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International Symposium on

Early Palaeozoic Palaeogeography and Palaeoclimate

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Erlangen, Germany

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ORDOVICIAN PALAEOGEOGRAPHY AND PALAEOCLIMATE

GEOLOGISCHE VEREINIGUNG e.V.

Friedrich-Alexander-Universität Erlangen-Nürnberg

Kitzmann
Unser Erlanger Bier seit 1712

Preface for the International Symposium
"Early Palaeozoic Palaeogeography and Palaeoclimate"

During the past few years, knowledge about the Early Palaeozoic has increased markedly, and it is now known that the conditions during this time were much more variable than previously assumed. Progress has resulted from the integration of tectonical, stratigraphical, palaeoclimatological, palaeomagnetic, palaeontological, and geochemical evidence. Pronounced changes in environmental conditions are recorded, for example, in several distinct short-lived C- and O-isotope excursions that are globally recognised (including the isotope excursion of the Late Ordovician glaciation), with amplitudes of $\delta^{13}C$ values of up to 10‰. The causes and the steering mechanisms of these excursions are recently a matter of intense debate. It is also known that during the Ordovician radiation with the establishment of the Palaeozoic Evolutionary Fauna, the marine diversity has increased dramatically, including vastly increased morphological diversity. Knowledge of development of biodiversity is very precise for several groups of organisms, especially the graptolites, trilobites, and brachiopods, which have been studied in great detail for two centuries. However, for other groups, including chitinozoans, acritarchs, radiolarians, vertebrates, and land plants the data sets are still underrepresented, and their complete diversity spectrum is far from understood. The radiation subsequent to the end-Ordovician mass extinction characteristically is represented by development from surviving members of this Palaeozoic Evolutionary Fauna and did not result in the appearance of a plethora of new forms. This style of recovery in the Silurian, with the same levels of familial and generic diversity and ecologic complexity as in the Ordovician, demonstrates the robustness and stability of the Palaeozoic Evolutionary Fauna.

Currently, the possible causes of the Ordovician biodiversification, the end-Ordovician extinction, and the subsequent Silurian radiation are investigated especially with respect to palaeogeographic and climatic changes. Our symposium aims at discussing those and related topics, but will also serve as the Opening Meeting for the new IGCP project n° 503 "Ordovician Palaeogeography and Palaeoclimate", the successor project of the successful IGCP project n 410 "The Great Ordovician Biodiversification Event" (1997– 2002). After three days of indoor presentations in Erlangen, a field meeting the famous outcrops of southern Sweden will take place. Visits to the GSSP of the base of the Upper Ordovician at Fågelsång, the Ordovician of the island of Öland, and the Silurian succession of the island of Gotland are planned.

We hope that the meetings will provide a forum for palaeontologists, sedimentologists, geochemists, and climate modellers for fruitful exchange and discussion of their results and ideas.

Axel Munnecke & Thomas Servais

Organising Committee

International Scientific Committee

D.A.T. Harper	*Copenhagen, Denmark*
Li Jun	*Nanjing, China*
A. Munnecke	*Erlangen, Germany*
A.W. Owen	*Glasgow, Scotland, UK*
F. Paris	*Rennes, France*
P. Sheehan	*Milwaukee, USA*
T. Servais	*Lille, France*
Chen Xu	*Nanjing, China*

Local Organising Committee
(Institute of Palaeontology, Erlangen University)

Tim Beck
Lydia Beuck
André Freiwald
Oliver Lehnert
Sonja-Bettina Löffler
Axel Munnecke
Alexander Nützel
Christian Schulbert
Barbara Seuß
Jürgen Titschack
Petra Wenninger

Ingenieurbüro f. Kartographie Bernhard Spachmüller

General Programme

Wednesday, September 1st

09h00 – 09h30 Welcome
09h30 – 10h15 Invited lecture: PARIS & Webby

10h15 – 10h45 *Coffee & Poster*

10h45 – 11h30 Invited lecture: BICKERT et al.
11h30 – 11h50 Cramer & Saltzmann
11h50 – 12h10 Kaljo et al.
12h10 – 12h30 Joachimski et al.

12h30 – 12h45 *Group Photograph*
12h45 – 14h00 *Lunch*

14h00 – 14h20 Alvaro et al.
14h20 – 14h40 Villas et al.
14h40 – 15h00 Brenchley et al.
15h00 – 15h20 Armstrong et al.
15h20 – 15h40 Le Heron et al.
15h40 – 16h00 Moreau et al.

16h00 – 16h20 *Tea & Poster*

16h20 – 16h40 Albanesi & Voldman
16h40 – 17h00 Cherns et al.
17h00 – 17h20 Li & Kershaw
17h20 – 17h40 Calner et al.
17h40 – 17h50 Königshof et al.

18h00 – 18h30 Business meeting IGCP 503

18h30 – 20h30 *Guided Tour through Erlangen*

Thursday, September 2nd

08h15 – 09h00 Invited lecture: COCKS
09h00 – 09h20 Schulz et al.
09h20 – 09h40 Su & Shi
09h40 – 10h00 Lubnina

10h00 – 10h20 *Coffee & Poster*

10h20 – 11h05 Invited lecture: SCOTESE
11h05 – 11h25 Bassett et al.
11h25 – 11h45 Rong & Harper.
11h45 – 12h05 Servais et al.

12h05 – 13h15 *Lunch*

13h15 – 19h15 *Palaeontological Excursion: Solnhofen Museum*

20h00 – 23h00 *Conference Dinner*

Friday, September 3rd

08h30 – 09h00 Invited lecture: MICHEELS et al.
09h00 – 09h20 Herrmann & Patzkowsky
09h20 – 09h40 Fortey & Cocks
09h40 – 10h10 Invited lecture: FRANÇOIS

10h10 – 10h30 *Coffee & Poster*

10h30 – 10h50 Achab et al.
10h50 – 11h10 Li & Yan
11h10 – 11h30 Esprit et al.
11h30 – 11h50 Harper & Tychsen
11h50 – 12h10 Owen
12h10 – 12h30 Tolmacheva

12h30 – 14h00 *Lunch*

14h00 – 14h20 Lefebvre & Esprit
14h20 – 14h40 Rozhnov
14h40 – 15h00 Fatka & Brocke
15h00 – 15h20 Dubinina & Ryazantsev
15h20 – 15h40 Zigaite
15h40 – 16h00 Bogolepova & Siveter

16h00 – 16h20 *Tea & Poster*

16h20 – 16h50 Dronov & Popov
16h50 – 17h10 Lehnert et al.
17h10 – 17h30 Díaz-Martínez & Grahn
17h30 – 17h50 Chen et al.
17h50 – 18h20 Invited lecture: SCOTESE

18h30 – 18h45 CLOSING CEREMONY

19h00 – 20h30 *Brewery Visit*

Saturday, September 4th

08h00 Departure for field trip.

Scientific Programme

Tuesday, August 31st

16h00 – 22h00 *Registration and fix posters*

18h00 – 22h00 *Icebreaker Party (hall on the first floor of the Castle)*

Wednesday, September 1st

OPENING SESSION

09h00 – 09h30 Welcome

09h30 – 10h15 Invited lecture F. PARIS & B.D. Webby: *Aims, achievements and lessons learnt from six years of IGCP project n° 410*

10h15 – 10h45 *Coffee & Poster*

SESSION 1: ISOTOPE GEOCHEMISTRY AND INTERPRETATION

(Chairman: Peter Sheehan)

10h45 – 11h30 Invited lecture: T. BICKERT et al.: *Application of brachiopod carbon and oxygen isotopes for Paleozoic climate reconstruction: Examples from the Silurian of Gotland*

11h30 – 11h50 B.D. Cramer & M.R. Saltzmann: *Glaciation, CO_2, and organic carbon burial in the early Silurian (Wenlock)*

11h50 – 12h10 D. Kaljo et al.: *Ordovician carbon isotope trend based on Baltoscandian data: some aspects of composition and environmental interpretation*

12h10 – 12h30 M. Joachimski et al.: *Does the oxygen isotope composition of Palaeozoic brachiopods reflect palaeoenvironmental conditions? A critical reappraisal*

12h30 – 12h45 *Group Photograph*

12h45 – 14h00 *Lunch*

SESSION 2: END-ORDOVICIAN GLACIATION AND SEA-LEVEL CHANGES

(Chairman: Richard Fortey)

14h00 – 14h20 J.J. Álvaro et al.: *Hirnantian valley-glacier sedimentation in the eastern Anti-Atlas, Morocco*

14h20 – 14h40 E. Villas et al.: *Modelling the Hirnantian eustatic fall and its related Gondwanan ice-sheet growth time*

14h40 – 15h00 P.J. Brenchley et al.: *Karstified limestones in a submarine channel record end-Ordovician glacio-eustatic sea level fluctuations*

15h00 – 15h20 H.A. Armstrong et al.: *Hirnantian deglaciation: a high latitude perspective from Palaeo-Tethys*

15h20 – 15h40 D.P. Le Heron et al.: *Defining the maximum extent of the Hirnantian ice sheet in Morocco*

15h40 – 16h00 J. Moreau et al.: *Ice-proximal sedimentary records of the Late Ordovician glacial cycles*

16h00 – 16h20 *Tea & Poster*

SESSION 3: OPEN SESSION I

(Chairman: Chen Xu)

16h20 – 16h40 G.L. Albanesi & G.G. Voldman: *Ordovician paleothermometry of the Argentine Precordillera based on Conodont Color Alteration Index*

16h40 – 17h00 L. Cherns et al.: *Late Ordovician cool water bryozoan mud mounds from Lybia*

17h00 – 17h20 Li Yue & S. Kershaw: *Reef reconstruction after extinction events of the Latest Ordovician in the Yangtze Platform, South China*

17h20 – 17h40 M. Calner et al.: *Correlation of the middle Silurian graptolite crisis and coeval laminated sediments across the Baltic Shield and East European Platform*

17h40 – 17h50 P. Königshof et al.: *"Devonian land-sea interaction: Evolution of ecosystems and climate" (DEVEC) – the new IGCP Project 499*

OPENING SESSION OF IGCP 503

18h00 – 18h30 Business meeting IGCP 503

18h30 – 20h30 *Guided tour through Erlangen*

Thursday, September 2nd

SESSION 4: EARLY PALAEOZOIC PALAEOGEOGRAPHY

(Chairman: David Harper)

08h15 – 09h00	Invited lecture: L.R.M. COCKS: *Ordovician geography: probabilities and problems*
09h00 – 09h20	B. Schulz et al.: *New zircon ages and isotope data from the Austroalpine Cambrian to Silurian magmatic record and the consequences to models of north-Gondwanan terrane configuration*
09h20 – 09h40	Su Wenbo & Shi Xiaoying: *K-bentonites and progressive flysch succession around Ordovician-Silurian transition in South China: New evidences for accretion of Cathaysia to Yangtze Block and break-up of Gondwanaland*
09h40 – 10h00	N. Lubnina: *Ordovician palaeogeographical reconstruction of Baltica: palaeomagnetic data*
10h00 – 10h20	*Coffee & Poster*

SESSION 5: EARLY PALAEOZOIC PALAEOBIOGEOGRAPHY

(Chairman: Alan Owen)

10h20 – 11h05	Invited lecture: C.R. SCOTESE: *Early Paleozoic plate tectonics, paleogeography, and paleoclimate*
11h05 – 11h25	M.G. Bassett et al.: *Biogeographical assessment of Early to Mid Ordovician benthic faunas of north-central Iran*
11h25 – 11h45	Rong Jia-Yu & D.A.T Harper: *A Middle Ordovician silicified brachiopod fauna from Guiyang, South China and its palaeobiogeographical significance*
11h45 – 12h05	T. Servais et al.: *Are some fossils better than others for inferring palaeogeography? An old question revisited*
12h05 – 13h15	*Lunch*
13h15 – 19h15	*Palaeontological Excursion: Solnhofen Museum*
20h00 – 23h00	*Conference Dinner*

Friday, September 3rd

SESSION 6: EARLY PALAEOZOIC CLIMATE AND CLIMATE MODELLING

(Chairman: Michael Joachimski)

8h30 – 9h00	Invited lecture: A. MICHEELS et al.: *Palaeoclimate modelling studies for the Late Miocene and for the Neoproterozoic*
9h00 – 9h20	A.D. Herrmann & M.E. Patzkowsky: *Late Ordovician ocean-climate system and paleobiogeography*
9h20 – 9h40	R. Fortey & L.R.M. Cocks: *A late Ordovician global warming event?*
9h40 – 10h10	Invited lecture: L. FRANÇOIS: *Modelling atmospheric CO_2 changes at geological timescales*
10h10 – 10h30	*Coffee & Poster*

SESSION 7: EARLY PALAEOZOIC BIODIVERSITY TRENDS

(Chairman: Florentin Paris)

10h30 – 10h50	A. Achab et al.: *Patterns and driving factors of the chitinozoan diversification during the Ordovician*
10h50 – 11h10	Li Jun & Yan Kui: *The Ordovician acritarch assemblage from Meitan Formation, Tongzi, South China: Biostratigraphy and biodiversity*
11h10 – 11h30	N. Esprit et al.: *Radiation of bivalves during the Ordovician: morphological quantification of peri-Gondwanan faunas*
11h30 – 11h50	D.A.T. Harper & A. Tychsen: *The Orthida: Disparity, diversity and distributional dynamics in a Palaeozoic brachiopod clade*
11h50 – 12h10	A.W. Owen: *Trilobite diversity in Avalonia prior to the end Ordovician extinction - the peak before the trough*
12h10 – 12h30	T.Y. Tolmacheva: *Fossil assemblages from radiolarites of Central Kazakhstan – a key for the reconstruction of the pelagic ecosystem*
12h30 – 14h00	*Lunch*

SESSION 8: EARLY PALAEOZOIC PALAEOECOLOGY AND PALAEOBIOGEOGRAPHY

(Chairman: Rong Jia-Yu)

14h00 – 14h20 B. Lefebvre & N. Esprit: *Palaeoecology and palaeobiogeography of Cambro-Ordovician stylophoran echinoderms*

14h20 – 14h40 S.V. Rozhnov: *Palaeogeography and the origin of higher taxa of echinoderms in the Early Palaeozoic*

14h40 – 15h00 O. Fatka & R. Brocke: *Changes in Darriwilian acritarch and prasinophyte assemblages of the Yangtze Platform (South China) and the Barrandian area (Czech Republic)*

15h00 – 15h20 S.V. Dubinina & A.V. Ryazantsev: *Ordovician conodonts in different palaeogeographical environments of the southern Urals*

15h20 – 15h40 Z. Zigaite: *Endemic thelodonts (Agnatha) of the Silurian of Central Asia and Siberian Platform*

15h40 – 16h00 O.K. Bogolepova & D.J. Siveter: *The myodocope ostracode Entomozoe from the early Silurian of Severnaya Zemlya, Russian Arctic: biostratigraphical and palaeogeographical significance*

16h00 – 16h20 *Tea & Poster*

SESSION 9: OPEN SESSION II

(Chairman: T. Servais)

16h20 – 16h50 A.V. Dronov & L.E. Popov: *Traces of frost action in the Obolus-Sand: the evidence for subglacial climate in the mid Cambrian to early Ordovician (Tremadocian) of the East Baltic*

16h50 – 17h10 O. Lehnert et al.: *The oldest record of hydrothermal vent communities: intracratonic sites formed in the early stage (Tremadocian) of the Prague Basin*

17h10 – 17h30 E. Díaz-Martínez & Y. Grahn: *Ordovician-Silurian boundary near La Paz (Bolivia): stratigraphy, sedimentology, chitinozoan biostratigraphy and regional palaeogeographic implications*

17h30 – 17h50 Chen Xu et al.: *Consistency of the faunal replacement and environmental change through Ordovician and Silurian transition in South China*

17h50 – 18h20 Invited lecture: C.R. SCOTESE: *Early Paleozoic paleoclimatic simulations: data and model comparisons*

18h30 – 18h45 CLOSING CEREMONY

19h00 – 20h30 *Brewery Visit (Kitzmann)*

Saturday, September 4th

08h00 Departure for the field trip to Fågelsång, Öland, and Gotland (departure and arrival point is the Erlangen Bus Terminal)

Poster Presentations

Antoshkina, A.I.: *Late Silurian reef biota in the northwestern Salair: Application to Silurian geography*

Bagnoli, G., Ribecai, R. & Albani, R.: *Changes in some acritarch genera across the Volkhov/Kunda boundary on Öland (Sweden)*

Blanchon, M., Raevskaya, E., Servais, T. & Vecoli, M.: *The Cambro-Ordovician acritarch Vulcanisphaera*

Couto, H., Sodré-Borges, F., Roger, G., Gutiérrez-Marco, J.C.: *The Ordovician of the Valongo Anticline (Portugal)*

Dahlqvist, P., Calner, M., Bergström, S.M. & Harper, D.A.T.: *The Upper Ordovician-Lower Silurian stratigraphic succession in the Caledonian foreland basin of central Sweden: relationship to the Hirnantian glacial interval*

Ernst, A. & Suttner, T.: *Bryozoa from the Pin Formation (Upper Ordovician – Lower Silurian) in the Tethyan Zone of the Indian Himalayas*

Fan Juanxuan & Chen Xu: *Late Ordovician graptolite extinction and biogeography of graptolites in the Yangtze region*

Fan Juanxuan & Zhang Yuandong: *SinoCor 3.0, a biostratigraphic program for graphic correlation*

Ghobadipour, M., Popov, L.E., Lehnert, O., Hairapetian, V. & Hosseini, M.: *Emergence of the Palaeozoic Evolutionary Fauna in the early Ordovician of the Alborz Range, northeastern Iran*

Gubanov, A.P. & Bogolepova, O.K.: *The earliest record of a colour pattern in molluscs*

Hints, O. & Eriksson, M.E.: *Early diversification of jaw-bearing polychaetes*

Jankauskas, T. & Gritite, J.: *Acritarch assemblages of the Ordovician and Silurian deposits in Lithuania*

Jendryka-Fuglewicz, B.: *Cambrian brachiopods from near the Teisseyre-Tornquist Line in Poland and their implications for palaeogeography*

Kershaw, S. & Young, G.A.: *Internal banding in Palaeozoic stromatoporoids and colonial corals: Classification and controls of formation*

Kiipli, T., Kiipli, E. & Kallaste, T.: *Record of Ordovician and Silurian volcanism in Estonian sections – prospect of research*

Lee, S.-b., Lefebvre, B. & Choi, D.K.: *Tremadocian stylophoran echinoderms from the Taebaeksan Basin, Korea*

Manda, S.: *Early Silurian cephalopod migrations to the Prague Basin (Perunica micro-plate, Bohemia)*

Mergl, M.: *The earliest brachiopod-bryozoan dominant community in North Gondwana: a case from Late Arenigian of the Barrandian, Bohemia*

Nardin, E. & Levebvre, B.: *Palaeogeography and biodiversity of Cambro-Ordovician echinoderms*

Nolvak, J.: *Ordovician chitinozoan distribution in the different areas of Baltoskandia*

Nützel, A., Lehnert, O. & Frida, J.: *Major changes in gastropod larval strategies during the Early Ordovician*

Ortega, G., Albanesi, G.L. & Frigerio, S.E.: *Early Darriwilian graptolite and conodont biofacies in the Los Azules Formation, Cerro Viejo section, Central Precordillera, Argentina*

Podhalanska, T.: *New data on the Ordovician ichnofossils from the Koszalin – Chojnice Region (Pomerania, NW Poland) – palaeogeographic implication*

Raevskaya, E., Le Hérissé, A. & Steemans, P.: *Quantitative distribution and evolution of palynomorphs associated with kukersite deposits in the Middle-Upper Ordovician of the East-European Platform*

Stricanne, L., Munnecke, A., Pross, J. & Servais, T.: *Development of acritarch communities across the late Silurian positive* $\delta^{13}C$ *excursion – data from Gotland, Sweden*

Trotter, J.A., Eggins, S.M., McCulloch, M.T., Barnes, C.R., Nicoll, R.S., Nowlan, G.S. & McCracken, A.D: *Sr isotopic and Mg cycling in Early Palaeozoic seawater: Implications for tectonic and climatic processes*

Vaida, M., Veliciu, S. & Verniers, J.: *Basin analysis: a punctual example in the South of Romania*

Vaida, M., Verniers, J. & Seghedi, A.: *The biostratigraphy of new chitinozoans from the South of Romania*

Vandenbroucke, T.R.A., Van Nieuwenhove, N. & Verniers, J.: *Towards an Upper Ordovician chitinozoan biozonation on Avalonia? Research on historical type areas and other UK key sections*

Vanmeirhaeghe, J., Van Noten, K., Van Grootel, G. & Verniers, J.: *Chitinozoans from the Upper Ordovician of the Fauquez area (Brabant Massif, Belgium)*

Vecoli, M., Al-Ruwaili, M., & Le Hérissé, A.: *Palaeobiological and palaeoenvironmental significance of cryptospores and acritarchs from the Llanvirn of Saudi Arabia*

Vennin, E., Álvaro, J.J., Villas, E. & Destombes, J.: *High-latitude bryozoan-dominated communities as a major carbonate factory on mixed carbonate-siliciclastic platforms of the late Ordovician northern Gondwana*

Vyhlasová, Z.: *Ordovician conulariid diversity in the periGondwana and Baltica regions – a summary with a special view to the Ordovician of Barrandian*

Wheeley, J.R., Cherns, L. & Wright, P.: *The Ordovician Baltic epeiric sea – taphonomy and early diagenesis of its carbonate sediments*

Woo, J. & Chough, S.K.: *Depositional environments and sequence stratigraphy of the Jigunsan Formation (Middle Ordovician), Taebaeksan Basin, Mideast Korea*

Wrona, R.: *Gondwanan provenance of the Lysogóry block (Holy Cross Mountains, Poland) supported by Upper Ordovician chitinozoans from the Pobroszyn section*

Xu Honggen & Yu Guohua: *Brief introduction of the Ordovician and Silurian in Northwest Zhejiang*

Zuykov, M.A. & Harper, D.A.T: *Platystrophia-like brachiopods: their potential use in biostratigraphy, palaeoecology and palaeogeography*.

Patterns and driving factors of the chitinozoan diversification during the Ordovician

A. ACHAB[1], F. PARIS[2], J. NÕLVAK[3], and E. ASSELIN[4]

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[2]Géosciences-Rennes, UMR 6118 du CNRS, Université de Rennes 1, 35042 Rennes-cedex, France
[3]Tallinn Technical University, Institute of Geology, EE -10143 Tallinn, Estonia
[4]Centre géoscientifique de Québec, Natural Resources Canada, Geolological Survey of Canada, GSC-Québec, 880 chemin Ste-Foy, Qc, G1S 2L2

Oral Presentation

Ordovician chitinozoans have been fairly well documented from Gondwana, Baltica and Laurentia. Data from these palaeoplates have contributed to more than ⅔ of the global chitinozoan database established for the IGCP 410 project.

Notwithstanding the bias caused by irregular sampling through time and space, the regional chitinozoan diversity curves and their related parameters (normal total diversity, origination, extinction rates and turnover ratios) have permitted to document and to compare the changes undergone by chitinozoans at low, intermediate and high latitudes during the Ordovician.

In general, chitinozoan diversity is moderate (10 to 30 species per time-slice, i.e. usually less than 10 species per million years). However, this specific diversity is slightly higher in low latitude regions (Laurentia) than in high latitude ones (North Gondwana). Conversely, chitinozoan abundance is greater in high-latitude regions, where it may reach several thousand of specimens per gram of rock, than in low-latitude regions where the most productive samples have yielded no more than a few hundred specimens per gram of rock. Because of the Ordovician provincialism, which seems partly related to the dispersion of the main palaeoplates, three regional biozonations broadly reflecting the main Ordovician palaeoclimatic belts have been recognized.

