the latitudinal variation in the total mass, opal or organic matter fluxes recorded from the same experiments.

The relative abundance of most of the families did not vary much during the experiment at each site; i.e., polycystine faunal composition remains fairly stable in each oceanic climatic zone. This is likely to be because most polycystine radiolarians are produced in the depths where there is little seasonal environmental change. Latitudinal changes of total polycystine assemblages of the three sites are clear. Plagiocanthidae dominate the assemblage from the subarctic site, and Actinommididae become abundant in the assemblage from the transitional zone. No single family dominates the total assemblage from the subtropical region. These faunal differences between the climatic zones probably relate to differences in temperature of the water at depths of 50-200 m where most polycystines live. Consequently, the percentage abundance of sinking polycystine radiolarians retain a great deal of environmental information on the water masses below the seasonal thermocline in each climatic zone, but possibly do not record much information about seasonal oceanographic changes in the surface layer above the seasonal thermocline.

NISHIHARA, C. & YAO, A. 2005. Faunal change of Middle Jurassic (Bajocian) radiolarians from manganese carbonate nodules in the Inuyama area, Central Japan. *Journal of Geosciences, Osaka City University* **48**, 109-121.

NISHIHARA, C. & YAO, A. 2005. Faunal change of Middle Jurassic (Bajocian) radiolarians in the Inuyama area of the Mino Terrane. *Fossils*(78), 32-39.

This paper reports on a faunal change of Middle Jurassic (Bajocian) radiolarians from manganese carbonate nodules in the Inuyama area, Mino Terrane. Five radiolarian assemblages, distinguished from five horizons (IN-16, IN-10, IN-7, IN-3 and IN-1 in ascending order) of the Unuma section, are well-preserved and extremely diversified in specific composition. About 300 species of radiolarian fossils are obtained from each manganese carbonate nodule. Approximately two thirds of radiolarian species are composed of common species between two horizons. The value of Spumellaria/Nassellaria (S/N) ratio is high in the lowermost horizon (IN-16) and low in the uppermost horizon (IN-1). Although the extinction and origination rates of radiolarian species are totally constant through the section, the origination of nassellarian species in the uppermost horizon shows a high rate. On the basis of these faunal analyses, the radiolarian faunal change was constant during Bajocian time except for a little change of the S/N ratio and the origination rate of nassellarian species. It is suggested that there was not the large oceanic environmental change during Bajocian time in the western part of the Panthalassa.

O'DOHERTY, L., BILL, M., GORICAN, S., DUMITRICA, P. & MASSON, H. 2005. Bathonian radiolarians from an ophiolitic melange of the Alpine Tethys (Gets Nappe, Swiss-French Alps). *Micropaleontology* **51**(6), 425-485.

The determination of radiolarite ages of supraophiolitic rocks date the expansion age of oceanic crust. Radiolarites from the Gets nappe, a decollement cover nappe, provide the means of dating selected localities of outcropping oceanic crust based on their radiolarian faunas. Some studied samples from the ophiolitic melange (Perri re series) have a very well preserved and highly diverse radiolarian fauna of biochronological significance. The age of the radiolarites is established by correlation with the biozonation of Baumgartner et al. (1995b), which indicates a Bathonian age for the oldest radiolarian assemblages. Accordingly, these radiolarites represent remains of the oldest sediments recorded after the opening of the Piemont-Ligurian Ocean. This

age is in agreement with those recently established by isotopic methods (166 +/- 1 Ma U-Pb and 165.9 +/- 2.2 Ma Ar-40/Ar-39) in the associated gabbros from the ophiolitic melange. The isotopic age and paleontological results are important because they represent the oldest dating of the oceanic crust of the Piemont-Ligurian Ocean, proving a Late Bajocian-Early Bathonian age for the oceanization in the western Tethys. The systematic part presents a complete Bathonian radiolarian assemblage from two of the best preserved samples; the illustrated assemblage contains 180 species attributed to 66 genera (44 nassellarians, 22 spumellarians and 1 entactinarian). Twenty new species and three new genera (*Helvetocapsa*, *Plicatorocapsa* and *Theocapsomella*) are formally described.

OBUT, O.T., BUSLOV, M.M., IWATA, K. & ZHIMULEV, F.I. 2006. Timing of collision of the Kokchetav massif with the Stepanyak island arc on the basis of conodonts and radiolarians from siliceous rocks of juxtaposed terranes of different geodynamic settings. *Russian Geology and Geophysics* **47**(4), 451-457.

The siliceous rocks from structures of the junction zone of the Kokchetav massif and Stepanyak trough that occur in turbidites of the accretionary wedge, silica-volcanogenic sequence of the Stepanyak trough and syntectonic olistostrome were dated on the basis of findings of conodonts and radiolarians within the Middle-Upper Arenigian (conodont zones *O. evae*, *B. navis* - lower *Par. originalis*). This range of time is marked by a powerful tectonic rearrangement, involved with the rearrangement of the accretionary wedge and overriding of the Kokchetav massif upon the Stepanyak fore-arc trough.

OGANE, K. & SUZUKI, N. 2006. Morphological terms describing discoidal radiolarians. *Revue de Micropaleontologie* **49**(2), 97-104.

Discoidal radiolarians have been described by several authors. However, their terminology has not yet been adequately defined, and additional terms are necessary for adequate description. In this paper we summarize the definition of 16 existing morphological terms and propose 35 new, which we believe are useful to describe discoidal radiolarians. The terminology summarized here makes it possible to describe the structure of discoidal radiolarians clearly and can be applied in future work.

OGAWA, Y. & SASHIDA, K. 2005. Lower Cretaceous radiolarian bedded chert from the Mineoka Belt, Boso Peninsula, Japan. *Journal of the Geological Society of Japan* **111**(10), 624-627.

A meter-scale, bedded red radiolarian chert block was found on the Yo-oka Beach at the eastern edge of the Mineoka Belt, Boso Peninsula, central Japan. The block is included in the area composed of fragments of the Mineoka ophiolite and other sedimentary and igneous rocks, including a Paleocene to Miocene pelagic limestone/chert sequence. The radiolarian fauna indicates an assemblage zone of middle to late Albian (Early Cretaceous), partly corresponding to the age of the Tethyan fauna. The tectonic significance of this Cretaceous radiolarian chert block is not clear: it could be from either the Mineoka ophiolite and related oceanic plate stratigraphy or from the Shimanto Supergroup.

OKADA, M., TAKAGI, M., NARITA, H. & TAKAHASHI, K. 2005. Chronostratigraphy of sediment cores from the Bering Sea and the subarctic Pacific based on paleomagnetic and oxygen isotopic analyses. *Deep-Sea Research Part II-Topical Studies in Oceanography* **52**(16-18), 2092-2109.

The chronostratigraphy of six piston cores collected from the

Bering Sea and one piston core from the subarctic Pacific is reported. Age models are primarily based on oxygen isotope data from Cores BOW-8A and ES in conjunction with relative paleointensity proxy records, biogenic opal data, and a radiolarian datum from other cores whose sediments mainly consist of diatom microfossils and poorly preserved calcium carbonate. The records, the first paleointensity proxy reported from the Bering Sea, show that characteristic paleointensity lows at similar to 40, similar to 60 and similar to 100 ka, which have been well documented in other paleointensity records. Those features can be correlated to standard paleointensity curves with the aid of biogenic opal data and a radiolarian datum. The mean sedimentation rates of the diatom-rich cores collected in the eastern Bering Sea range from 10 to 20 cm kyr⁻¹. In contrast, the mean sedimentation rate of Core BOW-8A, from the western edge of the Bowers Ridge, is only similar to 3 cm kyr⁻¹, which is comparable to Core ES from the pelagic realm in the subarctic Pacific. These results suggest that biological productivity has been quite high during the late Pleistocene in the eastern part of the Bering Sea, but low over the western edge of the Bowers Ridge.

OKAZAKI, Y., SEKI, O., NAKATSUKA, T., SAKAMOTO, T., IKEHARA, M. & TAKAHASHI, K. 2006. *Cycladophora davisiana* (Radiolaria) in the Okhotsk Sea: A key for reconstructing glacial ocean conditions. *Journal of Oceanography* **62**(5), 639-648.

Cycladophora davisiana, a radiolarian species dwelling at mesopelagic depths, is known as a representative glacial fauna due to its unique distribution during glacial periods. In the present ocean, abundant production of *C. davisiana* is only observed in the Okhotsk Sea, indicating an adaptation of *C. davisiana* for seasonal sea-ice covered conditions. We found pronounced abundant production of *C. davisiana* during the early to middle Holocene in the Okhotsk Sea, suggesting more favorable conditions for *C. davisiana* than the present Okhotsk Sea. In order to clarify the reason, oceanographic conditions during the Holocene were reconstructed based on biomarkers, lithogenic grains including ice-rafted debris (IRD), biogenic opal, and total organic carbon (TOC) in two sediment cores from the Okhotsk Sea. These indicators suggest that the pronounced *C. davisiana* production may be attributed to: 1) a supply to mesopelagic depths under intensified stratification of fine organic particles derived from coccolithophorids, bacteria, and detrital materials; and 2) cold, well-ventilated intermediate water formation.

OKAZAKI, Y., TAKAHASHI, K., KATSUKI, K., ONO, A., HORI, J., SAKAMOTO, T., UCHIDA, M., SHIBATA, Y., IKEHARA, M. & AOKI, K. 2005. Late Quaternary paleoceanographic changes in the southwestern Okhotsk Sea: Evidence from geochemical, radiolarian, and diatom records. *Deep-Sea Research Part II-Topical Studies in Oceanography* **52**(16-18), 2332-2350.

High-resolution analyses of geochemical parameters (biogenic opal, calcium carbonate, organic carbon, and nitrogen) and microfossil assemblages (diatoms and radiolarians) on Core MD01-2412 clarified detailed paleoceanographic changes such as sea-ice cover and biological production in the southwestern Okhotsk Sea during the last 115 kyr. An age model of Core MD01-2412 was established based on delta(18)O stratigraphy, accelerator mass spectrometer (AMS) C-14, and tephrochronology. Sea-ice history reconstructed by siliceous microplankton records indicated that the present sea-ice condition was formed during the last 8 kyr. Only during Marine Isotope Stage (MIS) 2 was the duration of sea-ice cover in this region much longer than that of today (4-5 months a year). Two diatom species, *Thalassionema nitzschioides* and *Fragilariopsis doliolus*, revealed that the Soya Warm Current Water (SWCW) flowed into the Okhotsk Sea near the site of Core MD01-2412 during the last 12-14 kyr and during MIS 5a, and was associated with sea-level rise. Biological productivity rapidly increased during MIS 1,

associated with sea-ice retreat. Two major increases of organic carbon (OC) contents (wt%) and C-org/N ratios were observed, and the timings of these events were 15.8-16.7 ka (Event 1) and 13.1-13.6 ka (Event 2). Corresponding to these events, the abundance of *Cycladophora davisiana*, an intermediate water dwelling radiolarian species, increased. This high *C. davisiana* abundance can be correlated to the input of terrestrial organic matter from the submerged shelf to the intermediate water. Apart from the radiolarians, the production of diatoms in the surface waters was suppressed by the development of well-stratified surface water along with sea-ice melting during the early Holocene. Diatom production increased gradually during the last 10 kyr with enhanced vertical mixing.

OKAZAKI, Y., TAKAHASHI, K., ONODERA, J. & HONDA, M.C. 2005. Temporal and spatial flux changes of radiolarians in the northwestern Pacific Ocean during 1997-2000. *Deep-Sea Research Part I-Topical Studies in Oceanography* **52**(16-18), 2240-2274.