A continuous diversification is observed in the three regions from the Early to the Middle Ordovician with the first maximum peak reached during the Darriwilian. A progressive decrease in diversity marks the Late Ordovician, with the minimum diversity being attained during the Late Ordovician coincident with the Hirnantian glaciation. In these three regions, this decrease is marked, however, by a short-lived diversification event in the middle part of the Ashgill. Other signals expressed by the curves are diachronous and seem to be related to features specific to each paleoplate (e.g. paleolatitude, local sea level variation, tectonics etc.). For example, the first occurrence of chitinozoans in North Gondwana has been recorded in the early Tremadocian, while in Laurentia it has been reported from the upper Tremadocian. Maximum diversity occurs in the upper Darriwilian in North Gondwana, while in Baltica it spans the late Darriwilian-early Caradoc interval and it peaks in the middle-late Caradoc in Laurentia. On the other hand, the decrease in diversity seems to have begun earlier and more drastically in Laurentia than in Baltica and North Gondwana.

Because of their pelagic mode of distribution, chitinozoans are usually associated with graptolites. However, if one compares the diversity curves available for the graptolites from low (Australasia), middle (Baltica) and higher latitude regions (Avalonia), no obvious relationships have been observed with the exception of the latest Ordovician drop in diversity. Although no paleolatitudinal trend was reported among graptolite diversity features, it is worth mentioning that contrary to the chitinozoans, the graptolite diversity is at a maximum earlier (early Arenig) in low latitude than in higher latitude (late Arenig - early Caradoc); the decrease in graptolite diversity is also observed earlier in high latitude regions.

Ordovician paleothermometry of the Argentine Precordillera based on Conodont Color Alteration Index

G.L. ALBANESI[1,2] and G.G. VOLDMAN[2]

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[2] Museo de Paleontología, Universidad Nacional de Córdoba,
Casilla de Correo 1598, 5000 Córdoba, Argentina

Oral Presentation

The present study aims to record and interpret paleotemperatures in Ordovician rocks of the Argentine Precordillera. Paleotemperatures are estimated by using the conodont color alteration index (CAI) method. The present work is one of the first to use this method at a regional and local scale in Argentine basins, and it is based on conodont collections deposited in the Museum of Paleontology of the National University of Córdoba, Argentina. Most conodonts were recovered from carbonate rocks by means of conventional acid etching techniques, and the color alteration and preservational characteristics were assessed by direct comparison with a set of standard reference conodont elements kindly provided by Dr. Anita Harris. CAI values of conodonts from numerous localities were plotted on a geological map of the Precordillera. Distributional patterns of paleotemperatures indicate a gradual increase toward the West and South, as well as the presence of several local anomalies caused by mafic intrusions. CAI patterns allow us to identify two paleothermometric domains: the diacaizone and the ancaizone. The diacaizone approximately corresponds to the Eastern and Central Precordillera, where overburden effects are the main cause of elevated paleotemperatures. The ancaizone, which corresponds to the Western Precordillera, shows paleotemperatures representing a very low grade metamorphism. Apparently, the thermal peak of this metamorphism occurred during a late Silurian – early Devonian event related to the obduction of the Famatinian ophiolites. Local anomalies are analysed within the evolving geotectonic context of the Precordillera. A case study from the Villicum Range, Eastern Precordillera, shows a particular congruence between theoretical and field results, suggesting that the thickness of phantom units represented by intra-Ordovician and Silurian unconformities is in the order of meters.

Hirnantian valley-glacier sedimentation in the eastern Anti-Atlas, Morocco

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Oral Presentation

Although the Late Ordovician palaeogeographical reconstructions of the glacial episode show an ice-sheet centre located near central Africa, the peripheral extension of its palaeo-northern ice front remains unresolved. In Mauritania, terrestrial glacigenic deposits are prevalent in the southern Hoggar and Hodh areas, while glacimarine deposits are dominant in northern Hoggar and Adrar. Subsurface data from the northern Sahara basins show a third palaeogeographical domain absent in Mauritania, where glacially related marine muds reach several hundred of metres in thickness (Ghienne & Deynoux, 1998). As a result, between the well-defined subaerial glaciation of the southern Sahara and the glacimarine deposits of south-western Europe exists an enormous gap of glacial landforms, in which the palaeogeographical models suppose the absence of continental ice-sheet deposits by erosion or non-sedimentation. Modelling the behaviour of the Late Ordovician North Gondwana Ice Sheet requires an integration of the deglaciation history of both the European and North-African platforms, in which the valley-glacier and fjord deposition reported here from the Moroccan Anti-Atlas represents the northernmost prolongation of the Gondwanaland Ice Sheet, and can be considered as the hinge for comparison of both major palaeogeographical regions.

The Hirnantian sedimentary succession of the Alnif area (eastern Anti-Atlas) contains two glacigenic stratigraphical units named here the Alnif and Tamekhtart Members. The Alnif (subaerial) diamictite contains several glacial landforms, in particular flute (up to 3.5 km long) and associated end (De Geer-like) moraines, and gives the first sedimentary evidence of a grounded ice tongue northwards of the south-Saharian ice sheet. The glacial retreat from the Alnif palaeo-valley took place in a stepwise manner, with deposition of at least six moraines during halts in the recession. The overlying Tamekhtart glacimarine diamictite consists of chaotic beds directly onlapping a scarp inherited of the palaeo-valley after moraine erosion, finely laminated siltstones and claystones, and homogeneous claystones supporting isolated silt to granule dropstones filling the fjord depression.

The Alnif valley glacier, on the scale of 180 m deep, up to 1.5 km wide, and mapped along 10 km, incised into Ashgillian to Caradocian sedimentary rocks. This incision represents a relative sea-level fall greater than those previously reported from other palaeo-continents, although it is close to the supposed maximum sea-level lowering estimated for the Quaternary glaciations. The reason why other subaerial diamictites are probably still unrecognized in the Anti-Atlas could be related to their special geometries, if they are preferentially preserved as infilling of narrow valley glaciers.

The glacigenic unconformity located at the Alnif valley glacier (the base of the Upper Formation of the Second-Bani Group) corresponds to the greater Hirnantian ice-sheet extent on the northern peripheral extension of the Gondwanaland Ice Sheet. The final melting of the ice lobes and the succeeding glacimarine Tamekhtart sedimentation covered the entire Anti-Atlas basin forming a widespread onlapping geometry indicating a long-term transgression coeval with the final ice-lobe recession.

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Late Silurian reef biota in the northwestern Salair: application to Silurian geography

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Poster Presentation

The Salair Ridge is a fragment of the mosaic structure of the Altaj-Sayan folded area (southwestern Siberia). The Silurian of this region is poorly known and poorly exposed. Silurian formations in the Salair region that are represented in composite sections have diverse Llandovery-Ludlow faunas. Much more work is to be done on the known sections to clarify their correlation and faunas. Essential new biota associations have been made from Silurian massive reefal limestones of subsurface data and the former Limestone quarry in the Vetokhino Square of the Zalesovo region in the northwestern Salair. The sequence under study was corresponded to the Potapovka and Baskuskan formations (geological service data of Kharin, 1967). Now, according to Elkin et al. (2003), the Potapovka Formation is the latest Telychian-Pridoli and the Baskuskan Formation – late Telychian in age. It is established that main frame builders of boundstones equally with common Silurian reef organisms (rugose corals, bryazoans, etc.) and calcareous algae (*Solenopora*, Codiaceae) were distinctive metazoans such as sphinctozoan aphrosalpingid sponge (*Aphrosalpinx*, *Palaeoshada*), and ?hydroids, *Fistulella* in association with very distinctive consortium of microbial taxa (such as *Girvanella*, *Renalcis*, *Wetheredella*, *Rothpletzella*, *Ludlovia*, *Sphaerina*). Strikingly similar reef biota communities of Ludlow age were described from sites in the Urals for the first time (Antoshkina 1979, 1994, 2003). The Ludlow reefs were rigid organic structures that grew at a passive platform margin of Baltica towards of the Paleo-Uralian Ocean. Reef paleolandscape elements – reef core, reef platform, and slopes and the typical association of reef rocks – boundstones, bioclastic and rudstone-breccias are distinguished in the Vetokhino massive limestone formation. This fact allows to determine the Vetokhino organic structure as a reef that formed in open sea conditions with active hydrodynamics. Some researchers believe that after the Early Caledonian Orogeny, the Salair island arc was a shelf margin of Siberia in the Paleo-Asian ocean. Other authors suggest that Salair island arc system existed in the Paleo-Asian ocean up to the Carboniferous. By occurring in the Urals and Salair, the distinctive microbial-sponge-hydroid biota establish an ancient biogeographic relationship between eastern East-European and southeastern Siberian cratons (in modern co-ordinate) in the Late Silurian. The fact of reef growth on the margin of platform shelves suggests a marine connection to communities evolving along the margins of the Uralian Seaway during the Late Silurian. However, the well-known paleogeographic reconstructions by Scotese and McKerrow (1990), Torsvik et al. (1996), Scotese (1997, 2000), etc. do not support this idea. There seem to be two explanations for this problem: 1. Position of the Siberian paleocontinent in the Middle Paleozoic, offered by these authors, is greatly erroneous. The ancient craton should be located near its present orientation, but was shifted by them along its Altaj-Sayan folded area towards the equatorial latitudes. 2. The accretion of the Salair island arc to Siberia is not connected with the Early Caledonian Orogeny and an arc's migration during Silurian can be discussed.

Hirnantian deglaciation: a high latitude perspective from Palaeo-Tethys

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Oral Presentation

At the present day the presence of permanent ice is controlled by high latitude summer insolation modulated by obliquity (43kyr) forcing; eccentricity is not significant as a direct cycle of seasonal insolation change. Was this the case during the late Ordovician? The Hirnantian "hot" black shale member of the Batra Formation, Jordan was deposited in a high latitude anoxic basin that preserved an early deglacial record of TOC and carbon isotope ratios from organic matter ($\delta^{13}C_{org}$). Spectral analysis indicates cycles in the TOC data, a proxy for palaeoproductivity, have a period of 35,556 yrs, close to the predicted 36,000 yr Ordovician obliquity timescale. $\delta^{13}C_{org}$ values show a rising trend of -31 to -29‰, similar in magnitude but opposite in trend to those from low palaeolatitude. In the absence of changes in the source materials this variance could be explained if the $\delta^{13}C$ of dissolved CO_2 were elevated to levels similar to those predicted from low palaeolatitude carbon isotope ratios from carbonates ($\delta^{13}C_{carb}$). A hypothesis that cannot be tested in the Jordan section. Alternately, if $\delta^{13}C_{org}$ was primarily controlled by concentration of $[CO_2(aq)]$, as some believe is the case for the modern high Southern Ocean, then $[CO_2(aq)]$ in high palaeolatitude Palaeo-Tethys waters was falling during early deglaciation, probably in response to increased bioproductivity.

This work supports the hypothesis that obliquity-forced seasonal variations in high latitude insolation affected the melting dynamics of the ice sheet during early deglaciation which in turn, through the biosphere, effected drawdown of $CO_{2(atm)}$. During early deglaciation high latitude Palaeo-Tethys was a net sink of carbon, a situation that lasted for at least 100 kyrs. If global $CO_{2(atm)}$ levels were to rise in line with a return of greenhouse conditions the $CO_{2(atm)}$ must have been sourced from low-mid palaeolatitudes.

Changes in some acritarch genera across the Volkhov/Kunda boundary on Öland (Sweden)

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Poster Presentation

The Lower to Middle Ordovician *Orthoceras* Limestone is a condensed carbonate sequence that accumulated on the East European Platform. The *Orthoceras* Limestones of Horns Udde and Horns Udde Quarry on the island of Öland (Sweden) have been investigated in great detail for acritarch, conodont and chitinozoan studies. These microfossils are abundant, well preserved, and are co-occurring in the same samples.

The acritarch taxonomy has been carefully examined and also intraspecific changes have been studied and documented, and compared with other sections from Öland. The succession of the acritarch species has been compared with available data on conodont biostratigraphy and biofacies, and sea-level changes.

The Horns Udde microflora spanning the Volkhov/Kunda boundary is dominated by representatives of the genus *Baltisphaeridium*, but other genera such as *Liliosphaeridium* and *Peteinosphaeridium* exhibit relevant evolutionary developments, and characterize the Volkhov/Kunda transition.

In the interval corresponding to the base of Darriwilian, with the beginning of a transgression, several species with a short stratigraphical range are present.

The following interval, spanning the Volkhov/Kunda boundary is characterized by the relative abundance of longer ranging species of *Peteinosphaeridium* and *Liliosphaeridium*.

In the higher part of the section *Peteinosphaeridium* and *Liliosphaeridium* are reduced, and several species make their last occurrence. In this interval a shift in conodont biofacies indicates a fast regressive episode. It is interesting to note that the biofacies conodont change is delayed compared to the disappearance of several acritarch taxa and appearance of new ones.

The changes in acritarch association are compared with the changes in chitinozoan succession as well.

Biogeographical assessment of Early to Mid Ordovician benthic faunas of north-central Iran

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Oral Presentation

In plate-tectonic reconstructions Iran is interpreted as an assemblage of several peri-Gondwanan terranes, but existing data are not sufficient to define their positions in relation to the Gondwanan margin and other peri-Gondwanan terranes. Preliminary analysis of new collections of Early to Mid Ordovician faunas from the Derenjal Mountains of the Tabas region (Central Iranian plate) and the Simeh-Kuh Section near Damgham (Alborz plate) shows that in both regions shallow marine environments of BA2 were dominated by a low diversity *Protambonites* brachiopod assemblage. This fauna is known also from Armorica and Perunica and can be considered as essentially West Gondwanan, but it also occurs on the Uralian Margin of Baltica in the early Arenig. In the Tabas Region *Protambonites* is accompanied by *Tritoechia*, together with mostly cosmopolitan orthides (e.g. *Apheoorthis* and *Archaeorthis*) and syntrophiides. The accompanying trilobite fauna is of low diversity, but the occurrence of *Tungtzuella* sp., otherwise known from South China, is of particular interest. The lower part of the Darriwilian interval contains a low diversity brachiopod fauna of mostly endopunctate orthides and a new genus of polytichioids, associated with a trilobite assemblage dominated by *Paraszechuanella*. Notwithstanding previous reports, the upper Darriwilian contains abundant *Neseuretus* and *Birmanites*, which are considered as characteristic mostly of East Gondwana. Associated brachiopod faunas contain the orthide *Nicolella* which is also known from approximately contemporaneous deposits of Burma (Siburnasu) and South Tien Shan but appears in West peri-Gondwana only in the Late Ordovician. Other components of the assemblage include endopunctate orthides, plectambonitoids and the strophomenoids *Longvillia* and, possibly *Dirafinesquina*. Tremadoc to Arenig faunas of Alborz contain, among other trilobites, *Dikelocephalus* and *Taihungshania*, and the brachiopods *Yangtzeella* suggesting affinity with South China and the Tauride terrane. A diverse echinoderm fauna includes glyptosphaeritid and sphaeronitid diploporans together with echinosphaeronitid, caryocystid and hemicosmitid rombiferans with mixed Baltic and West Gondwanan signatures, but affinity of the Middle Ordovician echinoderm faunas with West peri-Gondwana is more evident. The Alborz terrane was most probably separated from mainland Gondwana and located in temperate latitudes, occupying an intermediate position between South China and the Tauride terrane during the Early to Mid Ordovician. In general, a Baltic affinity is more evident for the Early Ordovician faunas of Alborz, but this weakened significantly by the Mid Ordovician. Early to Mid Ordovician benthic faunas of the Central Iranian plate are more strictly Gondwanan with some affinity to South China, but affinity to contemporaneous fauna of Sibumasu becomes evident by the end of the Mid Ordovician.

Application of brachiopod carbon and oxygen isotopes for Paleozoic climate reconstruction: Examples from the Silurian of Gotland

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Oral Presentation

Stable carbon and oxygen isotopes in biogenic calcites are common tools for reconstructing past environmental conditions. For the Paleozoic, brachiopods are thought to be the most reliable recorders of stable carbon and oxygen isotopes because they are widespread in marine carbonate sediments, they are assumed to secrete shell material at or near isotopic equilibrium with the surrounding seawater, and their shells consist primarily of low-magnesian calcite most resistant to diagenetic alteration. However, restrictions for isotope interpretations result from species-dependend disequilibria observed for several brachiopod orders (e.g., strophomenida, pentamerida), and from kinetic isotope fractionation during calcite precipitation from seawater. Brachiopods sampled within a single stratum or even within a taphozoenosis exhibit a significant range of isotope values. Furthermore, even if those effects are considered, isotope measurements are difficult to interpret in terms of paleoenviromental changes, since the fractionation of those isotopes each relies on more than one environmental parameter.

Here, we present the application of brachiopod carbon and oxygen isotopes from the Swedish island of Gotland for the reconstruction of Silurian paleoclimatic changes. In a combined approach using sedimentological, paleontologcial, and geochemical data, we interpret the repeated drastic changes of carbonate facies succession, extinctions, and stable isotope development in terms of climate variability and ocean circulation changes. The relative timing of positive isotope excursions, mass extinctions, and facies development is shown to be typical not only for the Silurian (Wenlock and Ludlow), but also for similar events in the late Ordovician, the late Cambrian, and, with some reservations, in the Proterozoic. A paleoclimatic model postulated for the Silurian of Gotland may, therefore, be applicable also for the older events.

The Cambro-Ordovician acritarch *Vulcanisphaera*

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Poster Presentation

The acritarch genus *Vulcanisphaera* Deunff, 1961, and its type species *V. africana* were first described from Cambro-Ordovician sequences of the Algerian Sahara. A first detailed revision of the genus, with a description of three new species of the Tremadocian of Shropsire, England, was provided by Rasul (1976). Additional species were subsequently described from different other areas, including Spain, France, Poland, and Canada.

The revision of the literature shows that over 30 species have been attributed to the genus. The revision of the data available in previously published papers, together with the reinvestigation of large populations of *Vulcanisphaera* from the type-localities in Algeria and England, allow a new classification concept and a revision of the biostratigraphy and the palaeobiogeography of the genus.

The revision indicates that *Vulcanisphaera* shows a large intraspecific variability. From the 31 species described in literature, 11 can not be maintained within the genus. Three morphotypes can easily be distinguished and could be retained as species: *Vulcanisphaera africana*, *V. capillata*, and *V. simplex*. The 17 remaining taxa previously described as species could be classified as infraspecific taxa. At the generic level, *Vulcanisphaera* is clearly distinguished from other acritarch genera, although some relations exist with the genera *Cristallinium* Vanguestaine, 1978, and *Timofeevia* Vanguestaine, 1978.

In terms of biostratigraphy, the species attributed to the genus *Vulcanisphaera* described from the Precambrian clearly do not belong to the genus. The first *Vulcanisphaera* species appear in the Middle Cambrian, indicating a First Appearance Datum (FAD) in the *Pardoxides paradoxissimus* trilobite Biozone in eastern Newfoundland.

However, *Vulcanisphaera* is rare in the Middle Cambrian, and the genus only becomes very abundant in the Upper Cambrian. It reaches its highest morphological variability in the latest Cambrian and during the Tremadocian.
Palaeogeographically, as most acritarch genera of the Cambrian-Ordovician transition, the genus shows a cosmopolitan distribution, occurring from high latitudes in the southern hemisphere to lower, near-equatorial latitudes worldwide.

The myodocope ostracode *Entomozoe* from the early Silurian of Severnaya Zemlya, Russian Arctic: biostratigraphical and palaeogeographical significance

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Oral Presentation

The myodocope ostracod *Entomozoe* aff. *Entomozoe tuberosa* (Jones, 1861) has been identified from strata of early Silurian Llandovery Series age from October Revolution Island, Severnaya Zemlya in the Russian Arctic. *Entomozoe* was previously known only from Scotland (*E. tuberosa*), Greenland (*E.* aff. *tuberosa*;), and South China (*E.* cf. *tuberosa*). The new find signifies that *Entomozoe* has biostratigraphical and palaeogeographical significance: all occurrences are from late Llandovery sediments deposited in tropical to subtropical palaeolatitudes.
The islands of the Severnaya Zemlya Archipelago are located in the Kara Sea, north of the Taimyr Peninsula of central Siberia. In 1999, the SWEDARCTIC international expedition visited Severnaya Zemlya to study its stratigraphy, palaeontology, structural geology, and palaeomagnetism. Collections were made in the Sredninskaya Formation, composed of limestones with alternating shales, siltstones and dolomites exposed in the middle reaches of the Ushakova River in the central part of October Revolution Island. The locality yields graptolites indicating a mid Telychian (late *cripsus – griestoniensis*) age for the strata (Bogolepova *et al*. 2000).
The Silurian ostracodes from Severnaya Zemlya are known to consist of various leperditiocopes, palaeocopes and podocopes (Abushik 1982), but myodocope ostracods have not been previously reported from the area. *Entomozoe* is an early and rare Llandovery myodocope ostracod. Occurrence of the genus in Scotland (Siveter & Vannier 1990), South China (Siveter *et al*. 1991) and North Greenland (Siveter & Lane 1999), as in Severnaya Zemlya, is confined to the late Llandovery Telychian Stage.
The myodocope ostracods occur in carbonate nodules with common graptolites, brachiopods, cephalopods, gastropods, and rare bivalves, machaeridians and algae. Notwithstanding the occurrence of graptolites and probable pelagic cephalopods, the facies and fauna imply a relatively shallow shelf setting dominated by epibenthonic forms. Similar, low diversity graptolite faunas dominated by *Stimulograptus*, with subordinate *Streptograptus*, have been described from shelf environments in Wales (Loydell & Cave 1993). The shelf setting of the Russian material is consistent with the previous occurrences of *Entomozoe* and with the idea that this early Silurian myodocope was probably benthonic.
The known global distribution of *Entomozoe* reflects low palaeolatitudes. The Severnaya Zemlya Archipelago together with the northern part of Taimyr represent the North Kara Terrane, a microcontinent that collided with central Taimyr (today part of Siberia) during late Palaeozoic times. During the Silurian, North Kara was located at low latitudes, perhaps separate from the nearby Baltica and Laurentia; Scotland and Greenland formed a part of the eastern margin of Laurentia; south China was at similar latitudes but distant. This palaeogeography is based on a range of geological data such as facies patterns and faunal distributions, and is supported by palaeomagnetic data (Metelkin *et al*. 2000). The occurrence of *Entomozoe* in Severnaya Zemlya provides additional evidence of proximity between North Kara and Laurentia and provides a possible option for "island hopping" further east to the south China plate.
Field work on Severnaya Zemlya was funded by the Swedish Polar Research Secretariat. This is an INTAS – NEMLOR (Northern Eurasian Margin & Lomonosov Ridge) contribution.

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Karstified limestones in a submarine channel record end-Ordovician glacio-eustatic sea level fluctuations

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Oral Presentation

The late Ordovician glaciation of Godwanaland induced major global sea-level changes. The major regression at the start of glaciation and flooding at its demise are particularly significant as they correspond to the two phases of the end Ordovician mass extinction. Globally the sea-level changes are accompanied by major shifts in marine carbon and oxygen isotope values with a single positive isotope excursion commencing at the Rawtheyan-Hirnantian boundary and declining in the mid-Hirnantian.

The shelf sequence on the eastern margin of the Welsh Basin (UK) records early Hirnantian sea-level fall with a widespread erosion surface and channels that incise deeply into shelf mudstones. Above the erosion surface are marine sandstones deposited during the subsequent transgression. In one channel, at Meifod in Powys, Central Wales there is a more complex fill that includes a significant unit of limestone below the main sandstone body. The channel is about 370m wide and cuts at least 27m into the shelf mudstones. The sediments that form the initial, 8m of the channel-fill are sandy bioclastic packstones and grainstones with a fauna dominated by transported bryozoans. Oolitic intraclasts and phosphate nodules also occur. The limestones occur as a series of localised domes and pillars with vertical and overhanging margins. There is no evidence that these are constructional features as they are solely composed of detritus and are topped by a highly irregular corrosion surface. This is overlain by a micritic encrustation containing an *in-situ* fauna of encrusting bryozoans, cystoids, crinoids and clusters of brachiopods. We suggest that the limestones were lithified, karstified and then during the subsequently flooding colonised by a marine fauna. As transgression progressed the karstic surface was buried beneath a shallow marine sandstone cover. Constraints on the interpretation of the events within the Hirnantian channel are provided by comparison of the isotopic compositions of carbonate material with the global isotopic record. Somewhat surprisingly much of the limestone within the channel has Rawtheyan rather than Hirnantian isotopic values, suggesting to us that the detrital carbonate had been eroded from a Rawtheyan source elsewhere on the shelf. The sandstones above the karstic surface on the limestones record typically elevated Hirnantian isotopic values.

The Meifod succession reveals a particularly detailed record of end Ordovician sea-level change and enables an estimation of the magnitude of successive changes. These results are important because they constrain the magnitude and sequence of glacio-eustatic sea-level change which might be related to latest Ordovician biotic change.

Correlation of the middle Silurian graptolite crisis and coeval laminated sediments across the Baltic Shield and East European Platform

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Oral Presentation

The near-total extinction of the graptolites at the end of the *Cyrtograptus lundgreni* Chron in the Late Wenlock (middle Silurian) forms part of a global extinction-radiation event much resembling more well-known Lower Palaeozoic marine faunal crises. The event records a 95 per cent extinction among graptolites (Lenz & Kozłowska-Dawidziuk 2001) = the 'Big Crises' of Jaeger (1991), the '*lundgreni* Event' of Koren´ (1991), or a part of the Mulde Event of Jeppsson & Calner (2003). The event also coincides with a positive $\delta^{13}C$ excursion from remote locations (Kaljo et al. 1997; Zimmerman et al. 2000; Kozłowska-Dawidziuk et al. 2000; Samtleben et al. 2000; Saltzman 2001), implying that this might have been a significant oceanographic-climatic turnover.

New biostratigraphic data from distal epicontinental strata of the Grötlingbo-1 core, southern Gotland (Sweden), constrain the extinction interval to within less than a 3.58 m thick interval without graptolites, which is between the last occurrence of *Monograptus flemingii* and the first occurrence of *Gothograptus nassa*. The 0.38 m thick Grötlingbo Bentonite occurs within the upper part of this interval. This bentonite post-dates the extinctions and its base is 2.83 m above the youngest find of *M. flemingii*. The non-graptolitic interval below the bentonite includes a 0.8 m thick unit of conspicuously laminated, calcareous mudrock.

The investigated interval also contains a rich acritarch succession. The frequency of acritarchs varies depending on stratigraphic interval. The part of the core yielding *M. flemingii* is characterised by a quite abundant acritarch assemblage that is poorly diversified and dominated by the genus *Leiofusa*. Contrary, the interval with no graptolite fauna includes a very poor, low frequency acritarch assemblage, with the same dominant genus. The same trend, both in diversity and frequency, is observed in the Bartoszyce core (Masiak & Kozłowska-Dawidziuk 2000), although here, the dominant species of *Leiofusa* is different.

The graptolite and acritarch successions in Grötlingbo-1 core show strong similarities to the Bartoszyce core in the East European Platform of Poland. The coincidence of the extinction event and barren, laminated basin facies, similarly, occurs in the Bartoszyce core and is previously known also from the Riga Formation (Ancia Member) in Latvia. Therefore, laminated basin facies was a widespread extinction-related phenomenon across the Baltic Shield and East European Platform.

The Grötlingbo-1 core further serves as an important link between the laminated basin facies and the carbonate platforms that fringed the basin coastlines. The corresponding time interval in outcrops and the Hunninge-1 core of central Gotland, and in the Ruhnu (500) core off Estonia (Põldvere 2003), includes a basin-regional unconformity overlain by oolitic strata and the Grötlingbo Bentonite. Thus, the brief but conspicuous interval with widespread laminated basin facies correlates with pronounced environmental changes also in the more proximal carbonate platforms.

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Consistency of the faunal replacement and environmental change through Ordovician and Silurian transition in South China

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Oral Presentation

Patterns of graptolite species turnover during the latest Ordovician mass extinction have been studied based on four continuous Ashgillian to earliest Llandovery sections together with data from more than 30 other published sections. Graphic correlation among these sections reveals that the mass extinction was gradual or stepwise and began with a major extinction event spanned near the top of *Tangyagraptus typicus* Subzone to the middle of the *Normalograptus extraordinarius* Biozone. A secondary, more minor pulse of extinction took place late in the upper *Normalograptus persculptus* Biozone. The Ordovician DDO graptolite fauna was completely replaced at the end of Ordovician and a new Silurian normalograptid fauna occurred from the base of the *Akidograptus ascensus* Biozone. A *Hirnantia* brachiopod fauna associated with trilobite *Dalmanitina* and other shelly faunas usually occur from the lower *N. extraordinarius* Biozone to the lower *N. persculptus* Biozone in the Yangtze region, in particular from the Upper Yangtze region. However, the *Hirnantia* fauna became extinct before the end of the *N. persculptus* Biozone. An early Rhuddanian *Alispira* brachiopod fauna replaced the *Hirnantia* fauna in near shore, shallower water environmental conditions of southwestern margin of the Yangtze Platform.

The change of lithofacies and biofacies through the Ordovician and Silurian transition on the Yangtze Platform is consistent with the stepwise mass extinctions, recovery events, global sea-level changes, and regional palaeogeographic configurations. Facies patterns through three intervals, late-mid Ashgill, Hirnantian, and early Rhuddanian, indicate that black shale occupied most of the Yangtze Platform region during the late-mid Ashgill and early Rhuddanian, while the Hirnantian developed more diverse facies types. The black shale was replaced by carbonate facies during the Hirnantian coincident with a global sea-level low stand. The early Rhuddanian pattern of biofacies is a result of global sea-level rise, which may be synchronized with a recovery bioevent of graptolites after Hirnantian mass extinction.

Late Ordovician cool water bryozoan mud mounds from Libya

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Oral Presentation

Upper Ordovician bryozoan mud mounds are identified from subsurface well material and seismic data of the Jifarah Formation of Tripolitania, NW Libya. These limestones form part of a much wider, high latitude belt of cool water carbonates across several hundred kilometres through NE Spain, Morocco, Algeria and western Libya, which lay on the NW margin of Gondwanaland. In the mud mounds, the diverse bryozoan assemblage includes delicate and robust branching, encrusting and nodular bryozoan growth forms. The mounds lack organic framework and microbial fabrics; limestones have mudstone/wackestone matrices and a floatstone texture. Regional geophysical data suggest rapid thickness changes between wells, where mud mounds in complexes up to 100m thick had some topographic relief over the surrounding muddy sea floor. In North Africa, glacial advances have been dated from Caradoc – Lower Silurian, although widespread glacial deposits are mostly dated as Hirnantian. The Jifarah limestones have been interpreted as developing during an early Ashgill period of warmer climates that preceded glaciation, when coral - stromatoporoid reefs formed at low latitudes in areas of Laurentia and Baltica. The Jifarah limestones are overlain by glaciomarine shales of Hirnantian age. Contemporaneous bryozoan mounds in NE Spain were interpreted as outer-ramp features; they became exposed during Hirnantian regression, and are also overlain by Hirnantian glaciomarine shales. It is proposed here that analogues of the Jifarah bryozoan mounds are represented from the Quaternary of the Great Australian Bight by cool-water bryozoan mud mounds, which apparently flourished at depths of 80-200m during the last glacial lowstand, associated with ocean current upwelling. Well data and seismic images indicate that these mounds form elongate features up to 10km across the slope, in mound complexes that form part of a much wider slope-parallel zone across several hundred kilometres. This comparison suggests that the Jifarah mounds may have developed in slope/outer ramp environments at an early Ashgill lowstand, and in cool climates. Late Caradoc and Ashgill stromatactis mud mounds of the Kullsberg and Boda limestones in Sweden may provide further evidence of cool water mound growth at times of regional or wider lowstand.

Ordovican geography: probabilities and problems

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Oral Presentation

Terrane positioning is best achieved through combining the separate disciplines of palaeomagnetics (which can only determine palaeolatitudes and rotations), palaeobiogeography (which can demonstrate closeness and distancing of terranes) and, to a lesser extent, sediment distributions (which can help towards latitudinal positioning. The relative positions of the three large terranes in today's North Atlantic area, Laurentia (most of North America), Baltica (most of northern Europe), and Gondwana (which included South America, Africa, peninsular India, Antarctica, Australia and more) are reasonably well-known. The medium-sized terrane of Avalonia is also well-constrained, moving as it did from being an integral part of Gondwana at the start of the Ordovician, across the Iapetus Ocean, and docking with Baltica as the Ordovician ended. All of these were in the southern hemisphere, although Laurentia straddled the palaeoequator. The large terrane of Siberia (which consisted of much, but not all, of today's Siberia) is known to have been inverted, in relation to today's orientation, and much of it was in northern latitudes during the Ordovician; however, its distance from Baltica is unknown at the beginning of the period, although probably relatively close by Ordovician-Silurian boundary times. Most of the northern hemisphere was occupied by the vast Panthalassic Ocean. Some of the most difficult questions are posed by the many terranes, some of which were substantial, which may or may not have been either integral parts of, or immediately adjacent to, the vast Gondwana superterrane. The Armorican Terrane assemblage (ATA), which covered much of southern Europe, including France and the Iberian Peninsula, includes faunas indicating that it was probably an integral part of Gondwana during the whole Ordovician. However, the relationships between the ATA and the various parts of Sardinia, the Perunica (Bohemia) Terrane, Apulia, the Hellenic Terrane, and the two terranes (Pontides and Taurides) which today make up Turkey are arguable. Comparably, the Middle Eastern Sanand, Lut, Alborz, Afghan and Karakorum Terranes have yielded variable amounts of evidence, much of it slim, which makes their Ordovician positions uncertain. Today further east, the Ordovician positions of the North China, South China, Sibumasu and Annamia (Indo-China) terranes are also debateable, although faunal evidence indicates that the South China and Sibumasu terranes were not far away from each other during at least the late Ordovician. Even more contentious is the immense area of Central Asia today: all workers are agreed that a large number of Ordovician terranes, possibly as many as twenty, are represented there; however, their relative positions and relationships both with each other and with the large terranes in the Ordovician are not agreed. To today's west of Gondwana, the various terranes making up Argentina are now better-known, although the geological history of the Precordillera Terrane is in dispute; however, the central America area has several Lower Palaeozoic terranes whose Ordovician identities and positionings are very poorly constrained.

The Ordovician of the Valongo Anticline (Portugal)

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Poster Pesentation

The Valongo Anticline, near Oporto, is situated in the Central Iberian Zone of the Iberian Massif, lying in the axial part of the Variscan Fold. The Ordovician rocks discordantly overlie folded metasedimentary rocks of the Schist-Greywacke Complex, interpreted to be of Precambrian? and/or Cambrian age.

The Ordovician sequence above the unconformity starts with shelf deposits represented by alternances of fine and coarse grained sediments of the Santa Justa Formation (Arenigian), which includes massive quartzites that correlates with the "Armorican Quartzite" facies so widely distributed in southwestern Europe. The Arenigian alternances are composed mainly of banded arenitic, siltitic and pelitic beds. We emphasize the occurrence of exhalative-sedimentary intercalations ("black layers") and of distal volcanogenic prints in the metasediments. Organic matter is represented by migrabetumes and fusinitizated fragments which sometimes have a graphitoïd texture. Sporadic occurrence of some transported algal and bryozoan remains also suggest that these black intercalations of carbonaceous fine-grained black sediments were related with episodic development of anoxic conditions. Towards the top of Santa Justa Formation, a lingulid shell bed consisting in a phosphate-rich layer allows direct correlation with the same horizon recorded in other places of the Iberian Peninsula, France, Morocco and Serbia, and suggest the proximity to the coastline of northern Gondwana by the early Middle Ordovician.

In the Valongo Formation (Upper Arenigian to Lower Dobrotivian) the record of diploporid echinoderms is discrete comparatively with their great abundance in Spain, which may be related with the preference of these echinoderms for a shallow and softer substratum, conditions only present in the inner parts of the Central-Iberian platform. Relatively deeper environments are also indicated by some cheirurid and trinucleid trilobites (*Dionide, Valongia, Protolloydolithus*) which are typical or exclusive from the Valongo Formation.

The Ordovician sequence of the Valongo Anticline ends with the Sobrido Formation, that lies disconformably on the Middle Ordovician shales and consists of Kosovian (Hirnantian) quartzites and glaciomarine diamictites.

Glaciation, CO_2, and organic carbon burial in the early Silurian (Wenlock)

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Oral Presentation

The Llandovery-Wenlock boundary interval marks a major turning point in the middle Paleozoic. The late Ordovician glacial epoch, which may have begun as early as the Caradoc, continued into the early Silurian. Recent advances in South American stratigraphy are beginning to indicate that the bulk of glaciation was coming to a close by the late Llandovery.

The Llandovery-Wenlock boundary is also coincident with a major biotic crisis known as the Ireviken Event where roughly eighty percent of all conodont species became extinct. A similar fate was shared by many marine organisms including trilobites, graptolites, and acritarchs. A pronounced shift in the carbon isotope ratio of marine carbonates began during this protracted extinction event and lasted much of the early Wenlock (Sheinwoodian). The Llandovery-Wenlock boundary interval is also marked by a change in carbonate deposition from clastic/marl dominated lithologies to clean carbonate deposition throughout the tropics. Interpretations of these coincident changes in biology, chemistry, and lithology that occurred during this interval of the Silurian have produced several contrasting oceanographic models. However, the causal connections between glaciation and the Silurian global carbon cycle remain a matter of debate. In particular, the location and timing of organic carbon burial have been difficult to define.

In an effort to determine if the coincident increase in carbonate production and carbon isotope values observed elsewhere is a global pattern, carbon isotope ($\delta^{13}C_{carb}$) stratigraphy was carried out on three geographically widespread, well dated marine carbonate successions from the mid-continent of North America. The Ireviken Excursion is recorded in Tennessee, Ohio and Iowa. Carbon isotope values begin at +2.5‰ at the base of the Maddox Member of the Wayne Formation in central Tennessee and increase to +3.9‰ before decreasing back to a baseline of +1‰ halfway through the Maddox Member. In a core from Eastern Iowa, carbon isotope values begin at +1‰ at the base of the Scotch Grove Formation. The Ireviken Excursion is recorded in a rapid shift to +4.5‰ with heavy values continuing into the Gower Formation. A quarry from Western Ohio exposes the Brassfield and Dayton Formations with values beginning at +2.3‰ at the base of the Dayton but only reaching a high of +3.4‰. In each of the three sections an unconformity occurs immediately prior to the Ireviken Excursion, consistent with the rise in $\delta^{13}C$ and clean carbonate deposition tracking post-glacial transgression.

In order to investigate changes in Silurian climate, paired $\delta^{13}C_{carb}$ and $\delta^{13}C_{org}$ analyses were carried out on the section from Tennessee. The results of this study indicate that a positive shift in $\delta^{13}C_{carb}$ coincided with a minimum in $\delta^{13}C_{org}$ (-30.11‰). This suggests that a period of rising pCO_2 was also characterized by enhanced organic carbon burial, which supports a model in which the site of deep water formation switched to low latitudes during the post-glacial early Wenlock period.

The Upper Ordovician-Lower Silurian stratigraphic succession in the Caledonian foreland basin of central Sweden: relationship to the Hirnantian glacial interval

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Poster Presentation

The Upper Ordovician-Lower Silurian sedimentary rocks in Jämtland, central Sweden, form part of the Caledonian foreland basin-fill. This is an area relatively isolated from the nearest Ordovician-Silurian outcrops in Scandinavia. As a consequence and due to previous limited biostratigraphic control, these strata have previously not been adequately placed in the context of global changes related to the Hirnantian glacial interval and have received little attention in related discussions. The most recent analyses have, however, integrated detailed studies on sedimentology with conodont biostratigraphy and brachiopod faunas and the results are presented herein.

Stratigraphic summary

A major part of the upper Caradoc to upper Ashgill succession in Jämtland is characterised by continuous and uniform deposition of clay and silt over wide areas, now forming the Kogsta Siltstone. The uppermost few metres of this unit yield shelly faunas suggesting a Rawtheyan-Hirnantian age. Overlying strata are much more complex stratigraphically, including erosional surfaces and complex lateral facies relationships between the Ede Quartzite in the west and the Kyrkås Quartzite in the east.
In the west, a major syn-sedimentary erosional surface, with at least one metre of relief locally, forms the boundary between the Kogsta Siltstone and the Ede Quartzite. Lower parts of the latter unit consist of medium to thick-bedded quartzites capped by a discontinuity surface. Above this discontinuity the unit consists of a basal favositid biostrome overlain by thin bedded, calcareous sandstones, skeletal limestones and intensely bioturbated shales. The presence of the conodont species *Kockelella*? *manitoulinensis* and *Pranognathus tenuis* in this upper part establishes for the first time the previously controversial age of early-mid Aeronian for the upper Ede Quartzite. Brachiopods from this upper part also suggest a mid-Aeronian age for the strata. Hence, a significant time gap separates the lower part of the Ede Quartzite (or less likely the uppermost Kogsta Siltstone) and the upper Ede Quartzite, and the Rhuddanian and perhaps parts of the Hirnantian, are missing. The Ede Quartzite, which represents the end of terrigenous deposition in this part of the basin is overlain by the Berge Limestone, a fine-grained micritic limestone. A conodont sample from the base of this unit yields a similar fauna as that in the upper Ede Quartzite.
By comparison, the eastern part of the basin shows a markedly different development. As indicated by brachiopods and trilobites, coarse clastics (the Kyrkås Quartzite) entered the basin during the Rawtheyan-Hirnantian transition and two Late Ordovician depositional sequences separated by a transgressive surface were developed. The presence of the brachiopods *Dalmanella testudinaria*, *Eostropheodonta hirnantensis*, and ?*Kinnella kielanae* and the trilobites *Dalmanitina* (*Mucronaspis*) *mucronata* and *Brongniartella platynota* a few meters above this transgressive surface constrain the age of the upper sequence to the Hirnantian. Graptolites of the *Normalograptus persculptus* Biozone are found only some metres above this level. The two sequences indicate two late Ordovician regressive events in this part of the basin. Due to post-Ordovician erosion, these are the youngest preserved sediments in the eastern part of the study area.

Conclusion

The new results constrain the stratigraphic position of the O-S boundary to within less than a three metres thick interval and thereby improve, significantly, the timing of facies changes within the Jämtland basin complexes. The new data show that a substantial downward shift in coastal onlap and hiatus development overlap in time with the glacial interval, suggesting that the interaction of allocyclic controls such as glacio-eustasy and climate change were the overriding controls on deposition.

Ordovician-Silurian boundary near La Paz (Bolivia): stratigraphy, sedimentology, chitinozoan biostratigraphy and regional palaeogeographic implications

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Oral Presentation

The Ordovician-Silurian transition along the Eastern Cordillera of Bolivia north and east of La Paz is characterized by a conspicuous diamictite-bearing unit (Cancañiri Formation) which overlies several different upper Ordovician units (Amutara, San Benito and Tokochi formations), and underlies the shales of the Silurian Uncía Formation. Near the pass of La Cumbre, 20 km NE of La Paz and at an altitude of about 4850 m, the road from La Paz to Coroico offers a continuous outcrop of the Cancañiri Formation, and allows to corroborate its stratigraphic relationships and to test some ideas and interpretations previously proposed for these units.

A detailed stratigraphic section including facies analysis and sampling for petrology and chitinozoan biostratigraphy allowed for a thorough interpretation of sedimentary processes and environments involved during its deposition, and to reassess and constrain the age of this unit. Intermediate to distal turbidites and dark shales indicate a deep marine environment, with interbedded mud flows, debris flows, slumps and large slided slabs providing evidence for sediment instability and resedimentation.

The chitinozoan assemblage present in the Cancañiri Formation includes *Belonechitina* sp., *Conochitina* sp., and *Cyathochitina* sp. B Paris 1981. Despite its poor preservation, this newly discovered assemblage indicates a middle to late Llandovery age, which settles the long maintained discussion on the age of this unit, at least for this part of the Peru-Bolivia basin. The resedimented character of the deposit explains the Ordovician fauna previously described in the Cancañiri Formation, which must be considered as recycled from underlying units. Evidence for glaciation, in the form of glacially faceted and striated clasts, as well as large granitoid boulders within the resedimented materials, indicate local glaciation of the source area, and may be interpreted as recycled from former glacigenic deposits. The evidence found in the Cancañiri Formation corroborates glaciation of the source area most probably prior to the late Llandovery (Telychian), but does not allow to confirm the precise age of the glaciation in this part of Gondwana. A similar chitinozoan assemblage has been recently found in equivalent diamictite-bearing units from adjacent Early Paleozoic intracratonic basins in South America (Amazonas, Parnaiba, Chaco-Paraná), and from the southern end of the Peru-Bolivia basin, suggesting an Aeronian to early Telychian age for all of them. In the case of central and western Bolivia, tectonic deformation and the resulting relief along the active margin of western Gondwana may be respectively identified as the origin for the instability and local glaciation. The new data imply that the Ordovician-Silurian boundary was not preserved in the area around La Paz, and that an erosional hiatus (disconformity with variable regional significance) is present between different Ordovician units (Caradoc quartzites and shales of the Amutara Formation in the case of La Cumbre) and the Cancañiri Formation. The euxinic black shales of the Tokochi Formation, in the central Altiplano and Eastern Cordillera of Bolivia, would therefore represent the youngest Ordovician unit in the region, and more research should be focused on it.

Traces of frost action in the *Obolus*-Sand: the evidence for subglacial climate in the mid Cambrian to early Ordovician (Tremadocian) of the East Baltic

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Oral Presentation

The Middle Cambrian to Early Ordovician (Tremadocian) shallow marine siliciclastic deposits of the East Baltic known as *Obolus*-Sands demonstrates remnants of beach and bar systems as well as discontinuity surfaces developed during periods of the sea level low stand and subaerial exposition of sediments. Various features suggesting frost action during their formation can be seen in the natural and artificial outcrops. Most of the observed structures most likely had been caused by seasonal freezing, but existence of collapse structures may suggest that permafrost developed during a pronounced subaerial exposition of sediments in the periods of regression. The best preserved ice wedge casts, can be observed in tunnels on the east side of the Syas River near the village of Rebrovo, east of St Petersburg. They are apparently singenetic to the deposition of the uppermost Sablinka Formation. However, collapse occurred during transgression at the beginning of the Late Cambrian (*Agnostus pissiformis* to *Leptoplastus* biozones) at the initial stages of deposition of the Ladoga Formation. The collapse structures reported from the Cambrian deposits of Sweden (e.g. 'Bratterfors plugs' from Västergötland and 'funnel grabens' from Skåne) were formed within the same time interval and could also be a result of transgression of the sea onto the shore affected by permafrost.

According to the latest palaeogeographic reconstructions Baltica in the Mid to Late Cambrian was geographically inverted with Caledonian margin facing north and occupying latitudes of more then 40°, whereas the Uralian margin faced the North African part of Gondwana at somewhat more then 60° south. Even if assume that position of the geographical pole in the Cambrian was somewhat different from the palaeomagnetic pole and Baltica was shifted up to 10° south, Scandinavia still maintained geographical position slightly more then 50° south. Development of ice wedges about a size of 'Bratterfors plugs' suggests an existence of severe periglacial environment at these latitudes with mean annual temperature below -6° C. The appearance of extensive permafrost with a development of ice wedges in temperate latitudes between 40° and 50° could be regarded as a strong evidence for existence of extensive ice shield covered southern part of Baltica. A substantial sea level rise at the transgressive phase of the Black Mountain Event could be caused by degradation of the Baltic ice shield at the beginning of the Ordovician resulted from a rapid northward drift of the continent at that time.