In order to examine the radiolarian fluxes and evaluate their relationship to the physical and biological environments, time-series sediment traps were deployed at three stations (Stations 50N, KNOT, and 40N) in the northwestern North Pacific from 1997 to 2000. Station 50N (50 degrees N, 165 degrees E, 3260 m) is located in the center of Western Subarctic Gyre (WSAG); Station KNOT (44 degrees N, 155 degrees E, 2957 m) is located toward the margin of WSAG; and Station 40N (40 degrees N, 165 degrees E, 2986 m) is located in the Subarctic Boundary. Total radiolaria fluxes at Station 40N showed higher values than those at the other two stations, and were mainly attributed to the influence of relatively high-temperature and high-salinity subtropical gyre waters. Correlation coefficients between total mass fluxes (mainly composed of diatoms) and radiolarian fluxes at three stations were relatively low. This is primarily because of the wide vertical distribution of radiolarians and various trophic patterns corresponding to their niche. Radiolarian species were classified according to their geographic water mass and vertical distributions based on previous studies using sediment samples. As a result, seasonal changes of radiolarian fluxes in each water mass showed patterns corresponding to particular controlling factors such as physical hydrography and food conditions. Among these patterns, temporal changes in radiolarian taxonomic composition in the upper layer (0-100m) seemed to reflect well the sea-surface temperature anomaly (SSTA) changes, affected by El Nino and La Nina events, at Station 40N. Therefore, radiolarian assemblages can be used to reconstruct past SSTA changes and to understand the past El Nino and La Nina teleconnection in the Kuroshio-Oyashio Extension region.

OLFER'EV, A.G., ALEKSEEV, A.S., BENIAMOVSKII, V.N., VISHNEVSKAYA, V.S., IVANOV, A.V., PERVUSHOV, E.M., SEL'TSER, V.B., KHARITONOV, V.M. & SHCHERBININA, E.A. 2004. The Mezino-Lapshinovka reference section of the Upper Cretaceous and problems of Santonian-Campanian boundary in Saratov area near the Volga River. *Stratigraphy and Geological Correlation* **12**(6), 603-636.

Results of multi disciplinary study in the Upper Cretaceous reference section and characteristics of the Mezino-Lapshinovka Formation stratotype are presented. The late Santonian age of the formation is substantiated based on the analyzed organic remains. The formation is considered to be a stratigraphic equivalent of the Pterid Beds, the age of which was animatedly discussed during over a century. The age of the Mozhdzev-elovyi Ovrage Formation that underlies the Mezino-Lapshinovka Formation and yields foraminifers, radiolarians, and calcareous nannoplankton is also discussed. The ammonite assemblage of the lower upper Campanian first discovered in the basal part of the Ardym

Formation of the Volga region is characterized.

OMANA, L., GONZALEZ-ARREOLA, C. & RAMIREZ-GARZA, B.M. 2004. Barremian planktonic foraminiferal events correlated with the ammonite zones from the San Lucas Formation, Michoacan (SW Mexico). *Revista Mexicana De Ciencias Geologicas* **22**(1), 88-96.

We studied the Tringueo section from the San Lucas Formation, located in the state of Michoacan, SW Mexico. The section is a flysch sequence consisting of a rhythmic deposit of shale, siltstone, and fine to medium graded sandstone interbedded with limestone. The sequence contains ammonites, foraminifera and radiolarians. The biostratigraphic analysis, based on the planktonic foraminifera and ammonites, permitted the recognition of the biostratigraphic units established on both fossil groups, for first time in SW Mexico. Although the planktonic foraminifera are scarce and poorly preserved, some important events such as the first occurrence of *Hedbergella similis*, *Globigerinelloides blowi* and *Globigerinelloides aptiensis* were correlated with the ammonite zones. By means of these foraminiferal events, the Zones of *Hedbergella similis* and *Globigerinelloides blowi* partim (early and late Barremian) were identified. The faunal assemblage and distinctive lithological characteristics suggest that the San Lucas Barremian sequence was deposited in pelagic conditions.

OSAWA, M., TAKAHASHI, K. & HAY, B.J. 2005. Shell-bearing plankton fluxes in the central Black sea, 1989-1991. *Deep-Sea Research Part I-Oceanographic Research Papers* **52**(9), 1677-1698.

Seasonal and vertical flux variations of coccolithophorids, discrete coccoliths, silicoflagellates, ebridians, and diatoms were investigated using time-series sediment traps deployed in the central Black Sea for 2 years from September 1989 through August 1990 (Year 1) and from October 1990 through September 1991 (Year 2). The following marine plankton groups were not observed during the enumeration: dinoflagellates, radiolarians, planktonic and benthic foraminifers, and pteropods. High fluxes of coccolithophorids, discrete coccoliths, and silicoflagellates occurred from September to December in Year 1 and October to December in Year 2. High ebridian fluxes occurred during short periods from October to November in Year 1 and from February to April in Year 2. High diatom fluxes occurred from September to January in Year 1 and from October to April in Year 2. The seasonal variations and magnitudes of most plankton assemblages were similar between the Shallow trap (at a depth of 400 m) and the Bottom trap (at a depth of 2090 m) suggesting that the plankton shells settled at a rate of 60 m d(-1) or greater without significant loss or lateral input. The exception was the diatom flux in Year 2, which was offset by approximately 2 months between the Shallow and Bottom traps, suggesting a sinking speed of approximately 38 +/- 18 m d(-1). The slower setting speed is attributed to *Pseudo-nitzschia* spp., which was the dominant diatom taxon in Year 2. Maximum flux magnitudes of each plankton assemblage were on average two times greater in Year 2 than in Year 1. *Emiliania huxleyi*, *Distephanus pulchrus*, and *Pseudo-nitzschia* spp. dominated the fluxes of coccolithophorids, silicoflagellates, and diatoms, respectively. Significant changes in taxonomic composition of the silicoflagellate and ebridian fluxes were observed between Year 1 and Year 2. The higher fluxes in Year 2 and the observed taxonomic changes imply that the upper water column in Year 2 was warmer and more eutrophic compared to Year 1, possibly linked to greater advection of nutrient-rich coastal waters to the center of the Black Sea through meso-scale eddies.

PACKER, S.R. & HART, M.B. 2005. Coniacian-Santonian Radiolaria from the Upper Cretaceous of Bornholm, Denmark: A preliminary investigation. *Bulletin of the Geological Society of Denmark* **52**,

141-157.

A moderately diverse fauna of Late Cretaceous Radiolaria are described for the first time from the Amager Limestone and Bavnodde Greensand formations exposed on the island of Bornholm (Denmark). Our preliminary investigation suggests that the fauna from the Amager Limestone Formation is relatively abundant and is assigned to the *Orbiculiforma vacaensis* Subzone (*Alievium praegallowayi* Zone) of Coniacian age. Relatively poor recovery from the Bavnodde Greensand Formation precludes assignment to the zonation scheme of Pessagno, although, the radiolarian taxa present indicate that the formation can be no younger than Santonian. The ages given for both formations by the radiolarian faunas compare favourably with published microfossil and microfossil data. The radiolarian faunas described are of moderate abundance and diversity when compared to contemporaneous faunas described elsewhere, particularly the Tethyan area. Maximum radiolarian abundance and diversity is reached in the middle of the Amager Limestone Formation equating to a level of maximum water depth from the foraminiferal data. A decline in radiolarian recovery is recognised in the Bavnodde Greensand Formation and is associated with a reduction in relative water depth to inner and (?)middle shelf conditions, as indicated by foraminiferal data.

PATTAN, J.N., MASUZAWA, T., BOROLE, D.V., PARTHIBAN, G., JAUHARI, P. & YAMAMOTO, M. 2005. Biological productivity, terrigenous influence and noncrustal elements supply to the Central Indian Ocean Basin: Paleooceanography during the past similar to 1 Ma. *Journal of Earth System Science* **114**(1), 63-74.

A 2 m-long sediment core from the siliceous ooze domain in the Central Indian Ocean Basin (CIOB; 13 degrees 03'S: 74 degrees 44'E; water depth 5099 m) is studied for calcium carbonate, total organic carbon, total nitrogen, biogenic opal, major and few trace elements (Al, Ti, Fe, K, Mg, Zr, Sc, V, Mn, Cu, Ni, Zn, Co, and Ba) to understand the productivity and intensity of terrigenous supply. The age model of the sediment core is based on U-Th dating, occurrence of Youngest Toba Tuff of similar to 74 ka and Australasian microtektites of similar to 770 ka. Low carbonate content (< 1%) of sediment core indicates deposition below the carbonate compensation depth. Organic carbon content is also very low, almost uniform (mean 0.2 wt%) and is of marine origin. This suggests a well-oxygenated bottom water environment during the past similar to 1100 ka. Our data suggest that during similar to 1100 ka and similar to 400 ka siliceous productivity was lower, complimented by higher supply of terrigenous material mostly derived from the metasedimentary rocks of High Himalayan crystalline. However, during the last similar to 400 ka, siliceous productivity increased with substantial reduction in the terrigenous sediment supply. The results suggest that intensity of Himalayan weathering, erosion associated with monsoons was comparatively higher prior to 400 ka. Manganese, Ba, Cu, Ni, Zn, and Co have around 90% of their supply from noncrustal (excess) source and their burial to seafloor remained unaffected throughout the past similar to 1100 ka.

PEREZ-CRUZ, L. 2006. Climate and ocean variability during the middle and late Holocene recorded in laminated sediments from Alfonso Basin, Gulf of California, Mexico. *Quaternary Research* **65**(3), 401-410.

A laminated sequence (core BAP96-CP 24 degrees 3 8.12'N, 110 degrees 3 3.24'W; 390 m depth) from the Alfonso Basin in Bay of La Paz, southern Gulf of California, contains a record of paleoceanographic and paleoclimatic changes of the past 7900 yr. Radiolarian assemblages and magnetic susceptibility are used as proxies of oceanographic and climatic variability. The records provide a regional scenario of the middle and late Holocene, suggesting two major climatic regimes and several millennial-scale

events. Conditions relatively warmer and drier than today occurred from similar to 7700 to 2500 cal yr BP, promoting the intensification of evaporation processes and the prevalence of the Gulf of California water in the Basin. These conditions correlate with strong droughts in the middle Holocene of North America and with minimal incursion of tropical waters into the Gulf of California. Proxies indicate a warm scenario and the dominance of the Equatorial Surface Water in the Alfonso Basin from similar to 2400 to 700 cal yr BP, suggesting the intensification of ENSO cycles. A climatic signal between similar to 1038 and 963 cal yr BP may be correlated with global signal of the "Medieval Warm Period." Several cooling events are recognized at 5730, 3360, 2700, 1280 and 820 cal yr BP and are associated with intensification of northwest winds leading to upwellings and enhanced productivity in the Basin.

PESSAGNO, E.A.J., GHAZI, A.M., KARIMINIA, M., DUNCAN, R.A. & HASSANIPAK, A.A. 2005. Tectonostratigraphy of the Khoy Complex, northwestern Iran. *Stratigraphy* **2**(1), 49-63.

Previous studies suggested that only one ophiolite, the "Khoy ophiolite", existed near Khoy, northwestern Iran. This thesis is no longer tenable.

Combined investigations (biostratigraphic, chronostratigraphic, geochronometric, geochronologic, and geochemical) demonstrate that there are at least two and perhaps three ophiolite remnants in the Khoy area:

- (1) A Late Jurassic (early to middle Oxfordian: 156 Ma to 159 Ma 40Ar-39Ar on gabbro) remnant;
- (2) A Late Cretaceous (early Coniacian: Radiolaria) remnant (~N-MORB geochemistry); and, possibly,
- (3) A Late Cretaceous (latest Campanian) remnant (E-MORB geochemistry).

Because it is impossible to use the term "Khoy ophiolite" in this report, we refer the ophiolitic rocks in the Khoy area to the "Khoy Complex" (sensu International Stratigraphic Guide).