Ordovician conodonts in different paleogeographical environments of the Southern Urals

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Oral Presentation

Among complexes of the Ordovician convergent margin investigated in the Southern Urals structure, the Guberlinskaya ensimatic island arc complexes and those formed in basins located on both sides of this arc, are distinguished. A marginal basin was located between the Ordovician Guberlinskaya arc and passive margin of the Eastern European craton; another basin – to the east of this arc. Later, since Early Devonian, the part of the second basin was enclosed between waning Ordovician arc and nascent Magnitogorsk ensimatic island arc. In modern structure these complexes are present in Sakmara allochthon and at the boundary of Prisakmara-Voznesensk and Western-Magnitogorsk zones.

Complexes of the marginal basin cover the Tremadoc-Ashgill stratigraphic range. At the Tremadoc level (i.e., Kidryasovskaya Formation) a significant volume is occupied by arkoses formed due to a transportation of terrigenous material from a platfom margin. Facies changes are expressed in presence of shallow-water coarse-grained rocks with shelly fossils and more deep-water clayish rocks with graptolites. Tuffaceous sandstones and aleurolites predominated at the Arenig-Llanvirn level, are facially replaced by cherty tephroites in the Llanvirn-Ashgill. Tuffaceous rocks of this type (i.e., Kuraganskaya Formation) mark a slope and bottom of the volcanic arc faced to a continental margin; cherty tephroites - arc bottom and forearc trough.

As established on conodonts, complexes of basins located to the east of the Ordovician arc, cover the Arenig-Ashgill stratigraphic range. Redeposited Late Tremadoc *Loxodus bransoni* Furnish has been found as well. This type is traced in a system of nappes where different elements of the paleobasin are juxtaposed. Nappes belong to the structure of an accretionary prism in front of a Devonian Magnitogorsk arc. They are represented by a chert/basalt complex (i.e., Polyakovskaya Formation), which is the upper member of the ophiolite association.

The island arc complex of this basin is represented by Guberlinskaya and Bauluskaya formations. Tuffites, acid and mixed composition tuffs, basalt and rhyolite flows predominate in a section of Guberlinskaya Formation. Conodonts in a section of this Formation belong basically to the Middle Ordovician. These are: *Pygodus serra* (Hadding), *Periodon aculeatus* Hadding, *Eoplacognathus robustus* Bergstrom, *Dapsilodus mutatus* (Branson et Mehl), *Protopanderodus varicostatus* (Sweet et Bergstrom). Acid and basic effusive rocks and minor component of andesites represent Bauluskaya Formation. Series of massive sulfide ore deposits are connected with these rocks in the Mednogorsk area. In the middle part of the section, above ore bodies, where acid and basic effusive rocks are replaced by basaltoids, cherts, jaspers, and cherty/hematite shales are present. The latter yield the Late Caradoc-Ashgill *Hamarodus brevirameus* (Walliser), *Protopanderodus liripipus* Kennedy et al., *Periodon grandis* (Ethington), *Scabbardella altipes* (Henningsmoen), *Belodina confluens* Sweet. Upsection, in Blyava quarry, basalts contain beds of carbonaceous shales with Llandovery graptolites. The Ordovician arc complexes are traced into Tagil Zone.

Guberlinskaya arc waning and arc jump to the east was accompanied by spreading in the basin located between these arcs. It has created conditions for a collision of a dying arc and the platform margin. In the Late Devonian this process coincided with the formation of nappes and high-pressure metamorphites.

Bryozoa from the Pin Formation (Upper Ordovician – Lower Silurian) in the Tethyan Zone of the Indian Himalayas

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Poster Presentation

The Pin Formation consists of a 280 m thick sequence, from which the lower part (90-220 m) has been dated as the Upper Ordovician (*A. ordovicicus* Zone) and the upper part (220-280 m) as the Lower Silurian. The age is provided by conodonts occurring in the sequence from 90 to 220 m. The uppermost part could be dated by coeval conodont bearing beds from a closely located site at Mikkim.

Micro facial analyse points to shallow marine environment. Three distinct sedimentation cycles are distinguished in the Pin Formation. The middle part of the Formation contains reefal structures built by stromatoporoids and corals. Other fauna is represented by brachiopods, bryozoans, corals, echinoderms, molluscs, tentaculites and trilobites. The glaciation and global cooling phase during late Rawtheyan to Hirnantian cannot be identified through fossils (and sediments); it may be represented by a hiatus between Cycle 2 and 3 (220 m).

Bryozoa appear in the lower part of the Pin Formation becoming most abundant and diverse in the middle part regarded as Caradocian (?) to Ashgillian in age (140-220 m). They seem to be lacking in the Silurian part (220-280 m) of the section. Bryozoans are represented by all main stenolaemate orders. The most abundant and diverse group are bifoliate cryptostomes from which different species of genera *Phaenopora*, *Insignia*, *Pseudopachydictya*, *Graptodictya* and *Pseudostictoporella* were found in the middle part of the Pin Formation. Trepostome bryozoans are less abundant represented by few species of genera *Eridotrypa*, *Monotrypa* and *Monticulipora*. Two phylloporinid bryozoans, *Enallopora* and *Pesnastylus*, occur in the Pin Formation. The latter one is known with the single species from the Upper Silurian of Australia and Lower Silurian of Kazakhstan. Cystoporid bryozoans are represented by the genus *Ceramopora*. Some few species of rhabdomesid bryozoans were also found in this fauna. The cyclostome species *Kukersella borealis* (Bassler 1911) found at the level of 190 m is cosmopolite for Upper Ordovician.

The investigated bryozoan fauna confirms mainly to the Upper Ordovician age dating provided by other groups. However, some distinct Silurian elements occur too. This fauna displays paleobiogeographic connections to Australia and Siberia.

Radiation of bivalves during the Ordovician: morphological quantification of peri-Gondwanan faunas

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Oral Presentation

Bivalve molluscs underwent a major radiation in Early Palaeozoic times, with no more than 5 genera reported in Early and Middle Cambrian and near 150 in the Ordovician period [1]. This «great Ordovician biodiversification event» has been documented by several uni- or bi-variate analyses focusing on taxonomic diversity [2, 3, 4 & 5], and has been studied by only descriptive approach regarding morphological disparity [2, 3, 5 & 6]. No multivariate analysis have been yet used to assess morphological evolution of this molluscan class. The aim of this work is to establish a multivariate morphospace of Ordovician bivalves relating their fast evolution of disparity during this period.

From this point of view, each genus reported in the Ordovician has been here described according to different morphological statements of qualitative characters (e.g. dentition, ligament, valve shape, ornamentation, shell microstructure, soft parts scars, etc). Each state of character is then encoded and included in a matrix, which is computed by multivariate analysis (PCO). This produce principal components which define the morphospace axes in which bivalve genera are ordinated according to similarities in morphologies.

Then, the spatiotemporal settings of these faunas is compared with evolution and occupation of their morphospace:

*In Early Ordovician times, the majority of bivalves are endobenthic or semi-endobenthic (mainly Paleotaxodonts, Heteroconchs, few Pteriomorphs). They seem to be restricted to siliciclastic environments on peri-Gondwanan shelves (from low to high latitudes of Gondwana, Avalonia).

*In Middle Ordovician times, under intrinsic impulse (e.g. development of gill grade for cardiolariids –Paleotaxodont forms–), epibenthic and semi-endobenthic faunas start to expand. If Paleotaxodonts and Heteroconchs are still abundant, Pteriomorphs increase in diversity, and morphological disparity follows.

*In Upper Ordovician, and after a fast morphological diversification, these faunas colonize other palaeocontinents (Laurentia, Baltica, Siberia) and prevail there in more warm and carbonate environments (extrinsic factors). Simultaneously, taxonomic diversity decrease on peri-Gondwanan margins.

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Late Ordovician graptolite extinction and biogeography of graptolites in the Yangtze region

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Poser Presentation

The present work is mainly based on four continuous Ashgillian to earliest Llandovery sections together with data from more than 30 other published sections from South China. The studied sections represent relatively shallow-water and deeper-water belts in the Yangtze region. We have combined the species range data from these sections into a single graptolite composite standard sequence (GCSS) using Shaw's (1964) graphic correlation technique (see Fan, 2001). As is common in graphic correlation analyses, the stratigraphic scale of the GCSS is a function of the scale of the reference section, the Wangjiawan North section. A temporal scale for graptolite zones in the Ordovician and Silurian developed by Cooper and Sadler (in press) and Melchin et al. (in press) was adopted and the GCSS ranges were plotted against this temporal scale.

The new GCSS reveals that the mass extinction was gradual or stepwise and began with a major extinction event that spanned an interval from near the top of *Tangyagraptus typicus* Subzone to the middle of the *Normalograptus extraordinarius-N. ojsuensis* Zone. A secondary, more minor pulse of extinction (minor extinction) took place late in the interval of the upper *Normalograptus persculptus* Zone. This result coincides with a binary cluster analysis of the four sections, especially the GSSP candidate section of the Hirnantian Stage, the Wangjiawan North section, which indicates two separate faunal turnover near the base of the *N. extraordinarius-N. ojsuensis* Zone and the top of *N. persculptus* Zone.

Using temporally scaled range data, species diversities, extinction and origination rates can be calculated more precisely. According to the species-area relationship method, we can calculate that if the area of the Yangtze Sea were reduced to 50%, the diversity will drop down to 19%. But actually, in the Yangtze region, during the major extinction event, less than 50% reduction of the area of the epicontinental sea was gone with 75% reduction of graptolitic species. So, the deterioration of the environment, such as the cooling of the seawater and the accompanying changes of the quality of the seawater (e. g., the upward movement of dysaerobic and anaerobic water), can result in at least 56% declining of the species diversity.

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SinoCor 3.0, a biostratigraphic program for graphic correlation

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Poster Presentation

As a method for quantitative biostratigraphic analysis, graphic correlation has been widely applied in biostratigraphic analysis (Sweet, 1984; Sweet and Tolbert, 1997; Kleffner, 1989,1995; Cooper and Lindholm, 1990; Cooper, 1992; Zhang and Chen, 1994; Zhang, 1995; Carter *et al*., 1995; Grubb and Finney, 1995; Klapper and Kirchgasser; Macleod, 1995; Mann and Lane, 1995; Melnyk, 1995; Finney *et al*. 1996; Fan *et al*., 2002). SinoCor is strictly designed in accordance with the principles of graphic correlation and therefore can be effectively used in stratigraphic analysis of fossiliferous sections of any age.

In order to enhance the function and capacity of SinoCor 3.0, the authors began to design the new version of SinoCor from early 2004. It is written in Visual Basic programming language and designed for Microsoft Windows. SinoCor 3.0 adopts interactive graphical interface and can deal with almost unlimited dataset, which is only depended on how fast the user's computer is.

1. What is new in SinoCor 3.0?

- SinoCor 3.0 was designed under Windows 2000 circumstance and can also run under Windows 9x, Me, XP etc.
- The processing ability of SinoCor 3.0 enhances greatly. It can deal with almost unlimited dataset, which is mainly depended on how fast the user's

computer is.

- SinoCor 3.0 supports dogleg fit method as well as linear fit method.
- SinoCor 3.0 is more convenient to use. Its graphic interface is similar with that of some popular software such as Microsoft Word. All the functions can be obtained using mouse.
- The output function has been greatly enhanced. Users can output results to any printer supported by Windows.
- All the steps during the compounding are restored and users can back to any previous step.
- The result can be output to Microsoft Excel as data or to Corel Draw as figures.

2. System requirement

- Intel Pentium II processor or equivalent
- 64MB of RAM
- 20M hard disk space
- 65,000-color (High Color/16-bit) video display card
- printer supported by Windows
- MS Windows 95 or higher version

3. Acquisition

SinoCor 3.0 was designed and programmed for scientific purpose. Anyone that wants to have a copy please contacts the present authors, fanjuanxuan@yahoo.com and ydzhang@jlonline.com. It will also be put on the new website of International Subcommission on Ordovician, www.ordovician.org.cn.

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Changes in Darriwilian acritarch and prasinophyte assemblages of the Yangtze Platform (South China) and the Barrandian area (Czech Republic)

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Oral Presentation

Sediments of the Upper Dawan and Shizipu formations (Yangtze Platform, South China) and of the Sárka Formation (Barrandian area, Czech Republic) are characterized by different fossil groups, including common and well diversified assemblages of organic walled microfossils (OWM), such as acritarchs, prasinophytes and chitinozoans. During the Lower and Middle Ordovician both areas were located in different parts of peri-Gondwana. A position from intermediate to low palaeolatitudes has been documented for the Yangtze Platform while a placement of the Barrandian area is supposed to correspond to high southern palaeolatitudes. Succesions in both areas are well dated by graptolites (Barrandian area) and/or by graptolites and conodonts (South China), respectively.

However, the composition of OWM assemblages throughout the transition from the Lower to the Middle Ordovician shows very similar patterns of diversification and evolution in both peri-Gondwanan sectors. An example of comparable trends in the development of acritarch and prasinophyte assemblages has been recently established within the Middle Ordovician sequence, namely above the base of the Darriwilian Stage. This stratigraphic interval is characterized by a global transgressive event (CHEN & BERGSTROM 1997).

Changes in acritarch and prasinophyte assemblages.

BROCKE et al. (2000) distinguished four acritarch assemblages (designated as assemblages *A* to *D*) within upper Arenigian – lower Llanvirnian sequences on the Yangtze Platform. The older assemblages *A*, *B*, and also the younger assemblage *D* are highly diversified, whereas the assemblage *C* (= *U. austrodentatus* graptolite biozone and corresponding to the base of the Darriwilian Stage) is characterized by a common occurrence of large representatives of the prasinophyte genus *Leiospharidia* associated with poorly to moderately diversified acritarchs.

Comparable results regarding diversification trends in acritarch and prasinophyte assemblages have been also documented from the Barrandian sections by FATKA (2003 - locality Praha - Cervenývrch and FATKA et al., 1996 - locality Rokycany – Drahous).

Study of changes in acritarch and prasinophyte assemblages during transgressive-regressive pulses in moderately deep to deeper water enable to explain fluctuations in diversity and productivity of the primary producers.

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A late Ordovician global warming event?

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Oral Presentation

The attention focussed upon the latest Ordovician Hirnantian glacial event has deflected attention away from an important pre-Hirnantian climatic fluctuation. Changes in pre-Hirnantian facies distributions, endemic faunas, and migration of key trilobite and brachiopod taxa all point to a phase of global warming. On the Gondwana continent the event is marked by a short-lived, but practically universal interval of bryozoan limestone deposition interrupting previously clastic formations. Movement pole-wards of previously palaeoequatorial taxa (known in earlier strata from China and the Far East), including hammatocnemid trilobites and *Paraphillipsinella*, is consistent with the same climatic change. A few trilobite taxa, such as the cheirurid *Heliomera* from the Cystoid Limestone of Spain, apparently crossed to Gondwana from Laurentia at the same time. On the Yangtze Platform in China the same climatic phase induces a most unusual endemic evolution of graptolites such as *Tangyagraptus*, presumably adapted to elevated temperatures. In Baltica/Avalonia the distinctive and richly fossiliferous Boda Limestone and its equivalents appears to equate with the same event. Other carbonate mudmounds marking the event are known from Ireland, England, Estonia and as far eastwards as eastern Siberia. The interval marks a peak in strophomenoid brachiopod diversity. Laurentian endemic platform coral faunas, and a diverse succession of Midcontinent conodont faunas are probably the result of unusually elevated temperatures on that palaeocontinent. This positive climatic excursion invariably predates the latest Ordovician deterioration.

Modelling atmospheric CO_2 changes at geological timescales

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Oral Presentation

Temporal variations of atmospheric CO_2 at geological timescales ($\Delta t > 0.1$ my) can be described with simple geochemical box models. Such models couple the major biogeochemical cycles, such as those of carbon, calcium, magnesium, sulphur, etc. They contain a representation of the climate system, either through simple parametric relationships (Berner and Kothavala, 2001), energy balance models (François and Walker, 1992) or even general circulation models (Donnadieu et al., 2004). They thus allow taking into account the feedbacks between climate and geochemical processes. The core of these models is the description of continental weathering, which is a function of surface temperature, runoff, soil pCO_2 and rock type. Recent work has emphasized, for instance, the important role of basaltic rocks in the evolution of atmospheric CO_2 and climate over Earth's history (Dessert et al., 2001).
In this talk, the general characteristics of geochemical box-models will be described, together with the hypotheses on which they rest. Some results will illustrate the use of these models for calculating long-term evolution of atmospheric CO_2 and climate over Cenozoic or Phanerozoic times, as well as for studying shorter geological events, such as the impact of basaltic trap emplacement and biological crisis on the carbon cycle and climate at the K-T boundary (Dessert et al., 2001), the Permo-Triassic boundary (Grard et al., in preparation) and in relation with snowball Earth episodes (Goddéris et al., 2003).

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Emergence of the Palaeozoic Evolutionary Fauna in the early Ordovician of the Alborz Range, northeastern Iran

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Poster Presentation

The Simeh-Kuh section northwest of Damghan (eastern Alborz Range) provides a nearly continuous record of environmental and faunal changes from the Upper Cambrian through the Middle Ordovician. The Upper Cambrian bioclastic carbonates of the Mila Formation formed in shallow water. They are comprised mostly of *Billingsella* coquina beds and echinoderm limestones which accumulated in some high energy environments. Carbonate sedimentation ceased by the end of the Cambrian and started again after rapid subsidence with deposition well below storm wave base in the basal Ordovician. The Tremadocian interval of the lower Lashkarak Formation is represented by fine clastics with a characteristic deep water trilobite fauna dominated by *Schumardia* and agnostides, but including also *Apatokephalus*, *Asaphellus, Dikelocephalus, Asaphopsis,* and *Psilocephalia*. Shallow water brachiopod faunas dominated by the billingsellid *Protambonites* and orthides are only preserved in some slump deposits and silty limestone beds most likely representing tempestites.

The lower Arenig boundary is well defined by the appearance of *Tetragraptus* and *Didymograptus,* and a characteristic trilobite assemblage including *Taihungshania miqueli*, *Paramegalaspis*, *Asaphellus*, and *Basilicus* (*Basiliella*). In the Lashkarak Formation, most Arenig deposits formed in storm dominated environment slightly below storm wave base. The background sedimentation is characterized by silt and clay. Beds of fine grained sand within the *Prioniodus elegans* Biozone and bioclastic limestones in the predominantly carbonatic sequence are representing proximal tempestites. The transition to a storm dominated carbonate sedimentation is marked by the sudden appearance of the obolid *Thysanotus* and the associated lingulate brachiopod assemblage known also from Baltica (South Urals, Poland and Estonia) and Perunica. It is regarded as an opportunistic fauna taking advantage of a rapidly changing environment. With the onset of carbonate deposition during the uppermost *Prioniodus elegans* or *Oepikodus evae* biozones, benthic faunal assemblages acquire typical features of the Palaeozoic Evolutionary Fauna. The importance of trilobites declines dramatically, whereas rhynchonelliform brachiopods become predominant. The early appearance of bryozoans and ostracodes in the upper *P. elegans* Biozone and the diversification of echinoderms are also remarkable. Taxa of the cold water group are clearly dominating the upper Tremadoc and Arenig conodont faunas which are “contaminated” by only a few elements of the temperate water group. The faunal composition typical for the Balto-Scandic province is well comparable to other cold water peri-Gondwana areas and far less diverse than on Baltica.

The series of events preceeding the emergence of benthic assemblages dominated by the Palaeozoic Evolutionary Fauna strongly resembles the succession of Baltica. On both plates, the development of storm dominated environments following a pronounced sea level rise is connected with the invasion of the *Thysanotus* brachiopod assemblage and an onset of carbonate sedimentation formed in temperate water environments at higher latitudes. However, Lower Ordovician trilobites of the Alborz terrane retain strong Gondwanan signatures and the Arenig rhynchonelliformean brachiopod assemblage includes *Yangtzeella* known from South China and the Turkish Taurides. Thus, the observed similarity presumably reflects a similar paleogeographic position in latitudes between 40 and 50 degrees south. It most likely displays a general pattern in environmental and faunal turnover occurring in higher latitudes of the southern hemisphere between Baltica and East Gondwana during early Ordovician times.

The earliest record of a colour pattern in molluscs

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Poster Presentation

Unique preservation of the oldest colour pattern (? 490 Ma) of a molluscan shell, and the first record in monoplacophorans, are reported from the borehole that penetrated the Early Ordovician (Tremadocian) sediments in the Pechora Basin of Arctic Russia. The unusual preservation reflects low subsidence temperatures and minimal tectonic deformation, possibly due to close association of the fossil-bearing strata to the solid metamorphosed Precambrian basement. A colour pattern in the form of radial stripes coincides with the pattern of multiple muscle attachments to the shell which obviously influenced the mantle margin responsible for the shell formation and pigment deposition. We assume that this type of colour pattern is one of the most ancient to have appeared in molluscan evolution.

The Orthida: Disparity, diversity and distributional dynamics in a Palaeozoic brachiopod clade

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Oral Presentation

The orthides were one of the most diverse, numerically-abundant and successful groups of Palaeozoic benthos, appearing first in the early Cambrian and disappearing around the Permian-Triassic boundary. The two suborders, the orthidines (impunctates) and dalmanellidines (punctates) appeared sequentially during the Cambrian and Ordovician, respectively, diversifying into deeper-water and carbonate environments during the Ordovician and Silurian in a step-wise manner. The overall morphological disparity of the group peaked during the Caradoc; although the orthidines developed much greater disparity during the mid Ordovician, already in the late Ordovician, the dalmanellidines were a focus for increasing disparity and morphological innovation. Although the orthidines developed their greatest disparity during the mid Ordovician, the overall morphological disparity of the Orthida peaked during the Caradoc, where the dalmanellidines were a focus for increasing disparity and morphological innovation. The Ordovician radiations within the order are related to dispersed plate configurations during the earlier Ordovician and the capitalization of sparsely populated ecospace in the later Ordovician. A revised global diversity curve for the order displays a distinctive two-phase pattern. First, a near isometric increase in biodiversity during the mid Cambrian to early Caradoc was then followed by a latest Caradoc to late Permian interval of exponential decline. The radiation was rapid and correlation between absolute geological time and generic diversity reveals a linear trend, peaking during the late Caradoc. The interval of decline, however, models an almost exponential decay curve, gathering momentum at the Hirnantian extinction event and interrupted only by a minor diversity increase during the early Devonian. The early Palaeozoic radiation possibly conforms to a logistic model although the paucity of Cambrian data inhibits information on the early part of the curve. The later stages of the Palaeozoic decay curve may reflect the persistence of several cosmopolitan and eurytopic taxa continuing after the last major diversifications during the Devonian. Conversely the early history of the group may provide proxies for changing environmental conditions and palaeogeographic configurations in Early Palaeozoic oceans.

Late Ordovician ocean-climate system and paleobiogeography

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Oral Presentation

The Ordovician was a time of extensive diversification and radiation of marine life. The end of the Ordovician is marked by a major mass extinction that is generally attributed to environmental perturbations associated with an extensive yet short-lived glaciation. The understanding of the climate dynamics during this crucial time period for the evolution of life is still fragmental.

We used an atmospheric general circulation model (AGCM) and an ocean general circulation model (OGCM) to study the climate system in the Caradoc (~454 Ma) and the Ashgill (~545 Ma). Specifically, we investigated the response to changes in paleogeography, atmospheric pCO_2, solar insolation cycles (obliquity), poleward ocean heat transport, and sea level. We also used a 3-dimensional ice sheet model to explore the necessary boundary conditions for ice sheet formation.

The AGCM results indicate that, assuming that pCO_2 did not fall below 8x PAL (a minimum value for this time period), a drop in pCO_2 and the paleogeographic evolution can only be regarded as preconditioning factors in the glaciation. In order for ice sheets to form, other factors must have changed such as a drop in sea level from its

generally high Late Ordovician levels and/or a reduction in poleward ocean heat transport.
In all OGCM simulations, a drop in sea level led to a reduction in poleward ocean heat transport. This indicates a possible positive feedback that could have led to enhanced global cooling in response to pre-glaciation sea level drop. Continental drift could explain the observed global cooling trend in the Late Ordovician through a combined reduction in poleward ocean heat transport and increased ice-albedo effect. The ocean-climate system was also dominated by strong latitudinal temperature gradients and vigorous horizontal and vertical ocean circulation.
Finally, we compared the paleobiogeography of different taxonomic groups to the results of the climate models. The spatial distribution of Caradocian marine organisms is consistent with climatic and oceanographic gradients inferred from coupled ocean-climate models. The paleobiogeographic data thus provide an important evaluation of the global ocean-climate models and lead to a more robust inference of the early Late Ordovician global ecosystem.

Early diversification of jaw-bearing polychaetes

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Poster Presentation

Polychaete annelids have been playing an important role in marine ecosystems already since the Early Palaeozoic. The jaw-bearing forms of the Order Eunicida, for which the fossil record is most complete due to their differentiated jaws – the scolecodonts, appeared in the latest Cambrian. However, their main diversification falls into the Early and Middle Ordovician during which many typical Palaeozoic families and genera first appeared. Another important diversification episode occurred when Palaeozoic faunas were replaced by Mesozoic and modern ones, but this is still very poorly documented.
Ordovician scolecodonts have been reported from many different regions of the world. However, except for North America and northern Europe the data available are too limited to allow any detailed analyses of diversity patterns and palaeobiogeography. The outdated parataxonomical treatment further complicates the situation since many old names are of little use without careful revisions of type collections and re-sampling of type localities.
Comparison of polychaete faunas from Laurentia and Baltica indicates that most Ordovician species were restricted to one continent, although few examples of inter-continental distribution have also been documented. Most genera, however, were common to both regions though in some cases their appearance has been diachronous. The few records from other continents also indicate worldwide distribution of many Ordovician genera. Thus, the genus-level data can be taken as so far the best approximation of the diversification history of jawed polychaetes. Currently altogether some 50 apparatus-based polychaete genera are known from the Ordovician Period.
The Early Ordovician record of polychaetes is still poorly documented. Although a recent discovery from Estonia indicates occurrence of more genera than reported earlier, the frequency and diversity seem to have been still very low during the Early Ordovician. Moreover, only forms with primitive placognath/ctenognath type jaw apparatus are known from that period, some of which related to xanioprionids and conjungaspids and the enigmatic *Lunoprionella*.
During the early Middle Ordovician the first more advanced forms, including those with labidognath/ctenognath apparatuses are recorded. Although the diversity remains relatively low until the early Darriwilian, it seems evident that already by the earliest Middle Ordovician the main polychaete lineages had become differentiated.
A major increase in species diversity and abundance, as well as a rapid increase in the number of genera are recorded in the Darriwilian and the earliest Late Ordovician. This interval marks the first appearance of most of the genera that become common in younger strata. Therefore the recorded genus-level diversity remains rather stable through the Late Ordovician. Also, since the majority of Ordovician genera range into the Silurian, there is no major drop in genus level diversity of jaw-bearing polychaetes at the Ordovician-Silurian boundary.
To further assess the early diversification of jaw-bearing polychaetes it is essential to go down to species level and obtain systematically collected and monographically treated material from other regions/continents and from the intervals that are still poorly covered, like the Early and early Middle Ordovician.

Acritarch assemblages of the Ordovician and Silurian deposits in Lithuania

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Poster Presentation

Some samples from the Upper Ordovician and Lower Silurian deposits in the well Ledai-179 (Lithuania) have been collected and examined. Ashgilian acritarchs have been identified at the depth 800.6 m (Saldaus Formation, *Glyptograptus persculptus* graptolite zone): *Baltisphaeridium longispinosum*, *B. constrictum*, *B. brevifilicum*, *B. perclarum*, *Orthosphaeridium rectangulare*, *Ordovicidium chondrododora*, *Diexallophasis* ex gr. *sanpetrensis*, *Hogclintia digitatum,* and others. Llandoverian acritarchs have been obtained from depth of 790.3 m and 778.5 m and contains numerous *Multiplicisferidium frondi*, *Cimbosphaeridium pilaris*, *Diexallophasis denticulata*, *Solisphaeridium nanum*, *Domasia elongata*, *D. trispiniosa*, *Deunffia monospinosa*, and others. Wenlockian acritarchs established in depth of 771 m and 758.2 m. Ludlovian acritarchs presents in the interval of 941.6 - 989 m in core material of well Shiupiliai-69. Pridolian acritarch assemblage recorded in core Bebirva-109 (interval 925.5 - 964.4 m).

Cambrian brachiopods from near the Teisseyre-Tornquist Line in Poland and their implications for palaeogeography

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Poster Presentation

The results of my investigation on Cambrian brachiopods of Poland are based on many years of work on them, and on comparative analyses with collections gathered in the natural history museums in Great Britain, Sweden and Norway.

Baltic Depression, Podlasie Depression and Lublin Slope are situated within the Polish part of the East-European Craton (EEC). Brachiopods from 25 boreholes from this area were studied. On the other side of the Teissyre-Tornquist Line, the investigations were conducted in the Holy Cross Mountains, and lately in the Upper Silesia Massif. The analysis of fossils from the Holy Cross Mountains were mostly done on materials from outcrops.

The Cambrian is represented by siliciclastic facies, mainly sandstones and mudstones intercalated with claystones. Complete sequences of Cambrian strata occur here and the collected fossils represent the entire Cambrian. Inarticulate brachiopods are quite common but the clastic facies are not very favourable for good preservation of their delicate shells. Mostly the specimens are preserved as external or internal moulds.

The described brachiopods from the Polish part of the EEC are grouped in three distinct faunal assemblages typical of each Cambrian Series: Lower, Middle and Upper and are strictly correlated with the facies present. Their optimum occurrence is related to mudstone and siltstone strata of the upper Holmia Zone and lower part of the *Eccaparadoxides oelandicus* Superzone. The oldest species (middle Holmia zone) belong to *Micromitra* and *Mickwitzia*. The dominant brachiopod group in the Lower Cambrian is composed of several species of the genus *Westonia* (not *Lingulella*). Very characteristic shells of botsfordids are present, 'acrotretids' have remained scarce, and calcareous species are absent. In the Middle Cambrian 'acrotretids' are most frequent and speciated. Species of '*Acrotreta*' are accompanied with shells of *Acrothele*. Among linguloids *Lingulella ferruginea* Salter is very common.

The Upper Cambrian deposits known from the Baltic Depression are very thin and brachiopods there are scarce and not speciated. Only in limestones of the *Parabolina spinulosa* Zone frequent recrystalized shells of *Orusia lenticularis* (Wahlenberg) commonly form coquina layers.

Overall 29 species are recognised, among them 19 are common with Scandinavia. It proves there were direct connections between these two areas and their association with the same faunal province. Toward E and SE less and less brachiopod species and shells occur in spite of fact that on Lublin Slope the thickest series of craton-type Cambrian are developed.

In the Holy Cross Mountains**,** Cambrian sediments are over 3000 m thick. On the base of facial development and tectonics two regions of Cambrian are distinguished: the southern Kielce Region where the Lower and Middle Cambrian deposits occur and the northern Łysogóry Region where only the Upper Cambrian is documented. 21 brachiopod species are recognised there. They form three faunal assemblages, as in the Polish part of the EEC, but their taxonomic content differ, including only few common species: *Mickwitzia* cf. *monilifera* (Linnarsson), *Obolella rotundata* Kiaer and *Westonia bottnica* (Wiman) in the Lower Cambrian, *Acrothele granulata* Linnarsson in the Middle Cambrian, and *Orusia* cf. *lenticularis* (Wahlenberg), *Lingulella ferruginea* Salter in the Upper Cambrian. The last two species are widely distributed within the Acado-Baltic faunal province. The remaining species from the Holy Cross Mountains are known from Wales, Atlantic Coast of Canada and the Mediterranean (Spain and Morocco) or are endemics. Scarcity of obolids and lack of botsfordids (both groups common in the EEC) is noticeable. Presence of taxons with calcareous shells, *Trematobolus sp.* in the Protolenus Zone and *Trematobolus pristinus* (Matthew) in the Eccaparadoxides oelandicus Superzone indicate connection of the Holy Cross Mountais with Avalonian part of Gondwana. At the same time the fauna of the Protolenus Zone from the EEC is less diverse and the thin sediments reflect shallowing facies. In Scandinavia stratigraphic breaks is present at the junctions of the Lower Cambrian and Middle Cambrian with exception to this found in the Baltic. The Alum Shale Formation of the later Middle Cambrian (Ptychagnostus gibbus Zone) contains beds and lenses of bitominous limestone locally developed as the *Acrothele granulata* Conglomerat. In the Holy Cross Mountains *A. granulata* in the sandstone facies occurs, other species here are endemic forms, and the Pepper Mountains Shale Formation has nothing in common with the Scandinavian Alum Shales.

The Upper Cambrian is thick and the brachiopods include abundant *Lingulella davisii* M' Coy, typical for Welsh Ffestiniog Flags. Morphology of *Orusia* cf. *lenticularis* (Wahlenberg) occuring in sandstone facies is different than in the EEC. The only common 'acrotretid' is the endemic '*Acrotreta' multa* Orłowski.

The faunal and facial differences, as well as the differences in the stratigraphical sections justify establishing a new subprovince within Acado-Baltic Province: the Holy Cross Mountains Subprovince. It shows greater resemblance to the Avalonian part of the Gondwana. This is more pronounces in the Middle than in the Lower Cambrian, and is especially striking in the Upper Cambrian. The differences reflect different environmental conditions on both sides of the TTL. The question is: are they caused by palaeogeographical separation of the HCM area from the nearby Baltica?

Does the oxygen isotope composition of Palaeozoic brachiopods reflect palaeoenvironmental conditions? a critical reappraisal

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Oral Presentation

Brachiopod shells have been extensively used to unravel the oxygen isotope history of past oceans and to reconstruct oceanic palaeotemperature variations. The applicability of the oxygen isotope composition of Palaeozoic brachiopod calcite as a palaeotemperature proxy is hampered by the tendency of Palaeozoic brachiopods to show lower $\delta^{18}O$ values with increasing age. This trend was explained by Veizer et al. (1999) to reflect a secular decrease in $\delta^{18}O$ of sea water. In order to verify this long-term decline, the $\delta^{18}O$ of Palaeozoic conodont apatite was investigated.

Oxygen isotope ratios of Early Devonian, Middle Devonian, Late Carboniferous as well as Early and Late Permian brachiopod calcite are in thermodynamic equilibrium with those of contemporaneous conodont apatite and give comparable and realistic palaeotemperatures. However, Late Devonian brachiopods are significantly depleted in ^{18}O in comparison to conodonts. Palaeotemperatures calculated from $\delta^{18}O$ values of Frasnian brachiopods range from 30 to 40° C, whereas $\delta^{18}O$ values of conodonts translate into more realistic palaeotemperatures of 27 to 32° C (assuming $\delta^{18}O_{seawater} = -1$ ‰ V-SMOW for an ice-free world). A similar pattern can be observed in the Silurian and Ordovician. $\delta^{18}O$ values of Silurian brachiopods translate into unrealistic palaeotemperatures of 24 to 40° C in comparison to 26 to 32° C calculated from $\delta^{18}O$ of coeval conodont apatite. $\delta^{18}O$ values of Caradocian brachiopods yield palaeotemperatures of 32 to 36° C while those calculated from conodont $\delta^{18}O$ range from 24 to 30°C.

Lower $\delta^{18}O$ values of brachiopods can not result from diagenetic alteration since only well-preserved shells were used for oxygen isotope analysis. In addition, different life habitats of benthic brachiopods and nectobenthic or nectonic conodonts cannot explain the difference in reconstructed palaeotemperatures. Furthermore, conodonts and brachiopods investigated in this study were partly collected from the same horizons and therefore no major differences in salinity/$\delta^{18}O$ of ambient sea water are expected. Lastly, it is questionable whether the observed offset can be explained by non-equilibrium fractionation. Brachiopods are generally assumed to precipitate calcite in near-isotopic equilibrium with ambient sea water. However, Auclair et al. (2003) observed a kinetic isotope fractionation effect for the modern brachiopod *Terebratalia transversa* that results in significantly depleted $\delta^{18}O$ values of shell calcite relative to expected equilibrium values. Although we are currently unable to give a satisfactory explanation for the discrepancy in $\delta^{18}O$ of early Palaeozoic calcite and apatite, we argue that Ordovician to Devonian conodonts record palaeotemperatures more faithfully than coeval brachiopods. Most important, the oxygen isotope record of conodont apatite does not support the hypothesis of a secular change in the oxygen isotope composition of sea water.

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Ordovician carbon isotope trend based on Baltoscandian data: some aspects of composition and environmental interpretation

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Oral Presentation

Carbon isotopes are nowadays increasingly applied in the Ordovician stratigraphy and palaeoclimatology. Most of the publications are devoted to the upper Ordovician, Hirnantian in particular, and only recently two papers read by Ainsaar and colleagues at the last WOGOGOB meeting reported the first middle Ordovician carbon isotope data. Application of carbon isotopes as a tool for stratigraphic correlation and dating of rock sequences is in principle a simple method, where success depends mainly on how complete and detailed is the standard trend used as a base for comparisons. Different environmental interpretations are more speculative and uncertain although some good progress has been achieved in isotope palaeoclimatology and palaeo-oceanology.
A more or less complete carbon isotope trend for the late Ordovician has been ascertained based on the studies carried out mainly in Baltica and Laurentia, but also elsewhere (a summary of published and our new data will be demonstrated). There remain some small gaps (e.g. at the Ordovician Silurian boundary) or debates about dating of the end-Ordovician isotope shift. The pre-Caradoc Ordovician trend shows at least one (Darriwilian) clear positive shift, but the older part of the curve still needs additional data for overcoming the indistinctness caused by hiatuses and slow sedimentation. Excluding the Tremadocian and Hunnebergian clastic rocks (occupying 10 Ma of time) we do believe that the general pattern of the carbon isotope changes can well serve as a stratigraphic tool for the remaining 30 Ma. It should be stressed that it is the shape of the curve that is most important, not so much the actual values of the $\delta^{13}C$, because the latter may depend to some extent on the facies characteristics of the rocks measured.
The main positive excursions of the $\delta^{13}C$ values are as follows (in brackets Baltoscandian data, published and new ones): mid-Darriwilian (1.9‰), mid-Caradoc (2.2‰), 1st late Caradoc (1.9‰), 2nd late Caradoc (2.4‰), early (2.5‰) and mid-Ashgill (2.0‰), Hirnantian (4–7‰). By intensity of the carbon cycling the post-Hunnebergian Ordovician is subdivided into a long (24 Ma) low variability period (the $\delta^{13}C$ values vary close but mainly below 1‰) with a single mid-Darriwilian shift at 464 Ma. The second increasingly variable period (10 Ma) began with the mid-Caradoc excursion at 454 Ma and ended with the major Hirnantian excursion. This change of intensity seems to have a profound palaeoclimatological sense and is marked also by sedimentological and palaeontological features. On this background several environmental events such as relatively cool-water beginning of the sequence enriched by glauconite and/or iron oxydes, levels with organic matter (kukersite, black shale) accumulations, micritic limestones, alternation of arid/humid episodes, glaciation and general warming are commented in the context of stable isotope changes.
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Internal banding in Palaeozoic stromatoporoids and colonial corals: classification and controls of formation

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Poster Presentation

Palaeozoic corals and stromatoporoids exhibit a variety of internal banding phenomena, many of which have been commonly interpreted as annual growth bands. We evaluate bands through analysis of colonial corals and stromatoporoids from three stratigraphic intervals: Upper Ordovician of Manitoba Canada, Llandovery–Wenlock, and Ludlow of Gotland, Sweden. Banding features are divided into four categories: (1) absence of banding; (2) density banding formed by variation in density or form of elements; (3) growth-interruption banding indicating growth cessation and regeneration; and (4) post-mortem banding caused by compaction or diagenesis. For discrimination of band types, it is essential to examine internal structures and skeletal margins in thin sections or acetate peels. Species vary considerably in degree and type of banding; each has a distinct pattern of variation. We propose criteria to determine if banding is consistent with seasonally-induced growth variation: (1) consistency in band character and thickness; (2) continuity of skeletal growth; (3) marginal features; and (4) evidence of diagenetic alteration. Density bands in tabulate and rugose corals probably represent annual growth variations, but results for stromatoporoids are more ambiguous; although stromatoporoids commonly show banding, unequivocal density banding is poorly developed and, growth interruption generated most stromatoporoid banding. Cerioid rugose and tabulate corals possess the thickest density bands; the thinnest bands are in stromatoporoids and heliolitid tabulates.

Record of Ordovician and Silurian volcanism in Estonian sections – prospect of research

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Poster Presentation

In Estonian Ordovician and Silurian carbonate rocks volcanic ash beds are represented by thin clay- or feldspar-rich interbeds with common thickness of few centimetres. At Early Palaeozoic this area was 600–2000 km apart from potential volcanic sources at plate margins. Consequently each of these ash beds has wide distribution over the ancient shelf sea, and represents very large eruptions. These ash beds can be used as perfect time markers in correlation of sections. For proving correlations, study of immobile trace elements in bulk samples (Kiipli et al. 2001), composition of pyroclastic sanidine (Kiipli and Kallaste, 2002) and biotite (Kiipli et al. 2002) is useful. When mapped over large areas, ash beds can be used to point directions to the source volcanoes and to get information of main wind directions. Assemblage of authigenic minerals (illite-smectite, K-feldspar, kaolinite, chlorite-smectite) formed from the volcanic ash reflects, besides other parameters, also sedimentary environment in shallow marine shelf sea.

Number of altered volcanic ash beds in Estonia occurring at particular stratigraphical levels is following: Ludfordian–1, Homerian–3, Sheinwoodian–26, Telychian–40, Aeronian–2, Rhuddanian–1, Ashgillian–4, Caradocian–25.

Using Zr/Ti ratio as fractionation index three following to each other magmatic cycles can be distinguished in Caradoc. Formation of new volcanic sources or additional magma intrusions into the existing magma chamber can explaine these cycles. Finds of rare phenocrystals, e. g. almandine garnet, in Caradocian volcanic ashes of Estonia and in massive volcanics from Lake District area in England point to the volcanoes in the island arc near the Avalonia microcontinent (Kiipli and Kallaste, 2003).

Trace element composition of 40 Telychian volcanic ashes points to at least two different volcanic sources being active at the same time. One of these magma types is characterised by high Zr and Nb contents, other by high Ti, Sr and P contents.

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"Devonian land-sea interaction: Evolution of ecosystems and climate" (DEVEC) – the new IGCP Project 499

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Oral Presentation

During the last two decades research on the Devonian period had been included in some of the successful IGCP projects, e.g., in IGCP 216 "Global biological events in Earth history" (lead by O.H. Walliser), IGCP 335 "Biotic recoveries from mass extinctions" (lead by D.H. Erwin and E.G. Kauffman), and IGCP 421 "North Gondwanan Mid-Palaeozoic bioevent / biogeography patterns in relation to crustal dynamics" (lead by R. Feist and J.A. Talent). In these projects, however, the main focus was on the "marine side", i.e., plaeobiological/palaeontological, sedimentological, facial, and other aspects mainly concentrated on areas more of less "well under water". Therefore, an interesting field of investigations has not much been considered: The transition zone between land and sea plus their continuation in both, landward and seaward directions. Of course, IGCP Project 328 "Palaeozoic microvertebrate biochronology and global marine / non-marine correlation" (lead by A. Blieck and S. Turner) dealt with this zone, but focus was exclusively on fish remains and preferably their potential in biostratigraphical use and subsequent correlation. The recently accepted new IGCP Project 499 "Devonian land-sea interaction: Evolution of ecosystems and climate" (DEVEC) aims a broader view of this transitional zone which will be one of the main aspects of the project. But not only the processes within this (limited) area on or immediately near the former continents shall be studied – adjacent areas on the shelves reaching even reef structures that built up in a fair distance from the coast will have to be investigated by the participants of the new project. Especially the interactions between continental/coastal – shallow-water siliciclastics – outer shelf to even reefal settings are to be considered; the evolution of "continental/near-continent areas" may turn out to play a key role influencing all other facies including further details about palaeoecosystems and the Devonian palaeoclimate.

In the following paragraphs the outline of the new project is briefly summarized.

The Devonian was a critical period with respect to the diversification of early terrestrial ecosystems. The geotectonic setting was characterized by the switch from the post-Caledonian to the pre-Variscan situation. Plant life on land evolved from tiny tracheophytes to trees of considerable size in combination with a global increase in terrestrial biomass, and vertebrates started to conquer the land. Extensive shallow marine areas and continental lowlands with a wide range of different habitats existed which are preserved in a large number of basins all around the world. Climate change finally led from greenhouse to icehouse conditions towards the end of the Devonian. Both, rapid evolution of terrestrial ecosystems and climate change had a pronounced influence on sedimentation and biodiversity not only in the terrestrial but also in the marine realm ("Devonian Change"). A major goal of the project will be to focus on controls and interactions of the respective facies parameters in different paleogeographic settings in order to refine the global picture by international co-operation in a number of case studies. Geoscientific co-operation will include a variety of disciplines, such as sedimentology, paleontology, stratigraphy, paleoclimatology, paleogeography, geochemistry, paleooceanography, and structural geology.

The rapid evolution of early life on land and its interaction with sedimentary processes, climate, and paleogeography, both on land and in marine settings, will be covered by studies in different terrestrial and marine facies. Increasing colonization of the land by plants in combination with soil-forming processes and changing runoff led to major changes of sediment input into the marine system. On the other hand, sediment input and climate are major controls for carbonate production and reef development. The study of responses and interactions thus needs detailed characterization of facies and high-resolution correlation which can only be provided by a refined stratigraphy including biostratigraphy, lithostratigraphy, chronostratigraphy, etc. Characterization of facies and correlation of stratigraphic units is especially difficult in marine-terrestrial transitions and will be an important focus of the project. Resolution of sea-level changes will be enhanced by recognition and exact correlation of their effects which may be hidden just in these transitions. On the background of the global geotectonic situation (paleogeography s.l.), this will be an important prerequisite for a better discrimination of eustatic, climatic, and biotic controls, both on regional and global scale.

The focus of the project concerns the interrelated evolution of terrestrial and marine paleoecosystems with respect to biotic and abiotic factors in space and time. Studies will include individual paleoecosystems and their components as well as their paleobiogeographic distribution. Biotic and abiotic factors of paleoecosystems are controlled by both, earthbound and extraterrestrial triggers causing either cyclicity and/or distinct events. Thus in turn, such studies may give a clue to underlying causes of global changes. The project will include sedimentologic and climatic controls of reef development and distribution as well as diversity, and paleoecology of reef building organisms throughout the Devonian, because the Middle to Late Devonian was a peak in reef development with reefs spreading into latitudes as high as 45-60 degrees. On the other hand, accomodation space for Early Devonian reefs was greatly reduced due to major input of sediment from the continents in combination with sea-level lowstand(s). A marked decline in reef development towards the end of the Devonian was probably caused by climatic deterioration.

The integrative kind of research which is needed for the success of the project can only be carried out by a worldwide network of research groups representing different disciplines. Such a network can now be based on core groups successfully participating in the recently terminated IGCP 421. Furthermore, the project will extend the results of the former IGCP 328. It will actively interlink with IGCP 491 which is mainly centered around vertebrate research. IGCP 499, however, will concentrate on the correlation and interaction of different ecosystems in a more general way. Special attention will be paid to coupling effects between the terrestrial and marine realm. Co-operation will also put forward with the new IGCP Project 497 "The Rheic Ocean: its origin, evolution and correlatives". Furthermore, an active network is represented by the members of the "Subcommission on Devonian Stratigraphy" (SDS). These existing networks will be integrated and thus providing the necessary base for an improved understanding of the Devonian period. A number of the respective colleagues and working groups have already agreed to contribute to the proposed project (see list of participants on the website).