The sedimentary contact between Late Cretaceous (early Coniacian) red manganeseiferous ribbon chert lacking calc-alkaline volcanic contributions and overlying pyroclastics (tuff and tuff breccia) in the far northwestern part of the Khoy complex is of great tectonostratigraphic significance. This interface represents a sudden change from pelagic to pyroclastic sedimentation. Field evidence indicates that the contact is disconformable and is associated with a hiatus of unknown magnitude. Red ribbon chert (lacking calcalkaline contributions) in the same area overlies and is interbedded with N-MORB pillow basalt; early Coniacian Radiolaria were recovered from interpillow siliceous mudstone. We postulate that by the early Coniacian oceanic crust (covered with a veneer of Radiolarian ooze) had moved close enough to an island arc system to receive calc-alkaline pyroclastics.

Tectonic mélange in the Khoy Complex represents a subduction complex probably associated with the island arc noted above. Micrite (pelagic limestone) knockers in the tectonic mélange belt contain Early Cretaceous (late Albian: Vraconian) planktonic foraminifera; Late Cretaceous (early Cenomanian) Radiolaria; Late Cretaceous (early Campanian to early Maastrichtian) planktonic foraminifera; Late Cretaceous (late Maastrichtian) planktonic foraminifera; and early Middle Eocene planktonic foraminifera. The age of the micrite knockers in the tectonic mélange, suggests that subduction associated with island arc volcanism continued from the Early Cretaceous (latest Albian) to the Early Tertiary (early middle Eocene).

PICKETT, E.A. & ROBERTSON, A.H.F. 2004. Significance of the volcanogenic Nilufer unit and related components of the Triassic Karakaya Complex for tethyan subduction/accretion processes in NW Turkey. *Turkish Journal of Earth Sciences* **13**(2), 97-143.

The Tethyan Karakaya Complex extends east-west across northern Turkey from the Aegean coast to Iran (c. 1100 km), and is interpreted as a Mid-Late Triassic subduction/accretion complex.

It comprises strongly deformed fragments of Triassic oceanic seamounts, mid-ocean ridge-type oceanic crust, trench-type sedimentary rocks (Ortaoba Unit) and Permian-Triassic continental fragments (Cal Unit). We focus on the Triassic Nilufer Unit, which comprises altered basic volcanic and volcanoclastic rocks, volcanogenic sedimentary rocks, heterogeneous debris flow deposits, calciturbidites, siliceous pelagic sedimentary rocks and, in places, Triassic shallow-water limestones. The predominant lithologies are massive basalt and reworked basic pyroclastic deposits. Additional detrital lithologies include volcanogenic sandstone/siltstone/mudstone and volcanogenic breccia. These lithologies document the construction of one, or several, volcanic seamounts within the Triassic Tethyan ocean, removed from a supply of terrigenous detrital sediment. Whole-rock geochemical analysis of basalt and electron-microprobe analysis of clinopyroxene phenocrysts confirm a within-plate, "enriched" composition, without a detectable subduction influence. The Nilufer Unit generally exhibits greenschist-facies metamorphism and locally also HP/LT (up to eclogitic) facies metamorphism. The structurally overlying Ortaoba (Hodul) Unit records the accretion of mid-ocean-ridge-type basalts, radiolarian chert and minor serpentinised ultramafic rocks in a trench-type setting where mainly arkosic sediments rich in altered silicic volcanic grains accumulated. Above this, the unmetamorphosed Cal Unit is dominated by blocks of Upper Permian neritic limestone associated with within-plate-type basalt. The bases of locally intact successions are commonly positionally associated with micaceous shale of terrigenous origin suggesting the former presence of a continental substratum that was probably removed by subduction. One or more of such continental fragments were possibly rifted from the southern margin (Anatolides) and drifted northward across the Triassic Tethys before being accreted to the Eurasian margin. The direction of subduction related to initial tectonic accretion is assumed to have been northward although definitive structural evidence is lacking. The Karakaya Complex was finally emplaced northward over the leading edge of the Eurasian margin (Sakarya basement), possibly in response to the collision of the Cal continental fragment(s) with the subduction zone, prior to covering by shelf carbonate in middle Jurassic time. PISIAS, N.G., HEUSSER, L., HEUSSER, C., HOSTETLER, S.W., MIX, A.C. & WEBER, M. 2006. Radiolaria and pollen records from 0 to 50 ka at ODP Site 1233: continental and marine climate records from the Southeast Pacific. *Quaternary Science Reviews* 25(5-6), 455-473.

Site 1233 drilled during Leg 202 of the Ocean Drilling Program provides a detailed record of marine and continental climate change in the Southeast Pacific and South American continent. Splits from over 500 samples taken at 20cm intervals for quantitative analysis of radiolarian and pollen Populations yield it temporal resolution of 200-400 years. In each sample, 39 pollen taxa and 40 radiolarian species and genera were evaluated. Age control is provided by 25 AMS C-14 dates [Lamy, F., Kaiser, J., Ninnemann, U., Hebbeln, D., Arz, H.W., Stoner, J., 2004. *Science* 304, 1959-1962]. Multivariate statistical analyses of these data allow us to conclude the following: (1) During the past 50 ka the region of the central Chile coast is not directly influenced by polar water from the Antarctic region. (2) Changes in ocean conditions off central Chile during this time interval primarily reflect north-south shifts in the position of the South Pacific transition zone. (3) Changes in Chilean vegetation reflect comparable latitudinal shifts in precipitation and the position of the southern westerlies. (4) The first canonical variate of radiolarian and pollen records extracted from Site 1233 are remarkably similar to each other as well as to temperature records from the Antarctic, which suggests that marine and continental climate variability in the region is tightly coupled at periods longer than 3000 years. (5) The phase coupling of these climate records, which lead variations of continental erosion based on iron abundance at the same site, are consistent with a hypothesis that erosion is linked to relatively long (i.e. few thousand years) response times of the Patagonian ice sheet, and thus is not a direct indicator of regional climate.

PITTAU, P., COTZA, F., CRISTINI, S., DEL RIO,

M. & LOI, M. 2006. Palaeontologic and biogeochemical characterization of the *Cyrtograptus lundgreni* event in the black shales of eastern Mid-Sardinia, Italy. *Lethaia* 39(2), 111-127.

A succession of biotic and geochemical changes that occurred during the *Cyrtograptus lundgreni* Event (Late Wenlock) have been recorded from the 'pelagic' black-shales in the Goni section, eastern mid-Sardinia, Italy. The studied interval encompasses the *Cyrtograptus rigidus* to *Pristiograptus dubius*-*Gothograptus nassa* zones. The fossil association includes graptolites, chitinozoans and microplankton i.e. probable linings of agglutinated foraminifera and radiolaria capsular membranes. Analysis of the chitinozoan distribution revealed a succession of several chitinozoan associations with low species diversity and dominated by opportunistic species. Three chitinozoan faunal turnovers and three extinction events have been recorded. Two of them coincide with graptolite extinctions whereas one probably is of local significance. Disappearance of the chitinozoan and microplankton associations occurred during four consecutive graptolite zones. Geochemical data (trace elements analysis) showed significantly higher (up to c. 100%) values for Co and Cd in the sedimentary organic matter (SOM) than in the whole rock samples. Possible relationships between peaks of metal enrichment, the major faunal changes among chitinozoans, extinction events among chitinozoans and graptolites and, to a certain extent, oceanic events may be inferred. The first extinction datum is older than those occurring in Gotland, Sweden and Thuringen, Germany and is so far considered to be of local significance. The second extinction datum of Sardinia can be matched with Datum 1 of Gotland and Thuringen. A close correlation between the third extinction datum of Sardinia and Datum 2 of Thuringen and Gotland reinforces the importance of these events at global scale.

POPOVA-GOLL, I.M. & GOLL, R.M. 2006. Cenozoic Radiolaria biostratigraphy of Hole 1223A in the North Pacific: ODP Leg 200. In: KASAHARA, J., STEPHEN, R.A., ACTON, G.D. & FREY, F.A. (Eds.), *Proc. ODP, Sci. Results*, pp. Avail. from World Wide Web: <http://www-odp.tamu.edu/publications/200_SR/007/007.htm>

Among the groups of oceanic microfossils, only Radiolaria occur in abundances and preservation states sufficient to provide biostratigraphic control for restricted intervals within sediments recovered in Hole 1223A. The distribution of these microfossils has been divided into four major intervals, A-D. Radiolaria distribution Interval A occupies the depth range 0-3.0 meters below seafloor (mbsf), where the abundance of specimens is very low and preservation is poor. Radiolaria distribution Interval B occupies the depth range 3.02-7.1 mbsf. Radiolaria in Interval B are locally rare to abundant and well preserved, and assemblages range in age from pure early Eocene to early Eocene admixed with late Neogene taxa. Radiolaria distribution Interval C occupies the depth range 7.1-36.99 mbsf and is characterized by sediments either barren of microfossils or containing extremely rare early Eocene specimens. Radiolaria distribution Interval D occupies the depth range 36.99-38.7 mbsf (base of the recovered sedimentary section), where early Eocene Radiolaria are present in rare to common frequencies, but opal-A to opal-CT recrystallization has degraded the preservation state. The late Neogene assemblage of Radiolaria distribution Interval B is dated at 1.55-2.0 Ma, based on occurrences of *Eucyrtidium matuyamai*, *Lamprocyclus heteroporos*, and *Theocorythium trachelium trachelium*. The early Eocene assemblage of Radiolaria distribution Intervals B and D is somewhat problematically assigned to the *Buryella clinata* Zone.

RIGO, M., DE ZANCHE, V., GIANOLLA, P., MIETTO, P., PRETO, N. & ROGGI, G. 2005. Correlation of Upper Triassic sections throughout the Lagonegro Basin. *Bollettino Della Societa Geologica Italiana* 124(1), 293-300.

The present paper is a preliminary contribution to the stratigraphy and conodont biostratigraphy of the Upper Triassic (Norian/Rhaetian) of the Lagonegro Basin (Southern Apennines, Italy). Four stratigraphic sections (Sasso di Castalda, Madonna del Sirino, Lagonegro, and Pignola-Abriola) were measured in basinal successions belonging to the Calcari con Selce (<<Cherty Limestones>>) and Scisti Silicei (<<Radiolarites>>) Fms. The former stratigraphic unit yielded a rich Alauanian (Middle Norian) to the Rhaetian conodont fauna. A red-clay horizon, widely used in literature as a physical correlation tool throughout the Lagonegro Basin, is here identified and dated to the Sevastian (upper Norian).

ROBINSON, S.A., WILLIAMS, T. & BOWN, P.R. 2004. Fluctuations in biosiliceous production and the generation of Early Cretaceous oceanic anoxic events in the Pacific Ocean (Shatsky Rise, Ocean Drilling Program Leg 198). *Paleoceanography* **19**(4).

Integration of geophysical logs with sedimentological, biostratigraphic, and physical properties data from poorly recovered chert-rich sequences at Ocean Drilling Program Leg 198 Sites 1207 and 1213 allows us to propose an Aptian-Albian (Early Cretaceous) depositional history for Shatsky Rise (North Pacific Ocean). The logs indicate that the lower Aptian and lower Albian deposits are relatively lithified and unporous compared to contiguous sediments. These characteristics are best explained by increased siliceous cementation that resulted from an elevated flux of radiolarians to the seafloor. The intervals of increased biosiliceous production may record a biotic response to enhanced nutrient delivery, coeval with (but longer in duration than) oceanic anoxic events (OAEs) 1a (early Aptian) and 1b (early Albian). On Shatsky Rise, OAE 1a is represented by organic-carbon-rich sediments, but OAE 1b is not. Thus "black shale" deposition in the Pacific Ocean was only possible when a "carbon-burial threshold" was crossed. We speculate that this threshold was related to the balance between productivity and carbon oxidation and that, ultimately, the supply of biolimiting nutrients through hydrothermal alteration of basalt may have been the key to the development of "black shale" in the Pacific basin.

ROJAY, B., ALTINER, D., ALTINER, S.O., ONEN, A.P., JAMES, S. & THIRLWALL, M.F. 2004. Geodynamic significance of the Cretaceous pillow basalts from North Anatolian Ophiolitic Melange Belt (Central Anatolia, Turkey): geochemical and paleontological constraints. *Geodinamica Acta* **17**(5), 349-361.