Tremadocian stylophoran echinoderms from the Taebaeksan Basin, Korea

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Poster Presentation

Abundant and diverse isolated remains of cornute and mitrate stylophorans are reported from the late Tremadocian (*Asaphellus* Zone) of the Tumugol Formation of Korea. Cornute skeletal elements represent an assemblage of marginals and brachials, suggesting the occurrence of at least four different species, very likely of cothurnocystid affinities. Mitrate remains include numerous isolated adorals, marginals and brachials of peltocystidans. Isolated peltocystid adorals from Korea had been previously described as *Anatifopsis cocaban* and *A. truncata* but interpreted as cirriped elements (Kobayashi, 1960) or problematica (Choi and Kim, 1989).

In this study, several morphometric analyses of kirkocystid adorals have been undertaken to explore the morphological diversity displayed by Korean adorals, and to compare their morphologies with those of other kirkocystids documented elsewhere. Main results of morphometric analyses are: (1) the distinction of three morphotypes within adorals of Gondwanan kirkocystids ("*Anatifopsis*", "*Balanocystites*", and "*escandei*" morphotypes); (2) the identification as *Anatifopsis* sp. of two Korean specimens corresponding to the "*Anatifopsis*" morphotype; and (3) the assignment of most Korean adorals, comparable in morphology to those already described as *A. cocaban* but clearly distinct from all

other kirkocystid adorals, to a new genus *Taebaekocystis*. Anatomy of peltocystids and kirkocystids is re-investigated and several internal structures are evidenced (e.g. palmar complex). Finally, a cladistic analysis shows that peltocystids from the Tumugol Formation are intermediate in morphology between primitive Peltocystida (*Peltocystis*) and Kirkocystidae.

In summary, this study expands the knowledge of peltocystid mitrates and evidences more diverse mitrate stylophoran fauna in the early Ordovician time.

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The oldest record of hydrothermal vent communities: intracratonic sites formed in the early stage (Tremadocian) of the Prague Basin

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Oral Presentation

Based on data from filament-rich jaspers, Little & Thorseth (2002) showed evidence for bacteriogenic Fe-oxide precipitation at low temperature deep-sea hydrothermal vent sites since the early Ordovician. The record of 490 Ma of clearly biogenic filaments in jaspers linked to Fe-oxidizing bacteria is usually connected with vent systems at mid-ocean ridges and spreading centres in back-arc basins. However, the oldest record of fossil communities from hydrothermal sites was up to date a low diverse association from Silurian massive sulphide deposits in the southern Ural Mountains (Little et al. 1997). In contrast to the economically interesting sulphidic deposits, the vent communities in the Prague Basin are of intracratonic origin connected with acidic to intermediate volcanism around volcanic centers and along fault systems.

In the western part of the basin near Rokycany-Holoubkov there is a unique record of stromatolitic deposits preserved as iron ores. The occurrence of a silicified receptaculitid fits with our interpretation of shallow water conditions. Cuts and polished slabs of iron ores show a high variety of morphologies from biolaminitic structures to stacked hemispheroids. There are extraordinary levels with microstromatolites growing on top of each other and forming small "reef structures" of approximately 3 cm in diameter. Similar microstromatolites are known from Neoproterozoic carbonates from Siberia. Of course, the Barrandean iron stromatolites formed under extreme environmental conditions, an influence of volcanic activity and hydrothermal solutions. We propose that mainly microorganisms, rather than chemical precipitation, generated the formation of the stromatolitic succession.

In general, stromatolites represent a dominant feature of Precambrian and Cambrian warm and shallow-water environments, later they are described mainly from restricted environments. This fits with the situation in the shallow western part of the early Prague Basin. No index fossils are known from the stromatolitic successions reflecting unfavourable life conditions, but causing problems for a detailed age control. However, the sites are Tremadocian in age based on the stratigraphic framework. The ore units represents shallow-water deposits within the Trenice Formation. This is supported by fossil assemblages from the underlying (Trenice) conglomerate and from the overlying greywackes.

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Defining the maximum extent of the Hirnantian ice sheet in Morocco

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Oral Presentation

The Lower Palaeozoic inliers of the Moroccan Hercynides (Meseta) and of the High Atlas contain large exposures of uppermost Ordovician sediments. Deposition of these rocks was coeval with the growth and decay of the major North and West African ice sheet during the Hirnantian. The uncertain relationship between the inliers has meant that the late Ordovician evolution of the Northern Morocco has remained poorly understood. In this paper, we present a palaeogeographic reconstruction and, on the basis of sedimentological data, define the maximum extent of the ice sheet in Morocco.

In the central High Atlas, Hirnantian sediments display an ice-proximal character, and comprise massive sandstones and sandy diamictites that are interpreted as glacially-derived mass flow deposits, separated by siltstones and bedded sandstones that reflect quiescent interglacial sedimentation. These sediments occur within a chaotic, folded package of 40-50 m thickness that bears internal truncation surfaces. These structures imply multiple phases of syn-sedimentary deformation and are interpreted as glaciotectonic structures. Overlying Silurian strata are unaffected. The association of streamlined subglacial bedforms (roches moutonées) with these deformation structures indicates that the High Atlas was occupied by ice. Northward, in the Rehamna inlier, the presence of soft-sediment deformation and downwardly injected sedimentary dykes suggests that the ice sheet continued into the southern Meseta.

In the Massif Central and Coastal Meseta, a succession of sandy diamictites is sharply overlain by two, stacked successions of thickening upward, parallel laminated and ripple cross-laminated, well sorted sandstones that were shed from the south or west. The latter sediments are undeformed and are interpreted to record the build out of shelf-edge deltas during maximum glacio-eustatic lowstands. Although these sediments would have been expected to provide a stable substrate during ice sheet advance, the absence of soft-sediment striated surfaces and ice proximal facies imply that the ice front never reached these areas. Northward, in the Tazzeka Massif, a thick turbidite-dominated succession (>300 m) is preserved. It records several glacial cycles in a very ice-distal slope setting with poor evidence of true glaciogenic sedimentation.

Palaeoecology and palaeobiogeography of Cambro-Ordovician stylophoran echinoderms

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Oral Presentation

Stylophorans (Cornuta, Mitrata) are a class of asymmetrical, free-living (unattached), arm-bearing Palaeozoic echinoderms, closely related to asterozoans and crinoids (Ubaghs 1961, Nichols 1972, David *et al*. 2000). In Cambro-Ordovician times, stylophorans frequently formed relatively dense populations on soft substrates. Palaeoenvironmental and palaeobiogeographical distributional characteristics of Cambro-Ordovician stylophorans both support their interpretation as psychrospheric faunas. Although they are known since the Early Mid Cambrian, stylophorans underwent a major radiation in the Upper Cambrian - Early Ordovician time interval. This diversification is well-documented in shallow to deep environments of cold to temperate seas of different high-latitude peri-Gondwanan regions (e.g. Montagne Noire, Morocco, Shropshire), but also, exclusively in deep environments, in several low-latitude regions (e.g. Australia, Korea, western North America). In Middle Ordovician times (Fennian to Llandeilian), palaeobiogeographical distribution of stylophorans appears to be restricted to high-latitude peri-Gondwanan regions (e.g. Bohemia, Brittany, Morocco). In contrast, during the Late Ordovician, stylophorans progressively extend to, and diversify in deep environments in the periphery of lower latitude regions (e.g. Australia, Baltica, eastern North America, Siberia). This palaeogeographical extension of stylophorans is particularly well-documented in the Upper Ordovician of eastern North America, where it coincides with a major shift in sedimentation and faunal assemblages, both probably correlated to a great transgression event (Patskowsky & Holland 1993). Interestingly, a similar «invasive» pattern is observed in the Upper Ordovician of eastern Laurentia for many other «cold» Gondwanan groups (e.g. bivalves, cryptolithinid trilobites; Shaw 1991, Cope & Babin 1999).

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The Ordovician acritarch assemblage from Meitan Formation, Tongzi, South China: biostratigraphy and biodiversity

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Oral Presentation

Five palynologic assemblage zones have been recognized from the Meitan Formation of the Honghuayuan section in Tongzi, Guizhou Province. Assemblage Zone I, in the *D. eobifidus* graptolite biozone, is poor in both acritarch diversity and abundance. The acritarch diversity of Assemblage Zone II in the *C. deflexus*-lower *A. suecicus* graptolite biozone is rather high. This assemblage is characterized by the appearance of *Acanthodiacrodium tasselii*, *Ampullula erchunensis*, *Arbusculidium filamentosum*, *Athabascaella playfordi*, *Cristallimium dentatum*, and *Tongzia meitana,* and is dominated by *Polygonium*. Assemblage Zone III, in the upper *A. suecicus* graptolite biozone, is characterized by the dominance of *Stelliferidium*. Acritarch diversity within Assemblage Zone IV, which occurs in the *U. austrodentatus* graptolite biozone, is closely consonant with that of Assemblage

Zone III. The relative abundance of *Polygonium* decreases but that of *Peteinosphaeridium* spp. becomes greater in this acritarch Assemblage Zone. Assemblage Zone V, recorded in the *U. austrodentatus* graptolite biozone, is dominated by *Leiosphaeridia* and *Polygonium*.
The acritarch assemblage recovered from the Meitan Formation from Tongzi shows close affinities to those reported from apparently coeval localities in central and southwest Europe, North Africa, the Middle East, South Asia, South America, and eastern Newfoundland, Canada. The Pre-Gondwana typical taxa *Coryphidium* and *Striatotheca* are found in all assemblages of the Meitan Formation in Tongzi. The Yangzte Platform belongs to pre-Gondwana acritarch province.
The FADs of *Ampullula erchunensis*, *Arkonia*, *Dicrodiacrodium*, and *Leprotolypa evexa* in the Meitan Formation are earlier than recorded from other localities.
Acritarch diversity in the Meitan Formation in Tongzi increases rapidly, and reaches a maximum in the *A. suecicusi* graptolite biozone. Acritarch diversity trends within the South China Plate provide some useful insights about Ordovician biotic radiation.
The distribution of acritarchs is seemingly affected by palaeoenvironment change. There is a correspondence between the generalized trend of acritarch diversity and the facies association curve for the same interval at Honghuayuan.
Vertical fluctuations in relative abundances of acritarchs appear to be related to changes in depositional facies. High relative abundances of *Leiosphaeridia* and *Striatotheca* indicate lower sea level, and high relative abundances of *Baltisphaeridium*, *Polygonium*, *Peteinosphaeridium*, the Galeata, and diacromorph group indicates higher sea level.
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Reef reconstruction after extinction events of the Latest Ordovician in the Yangtze Platform, South China

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Oral Presentation

Early Silurian reef reconstruction on the Yangtze Platform, in the northern part of the South China Block, is preceded by a combination of regional and global processes. During most of Ashgill time (Late Ordovician), the area was dominated by Wufeng Formation deep water graptolitic black shales. Reefs largely disappeared in the middle of the Ashgill Stage, from the northwestern margin of Cathyasian Land (southeastern South China Block), in advance of the Late Ordovician glaciation and mass extinction, due to regional sea-level changes and regional uplift, unrelated to the mass extinction itself. Late Ordovician microbial mudmound occurrence is also found in the western margin of the Yangtze Platform, its age corresponding to the *Dicellograptus complexus* graptolite biozone of pre-extinction time. On the Yangtze Platform, a thin, non-reef-bearing carbonate, the Kuanyinchiao Formation (= Nancheng Formation in some sites), thickness generally no more than 1 m, occurs near several landmasses as a result of Hirnantian regression. Reappearance of the earliest Silurian carbonates consisting of rare skeletal lenses in the upper part of Lungmachi Formation, are correlated to the *acensus* graptolite biozone, early Rhuddanian of Shiqian, northeastern Guizhou, near Qianzhong Land. Carbonate sediments gradually developed into beds rich in brachiopods and crinoids in the lower part of Xiangshuyuan Formation, middle Rhuddanian. In the middle part of Xiangshuyuan Formation, biostromes, containing abundant and high diversity benthic faunas such as corals, crinoids and brachiopods, show beginnings of reconstruction of reef facies. Substantial reef recovery occurred in the upper part of Xiangshuyuan Formation, lower Aeronian, as small patch reefs and biostromes. During the late Aeronian, carbonate sediments, especially reefs and reef-related facies, expanded on the upper Yangtze Platform, and radiation of reefs occurred in Ningqiang Formation, upper Telychian. The long period of reef recovery, taking several million years, remains difficult to explain, because redistribution of any refugia faunas would be expected to take place soon after the extinction. Reefs and reef-related facies subsequently declined after Telychian time due to regional uplift of the major portion of the Yangtze Platform. Carbonate facies are therefore uncommon in South China during the rest of Silurian time.

Ordovician palaeogeographical reconstruction of Baltica: palaeomagnetic data

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Oral Presentation

At the present day the position of Baltica during Early-Middle Ordovician time is still discussed. Based on the Scandinavian data mainly, the northern margin of Baltica was reconstructed at 40°S during Early-Middle Ordovician. However, palaeomagnetic data for of the Uralian shelf zone of Baltica (Eletsk zone) and sequences of the continental slope (Lemva zone) testify for more low-latitude position of Baltica (Tectonic history of the Polar Urals, 2001). According to the palaeomagnetic data for the Early-Middle Ordovician sequences form the St. Petersburg area, Baltica was located at 20°S (Lubnina & Zaitsev, 2004). New paleomagnetic data for the Upper Ordovician rocks is evidence the position of Baltica at 30°S (Lubnina, 2004). Summarised all new palaeomagnetic data the position of Baltica during Ordovician time have been reconstructed.

For the palaeomagnetic analysis Early-Middle Ordovician sedimentary rocks from St. Petersburg area, Late Ordovician rocks from Podolia, Ukraine and Late Cambrian-Early Ordovician rocks from the Uralian margin of Baltica, the Polar Urals have been sampled. All these rocks were carried out the palaeomagnetic treatments. More than 400 oriented samples were collected. Measurements were made at the palaeomagnetic laboratories of the Institute of Physics of the Earth (Moscow, Russia), Paris Institute of Physics of the Earth (France), and the Russian Scientific Research Geological Institute (VSEGEI, St. Petersburg, Russia), using cryogenics (SQUID) and JR-4, JR-5a spinner magnetometers. Characteristic high-temperature components were separated by detailed laboratory measurements. The primary origins of whose proving by conglomerate test (Lemva zone) and fold, conglomerate and reversal tests (Eletsk zone).

According to the palaeomagnetic and literary data, during Early Ordovician time Baltica moved to tropical southern latitudes, where its W-SW parts occupied the extreme south (up to 30°S). At the Late Tremadoc - Arenig along the Uralian margin of Baltica was formed active continental margin, to the west of which the Lemva deep-sea basin was generated. Palaeomagnetic data suggest the location of the Uralian margin of Baltica at 10°S, and the Lemva zone in near-equatorial latitudes. During the maximal rifting, width of this zone was more than 500 kms (Tectonic history.., 2001). Probably, at this time the Lemva zone was clockwise rotated about Baltica. Probably, this latitudinal difference was the result of forming the first oceanic basin of the PalaeoUrals to the east from the Lemva zone (Ruzhentsev, 1998). During Late Ordovician Baltica was located at 30°S.

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Early Silurian cephalopod migrations to the Prague Basin (Perunica micro-plate, Bohemia)

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Poster Presentation

Silurian transgression event caused the graptolite shale sedimentation on the north Gondwanan shelf. The early Silurian cephalopod radiation followed latest Ordovician extinction at the tropical carbonate platforms of the Laurentia and Baltica where characteristic Silurian cephalopod clades originated. The environment above the black shale biofacies in the Prague Basin was only suitable for the specialised cephalopods *Discinocaris* and *Plectocaris* with longicone shells closed by opercula. As the graptolite shale biofacies was progressively replaced by carbonate sedimentation the cephalopod migrated and colonised to new niches continued in the peri-Gondwana.

The pelagic cephalopod assemblage appears in the Prague Basin in the latest Llandovery, and its diversity

and density continually increases up to the early Ludlow. At the Llandovery-Wenlock boundary coiled nautiloid *Phragmoceras* occurs in the black shale environment, and documents first nektobenthic cephalopod migration to the Prague Basin. Since the late Wenlock the cephalopods are frequently more common than the graptolites.
The Prague Basin volcanic archipelago shallow slopes were since the late Aeronian colonised by benthic communities. First few cephalopod migrants of the Baltic-Avalonian origin (*Dawsonoceras*, *Peismoceras*, *Trubiferoceras* a.o.) occur in the early Sheinwoodian but the first prominent radiation of the cephalopod migrants started in the early Homerian. All Silurian cephalopod orders except actinocerids are presented. The cephalopod limestone biofacies originated within the shale biofacies where surface currents ventilated normally anoxic bottom since the late Wenlock. In the cephalopod limestone biofacies the pelagic and nektobenthic cephalopods with longicone shells are accompanied by a few nautiloids. The cephalopod radiation continued in the early Ludlow. The second cephalopod migration and adaptive radiation is connected with development of the isolated carbonate platforms in the early Ludfordian. The increase of the cephalopod diversity and the adaptations of the migrants to the cephalopod limestone biofacies are evident trends during the Wenlock and early Ludlow.
The current activity caused the ecosystem recovery after the late Ordovician glaciation and the later graptolite shale sedimentation after the early Silurian transgression. The peri-Gondwanan cephalopod fauna usually consist of the pelagic and nektonic cephalopods and a few nektobenthic nautiloids. The origin of highly diversified cephalopod assemblages in the Prague Basin is related to the position of the Perunican micro-plate north of the peri-Gondwana in the Rheic Ocean within the reach of the South Tropical Current. The relation between the graptolite extinctions and cephalopod migrations and radiations and appearance of the cephalopod limestone biofacies are prominent features of the early Silurian recovery. The cephalopod fauna documents faunal links between Baltica (Podoli, Gotland), Avalonia (Wales), Laurentia, and the Prague Basin.

The earliest brachiopod-bryozoan dominant community in North Gondwana: a case from Late Arenigian of the Barrandian, Bohemia

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Poster Presentation

In North Gondwana, the bryozoan-brachipod-pelmatozoan (BBP) communities are spread from the Middle Ordovician with the maximum in the early Ashgill. There are rare and only local occurrences in the older Ordovician stages contrary to other low-latitude palaeocontinents (Baltica, Laurentia). In North Gondwana, the BBP communities are typically known from the late Caradoc to middle Ashgill shallow shelves of the Iberian Peninsula, Montagne Noire of South France, Sardinia, the Carnic Alps, the Anti-Atlas and the Ghadamis Basin of Lybia, and from shallow-water volcanoclastic accumulations of the Armorican Massif.
In the Barrandian area of Bohemia, the communities of the BBP type are known in areally restricted sites in the Letná, Zahořany, Bohdalec, and the Králův Dvůr formations (Beroun to Ashgill). The most famous is the „*Polyteichus*" biofacies of Late Caradoc (Bohdalec Formation). There, the BBP communities originated on coeval tectonic rising zones.
In the Barrandian, the earliest communities that may be referred to the BBP communities are known in upper part of the Klabava Formation (Late Arenig). The foramtion consists of several depth-related lithofacies. The shallow lithofacies of rewashed volcanic tuffs bears a low-diversity *Nocturnellia* community bordered NW margin of the basin. It is dominated by a small dalmanellid *Nocturnellia nocturna* locally associated by moderately diverse fauna of siliceous sponges, trepostomate bryozoans, bellerophontid *Modestospira* and other fauna.
The most diversified fauna is known in nearby areas of ancient rocky coast, present in abandoned iron ore open mine near Ejpovice (SW part of the basin). The hematite oolite lens with abundant small chert pebbles yielded a remarkably rich fauna. This consists of massive, ramose and discoid trepostomate bryozoans (three undescribed species), encrusting bryozoan-like *Berenicea vetera*, orthid brachiopods *Nereidella pribyli*, *Nocturnellia nocturna*, *Poramborthis* sp. and *Protohesperonomiella* sp., hyperstrophic gastropod *Mimospira helmhackeri*, trilobite *Pseudopetigurus hoffmani*, a small conulariid, and large organophophatic brachiopods *Orbithele rimosa*, *Lithobolus plebeius* and *Elkanisca lineola*. All fossils are preserved in thin spongolite intercalation inside the larger oolite lense. The fossil accumulation is a taphocoenose, with shells trapped into the mat of detached and decayed sponges at the sea bottom. The absence of pelmatozoans is outstanding, but this group is unknown in the Klabava Formation. The taphocoenose represent the original benthic community of any sheltered crevice or cave of the nearby

rocky coast. Fossils attached to cliffs of ancient coast are known some 100-200 m apart. There, a thin stromatolite mat, with uncrusting *Berenicea vetera* and discoidal small tremapostomate bryozoan were found. Other encrusting mats and zoaria of bryozoan-like *Berenicea vetera* and *Marcusodictyon* sp. are know from abraded surface of the cliff, boulders, and pebbles in infillings of cliff and adjacent sediments.
The presence of the bryozoan dominant fossil association indicates that (1) origin of later BBP North Gondwanan communities can be sought in shallow temperate part of North Gondwana, and (2) the oldest BBP North Gondwanan communities are also of Arenig age, similar to BBP communities in low-latitude palaeocontinents.

Palaeoclimate modelling studies for the Late Miocene and for the Neoproterozoic

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Oral Presentation

We commonly use climate models to analyse the present-day climate and the future climate change, but they also allow us to identify and to understand the relevant processes of past climates. Exemplarily for palaeoclimate modelling we present here the application of (1) the model ECHAM4/ML to the Late Miocene (Tortonian, ~10 Ma), and (2) the model Planet Simulator to the Neoproterozoic (~850 Ma).
Late Miocene proxy data suggest a generally warmer and more humid climate than today, and particularly the Miocene meridional temperature gradient is weaker as compared to nowadays. In order to simulate the Late Miocene climate, we use the highly complex atmospheric general circulation model (AGCM) ECHAM4 coupled to a mixed-layer ocean model (ML). For our Tortonian model simulation we consider a lower palaeorography, a weaker palaeocean heat transport, and an appropriate palaeovegetation. On the global scale, the Tortonian simulation demonstrates a slightly warmer (+0.6°C) and more humid climate (+36 mm/a) as compared to a present-day control experiment. Primarily the high latitudes are warmer (up to +4°C) in the Tortonian simulation, and accordingly the polar sea ice cover and the meridional temperature gradient are reduced as compared to today. A quantitative comparison indicates that the Tortonian simulation agrees quite good with terrestrial proxy data, but the model tends to be too cool in the high latitudes. Thus, we understand the Late Miocene climate just partly and further studies are demanded.
In contrast to the warm Miocene, the Neoproterozoic (~850 Ma) was a cold episode during which the earth is assumed to have been largely ice-covered, but the degree of the Neoproterozoic glaciation is controversially discussed: A 'snowball earth' versus a 'slushball earth'. Referring to this debate, we perform a series of sensitivity experiments with the earth model of intermediate complexity (EMIC) Planet Simulator. Our preliminary results indicate that it is possible to maintain a global ice cover, but the model must be strongly forced at the initial setup. For the 'snowball earth'-scenario, the global average temperature is below –55°C. In addition to the 'snowball earth'-simulation we initialise the Planet Simulator with more moderate boundary conditions (e.g. the initial sea ice extension varies between 50° and 90°N/S) as compared to the 'snowball earth'-run. In these 'slushball earth'-scenarios the sea ice margin extends from the poles towards 30°N/S, but the equatorial regions remain ice-free. Basically, our Planet Simulator sensitivity experiments support the hypothesis of a 'slushball earth' rather more than this of a 'snowball earth'.

Ice-proximal sedimentary records of the Late Ordovician glacial cycles

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Oral Presentation

During the latest Ordovician (Hirnantian), western Gondwana was covered by an extensive ice sheet, the front of which fluctuated throughout the present-day North and West Africa. Field survey and 3D seismic interpretations on the Late Ordovician glacial sediments in the western Murzuq Basin (Libya) enable the sequence stratigraphy and architecture of an ice-proximal succession to be characterised. Five ice-related depositional sequences are identified. They are separated by erosional unconformities of subglacial origin.

Subglacial unconformities are inferred by the presence of highly deformed sandstones including intraformational striated surfaces and plurikilometre-scale streamlined bedforms visible on aerial or satellite images. These subglacial unconformities are gently dipping concave-up erosional surfaces, 5 to 15 km in width, up to 200 m in depth, which form up to 50 km long palaeovalleys. Geological mapping indicates that, due to different ice-flow orientations through time, the several generations of glacial valleys create a complex architecture of nested valleys and associated terraces. Depositional sequences are made up of a succession of glaciomarine, deltaic, estuarine or fluvial deposits recording glacial recession (transgressive) and highstand conditions. In the two upper depositional sequences, the backstep of successive outwash fans indicates that ice recession occurred during an overall post-glacial transgression.

The depositional sequences which comprise a succession of seismic-scale, unconformity-bound, ice-related depositional units, are climatically controlled and represent major glacial cycles throughout the north-gondwanian shelf. Therefore, the whole succession preserves a record of the evolution of the Late Ordovician ice sheet. The two first phases are dated as basal Hirnantian (chitinozoans) and represent the first occurrence of ice into the Murzuq Basin. A significant flooding is then recorded, indicating a major retreat of the ice fronts and a long-lasting interglacial phase before a third glacial advance of subordinate extent. The fourth phase is considered as the most important one in the area and, probably, by comparison with studies in ice-distal areas, in the whole North Gondwana. The subsequent ice-sheet recession comprises a number of subcycles. The last (fifth) glacial cycle was of limited extent as the ice did not re-advance further than the present day 25°N parallel. Overlying sediments record the post-glacial evolution prior to the deposition of Silurian shales.

Palaeogeography and biodiversity of Cambro-Ordovician echinoderms.

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Poster Presentation

In recent years, palaeobiogeographical aspects and biodiversity patterns (diversity, disparity) of the Cambro-Ordovician radiation of metazoans have been extensively investigated (Miller, 1997). However, most studies focused on the same three groups of marine invertebrates (articulate brachiopods, molluscs, and trilobites), whereas other significant components of Early Palaeozoic biota, such as echinoderms, remained largely neglected. (Harper & Mac Niocaill, 2002; Novack-Gottshall & Miller, 2003). Preliminary studies on the ecology of Cambro-Ordovician echinoderms have suggested relatively different diversification patterns in Laurentia (Guensburg & Sprinkle 2001) and on the northern Gondwanan margin (Lefebvre & Fatka 2003).

A comprehensive database including all records of Early Palaeozoic echinoderms has been built, so as to provide, for the first time, a global pattern of taxonomic diversity for this phylum in Cambro-Ordovician times. This global pattern of echinoderm diversity has been compared both with local diversity trends evidenced in selected regions of three palaeocontinents (Baltica, Gondwana, Laurentia), and with biodiversity patterns observed for several classes and/or major clades of echinoderms (e.g. asterozoans, blastozoans, crinoids, edrioasteroids, stylophorans). Finally, global and local diversity trends described for echinoderms have been compared with those reported for other marine invertebrates.

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Ordovician chitinozoan distribution in the different areas of Baltoscandia

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Poster Presentation

Chitinozoan species can be used to evaluate the fluctuation through time of the biodiversity of the still unknown metazoan group producing these microfossils, if one accepts the statements that the status of species (received by majority of experts) is regarded as representative of a true species, and their final count has not been achieved yet. The dataset of more than 5300 samples from Baltoscandia from the first occurrence of the group in the Tremadocian to the Ordovician-Silurian boundary is used for documenting the biodiversity. The total diversity, the origination and extinction rates as well as the turnover ratios are calculated for the 19 time-slices proposed by Webby et al. 2004. The distribution of chitinozoans from the eleven different areas of Baltoscandia (North-, West- and South Estonia, Russia (St Petersburg District), Latvia, Lithuania, Poland, Belarus, Ukraine, Norway, Sweden) is calculated separately, and the list of Ordovician chitinozoans summarizes the data of 157 species of 26 genera. Detailed data of chitinozoan quickly evolved assemblages from these regions has been relatively successfully used (see Nõlvak & Grahn 1993 for a general review) despite some complications in correlation of beds caused by (1) the differentiation of the sequence into five main composite belts, (2) unfavorable preservational conditions (barren active water sediments, dolomitization, thermal heath flow, marine redbeds or carbonate mounds etc.), (3) the differences in sampling and their size. In Baltoscandia it is difficult to obtain reliable data from largerly dominated bedded limestone samples with weight less than 300-400 grams. Their abundance usually ranges from small number of specimens to several tens of specimens per gram of rock. Specifically to the East Baltic sections in some portions in Upper Ordovician there are possibilities to adopt more detailed subdivision, e.g. in the time-slices 5b-5c. In the Lower Ordovician the situation reveals reverse: the time-slices 1c-2c are difficult to separate, which pronounces the “normal” scarcity in the early chitinozoan assemblages due to the noticeable stratigraphical gaps.

In general, (1) in the above listed different regions great similarities appear in the faunal logs, and in the order and levels of fluctuations (originations, extinctions); (2) regional differences do not exceed 10% of all taxa within the same time-slice; (3) this gives a good ground for the workable biozonation schemes in Middle and Upper Ordovician. Some problems appear in practical application of the chitinozoan zones. In first approximation the defining of range zones was comfortable; both zonal boundaries were fixed and clear according to the data available (Nõlvak & Grahn 1993). However, in some sections the earlier data about known ranges of important species may be out of date, and earlier criteria of the zonal boundaries should be redefined.

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Major changes in gastropod larval strategies during the Early Ordovician

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Poster Presentation

Minute steinkerns of molluscs commonly dominate Cambro-Ordovician small shelly assemblages. These assemblages indicate a major change in size and shape of early ontogenetic mollusc shells (protoconchs) across the Cambrian/Ordovician boundary. Based on new material and the published record, a fundamental faunal turnover and a drastic change in the overall shapes and morphologies across the Cambro-Ordovician boundary can be recognized. This turnover is suggested by the extinction of typical Cambrian small shelly molluscs and the origination of several gastropod clades with a characteristic early ontogeny.

Although the systematic and phylogenetic significance of these minute steinkern faunas is limited, size and shape of the internal molds give direct evidence for ontogenetic strategies (i.e. the amount of yolk) during this important time interval. Characteristic Cambrian, limpet shaped or coiled molluscs (e.g. *Aldanella, Anarbarella, Latouchella*) have relatively large, undifferentiated initial parts which indicate lecitotrophic ontogeny. In the early Ordovician, various forms of gastropod larval shells appear for the first time. Many of these protoconchs have a loosely coiled first whorl (see also Dzik 1994), and the size of their initial part suggests planktotrophic larval development. At the same time larger protoconchs are present which indicate lecitotrophic development. This shows that planktotrophy and nonplanktotrophy occurred at the same time during the Ordovician while planktotrophy cannot be substantiated for Cambrian molluscs. The acquirement of planktotrophy formed a major step for the evolution of the molluscs with far reaching consequences for larval dispersal. Gastropod protoconchs from Ordovician small shelly assemblages have a multitude of shapes and many of them are indeed openly coiled. This variation reflects the tremendous radiation of the Gastropoda during the Ordovician. The openly coiled form of protoconchs was still dominant during the Silurian but subsequently removed from the fossil record so that this once dominant morphology is unknown from the Mesozoic (Nützel and Frýda 2003).

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Early Darriwilian graptolite and conodont biofacies in the Los Azules Formation, Cerro Viejo section, Central Precordillera, Argentina

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Poster Presentation

The Middle-Upper Ordovician Los Azules Formation is part of a transgressive rock complex overlying the San Juan Limestone in the Central Precordillera of western Argentina. The type area of this formation is located on the western flank of the Cerro Viejo at Huaco, San Juan Province. The formation consists of three members: a lower claystone and K-bentonite member, a middle member of basal micaceous sandstones and siltstones, and an upper calcareous siltstone and limestone member. Graptolites and conodonts are the dominant faunal elements but palynomorphs, phyllocarids, inarticulate brachiopods, ostracodes, machaeridians, and trilobites are also present. The presence of guide fossils allows for the identification of the *Undulograptus dentatus, Holmograptus lentus, Pterograptus elegans, Hustedograptus teretiusculus,* and *Climacograptus bicornis* graptolite zones, and the *Lenodus*

variabilis, Eoplacognathus suecicus, Pygodus serra, and *Amorphognatus tvaerensis* conodont zones, which span the interval of the Darriwilian (Da2) to Gisbornian (Gi2) stages of the Australian chronostratigraphic scale. The contacts between the members coincide with two stratigraphic gaps. The lower hiatus is within the Darriwilian (probably Da3) as suggested by the absence of the *Diplograptus? decoratus* Zone (*Nicholsonograptus fasciculatus* Baltic Zone) and part of the *E. suecicus* Zone. The upper hiatus, corresponding to the Gisbornian (Gi1) is recognized by the absence of the *Nemagraptus gracilis* Zone, and the *Pygodus anserinus* and lower part of the *A. tvaerensis* zones. The *U. dentatus* Zone ranges through the lower 9 m of the the lower member. It contains a rich graptolite assemblage, including *Parisograptus caduceus, Glossograptus* sp., *Paraglossograptus tentaculatus, P. tricornis, Cryptograptus antennarius, Arienigraptus zhejiangensis, A. angulatus, Arienigraptus* sp., *Undulograptus austrodentatus, U. dentatus, U. primus, U. sinicus, U.* sp. cf. *U. cumbrensis*, *U.* sp. cf. *U. dicellograptoides,* and frequent dichograptids and sigmagraptids. The appearance of the *Archiclimacograptus* and *Hustedograptus* genera marks the overlying *H. lentus* Zone, although the eponymous species was not recorded. The major part of the preceding fauna remains unchanged. *Archiclimacograptus angulatus, Archiclimacograptus* sp., *Haddingograptus oliveri, "Climacograptus" pungens,* and *Cryptograptus schaeferi* appear within this interval. *Bergstroemograptus crawfordi* is recorded in the upper part of the biozone, just 30 cm before the appearance of the *P. elegans* fauna. This species is associated to *A. angulatus, A. marathonensis, C. schaeferi, "C." pungens*, *H. oliveri,* and isograptids. Most of the lower *H. lentus* Zone graptolite assemblage disappears at this level. *B. crowfordi* is associated with the first record of the conodont *Polonodus magnum*, just below the appearance of the *Pygodus anitae*, which indicates the upper part of the *E. suecicus* Zone. Despite the absence of diagnostic Da3 graptolites within this interval, a sudden change in faunal composition suggests either the presence of strata corresponding to the uppermost Da2 or a part of the Da3. The Pacific Province graptolite faunas of the lower member are similar to those from Australia and Laurentia, and are characteristic of deep water environments of the isograptid biofacies. Associated conodont species include *Bryantodina* aff. *typicalis, Drepanodus arcuatus, Drepanodus robustus, Drepanoistodus* spp., *Paroistodus horridus, Periodon aculeatus, Protopanderodus gradatus,* and *Spinodus spinatus* which span the *L. variabilis - E. suecicus* zonal boundary, and *Polonodus magnum,* which marks the presence of the *E. suecicus* Zone in the upper part of this member. Conodont diversity at the top of the San Juan Limestone is about 25 species. After the abrupt environmental change caused by the drowning of the carbonate platform, the conodont diversity dramatically drops to about 10 species in the lower member of the Los Azules Formation. These forms correspond to the pelagic biotope of conodont communities, which are restricted to cold waters of the deep-slope environments.

Trilobite diversity in Avalonia prior to the end Ordovician extinction – the peak before the trough.

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Oral Presentation

The trilobite biodiversity curve for Avalonia differs markedly from the global and other regional patterns in having the peak of diversity immediately prior to the Hirnantian extinction event rather than in the Caradoc or even earlier. This reflects both the very wide spectrum of biofacies represented in this part of the succession in Avalonia and the immigration of taxa resulting from the closure of the Iapetus and Tornquist oceans. Detailed analysis of the faunas demonstrates that Avalonia exemplifies the many factors involved in provincial breakdown and their influence on biodiversity. Furthermore, it emphasises the need to understand the palaeoenvironmental context within which such changes took place.

Nearly 80 trilobite genera are known from the Rawtheyan of Avalonia with half of these making their first appearance on this microcontinent in that or the preceding Cautleyan stage. The wide environmental spectrum reflected in the rock record not only includes the return of the deepest water (cyclopygid-atheloptic) biofacies but also marks the first recorded development in Avalonia of the pure carbonate illaenid-cheirurid association. The latter may reflect the drift of the microcontinent towards tropical latitudes and hence the appearance of a faunal association that was first established in low latitude Laurentia much earlier in the Ordovician. Half of the new taxa were restricted to this carbonate environment including several genera of cheirurids and lichids. Recruitment into this and other shelf environments was from several palaeoplates, but the largest cohort (over half of the genera) had its origins in Laurentia although some of these also had occurrences in Baltica in the late Caradoc and early Ashgill. The Rawtheyan sampled diversity is more than twice that of any part of the Caradoc

and, setting aside the 'new' pure carbonate environment, indicates that provincial breakdown resulted from the insinuation of immigrant taxa into existing communities across the shelf rather than any substantial replacement of the established incumbents. The peak of diversity in the Rawtheyan makes the climatically triggered Hirnantian extinction all the more dramatic in Avalonia.

Aims, achievements and lessons learnt from six years of IGCP project n° 410

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Oral Presentation

The main goal of IGCP project n° 410 from 1997 was to provide a global and quantified evaluation of the Great Ordovician Biodiversification Event based on the fossil record. Other aims were: 1) to develop a globally integrated time scale using graptolites, conodonts, and other zonal fossils, wide-ranging bioevents and graphic correlation; 2) to analyse onshore-offshore biofacies profiles across palaeolatitudes; 3) to identify patterns of biotic response to climatic change; 4) to depict extrinsic factors (e.g., plate movements, sea level change, volcanic activity), which possibly favoured the major biodiversification; and 5) to compare the organic-matter assemblages of economically important oil shales. In terms of societal benefits the project work was expected to: 1) identify possible causes of pre-industrial biodiversity change (i.e., "lesson from the past"); 2) assist in support of scientists from developing countries; and 3) increase awareness of the oil-shale deposits. To achieve all these ambitious tasks, seven regional teams and a global clade team were formed to collect the numerous data. Meetings and field excursions were held in China, Korea, Mongolia, Russia, the Czech Republic, France, USA, Australia and Brazil. Financial support allowed a number of scientists from developing countries to attend the activities. Some 200 Ordovician experts from 38 different countries participated in IGCP n° 410.

In terms of the original aims, the study of the oil shales made little progress. Also, opportunities to input all relevant biodiversity data in a web-based global relational database were not adopted by all workers, and in processing their biotal data, some workers did not attempt to interpret the effects of bathymetry or palaeolatitudes on their particular diversity patterns. Nevertheless, a number of fossil groups were shown to exhibit overall patterns of diversity increase to a maximum near the end of the Middle Ordovician and decline well before the Hirnantian glaciation. Other significant scientific advances include: 1) elaboration of a refined, 19 time-slice, subdivision of the Ordovician System, using ties between graptolite/conodont/ chitinozoan biozones, calibrated to radiometric data; 2) important progress towards defining a global sea level curve using records from the Baltic and N America; 3) development of global or regional databases for many fossil groups; and 4) assessment of the regional and global rate of diversity changes through time (biodiversity curves). The success of the project was largely due to the goodwill and cooperation of Ordovician specialists worldwide; they enthusiastically embraced most aspects of the work. We employed a good management structure, close linkages (e.g., Ordovician Subcommission and IGCP related groups) and networking, disseminating details of work programs as widely as possible (via the website, email, and other news sources). The project produced some 1000 relevant publications, including monographs, field guides, and an authoritative, 484-page book on the "Great Ordovician Biodiversification Event". The coverage, content and quality of the IGCP n° 410 publications is testimony to the success of the project. We expect participants in successor IGCP n° 503 to establish new initiatives and directions, but we hope they will also take over some of the programs we left unfinished. In particular, it would be nice to have the Ordovician oil-shale deposits properly evaluated on a worldwide basis.

New data on the Ordovician ichnofossils from the Koszalin – Chojnice Region (Pomerania, NW Poland) – palaeogeographic implication

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Poster Presentation

For the first time, well–preserved ichnofossil assemblage comprising other than the coprolite Tomaculum problematicum Groom ichnospecies, have been discovered in the tectonically disturbed Ordovician rocks drilled by deep boreholes in Koszalin – Chojnice Region in Pomerania (NW Poland). This area is a narrow band situated between the SW margin of the East Europen Craton to the NE and the Variscan belts to the SW. The Ordovician deposits are tectonically deformed, dipping from 20° to 90°, but are not metamorphosed.

The uppermost Llanwirn – Lower Caradoc succession is composed mainly of grey, brownish and green–greyish mudstones and silty mudstones as well as of grey, partly dolomitic siltstones. The Ordovician of the Koszalin – Chojnice Zone contains graptolites of teretiuscus, gracilis, multidens and clingani biozones.

The most rich and well-preserved ichnofaunas have been found in Skibno 1 profile. They are present in brownish–grey, greenish–grey and reddish mudstones and silty mudstones.

The strata of greyish-green fine-grained sediment of the Upper Llanvirn contain several examples of tracemakers activity represented mainly by fodinichnia (feeding–dwelling burrows of benthic organisms) of low–energy environment. This includes of mobile deposit-feeder *Planolites* isp., and, most characteristic of oxygen–deficient environment, *Chondrites* isp.

In greyish–brown and reddish–brown mudstone and silty mudstone of Caradoc (multidens biozone) *Chondrites* isp. are not present anymore. Besides examples of fodinichnia represented by *Planolites* isp. and *Palaeophycus* isp. a few examples of domichnia (dwelling burrows of benthic organisms) appear. This includes forms of cylindical shape ?*Cylindrichnus* isp. and ?*Bergaueria* isp. These trace fossils were made probably by suspension-feeders in shallower, more oxygenated and more agitated environment.

Grand trace fossils (domichnia) produced probably by suspension-feeders have been also found in Caradocian deposits of Chojnice 5 and Jamno IG-2 profiles. In Miastko 1 profile and in one, newly drilled core the examples of the mobile tracemaker *Planolites* isp. has been stated.

Faecal pellets Tomaculum problematicum (Groom) are present throughout the Ordovician profile; a few giant examples have been found in the Caradocian reddish mudstones of the Skibno 1 profile.

Trace fossils assemblage just described differs in some cases from this of Rügen Island and other regions of Avalonia. The typical deep–water Nereites–ichnofacies with typical graphoglyptids is not identified. This assemblage indicates rather shallower and better oxygenated environment especially in the upper part of the Ordovician.

The new data obtained from the Ordovician deposits of the Koszalin – Chojnice Zone give cause for the controversial discussion concerning the palaeoenvironmental and palaeogeographic connections of this area with the other regions of Avalonia and Baltica.

Quantitative distribution and evolution of palynomorphs associated with kukersite deposits in the Middle-Upper Ordovician of the East-European Platform

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Poster Presentation

Middle-Upper Ordovician Kukersite-type deposits occur in an area of about 100 000 square kilometers of the eastern part of Baltic basin, and they constitute important hydrocarbon source rocks for the region, exploited since the beginning of the last century. These organic-rich shales are dominated by a concentration of *Gleocapsomorpha prisca* Zallesky, 1917, for which the biological affinity (based on optical and geochemical characteristics) remains under discussion. Periodic blooms of this colonial marine microorganism were related to environmental changes, what was also influencing the diversity of associated phytoplankton communities. The present palynological study is focused on the qualitative and quantitative evolution of palynomorph distribution, below, within and above the kukersite-beds in the Alekseevka Quarry section (St.-Petersburg region). Here, 3 m of the Mednikovo Formation, consisting of bluish-grey marlstone, and 6 m of the overlying Solets Formation, represented by four productive kukersite beds intercalated with clay, yellowish-grey limestone with kerogen and clayey limestone, have been sampled. The sequence, embracing the Middle – Upper Ordovician transition (the Ukhaku and the Kukruse Stages respectively), corresponds to the interval of the *Glyptograptus teretiusculus* – *Nemagraptus gracilis* graptolite Zones.

In the upper part of the Mednikovo Formation "normal" phytoplankton community, comprising more than 25 different taxa belonging to *Baltisphaeridium*, *Leiofusa*, *Leiosphaeridia*, *Micrhystridium*, *Ordovicidium*, *Pachysphaeridium*, *Peteinosphaeridium*, *Polygonium,* and *Veryhachium* becomes dominated by *Gleocapsomorpha prisca* (92%). Then, in the kukersite beds at the base of the Solets Formation, palynomorph assemblage is characterised by almost a monospecific association with more than 99,5 % of *G. prisca*. Very few specimens of *Leiosphaeridia*, *Micrhystridium*, or small finely ornamented *Baltisphaeridium* are present in palynological slides made from kukersite. In the overlying sediments, however, together with *G. prisca* still in a remarkable quantity of 60-70 %, all previously identified acritarch species occur again.

G. prisca is clearly major contributor of kerogen-rich deposits of the kukersites. Its accumulation is probably not a result of selective preservation, because of accompanying acritarchs in the kukersites beds association, but due to particular paleoenvironmental and depositional conditions, related to sea-level changes in Baltica and/or higher salinity situations as suggested elsewhere.

A Middle Ordovician silicified brachiopod fauna from Guiyang, South China and its palaeobiogeographical significance

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Oral Presentation

A new silicified brachiopod fauna from the Kuniutan Formation (Darriwilian) at Wudang, Guiyang, central Guizhou, South China contains abundant *Yangtzeella, Orthambonites,* and *Leptellina*, along with common *Parisorthis*, *Saucrorthis*, rare *Anomalorthis*?, *Hemipronites*?, *Leptestia*? and significantly, *Aporthophyla*. Sparse trilobites, gastropods, crinoids and nautiloids are associated with the brachiopods. This shelly fauna is assigned to shallow-water, Benthic Assemblage 3. The first record of *Aporthophyla* in South China is significant since this genus has been regarded as one of the key taxa of the Toquima-Table Head Province (marginal North America, Kolyma and western Norway) during the Mid Ordovician, and indicates a link between South China and the latter province, where the *Aporthophyla* fauna is more typically developed. However, based on this study, the various assemblages bearing *Aporthophyla* may be different in nature, composition and diversity and may have different background palaeobiogeographical signatures. This association is characterized by 1) the absence of many other typical elements of the *Aporthophyla* fauna, 2) the presence of *Orthambonites* and *Hemipronites*?, suggesting some relationships between South China and the Baltic Platform during the Mid Ordovician and 3) the occurrence of some endemic taxa (*Yangtzeella*, *Saucrorthis* and *Parisorthis*). The assemblages containing *Aporthophyla* in South China, Qaidam, Malaysia (Sibumasu), Australia, and probably Tibet are clearly different biogeographically from those associated with the Toquima-Table Head and the high-latitude Celtic provinces.