The most widespread blocks within the Cretaceous ophiolitic melange (North Anatolian ophiolitic melange) in Central Anatolia (Turkey) are pillow basalts, radiolarites, other ophiolitic fragments and Jurassic-Cretaceous carbonate blocks. The pillow basalts crop out as discrete blocks in close relation to radiolarites and ophiolitic units in Cretaceous ophiolitic melange. The geochemical results suggest that analyzed pillow basalts are within-plate ocean island alkali basalts. The enrichment of incompatible elements (Nb, Ta, Light REE, Th, U, Cs, Rb, Ba, K) demonstrates the ocean island environment (both tholeiites and alkali basalts) and enriched MORB. Dated calcareous intrafills and biotrital carbonates reveal an age span of Callovian-Early Aptian. The thin-shelled protoglobigerinids, belonging to the genus *Globuligerina*, in the calcareous intrafills between pillow basalt lobes indicates a Callovian-Barremian age interval, most probably, Valanginian to Late Barremian. The volcanic and radiolarite detritus-bearing orbitolinid-*Baccinella* biotrital carbonates dated as Late Barremian-Early Aptian in age, were probably deposited around atolls and have a close relationship with the ocean island pillow basalts. The results collectively support the presence of a seamount on the Neo-Tethyan oceanic crust during the Valanginian-Late Barremian and atolls during the Late Barremian-Early Aptian interval. The presence of an oceanic crust older than that seamount along the Northern Branch of Neo-Tethys is conformable with the

geodynamic evolution of the Tethys.

SACCANI, E. & PHOTIADES, A. 2005. Petrogenesis and tectonomagmatic significance of volcanic and subvolcanic rocks in the Albanide-Hellenide ophiolitic melanges. *Island Arc* **14**(4), 494-516.

Ophiolitic melanges associated with ophiolitic sequences are wide spread in the Mirdita-Subpelagonian zone (Albanide-Hellenide Orogenic Belt) and consist of tectonosedimentary 'block-in-matrix-type' melanges. Volcanic and subvolcanic basaltic rocks included in the main melange units are studied in this paper with the aim of assessing their chemistry and petrogenesis, as well as their original tectonic setting of formation. Basaltic rocks incorporated in these melanges include (i) Triassic transitional to alkaline within-plate basalts (WPB); (ii) Triassic normal (N-MORB) and enriched (E-MORB) mid-oceanic ridge basalts; (iii) Jurassic N-MORB; (iv) Jurassic basalts with geochemical characteristics intermediate between MORB and island arc tholeiites (MORB/IAT); and (v) Jurassic boninitic rocks. These rocks record different igneous activities, which are related to the geodynamic and mantle evolution through time in the Mirdita-Subpelagonian sector of the Tethys. Melange units formed mainly through sedimentary processes are characterized by the prevalence of materials derived from the supra-subduction zone (SSZ) environments, whereas in melange units where tectonic processes prevail, oceanic materials predominate. In contrast, no compositional distinction between structurally similar melange units is observed, suggesting that they may be regarded as a unique melange belt extending from the Hellenides to the Albanides, whose formation was largely dominated by the mechanisms of incorporation of the different materials. Most of the basaltic rocks surfacing in the MOR and SSZ Albanide-Hellenide ophiolites are incorporated in melanges. However, basalts with island arc tholeiitic affinity, although they are volumetrically the most abundant ophiolitic rock types, have not been found in melanges so far. This implies that the rocks forming the main part of the intraoceanic arc do not seem to have contributed to the melange formation, whereas rocks presumably formed in the forearc region are largely represented in sedimentary-dominated melanges. In addition, Triassic E-MORB, N-MORB and WPB included in many melanges are not presently found in the ophiolitic sequences. Nonetheless, they testify to the existence throughout the Albanide-Hellenide Belt of an oceanic basin since the Middle Triassic.

SAKAGUCHI, M., NAKAYAMA, T., HASHIMOTO, T. & INOUE, I. 2005. Phylogeny of the centrohelida inferred from SSU rRNA, tubulins, and actin genes. *Journal of Molecular Evolution* **61**(6), 765-775.

Amoeboid protists are major targets of recent molecular phylogeny in connection with reconstruction of global phylogeny of eukaryotes as well as the search for the root of eukaryotes. The Centrohelida are one of the major groups of Heliozoa, classified in the Actinopodida, whose evolutionary position is not well understood. To clarify the relationships between the Centrohelida and other eukaryotes, we sequenced SSU rRNA, alpha-tubulin, and beta-tubulin genes from a centroheliozoan protist, *Raphidiophrys contractilis*. The SSU rRNA phylogeny showed that the Centrohelida are not closely related to other heliozoan groups, Actinophryida, Desmothoracida, or Taxopodida. Maximum likelihood analyses of the combined phylogeny using a concatenate model for an alpha + beta-tubulin + actin data set, and a separate model for SSU rRNA, alpha- and beta-tubulin, and actin gene data sets revealed the best tree, in which the Centrohelida have a closer relationship to Rhodophyta than to other major eukaryotic groups. However, both weighted Shimodaira-Hasegawa and approximately unbiased tests for the concatenate protein phylogeny did not reject alternative trees in which Centrohelida were constrained to be sisters to the Amoebozoa. Moreover, alternative trees in which Centrohelida were placed at the node branching before and after Amoebozoa or

Viridiplantae were not rejected by the WSH tests. These results narrowed the possibilities for the position of Centrohelida to a sister to the Rhodophyta, to the Amoebozoa, or to an independent branch between the branchings of Amoebozoa and Rhodophyta (or possibly Plantae) at the basal position within the bikonts clade in the eukaryotic tree.

SCHMIDT, D.N., LAZARUS, D., YOUNG, J.R. & KUCERA, M. 2006 (in press). Neogene climate and body-size evolution of marine plankton. *Earth Science Reviews*.

Body size is a central feature of any organism, reflecting its physiology, ecology and evolutionary history. Marine microplankton are major contributors to the particulate inorganic carbonate (foraminifers and coccolithophorids) and opal flux (radiolaria and diatoms) in the ocean and, hence, size changes in these organisms can influence global biogeochemical cycles.

This paper is discussing abiotic influences on micro- and macroecological size changes among major marine plankton groups, linking these to evolutionary size changes during the Neogene. We review the patterns and outline the causes of size changes geographically and through time in coccolithophorids, foraminifers and radiolarians. The main feature of the Neogene size record is a dramatic size increase in foraminifers, a similarly dramatic reduction in the size range of coccolithophorids and highly variable size patterns in radiolarians. We argue that the observed pattern is too complex to be explained by a simple common forcing and propose that speculations on the response of oceanic biomineralisation to global warming have to consider the scales at which marine plankton evolve.

SENOWBARI-DARYAN, B. 2005. Fossil names dedicated to Erik Flugel. *Facies* **51**(1-4), 3-11.

There are 3 genera and at least 19 species names of fossils, attributed to calcareous algae, sponges, hydrozoans, corals, ammonites, gastropods, foraminifers, and radiolarians that have been dedicated to Erik Flugel. These are listed with their original diagnosis or description and re-illustrations of the holotypes.

SERVAIS, T., BLIECK, A., CARIDROIT, M., CHEN, X., PARIS, F. & TORTELLO, M.F. 2005. The importance of plankton and nekton distributions in Ordovician palaeogeographical reconstructions. *Bulletin De La Societe Geologique De France* **176**(6), 531-543.

Trilobites and brachiopods are the two main fossil groups that allowed construction of the first palaeogeographical maps for the early Palaeozoic. Together with the bivalves and ostracodes, the benthic elements of these fossil groups have proved to be of great palaeobiogeographical importance. For this reason, these groups are usually considered to be 'better' fossils for inferring Ordovician palaeogeography. The present study indicates that planktic and nektic fossil groups should not be neglected in such palaeobiogeographical studies. The plotting on a palaeogeographical reconstruction for the Arenig (Lower Ordovician, ~480 Ma) of some planktic (acritarchs, chitinozoans) and nektic (vertebrates, pelagic trilobites) fossil groups indicates that their distribution appears in part surprisingly similar to that of the benthic trilobite faunas that are considered to display the greatest provincialism. For example, the distribution of the 'peri-Gondwanan' acritarch province including *Arbusculidium filamentosum*, *Coryphidium* and *Striatotheca*, and the distribution of the *Ereniochitina brevis* chitinozoan assemblage are almost identical to the palaeogeographical distribution of the Calymenacean-Dalmanitacean trilobite fauna. A review of the different planktic and nektic fossil groups also indicates that it is very important to carefully select 'good' palaeogeographical indicators, in most cases from a large number of taxa. It appears that almost all fossil groups include some 'good' palaeobiogeographical 'markers'. Therefore it is important to

search for 'better' taxa within each fossil group, instead of looking only for the 'better' fossil groups as a whole.

SHI, L., SUN, X.D., LI, H.D. & WENG, D. 2006. Hydrothermal growth of novel radiolarian-like porous ZnO microspheres on compact TiO₂ substrate. *Materials Letters* **60**(2), 210-213.

Radiolarian-like porous ZnO microspheres, consisting of ZnO nanosheets about 500 nm in length, 100 nm in width and 50 nm in thickness, have been synthesized by a facile hydrothermal process on compact TiO₂ substrate. The products were characterized and analyzed by SEM, TEM and XRD. Selected Area Electron Diffraction (SAED) pattern reveals that the nanosheets in ZnO microspheres are single crystalline. The preference orientation along (1010) plane was observed by the XRD and SAED results. A possible formation mechanism was preliminarily proposed for the formation of the novel nanostructure.

SLACK, J.F., DUMOULIN, J.A., SCHMIDT, J.M., YOUNG, L.E. & ROMBACH, C.S. 2004. Paleozoic sedimentary rocks in the Red Dog Zn-Pb-Ag district mid vicinity western Brooks Range, Alaska: Provenance, deposition, and metallogenic significance. *Economic Geology* **99**(7), 1385-1414.

Geochemical analyses of Paleozoic sedimentary rocks in the western Brooks Range reveal a complex evolutionary history for strata surrounding the large Zn-Pb-Ag deposits of the Red Dog district. Data for major elements, trace elements, and rare earth elements (REE) were obtained on 220 samples of unaltered and unmineralized siliciclastic rocks from the Upper Devonian-Lower Mississippian Endicott Group (Hunt Fork Shale, Noatak Sandstone, Kanayut Conglomerate, Kavak Shale), the overlying Carboniferous Lisburne Group (Kona Formation, unnamed drowned shelf facies), and the Pennsylvanian-pennian Silaikpuk-Formation. Major base metal sulfide deposits of the region are present only in the Kuna Formation, which in the Red Dog district comprises siliceous black shale and black chert, minor limestone (calcareous radiolarite), and sparse lithic turbidite and bedded siliceous rock. Gray and rare black shales of the Kayak Shale and common black shales of the Kuna Formation are anomalously low in iron (avg Fe/Ti = 6.25 and 6.34, respectively) relative to other Paleozoic shales in the region (9.58-10.6) mid to average Shales worldwide (10.1-10.5). In contrast, the bedded siliceous rocks contain appreciable hematite (avg Fe/Ti = 35.0) and high U/Ti and REE/Ti ratios that are interpreted to reflect low amounts of detrital material and a major Fe-rich eolian component. Geochemical data (e.g., MnO < 0.01 wt %; avg, Cr = 317 ppm), sizes of framboidal pyrite grains, and limited bioturbation suggest anoxic and denitrifying depositional conditions for most black shales of the Kuna Formation; low Mo/Ti ratios argue against euxinic (sulfate-reducing) conditions. Organic-rich black shales of the Kuna Formation with up to 8.4 wt percent C-organic and gray to black shales of the Kayak Shale with up to 4.1 wt percent C-organic typically have only sparse pyrite (< 1 wt % S) and very low iron-limited S/C ratios (mostly < 0.2). immobile element plots (e.g., Th-Zr/10-Sc) suggest that source terranes for all of the formations were dominated by one or more felsic-rich continental arcs; a small proportion of recycled sediments is present locally. A minor mafic igneous component also occurs in several shales of the Kuna and Siksikpuk Formations. High average values for the chemical index of alteration [Al₂O₃/(Al₂O₃+CaO+Na₂O+K₂O)] for shales of the Endicott Group (76.4-81.5) imply moderate to intense chemical weathering in source areas of these sediments. A lower average for black shales of the Kuna Formation (73.7) does not, require such weathering. Textural and geochemical data record the effects of diagenetic and/or hydrothermal fluid flow in some of the 0-11 Paleozoic rocks. Mobility of P, F, U, and light REE is documented in black shales of the Kuna Formation by, phosphate replacements of carbonate clasts and of matrix material surrounding the clasts. A relatively low average Ce/Cedegrees value of 0.73 for P-poor black shales of the Kuna Formation (less than or equal to 0.05 wt % P₂O₅) and a similar Ce/Cedegrees

value of 0.78 for a siderite concretion in Kavak Shale suggest that these diagenetic fluids were oxidizing. Many shales of the Kuna Formation have high $(K_2O \times 100)/(K_2O/Al_2O_3)$ ratios of 21.0 to 23.0, which contrast with low ratios of generally < 18.0 for shales of the underlying Endicott Group. The high ratios in shales of the Kuna Formation reflect preferential reaction of smectite to illite during the Jurassic-Cretaceous Brookian orogeny owing to high silica activities in pore fluids that were generated by the dissolution of abundant biogenic silica. The distribution and composition of Paleozoic strata in the western Brooks Range may have owed a fundamental role in Zn-Pb mineralization of the Red Dog district. In our model deposition and early lithification of biogenic chert and bedded siliceous rocks in the upper part of the Kuna Formation served as a regional hydrologic seal, acting as a cap rock to heat and hydrothermal fluids during Late Mississippian base-metal mineralization. Equally important was the iron-poor composition of black shales of the Kuna Formation (i.e., low Fe/Ti ratios), which limited syndepositional pyrite formation in precursor sediments, resulting in significant H_2S production in pore waters through the interaction of aqueous sulfate with abundant organic matter. This H_2S may have been critical to the subsurface deposition of the huge quantities of Zn and Pb in the district. On the basis of this model, we propose that low Fe/Ti and S/C ratios in black shale sequences are potential basin-scale exploration guides for giant sediment-hosted, stratiform Zn-Pb-Ag deposits.

SPERLING, E.A. & INGLE, J.C. 2006. A Permian-Triassic boundary section at Quinn River Crossing, northwestern Nevada, and implications for the cause of the Early Triassic chert gap on the western Pangean margin. *Geological Society of America Bulletin* **118**(5-6), 733-746.

The Upper Permian-Lower Triassic Quinn River Formation in northwestern Nevada was previously thought to represent an incomplete Permian-Triassic boundary sequence, owing to an inferred disconformable relationship between Permian radiolarian- and spicule-rich chert and overlying Triassic siltstone. Petrographic and geochemical studies demonstrate that the "siltstone" is in fact a radiolarian-bearing early authigenic dolomicrite, with both the chert and dolomicrite deposited conformably in deep water. Chert production declined or ceased in the Late Permian and reappeared in the Spathian, forming a widespread "chert gap" in Permian-Triassic sequences. Given the conformable lithofacies relationships, deepwater depositional setting, new radiolarian data extending ranges of key taxa, and the presence of the global chert gap, sedimentation in the Quinn River Formation was apparently continuous across the Permian-Triassic boundary. This represents the first Permian-Triassic boundary section in the United States portion of the North American Cordillera, and one of the few deep-water sections worldwide. Organic carbon isotope stratigraphy of the Quinn River Formation displays multiple excursions through sediments of Wuchiapingian-Anisian age, with a negative excursion 1.54 m above the chert-shale transition likely representing the Permian-Triassic boundary. The multiple excursions in the organic carbon record verify studies of the carbonate carbon record in China that suggest instability in the isotopic record throughout the Early Triassic, and demonstrate that the Permian-Triassic boundary isotope excursion was not an isolated event. Stratigraphic variation in redox-sensitive trace metals indicates that seawater became less oxidizing slightly before the chert-shale transition, in turn impacting siliceous sponge communities and creating the widespread chert gap. The distinctive dolomicrites in the Quinn River Formation represent a widespread lithofacies deposited in many localities during the Late Permian-Early Triassic and express early authigenic formation of dolomite via microbial sulfate reduction in organic-rich, low-oxygen environments.

SRIVASTAVA, R.K., CHANDRA, R. & SHASTRY, A. 2004. High-Ti type N-MORB parentage of basalts from the south Andaman ophiolite suite, India. *Proceedings of the Indian Academy of Sciences-Earth and Planetary Sciences*

113(4), 605-618.

A complete dismembered sequence of ophiolite is well exposed in the south Andaman region that mainly comprises ultramafic cumulates, serpentinite mafic plutonic and dyke rocks, pillow lava, radiolarian chert, and plagiogranite. Pillow lavas of basaltic composition occupy a major part of the Andaman ophiolite suite (AOS). These basalts are well exposed all along the east coast of southern part of the south AOS. Although these basalts are altered due to low-grade metamorphism and late hydrothermal processes, their igneous textures are still preserved. These basalts are mostly either aphyric or phyric in nature. Aphyric type exhibits intersertal or variolitic textures, whereas phyric variety shows porphyritic or sub-ophitic textures. The content of alkalis and silica classify these basalts as sub-alkaline basalts and alkaline basalts. A few samples show basaltic andesite, trachybasalt, or basanitic chemical composition. High-field strength element (HFSE) geochemistry suggests that studied basalt samples are probably derived from similar parental magmas. Al_2O_3/TiO_2 and CaO/TiO_2 ratios classify these basalts as high-Ti type basalt. On the basis of these ratios and many discriminant functions and diagrams, it is suggested that the studied basalts, associated with Andaman ophiolite suite, were derived from magma similar to N-MORB and emplaced in the mid-oceanic ridge tectonic setting.

STANLEY, S.M. 2006. Influence of seawater chemistry on biomineralization throughout Phanerozoic time: Paleontological and experimental evidence. *Palaeogeography, Palaeoclimatology, Palaeoecology* **232**(2-4), 214-236.

Although some organisms exercise considerable control over their biomineralization, seawater chemistry has affected skeletal secretion by many taxa. Secular changes in the magnesium/calcium ratio and absolute concentration of calcium in seawater, driven by changes in rates of deep-sea igneous activity, have influenced the precipitation of nonskeletal carbonates: low-Mg calcite forms when the ambient Mg/Ca molar ratio is 2 through calcification use it in their photosynthesis, an increase in the ambient Mg/Ca ratio results in accelerated aragonite secretion and overall growth for corals, and a decrease in the Mg/Ca ratio results in greatly accelerated growth rates for calcitic coccolithophores. Controlled experiments show that the increased concentration of Ca that accompanies a reduction of the ambient Mg/Ca ratio also accelerates coccolithophore population growth. Coccolithophores' production of vast chalk deposits in Late Cretaceous time can be attributed to the low Mg/Ca ratio and high Ca concentration in ambient seawater. The high Mg/Ca ratio and low Ca concentration in modern seawater apparently limit population growth for the large majority of modern coccolithophore species: ones that fail to respond to nitrate, phosphate or iron fertilization and are confined to oligotrophic waters. Presumably the low Mg/Ca ratio of ambient seawater was at least partly responsible for reduced reef-building by scleractinian corals in Late Cretaceous time. Some taxa have secreted more robust skeletons when seawater chemistry has favored their skeletal mineralogy. Strong intrinsic control of biomineralization can buffer a taxon against secular changes in seawater chemistry. Mollusks, for example, evolved the ability to severely limit the incorporation of Mg in their skeletal calcite in seawaters with Mg/Ca ratios as high as that of the present, but not in seawaters with still higher ratios. The ability to exclude Mg is useful because Mg reduces the rate of step growth of calcite crystals. On the other hand, labile skeletal mineralogy has permitted some taxa to respond to secular changes in the Mg/Ca ratio of seawater via phenotypic or evolutionary shifts of skeletal mineralogy. Sponges and bryozoans have apparently undergone evolutionary shifts of this kind polyphylogenetically. Increased incorporation of Mg in skeletal calcite with secular increases in the concentration of Mg in seawater has had little effect on seawater chemistry. In contrast, removal of Si by diatoms beginning in late Mesozoic time lowered the concentration of silicic acid in seawater, forcing siliceous sponges to secrete less robust skeletons.

STEPANJANTS, S.D., CORTESE, G.,

KRUGLIKOVA, S.B. & BJØRKLUND, K.R. 2006. A review of bipolarity concepts: history and examples from Radiolaria and Medusozoa (Cnidaria). *Marine Biology Research* **2**(3), 200-241 DOI: 10.1080/17451000600781767.

Bipolarity, its history and general interpretation are investigated and discussed herein. Apart from the classical view, namely that a bipolar distribution is a peculiar biogeographical phenomenon, we propose that it is ecologically controlled too. This approach was used for bipolarity assessment within the following groups: Phaeodaria, Nassellaria, Spumellaria (Radiolaria) and Medusozoa (Cnidaria). We recognize 46 bipolar radiolarian species and three radiolarian genera. However, although species concepts in radiolarians are relatively stable and well known, the high-rank taxonomy of radiolarians is still not well defined. Caution should therefore be taken in the interpretation of distribution data at a taxonomic level higher than the species. In the Medusozoa, bipolarity is observed for 23 species and 32 genera. The different ways in which bipolarity can develop are discussed under the different groups, but preference has been given to the recent and most probable routes of migration. In our investigation of the bipolarity phenomenon, we reviewed more than 400 articles dealing with taxonomy, ecology and biogeography of the modern fauna in both groups.

STOECK, T., HAYWARD, B., TAYLOR, G.T., VARELA, R. & EPSTEIN, S.S. 2006. A multiple PCR-primer approach to access the microeukaryotic diversity in environmental samples. *Protist* **157**(1), 31-43.

The Cariaco Basin off the Venezuelan coast in the Caribbean Sea is the world's largest truly marine body of anoxic water. The first rRNA survey of microbial eukaryotes in this environment revealed a number of novel lineages, but sampled only a fraction of the entire diversity. The goal of this study was to significantly improve recovery of protistan rRNA from the Basin. This was achieved by a systematic application of multiple PCR primer sets and substantially larger sequencing efforts. We focused on the most diverse habitat in the basin, anoxic waters approximate to 100m below the oxic-anoxic interface, and detected novel lineages that escaped the single PCR primer approach. All clones obtained proved unique. A 99% sequence similarity cut-off value combined these clones into operational taxonomic units (OTUs), over 75% of which proved novel. Some of these OTUs form deep branches within established protistan groups. Others signify discovery of novel protistan lineages that appear unrelated to any known microeukaryote. Surprisingly, even this large-scale multi-primer rRNA approach still missed a substantial part of the samples' rRNA diversity. The overlap between the species lists obtained with different primers is low, with only 4% of OTUs shared by all three libraries, and the number of species detected only once is large (55%). This strongly indicates that, at least in anoxic environments, protistan diversity may be much larger than is commonly thought. A single sample appears to contain thousands of largely novel protistan species. Multiple PCR primer combinations may be needed to capture these species.

SUN, D. & XIA, W. 2006. Identification of the Guadalupian-Lopingian boundary in the Permian in a bedded chert sequence, South China. *Palaeogeography, Palaeoclimatology, Palaeoecology* **236**(3-4), 272-289.

Middle-Upper Permian conodont biostratigraphy was examined in a bedded chert section in Dachongling area of southeastern Guangxi Zhuang Autonomous Region, South China. Four conodont zones were recognized, namely, *Jinogondolella granti* Zone, *Clarkina postbitteri hongshuiensis* Zone, *Clarkina postbitteri postbitteri* Zone, and *Clarkina dukouensis* Zone, in ascending order. The four conodont zones can be correlated with those recognized previously in bathyal carbonate and lime-chert

sequences. On the basis of the correlation, we identified the Guadalupian-Lopingian (G-L) geochronostratigraphic boundary (i.e. the basal boundary of Lopingian Series) in the Permian. Six radiolarian zones were also recognized in the same section, namely, *Pseudoalbaillella longtanensis* Zone, *Pseudoalbaillella globosa* Zone, *Follicucullus monacanthus* Zone, *Follicucullus scholasticus* Zone, *Follicucullus charveti* Zone and *Albaillella levis* Zone, in ascending order. Correlations between radiolarian zones and conodont zones are shown here. The ecological evolutionary process of conodonts and radiolarians changed abruptly through the inferred G-L geochronostratigraphic boundary. Besides these, a geochemical anomalous zone with the higher Ce / Ce* values occurred underlying the G-L geochronostratigraphic boundary and petrological diagnoses around the G-L boundary changed. The abrupt change of ecological evolution in coincidence with the geochemical anomalous zone and change of petrological diagnoses might show the pre-Lopingian catastrophic event of marine faunas. The reason of the event of marine faunas may be that a regression occurred at the end of the Guadalupian.

SUN, D., ZHANG, H. & XIA, W. 2005. Response of the pre-Lopingian marine animal crisis event in chert sequence. *Dizhi Xuebao* **79**(5), 587-594.

In a bedded chert section at Dachongling in Xiaodong town of Qingzhou, Guangxi, the authors found a rare earth elements (REE) geochemical anomaly zone with higher Ce/Ce values, a positive Ce anomaly zone (the background is negative Ce anomalous zone) in the shale-normalized REE pattern, and a zone of sharp lithological change at the basal boundary of the Lopingian Series. These zones coincide with the zone of sharp change in radiolarian groups. This fact may indicate that the pre-Lopingian crisis event are reflected very well in this section. It is inferred that the cause of the event was a global regression at the end of the Guadalupian, and the event continued for a long time that is equal to the late Capitanian period.

SUZUKI, N. 2006. Ontogenetic growth and variation in the skeletal structure of two Late Neogene *Sphaeropyle* species (Polycystina radiolarians). *Journal of Paleontology* **80**(5), 849-866.

Two four-shelled species characterized by a pylome-bearing outermost shell--*Sphaeropyle robusta* and its descendant, *Sphaeropyle langii*--are selected for morphological study. Both species are morphologically identical to three-shelled *Actinomma* morphotypes, morphotypes A and B, respectively. Furthermore, the number of pores on half a circumference of the primary cortical shell, the distinguishing feature between *Sphaeropyle robusta* and *Sphaeropyle langii*, accounts for the same between *Sphaeropyle robusta* and morphotype A, and between *Sphaeropyle langii* and morphotype B. It suggests that the three-shelled morphotypes A and B are juvenile forms of the four-shelled *Sphaeropyle robusta* and *Sphaeropyle langii*, respectively. This is strongly supported by the same stratigraphic distributions of each pair. The quantitative analysis of morphological variations in both species also revealed that they have nearly identical morphology, except for the number of pores on half a circumference of the primary cortical shell. In addition, the size range of primary and secondary cortical shells and the range of the number of radial spines increase in *Sphaeropyle langii*, while the length range of radial spines decrease.

TAKIGUCHI, T., SUGITANI, K., YAMAMOTO, K. & SUZUKI, K. 2006. Biogeochemical signatures preserved in ancient siliceous sediments; new perspectives to Triassic radiolarian bedded chert compositions. *Geochemical Journal* **40**(1), 33-45.

Major and minor elements of successively collected 70 Middle Triassic radiolarian bedded cherts from the Mino Belt in central Japan were studied. In order to reveal pre-diagenetic, primary geochemical signatures related to marine biogeochemical cycles,

composite data of chert-shale couplets in addition to raw data were examined. The results show that Mn, Cu, Sr, Ba and P were supplied significantly by non-lithogenic excess fractions. Positive correlation with SiO₂/TiO₂ suggests that accumulations of Ba, Sr, Mn and Cu were closely related to sedimentation of biogenic silica; Mn and Cu were probably incorporated into oxides, whereas Ba into barite. Relationship between SiO₂/TiO₂ and excess-Ba, proxy for surface productivity implies that regeneration of silica from sinking radiolarian tests was not significant. This may have been caused by an expected relatively short travel time of radiolarian tests from the ocean surface to the bottom, reflecting their large size compared with diatoms. Positive correlations between CaO and P₂O₅ imply that apatite species are host phases for P and Ca. Although conodont composed of apatite is abundant in both chert and shale, their CaO/P₂O₅ ratio differs markedly from those of cherts and shales. Other apatite species, possibly carbonate apatite of diagenetic origin, are present in the bedded cherts and contribute to excess-P accumulation. Early diagenesis is believed to have modified only slightly primary geochemical features of the studied bedded cherts. This suggests relatively oxic depositional environment for the bedded cherts, under which regeneration of redox sensitive elements were not active.

TANAKA, S. & TAKAHASHI, K. 2005. Late Quaternary paleoceanographic changes in the Bering Sea and the western subarctic Pacific based on radiolarian assemblages. *Deep-Sea Research Part II-Topical Studies in Oceanography* **52**(16-18), 2131-2149.

Seven piston cores were obtained from the Bering Sea and the western subarctic Pacific during Cruise KH99-3 of R.V. Hakuohmaru in August 1999: Cores BOW-8A, BOW-9A, BOW-12A, AB, UMK-3A, GAT-3A in the Bering Sea, and Core ES in the western subarctic Pacific. The quantitative high-resolution analyses of radiolarians in the cores revealed significant variations in both their faunal assemblages and accumulation rates (AR). A trend of conspicuous turn-over of the surface dwellers and intermediate dwellers (increase of one at expense of the other) after the last glacial maximum (LGM) is clearly visible in the Bering Sea data set. However, this turn-over is not present at Site ES in the western subarctic Pacific core. These changes in radiolarian assemblages around the LGM suggest that the surface waters had extremely low temperature and low salinity and that the subsurface dichothermal layer (temperature minimum layer) was thickened all the way across the entire east west span of the Bering Sea. Furthermore, sea-ice coverage extended to the central Aleutian Basin around the LGM. This suggests that the water-mass structure in the western subarctic Pacific around the LGM was basically the same as that of the eastern Bering Sea based on the species composition of the surface dwellers. However, the detailed development of intermediate water masses differed from that of the eastern Bering Sea. During Marine Isotope Stage (MIS) 5 to 3, such species turn-over events did not occur and species abundance stayed relatively uniform in the studied cores. Therefore, the present water-mass structure is interpreted to have been formed after the LGM. Based on the relative abundances of *Cycladophora davisiana* (the most dominant species dwelling in the intermediate water, and a useful tracer of cold and well-oxygenated intermediate-water in the North Pacific), the past North Pacific Intermediate Water (NPIW) had the following source regions during the last 100 kyr: (1) both the Okhotsk Sea and the Bering Sea during MIS 5 to 3; (2) the Bering Sea around the LGM; and (3) shifting from the Bering Sea to the Okhotsk Sea after the LGM. Relatively low radiolarian AR at Site BOW-8A, which is the shallowest site studied here (present water depth: 884 m), were observed during the glacial periods. This is due to decrease of radiolarian production in the thinned upper water layer above the dichothermal layer caused by sea-level drop. *Cycladophora davisiana* probably lived deeper during the glacials than today, as it was absent in the shallow piston core.

TOKIWA, T., MORI, Y. & SUZUKI, H. 2005. Cretaceous radiolarian fossils from the Ryujin Formation of the Shimanto Belt in the Kawabe area,

Wakayama Prefecture, southwest Japan. *Journal of Earth and Planetary Sciences Nagoya University* **52**, 11-23.

This study is focused on radiolarian fossils newly found from the Ryujin Formation of the Shimanto Belt, southwest Japan. The Ryujin Formation is an accretionary complex, which is divided into three tectonostratigraphic units; structurally from lower Unit to upper; the Disrupted sandstone and shale (R1) Unit, the Greenstone-shale (Rm) and the Tuff-shale (Ru) Unit. Due to scarce findings of radiolarian fossils, there had been very little age data from this formation. The present study based on radiolarian defined the detailed age of each unit of the Ryujin Formation as follows; 1) the R1 Unit is the late Campanian, 2) the Rm Unit is roughly correlated with the middle Santonian to earliest Maastrichtian, 3) the Ru Unit is confirmed as late Campanian in age by several newly discovered radiolarian fossils regarded as the *Amphipyndax* interval zone. Results of the present study have confirmed that the Rm Unit, widely distributing in the Kawabe area, is characterized not by imbricated thrust structure but by the prevalence of folded structure.

TSOY, I.B., TEREKHOV, E.P., SHASTINA, V.V., GOROVAYA, M.T. & MOZHEROVSKII, A.V. 2005. Age of the Kotikovaya Group in the Terpeniya Peninsula (eastern Sakhalin). *Stratigraphy and Geological Correlation* **13**(6), 632-643.

Micropaleontological study of the Kotikovaya Group (the Terpeniya Peninsula of eastern Sakhalin) suggests the Paleogene age of its upper formations referred previously to the Upper Cretaceous. The basal Uchir Formation of volcanogenic and siliceous rocks yielded radiolarians characteristic of the Cretaceous-Paleogene (Maastrichtian-Danian) boundary beds. The overlying Zaslono,urovskoe, and Ol'don formations of predominantly terrigenous deposits contain scanty palynoflora and leaf imprints, which indicate the Early Paleogene (Paleocene-Eocene) age of their host sediments.

UCHINO, T., KURIHARA, T. & KAWAMURA, M. 2005. Early Carboniferous radiolarians discovered from the Hayachine Terrane, Northeast Japan: the oldest fossil age for clastic rocks of accretionary complex in Japan. *Journal of the geological Society of Japan* **111**(4), 249-252.

Early Carboniferous radiolarians were newly discovered from siltstone of the Nedamo Complex in the Hayachine Terrane, Northeast Japan. This siltstone and other clastic rocks along with greenstone and chert are the components of an accretionary complex. Radiolarian fauna contains *Palaoscenidium cladophorum* Deflandre that ranges in age from Early or Middle Devonian to Early Carboniferous. Since the Fe-Mn chert intercalated in a MORB-type basalt of the Nedamo Complex was assigned an age of Late Devonian (Hamano et al., 2002), the accretionary age of the Hayachine Terrane is no older than Late Devonian, most probable Early Carboniferous. This is the first report of an Early Carboniferous accretionary complex recognized by biostratigraphic data in Japan.

UMEDA, M. & TAGA, H. 2005. Note of occurrence of radiolarian fossils in the Nanjo Massif, Fukui Prefecture, central Japan -No.9- Hiuchi. *Bulletin of the Fukui City Museum of Natural History* **52**, 67-73.

The Hiuchi outcrop is situated near Imajo town, Fukui Prefecture, where the geology belongs to Mino Terrane of the Inner Zone of Southwest Japan. Field observation showed that this outcrop consists of turbidity mudstone and sandstone alternation, shale, bedded siliceous shale, and bedded chert. Late Early Jurassic to early Middle Jurassic radiolarian fossils were obtained from a manganese nodule in the shale. SEM photographs of these

radiolarians are presented.

URGORRI, V., GARCIA-ALVAREZ, O. & LUQUE, A. 2005. *Laevipilina cachuchensis*, a new neopilinid (Mollusca : Tryblidia) from off North Spain. *Journal of Molluscan Studies* **71**, 59-66.

A new tryblidian species, *Laevipilina cachuchensis*, is described from a depth of 580-600 m on 'El Cachucho' Bank (Asturias, north Spain). This resembles the three described species of *Laevipilina* McLean, 1979, differing mainly in shell characters (height/length ratio, apex position, size of prisms forming prismatic layer, relative size and arrangement of insertion areas of dorsoventral muscles), and details of radular morphology. Two living specimens (1.9 and 1.6 mm in length) were found on ferromanganese laminar nodules. The digestive content is of organic particles, sediment and fragments of foraminiferans and radiolarians.

VISHNEVSKAYA, V.S. 2006. New species of the family Heliodiscidae Haeckel (radiolaria). *Paleontological Journal* **40**(2), 134-142.

The family Heliodiscidae Haeckel, 1881, which includes five genera, is reviewed. New methods of investigation are applied to the inner structure of Cretaceous spherical radiolarian skeletons, which reveal numerous taxa with an eccentric microsphere. Three new species, *Astrophacus marinae* sp. nov., *Excentrosphaerella kovalenkovi* sp. nov., and *Excentrosphaerella kurilovi* sp. nov., are described. The eccentric position of the microsphere suggests that these forms are nontypical Mesozoic radiolarians or new representatives of the family Heliodiscidae Haeckel, 1881, which was previously recorded in the Cenozoic

VISHNEVSKAYA, V.S., BASOV, I.A. & KURILOV, D.V. 2006. The first joint find of Coniacian-Santonian radiolarians and planktonic foraminifers in western Kamchatka. *Doklady Earth Sciences* **409**(5), 701-705.

VISHNEVSKAYA, V.S., KAZINTSOVA, L.I. & KOPAEVICH, L.F. 2005. Radiolarians across the Albian-Cenomanian boundary (examples from the Russian platform). *Stratigraphy and Geological Correlation* **13**(4), 438-452.

Data on Albian and Cenomanian radiolarians from the Russian platform are summarized. In total, 110 radiolarian species from Albian sediments are identified in samples collected at six new localities in central areas of the platform. Radiolarians originally described by Kh. Aliev and R. Smirnova from Vladimir oblast and taxa characteristic of Mediterranean and Californian sections are abundant among the identified species. At some localities, radiolarians occur in association with foraminifers and nannoplankton. A perspective task is to search for sections in the studied areas, which contain radiolarians associated with macrofauna.

VOLKER, H., ANDRZEJ, S., GASINSKI, M.A. & BAK, M. 2005. Konradsheim Limestone of the Gresten Klippen Zone (Austria); new insight into its stratigraphic and paleogeographic setting. *Geologica carpathica* **56**(3), 237-244.

Biostratigraphic investigations of pelitic intercalations and pebbles within the Konradsheim Limestone (Gresten Unit, "Gresten Klippen Zone") in the area of Konradsheim and Pechgraben — Maria Neustift (Lower and Upper Austria) imply that at least a part of that limestone is Cretaceous and not only Jurassic in age. In marly intercalations Foraminifera assemblages with *Caudamina*

ovulum were found, in addition some pebbles in conglomeratic limestones contain Radiolaria of Early Cretaceous age. Therefore, the sedimentation of the Konradsheim Limestone lasted at least to the Early Cretaceous. The provenance of the Cretaceous Radiolaria bearing limestones is interesting, as north from the anticipated paleogeographical position of the Gresten Unit (European Platform) there are no similar deposits; they are only known from the Alpine realm. Implications for the Alpine and Carpathian geodynamic evolution are discussed.

WANG, R.J. & CHEN, R.H. 2005. *Cycladophora davisiana* (Radiolarian) in the Bering Sea during the late Quaternary: A stratigraphic tool and proxy of the glacial Subarctic Pacific Intermediate Water. *Science in China Series D-Earth Sciences* **48**(10), 1698-1707.

Cycladophora davisiana (Radiolarian) contents are counted in two cores of the Bering Sea and correlated well with the oxygen isotopic records of ice in the deep core obtained by the Greenland Ice Sheet Project II (GISP 2) and deep-sea sediments (SPECMAP) of the world oceans. Millennial scale climatic events, for example, Younger Dryas and Bolling/Allerod events, Heinrich1 and Dansgaard-Oeschger1 events, recorded by *C. davisiana* percents are distinguished from Core B4-2. *C. davisiana* events b, c(1), c(2), d, e(1) and e(2), respectively, corresponding to oxygen isotopic 2.0, 3.1, 3.3, 4.0, 5.1 and 5.3, are identified from Core B2-9. High resolution records of *C. davisiana* are tuned to the oxygen isotopic records in GISP 2 and SPECMAP and the depth-age frameworks are established in the two cores, supplying a stratigraphic base for future paleoceanographic and paleoclimatic studies. High *C. davisiana* during the glacial periods in the two cores indicate that they can serve as a proxy of the glacial Subarctic Pacific Intermediate Water, which verifies the glacial Subarctic Pacific Intermediate Water brought from the Bering Sea.

WANG, R.J., XIAO, W.S., LI, Q.Y. & CHEN, R.H. 2006. Polycystine radiolarians in surface sediments from the Bering Sea Green Belt area and their ecological implication for paleoenvironmental reconstructions. *Marine Micropaleontology* **59**(3-4), 135-152.

Radiolarian in surface sediments along transects from the shelf edge, along the slope into the deep basin of the northern Bering Sea are dominated by *Stylochlamydidium venustum*, *Antarctissa?* sp. 1, the Spongodiscidae juvenile, *Pseudodictyophimus gracilipes*, *Ceratospyrus borealis*, the Plagoniidae (*Phormacantha* group and *Plectacantha* group), *Siphocampe arachnea*, *Cycladophora davisiana* and *Spongotrochus glacialis*. This dominance is most extreme on the shelf edge and slope, where *S. venustum*, *Antarctissa?* sp. 1, the Spongodiscidae juvenile, the Plagoniidae and *S. glacialis* have their highest relative abundance. There is thus a close relation between radiolarian distribution and the high productivity of the "Bering Sea Green Belt" (BSGB) due to periodic sea ice melt. The radiolarian depth distribution patterns indicate that some radiolarian species have specific ecological preferences. *S. venustum*, the Spongodiscidae juvenile, and *S. glacialis* live close to the surface water under relatively low-temperature and low-salinity conditions due to sea ice melting or melt water influx. *Antarctissa?* sp. 1 appears to dwell mainly in surface to subsurface waters, but has not been recorded in trap samples of the Bering Sea. The Plagoniidae probably live in subsurface and intermediate waters. *S. arachnea* and *C. davisiana* are intermediate to deep dwellers. The close association of these radiolarians with the BSGB and specific water depths provides a valuable reference for paleoenvironmental reconstruction in the region.

WANG, Y.-J., YANG, Q., CHENG, Y.-N. & LI, J.-X. 2006. Lopingian (Upper Permian) radiolarian biostratigraphy of South China. *Palaeoworld* **15**(1), 31-53.

Lopingian (Upper Permian) radiolarian cherts are well-developed in shelf basinal facies, slope facies and deep oceanic basins in South China. Investigations during the last 20 years have resulted in the discovery of numerous radiolarian-bearing siliceous sections of the upper Palaeozoic, assignable to 23 radiolarian zones. Lopingian radiolarian sequences in South China are most complete and among the most comprehensively studied regions in the world for the upper Palaeozoic. The Lopingian radiolarian zonation in South China includes six biozones, namely, the *Follicuculus bipartitus*-*F. charveti*-*F. orthogonus* Zone, the *Foremanhelena triangula* Abundance Zone (Wuchiapingian), the *Albaillella protolevis* Zone, the *Albaillella levis*-*A. excelsa* Zone, the *Neoalbaillella ornithoformis* Zone and the *Neoalbaillella optima* Zone (Changhsingian). The first and second zones are assignable to the Wuchiapingian Stage and the third through sixth zones to the Changhsingian. Detailed features and distribution of these radiolarian zones are presented. Furthermore, an international correlation of the South China Lopingian radiolarian zones with those of Japan, Southeast Asia, USA and the Russian Far East region is made. This study suggests that palaeobiogeographically, the Lopingian radiolarian faunas are cosmopolitan in nature, with Asian Lopingian radiolarian faunas and those from North America, Europe and Australia quite similar in taxonomic composition and biozonation.

WANG, Y.B., XU, G.R., LIN, Q.X. & GONG, S.Y. 2001. Depositional model of Early Permian reef-island ocean in Eastern Kunlun. *Science in China Series D-Earth Sciences* **44**(9), 808-815.

Many fusulinid fossils have been found in thin- to middle-bedded limestones which are distributed between the Early Permian limestone hills and formerly considered as Early Triassic. The fusulinid fossils, identified as *Neoshwagerina* sp., *Verbeekina* sp. and *Schwagerina* sp., can also be found in massive limestone hills. At the same time, Early Permian radiolarian chert of deep basin facies was discovered in Animaqing. All the above show that the massive limestone hills, thin- to middle-bedded limestones and radiolarian chert belong to syndeposits in Early Permian ocean. The sediments in the study area can roughly be divided into three types: shallow facies, basin facies and transitional facies. The carbonate buildup can be subdivided into massive bioclastic limestone and reef framestone. Basin facies contains thin- or middle-bedded limestone, abyssal red mudstone or ooze, blue-green mudstone and radiolarian chert. Transitional facies includes reef talus and platform skirt facies. The Early Permian ocean in Eastern Kunlun is recognized as a kind of reef-island ocean environment according to distribution and composition of different facies. The reef-island ocean in Eastern Kunlun is characterized by reef islands (or carbonate buildups) alternating with basins, complicated sea-floor topography, sharp facial change and well-developed reefs.

XIA, W., ZHANG, N., KAKUWA, Y. & ZHANG, L. 2006. Radiolarian and conodont biozonation in the pelagic Guadalupian-Lopingian boundary interval at Dachongling, Guangxi, South China, and mid-upper Permian global correlation. *Stratigraphy* **2**(3), 217-238.

High-resolution microbiostratigraphy has identified six conodont zones and five coeval radiolarian zones in the Guadalupian-Lopingian (G-L) transitional interval from a section of middle and upper Permian pelagic cherts at Dachongling, near Qinzhou city in Guangxi, South China. The basal Lopingian GSSP at Penglitan, South China, is correlated with the base of bed Dch 45-21 at Dachongling on the basis of the first occurrence of the conodont *Clarkina postbitteri postbitteri* Mei and Wardlaw. The first appearances of the radiolarians *Albaillella yamakitai* Kuwahara and *A. cavitata* Kuwahara at the same level indicate that both FADs can be used for identifying the G-L boundary in radiolarian-bearing pelagic cherty facies. The appearance of both radiolarian species in the sections at Sasayama, Gujo-Hachima in Southwest

Japan, and in the Quinn River Formation of north-central Nevada, indicates that both boundary-index fossils can be traced worldwide. We therefore suggest that Dachongling section is a good candidate as an auxiliary reference section for the Guadalupian-Lopingian boundary.

YAO, A. 2005. Permian radiolarians from the Global boundary Stratotype section and Point for the Guadalupian-Lopingian boundary in the Laibin area, Guangxi, China. *Journal of Geosciences, Osaka City University* **48**, 95-107.

YAO, A., KUWAHARA, K., EZAKI, Y., LIU, J., HAO, W., LUO, Y. & KUANG, G. 2005. Permian and Triassic radiolarians from the western Guangxi area, China. *Journal of Geosciences, Osaka City University* **48**(Art. 5), 81-93.

YUASA, T., TAKAHASHI, O., DOLVEN, J.K., MAYAMA, S., MATSUOKA, A., HONDA, D. & BJORKLUND, K.R. 2006. Phylogenetic position of the small solitary phaeodarians (Radiolaria) based on 18S rDNA sequences by single cell PCR analysis. *Marine Micropaleontology* **59**(2), 104-114.

Within the holoplanktonic protists group Radiolaria, the Class Phaeodarea is today represented by several hundreds species. The phaeodarian skeletons consist of opaline silica as well as organic matter and are very fragile and vulnerable to dissolution. Their tests are therefore rarely found in the fossil records; this has caused uncertainty with regard to their phylogenetic evolution. In this study, small, solitary phaeodarian species, namely, *Protocystis xiphodon* (Haeckel), *Challengeron didon* Haeckel and *Conchellium capsula* Borgert were examined using molecular techniques in order to clarify the phylogenetic position of the Phaeodarea. The phylogenetic trees obtained from the neighbor-joining, maximum-parsimony and maximum-likelihood methods of analysis showed that all phaeodarians formed a monophyletic group within the Phylum Cercozoa. This result contradicts Haeckel's classical taxonomy, wherein the phaeodarians were grouped along with the polycystines, i.e., nassellarians and spumellarians, and the acantharians under the common name "Radiolaria". Within the cercozoan clade, the Phaeodarea were closely related to the euglyphid and pseudodifflugid testate amoebae and the desmothoracid heliozoans. The tests and skeletons of both the phaeodarians and the euglyphid testate amoebae resemble each other in their chemical composition and construction. The similarities in the morphologic features may suggest that they are sisters as the Phylum Cercozoa in which leading from molecular methods.

YUASA, T., TAKAHASHI, O., HONDA, D. & MAYAMA, S. 2005. Phylogenetic analyses of the polycystine Radiolaria based on the 18S rDNA sequences of the Spumellarida and the Nassellarida. *European Journal of Protistology* **41**(4), 287-298.

Acantharea, Polycystinea, and Phaeodarea have members that are widely distributed in the marine plankton. Many biologists use the conventional term "Radiolaria" to include these three classes. However, on the basis of an 18S rDNA study, Polet et al. (2004, Protist 155, 53-63) recently suggested that the Phaeodarea, should be moved into the Phylum Cercozoa. In the present paper, the phylogenetic relationships of the Acantharea and the Polycystinea, especially the phylogenetic positions of Nassellarida, and Spumellarida, were inferred from 18S rDNA sequences including those we have determined from the Family Spongodiscidae (Class Polycystinea, Order Spumellarida) and the Family Pterocorythidae (Class Polycystinea, Order Nassellarida). Among major eukaryotic lineages, the Polycystinea were shown to constitute a paraphyletic

group: in the phylogenetic trees for the relationships among polycystines, the collosphaerid, sphaerozoid, and thalassicollid spumellarians and the pterocorycid nassellarians constantly formed a monophyletic group, from which the spongodiscid spumellarians were excluded. This conclusion is not consistent with the current taxonomy of the "Radiolaria," and leads us to consider that the collosphaerid, sphaerozoid, and thalassicollid spumellarians and the pterocorycid nassellarians may have evolved from an ancestor with triradiate branched spicules.

ZASKO, D.N. & RUSANOV, I. 2005. Vertical distribution of radiolarians and their role in epipelagic communities of the East Pacific Rise and the Gulf of California. *Biology Bulletin* **32**(3), 279-287.

Vertical distribution of different groups of radiolarians and mesozooplankton ($l = 0.2-3.0$ mm) and the contribution of radiolarians to total biomass of bathometer-sampled zooplankton were studied in the epipelagic East Pacific Rise and the Gulf of California during 49th cruise of R/V "Akademik Mstislav Keldysh" (September-October, 2003). The production of the symbiotic algae of acantharians and colonial radiolarians as well as their contribution to the total primary production were evaluated. The proportion of all radiolarian groups in the total zooplankton biomass was shown to range from 1.4 to 11.5%. The contribution of zooxanthellae to the total primary production was not great in the studied region and equaled 0.1-1.2 and 0.3-0.7% for colonial radiolarians and acantharians, respectively.

ZHANG, C.L., ZHOU, D.W., LU, G.X., WANG, J.L. & WANG, R.S. 2006. Geochemical characteristics and sedimentary environments of cherts from Kumishi ophiolitic melange in southern Tianshan. *Acta Petrologica Sinica* **22**(1), 57-64.

The cherts, developed in various blocks of the ophiolitic melange of the Tonghuashan area to the south of Kumishi in southern Tianshan, have high Al_2O_3 and Al_2O_3/TiO_2 values, and a good positive correlation between Al_2O_3 and trace elements including Zr, Nb, Hf, Ta and Th. Moreover, they are typical NASC-normalized flat REE patterns without visible Ce negative anomalies, similar to those of cherts in continental margin settings. They have Ce/Ce* values of 1.05 similar to 1.33, (La/Ce)(SN) of 0.74 similar to 0.98, Ti/V of 5.10 similar to 122.18 and V/Y of 0.39 similar to 6.03, respectively, consistent with the values of cherts formed in continental margin settings, suggesting that they were formed in sedimentary environments closely related to continental margin influenced by the input of terrigenous component. However, their sources are more or less different. Of those, the red cherts, interbedded in mudstone, have Th/Sc ratio ranging between 0.56 similar to 4.35, and chondrite-normalized REE patterns characterized by negative Eu anomalies ($Eu/Eu^* = 0.56$ similar to 0.71) and LREE enrichment (La-N/Yb-N = 3.92 similar to 7.43), implying a setting of forearc basin with terrigenous elements dominantly derived from differentiated magmatic are. In contrast, the green cherts in basic lavas show slightly right-dipping chondrite-normalized REE Patterns (La-N/Yb-N = 4.15 similar to 6.69) with small Eu anomalies ($Eu/Eu^* = 0.72$ similar to 0.93). Their Th/Sc values are from 0.57 to 0.87, displaying some input of materials from oceanic are. Therefore, they were formed in limited ocean basin relatively apart from continent and mainly affected by input of terrigenous and oceanic are components. Consequently, based on the occurrence of early later Paleozoic radiolarian in cherts, it could be concluded that a tectonic regime of gradually closed-ocean basin and slab-subduction in active continental margin started in southern Tianshan during early later Paleozoic.

ZHAROV, A.E., BRAGIN, N.Y. & RECHKIN, A.N. 2005. The Cretaceous-Lower Paleogene stratigraphy of accretionary rock complexes in the Tonino-Aniva

Peninsula of southern Sakhalin. *Stratigraphy and Geological Correlation* **13**(1), 80-98.

Geological revision of the Tonino-Aniva Peninsula showed that the intricately dislocated complex of a mixed composition that was previously regarded as the Albian-Cenomanian Novikovo Formation spans the interval from the uppermost Permian to the Lower Paleogene. Based on bio- and lithostratigraphic study of reference sections and key areas, the complex is divided into nine lithostratigraphic units different in age, lithology, geochemistry of volcanics, composition of sandstones, and position in the regional structure. The defined units form two stratigraphic successions that retain general stratification despite intense deformations. They likely represent fragments of two different-age terranes: the Tonino-Aniva and Ozerskii accretionary prisms formed near the continental margin and in oceanic settings during the Aptian-Maastrichtian and Campanian-early Eocene respectively. As is established after comparison of distinguished subdivisions with coeval sequences of Hokkaido, the former terrane is well correlative with the western Hidaka belt and the Idonnappu belts, while the latter is analogous to the Tokoro belt. The data obtained indicate a high efficiency of the complex approach to study the intricate accretionary complexes.

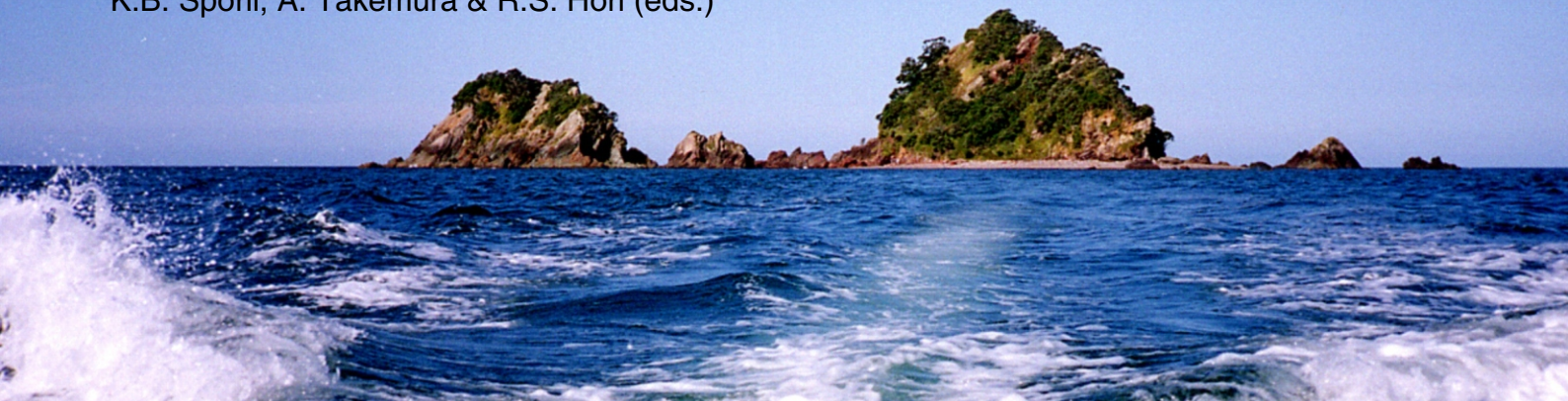
ZHU, J., DU, Y.S., LIU, Z.X., FENG, Q.L., TIAN, W.X., LI, J.P. & WANG, C.P. 2006. Mesozoic radiolarian chert from the middle sector of the Yarlung Zangbo suture zone, Tibet and its tectonic implications. *Science in China Series D-Earth Sciences* **49**(4), 348-357.

Three radiolarian fauna, aged as the Middle-Late Triassic, Late Jurassic-Early Cretaceous and Cretaceous radiolarian fauna, have been recognised in the radiolarian cherts from the middle sector of the Yarlung Zangbo suture zone, southern Tibet, China. The average contents of SiO_2 in the radiolarian cherts of the Middle-Late Triassic and Late Jurassic-Early Cretaceous are 90.24% and 92.58% respectively, with average ratios of $Al/(Al+Fe+Mn)$ as 0.75 and 0.74 respectively, the average ratios of MnO/TiO_2 as 0.36 and 1.24, the average ratios of Ce/Ce^* as 1.15 and 1.03, and the average ratios of $La-N/Ce-N$ as 0.85 and 0.93. These geochemical features indicate that both of them are biogenic, deposited in a continental margin basin. The SiO_2 content of the Early Cretaceous radiolarian chert is 94.12%, with the ratio of $Al/(Al+Fe+Mn)$ as 0.59, ratio of MnO/TiO_2 as 4.30, ratio of Ce/Ce^* as 0.60, ratio of $La-N/Ce-N$ as 1.59, which imply that the chert is biogenic and was deposited in a pelagic basin. The Middle-Late Triassic association of the radiolarian chert and turbidites as well as their geochemical characteristics indicates the existence of a strong rifting marginal basin in the belt of the Yarlung Zangbo River then. The association of radiolarian chert and bedded basalt indicate an initial Tethyan ocean basin in southern Tibet during the Late Jurassic-Early Cretaceous. The early Cretaceous radiolarian chert coexisting with pillow basalt in top of the ophiolite suite represents sediments from the oceanic Tethyan basin.

GNS Science Monograph 24

The Oceanic Permian/Triassic boundary sequence at Arrow Rocks (Oruatemanu Island), Northland, New Zealand: Geology and Paleontology

K.B. Spörl, A. Takemura & R.S. Hori (eds.)



This monograph is the result of a decade-long collaboration between Japanese and New Zealand scientists who have uncovered a remarkable succession of superbly exposed fossiliferous oceanic sedimentary rocks at Arrow Rocks (Oruatemanu Island), in eastern Whangaroa Bay, Northland, New Zealand. Radiolaria, conodonts and fusuline foraminifera show that the succession extends from Middle Permian to Middle Triassic times and spans the Permian-Triassic boundary. It is the finest Permian-Triassic record known from the Panthalassa Ocean in the Southern Hemisphere.

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