Palaeogeography and the origin of higher taxa of echinoderms in the Early Palaeozoic

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Oral Presentation

New higher taxa appear in geological history always suddenly, with already well formed body plans, and usually without demonstration of intermediate forms and supposed ancestors. For many of them is characteristic, that their ancestors lived in another region than that in which the first representatives of a new taxon appeared. In some cases this may be due with incompleteness of palaeontological record. However in most cases the sudden appearance of new body plans resulted from special mechanism of their formation, such as paedomorphosis (retention of the ancestral juvenile characters in the descendant adult) or other kinds of heterochrony (change in timing or rate of developmental events relative to the same events in the ancestors). In such cases the ancestral morphology may be reconstructed from ontogeny data and aberration of adult forms. In the Ordovician Baltic basin numerous echinoderm taxa which first appeared here have heterochronic, mostly paedomorphic traits. Appearance of these characters might be facilitated by the delay in individual development of benthic animals larva. This delay was possibly connected to the increase of their planktonic stage duration while cruising across large open ocean spaces between continents. Benthic animal larvae getting in the oceanic currents decay if they do not find suitable place for attachment. Under condition of suitable change of configuration, mutual disposition of continents or islands and directions of oceanic currents, some larvae, capable of especially long existence in plankton, reach the other shore of the ocean and attach. Extreme duration of planktonic stage favours numerous manifestations of paedomorphosis and other heterochronies. This very mechanism of a new body plan formation could be suggested for the Silurian-Devonian crinoid superfamily Pisocrinacea. Morphology, ontogeny, and stratigraphic distribution convincingly show that Pisocrinacea originated from Homocrinacea in the Early Silurian by paedomorphosis. The Baltic basin

was the center of origin and spreading of Pisocrinacea. At the same time ancestral Homocrinacea are known only in North America. That is why it may be suggested that the Pisocrinacea originated from the Homocrinacea during getting over of the Iapetus ocean from Laurentia to Baltica at the beginning of the Silurian. By this time the Iapetus became considerably narrower, and the larvae of numerous benthic animals could cross it, though over a long period of time. Crossing of this ocean by larvae of one of the homocrinid members led to a delay in skeleton formation and to acceleration of maturity after attachment of larvae in the Baltic basin. As a result a new body plan which characterized the Pisocrinacea appeared, firstly in the framework of the genus *Pisocrinus*. One of the *Pisocrinus* subgenera and its descendant genus *Parapisocrinus* might immigrate by reverse currents to the North American basins and achieved there high species diversity and abundance, particularly in shallow waters. In the Baltics, Urals, Tien-Shan, and Australia *Pisocrinus* gave rise to some new genera among which new forms with multiple arms appeared during the Devonian. The superfamily Allagecrinacea with multiple arms further originate from these genera by paedomorphosis. Notably, the ancestral Pisocrinacea inhabited only in Eurasia and Australia basins, and the earliest Allagecrinacea descendants appeared in North America at the end of the Devonian. Later during the Mississippian some of them migrated to European and Asian basins. This suggest that extremely long crossing of waters barriers by benthic animal larvae while changing of oceanic currents may be an important and a rather usual factor in the origin of the new taxa.

New zircon ages and isotope data from the Austroalpine Cambrian to Silurian magmatic record and the consequences to models of north-Gondwanan terrane configuration

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Oral Presentation

In the Austroalpine Basement to the south of the Tauern Window, distinct suites of metabasites occur with orthogneisses in the pre-Early-Ordovician units of the Northern-Defereggen-Petzeck- and the Defereggen Groups. Tholeiitic and alkaline within plate basalt type metabasites are associated with acid meta-porphyroids in the post-Early-Ordovician Thurntaler Phyllite Group. Pb-Pb single zircon evaporation protolith ages, whole-rock Ta/Yb-Th/Yb and oxygen, Sr, Nd isotope data define two principal magmatic evolution lines. An older evolution at elevated Th/Yb typical of subduction-related magmatism, started by 590 Ma N-MORB-type and 550 - 530 Ma volcanic arc basalt type metabasite suites which mainly involved depleted mantle sources. These remnants of an active margin are restricted to the pre-Ordovician Northern-Defereggen-Petzeck Group. The evolution of the active margin magmatism was completed by mainly crustal-source 470 - 450 Ma granitoids in both of the pre-Early-Ordovician units and by acid volcanics in the Thurntaler Phyllite Group. An other magmatic evolution line enclosing tholeiitic and 430 Ma alkaline within plate basalt type suites is characterized by an intraplate mantle metasomatism and enrichment trend along multicomponent sources. These former basalts occur as amphibolites in all Austroalpine lithostratigraphic units. The magmatic evolution lines can be related to a plate tectonic scenario which involved terranes aligned in the north-Gondwanan periphery. From the actual spatial position and polarity of the Austroalpine lithostratigraphic units, the progressively mature Neoproterozoic to Ordovician active margin should have been situated to the north, with southward-directed subduction of a Prototethys oceanic crust beneath the terrane assemblage. Early-Silurian alkali magmatism was related to subsequent Palaeo-Tethys opening and passive margin evolution to the south. Multicomponent sources of the alkali magmatites signal a mantle heterogeneity possibly induced by the precedent subduction. However, in the Austroalpine to the south of the Tauern Window no magmatic and metamorphic record of possible Early-Ordovician rifting and subsequent collision events has been found yet. There is no direct magmatic evidence of a Early-Palaeozoic convergent plate setting later than Ashgill until Variscan collision and metamorphism started at Carboniferous times.

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Early Paleozoic Plate Tectonics, Paleogeography and Paleoclimate

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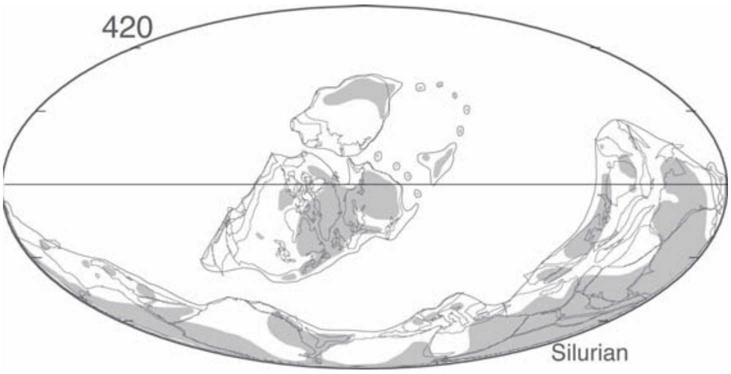
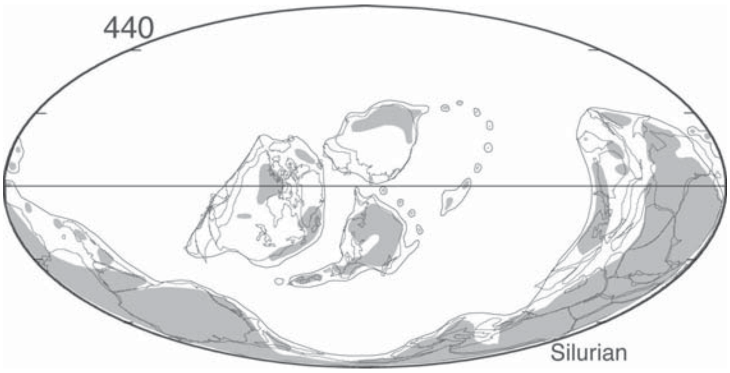
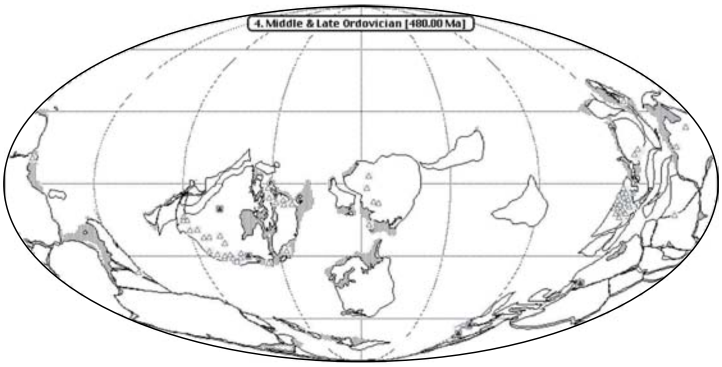
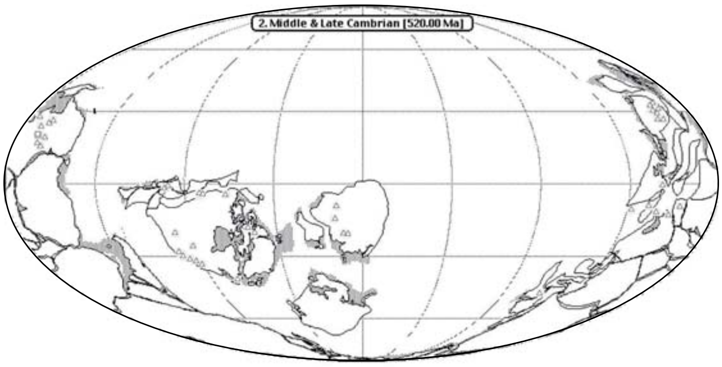
Oral Presentation

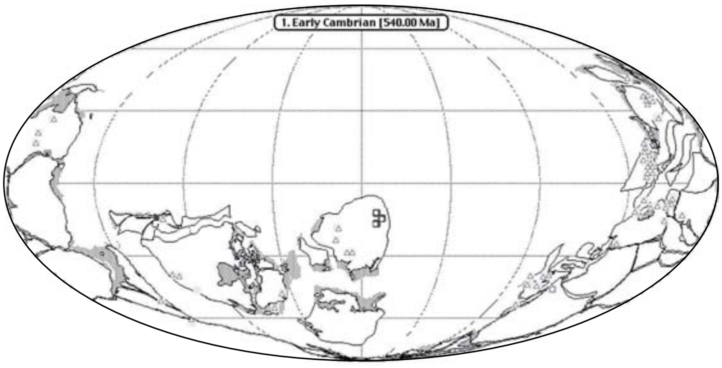
Ten paleoreconstructions are presented illustrating the plate tectonics, paleogeography and paleoclimate of the latest Precambrian and Early Paleozoic. The time intervals chosen include two maps for the latest Precambrian (600 Ma and 570 Ma), maps for the Early and Late Cambrian, four maps for the Ordovician (early Tremadoc, early Arenig, Llandeilo/Caradoc, and Ashgill), as well as paleoreconstructions for the Early and Middle Silurian. The plate tectonic reconstructions show the probable location of active plate boundaries (subduction zones, island arcs and mid-ocean ridges). The paleogeographic maps illustrate the distribution of deep oceans, shallow shelves, lowlands and mountainous areas for each time interval. There are two versions of each paleogeographic map. One map shows the extent of maximum flooding during a period of high eustatic sea level. The second map shows the paleogeography during a time of minimum sea level corresponding to a major sequence boundary. In the final set of maps, climatically sensitive lithofacies such as evaporites, calcretes, bauxites, and tillites are plotted on the paleoreconstructions. Climatic zones are mapped based on the distribution of these climatically sensitive lithofacies.











Early Paleozoic Paleoclimatic simulations: data and model comparisons

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Oral Presentation

Computer models that are used to simulate paleoclimate, such as GCMs and FOAMs are expensive to run, use excessive amounts of computing time, and often give results that are in poor agreement with the geological record. GCMs are notorious for results that look more like the present-day than the geological past. Hot Houses climates, like the Cretaceous, have been especially difficult to simulate. Though the GCM simulations for Hot House climates can be improved by drastically increasing CO_2 levels or enhancing equator-to-pole oceanic transport, these adjustments often seem forced and ad-hoc. An alternate climate modeling technique has been developed by the author, called the Parametric Climate Model (PCM), that is inexpensive, can be run quickly on personal computers, and makes paleoclimatic predictions that are in better agreement with the rock record. The PCM is a non-dynamical climate model uses geological information describing past climates to set important boundary conditions for the paleoclimatic simulations. These boundary conditions include: the pole-to-equator temperature gradient, surface moisture, land cover, and the size and extent of the paleo-Hadley cell circulation.

Most of the computing time and expense of a GCM run is the result of the repetitive calculations required to "spin up" a dynamical simulation of the oceans and atmosphere. Only after running for a number of "model years" (often weeks of computing time) are the estimates considered accurate. In contrast, the PCM starts with boundary conditions that reflect our knowledge of past climates and consequently gives more geologically satisfying results.

To test the Parametric Climate Model, five paleoclimatic simulations were run for the: Late Precambrian (600 Ma), the Early Cambrian, the Early Ordovician, the latest Ordovician (Ashgill), and the Middle Silurian (Wenlock). Global temperatures, precipitation patterns, surface ocean currents and upwelling zones that were predicted by the PCM were compared with availabale GCM runs and with the distribution of lithologic indicators of climate such as evaporites, calcretes, bauxites, kaolinites, and tillites. A database of lithologic indicators of climate comprising more than 8000 entries for the Phanerozoic has been compiled by A.J. Boucot (Oregon) and Chen Xu (Nanjing).

Are some fossils better than others for inferring palaeogeography? An old question revisited

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Oral Presentation

In their publication entitled "*Are some fossils better than others for inferring palaeogeography? The early Ordovician of the North Atlantic region as an example*", Fortey and Mellish (1992) asked whether some fossils were better than others for inferring Ordovician palaeogeography. Planktic fossil groups (graptolites, acritarches, etc.) were considered not to 'see' a separation between Gondwana and Baltica, while trilobites and ostracodes provided evidence for this separation. Fortey and Mellish (1992) concluded that planktic fossils such as graptolites, chitinozoans and acritarchs were in general of low palaeogeographical value, while their seleced groups of benthic organisms such as trilobites, brachiopods, and ostracodes were more useful for biogeographical discrimination.

Fortey and Mellish's (1992) paper has resulted in an ongoing discussion on the relative merits of palaeobiogeographical indicators in the Ordovician (e.g. Servais and Fatka, 1997; Samuelsson et al., 2001). At the heart of this debate is the question of whether the planktic groups were so widely distributed as to be virtually cosmopolitan in the Ordovician world, or whether distinct areas of the Earth were characterized by distinct faunas and microfloras (as they are in modern oceans and during the Mesozoic) and if so, what controlled their distribution during the Early Palaeozoic.

In the present study we discuss the palaeogeographic distribution of graptolites, chitinozoans, and acritarchs in detail, and, together with the distribution of conodonts and some pelagic trilobites, plot the occurrences on different palaeogeographic reconstructions, including the maps of Cocks (2001).

It appears that the distribution scenarios between planktic and benthic fossil groups are often surprisingly very similar, and that planktic groups have a clear palaeogeographical signal. The major problem is to find, for every fossil group (benthic or planktic), the good biogeographic marker.

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Development of acritarch communities across the late Silurian positive δ^{13}C excursion – data from Gotland, Sweden

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Poster Presentation

In the last decades, a rising amount of studies have underlined the potential of Palaeozoic acritarchs as accurate proxies for palaeoenvironmental reconstructions. In order to better understand the acritarch distribution in critical intervals, i.e. in times of strong climatic changes, a detailed palynological study has been carried out in the Ludlow (Upper Silurian) of Gotland (Sweden). The present work focuses on the distribution of acritarchs through a vertical profile from the Hemse to Hamra/Sundre Beds. In this time interval the strongest global positive δ^{13}C and δ^{18}O excursion of the entire Phanerozoic has been reported (Bickert et al., 1997; Samtleben et al., 2000). According to Bickert et al. (1997), the time of high isotope values corresponds to arid climate conditions in low latitudes, while the times of low values are attributed to humid conditions. Our results show a close connection of palynomorphs with the development of stable C and O isotopes. Not only the acritarchs, which most probably belong to the phytoplankton and, thus, are good indicators of surface water conditions, but all marine palynomorphs decline considerably in relative and absolute abundances during the isotope excursion. These results clearly indicate that the isotope excursion cannot be the result of increased marine phytoplankton productivity. Terrestrial spores, in contrast, strongly increase during the isotope excursion. Within the most common acritarchs, ornamentated genera (i.e., *Evittia*, *Percultisphaera*) are more common before the excursion, and decrease during the rise of the isotope values. Such genera have been previously reported in more distal environments in the Gorstian sediments of Gotland (Stricanne et al., 2004). Less-ornamentated acritarchs (i.e., *Micrhystridium*, *Veryhachium*) are more frequent during the excursion than before, and these genera have been attributed to proximal environments.

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K-bentonites and progressive flysch succession around Ordovician- Silurian transition in South China: new evidences for accretion of Cathaysia to Yangtze Block and break-up of Gondwanaland

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Oral Presentation

The 'Cathaysian Oldland' or 'Cathaysian Block' has been taken as a significant tectonic unit in the southeast China for many years (Grabau, 1924). Determination of its relationship with the Yangtze Block and its geologic development in the Paleozoic has an important impact to the understanding of the tectonic evolution of south China. Several problems in this topic, however, still remain to be solved. These problems include: whether or not existed such a Land in Paleozoic, where is the exact boundary between the two units, and what was the accretion process.

Recently, a number of K-bentonite beds have been recognized in the Ordovician-Silurian transition (Ashgillian ~ Early Llandovery) in the Yangtze Block, south China. A preliminary analyses on geochemical composition of the K-bentonites has suggested a parental magma origin of trachyandesite to rhyodacite with some rhyolite in general, which came from volcanic-arc (VA) and syn-collision (syn-COL) to intra-plate (WP) tectonic settings. A regional correlation of these K-bentonite beds has indicated that they have clearly potential of increasing southeastward both in thickness and grain-size. These characters suggest that the original volcanic ash may come from southeast part of the present south China.

In addition, along the southeast margin of the Yangtze Block, typical flysch successions have also been identified both from the Zhoujiaxi Group (early Llandovery) and Tianmashan Formation (Ashgillian) in the southern part of Hunan Province, south China. Geochemical analysis on the silicate minerals has suggested that the flysch successions were deposited in the basin on a passive continental margin. Field observations on the paleo-currents, cross-beddings, ripple marks as well as flute marks, all suggest that the detrital components must have been transferred from the southeast part of the present south China, in good agreement with the conclusion drawn from the analysis of the K-bentonites. Furthermore, the flysch successions both in Tianmashan Formation and Zhoujiaxi Group clearly show a northwestward progradation in space and time during the Ordovician-Silurian transition.

Based on the present study and also the former works, we would like to conclude that there did exist the Cathaysia Land or Cathaysia Block beside the Yangtze block in south China during Early Paleozoic. Both the K-bentonites and flysch successions could be regarded as the products in responding distantly of the area to the continuous northwestward collision and accretion process of the Cathaysia Block to the Yangtze Block. The west boundary of the Cathaysian block, however, probably located along the suggested Early Paleozoic suture (Wang et al, 1987; Yang et al, 1995). According to the present study, we also hold that the accretion of the Cathaysia to Yangtze Block may be related to the initial break-up of the Gondwanaland. At this time, the south China blocks were largely at the low latitude adjacent the Gondwanaland (McKerrow and Scotese, 1990; Fang et al, 1990; Wu et al, 1999; Zhang et el, 2004).

Fossil assemblages from radiolarites of Central Kazakhstan – a key for the reconstruction of the pelagic ecosystem.

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Oral Presentation

The ribbon-banded cherts of the Burubaital Formation exposed west of Lake Balkhash in Central Kazakhstan represent the complete and detailed record of basinal sedimentary succession ranging in age from at least the late Cambrian to the early Caradoc (*Eoconodontus notchpeakensis-Pygodus anserinus* biozones). The condensed sediments accumulated during that time interval on the seafloor are completely made up of skeletons of radiolarians and sponges spicules with the minor input of fine clastic material. Basinal environment was inhabited by conodonts, graptolites, pterobranchs, linguloid brachiopods, and caryocaridid arthropods showing that richly diversified marine fauna existed in the open ocean far from the continental margins. Besides the listed fauna cherts of the Burubaital Formation contain numerous silicified bacteria and chitinous microspheres (0.3-0.05 mm in diameter) that are commonly found in clusters and supposed to be arthropod eggs.

Faunal remains buried in radiolarian oozes are preserved in the poorly opaque and semi-transparent cherts, which like amber keep traces of trophic interactions of organisms in the marine ecosystem. One of the examples of trophic interplay are the silicified bacteria fed on organic matter of pterobranchs and graptolites. Numerous faecal pellets composed of conodont elements and small fragments of cariocaridid shells found in cherts evidently indicate the existence of carnivorous macrozooplankton and nekton in the Early Paleozoic. The size of faecal pellets, number and taxonomic composition of conodont elements composing the pellets differs significantly. It is possible to distinguish two types of pellets produced by organisms different in the predation strategy. Conodont animals were possibly one of the predators that consumed juvenile conodonts as well as mesoplankton arthropods (0.5- 1 cm). Single pellet of these predators contains the remains of one individual. The significantly larger faecal pellets containing elements of more then one conodont animal (up to 150 conodont elements) possibly were produced by another predator. These large pellets also show that either conodont animals existed in cohorts of individuals of the same age or predator was consistent with the selection of preys by size and taxonomy.

The degree of fossils fragmentation and disintegration of faecal pellets in the cherts of the Burubaital Formation differs from bed to bed through the succession and is strongly connected with the color and textural characters of cherts, that in turn, depends on the physical-chemical conditions of the bottom and sediment water during sedimentation. The latter is possibly controlled by changes in paleooceanographical circulation patterns as well as in variations in net primary productivity. The most significant changes recorded in the cherts of the Burubaital Formation are confined to the base of *Oepikodus evae* Biozone. Faecal pellets became less abundant since then possibly due to increase in oxygenation of the bottom waters and related to it growth of radiolarian productivity.

Sr isotopic and Mg cycling in Early Palaeozoic seawater: implications for tectonic and climatic processes

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Poster Presentation

Continental weathering, mantle degassing, and landmass distribution have long been recognized as major drivers of climate change. Resolving the relative contributions of these competing forces at short timescales is particularly challenging. This study attempts to recognize high-resolution fluctuations in Ordovician and Early Silurian seawater chemistry derived from minor element and isotopic compositions of conodont apatite, and thus deconvolve the relative shifts in the dominant processes operating during this period.

Temporal variations in Mg/Ca compositions of conodont apatite are correlated with established sea-level curves. Magnesium cycling in seawater is driven by the mass balance of hydrothermal activity, continental weathering, carbonate deposition and dolomitization (eustasy, pH and CO_2), and thus has implications for understanding palaeoclimate. An integrated approach utilizing high-resolution Mg/Ca and Sr isotopic compositions of Early Palaeozoic seawater, as inferred from conodont geochemistry, can help identify the major sources and sinks of Mg and Sr, and accordingly, better constrain tectonic, eustatic, and climate dynamics.

Conodont apatite was analyzed using high-resolution, in-situ, laser ablation micro-sampling techniques (ICPMS and MC-ICPMS) providing continuous compositional profiles of single conodont elements. Compositional heterogeneity can be significant hence the high spatial resolution afforded by laser micro-sampling can exclude diagenetic zones, thereby ensuring data integrity.

Basin analysis: a punctual example in the South of Romania

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Poster Presentation

The Moesian Platform on the territory of Romania is divided by the Intramoesian Fault into two parts with different tectonics, the eastern part being considered to have more complicated tectonics and many stratigraphic gaps in comparison with its western part. The eastern part is separated from the North-Dobrogean Orogen by the Pecineaga Camena Fault, which allowed it to develop as an independent sedimentation basin. Based on palynological data, especially new chitinozoan assemblages, the age of sediments as well as some palaeogeograghic conditions of sedimentation for a borehole located in northern Moesia have been revised. Sedimentation rate in the basin was greater in the Cambrian than in the Ordovician, while in the Silurian it suddenly accelerated; thereafter, during the Devonian, it decreased rapidly to a constant level, this being a little bit less than during Devonian and Carboniferous times. Sediment burial curves show that subsidence was pronounced from Cambrian until Silurian times. The Devonian and Carboniferous are characterized by burial curve patterns with a more important linear trend than earlier. As for the thermal basinal regime during the Cambrian-Carboniferous span, an important observation is that high terrestrial heat flow values are inferred from the reconstructed temperature versus time model. The high heat flow and the organic matter content of some of the Silurian sediments permitted hydrocarbon generation with a TOC (total organic carbon) range of approximately 0.5 mg HC/g initial dry rock. The Silurian sediments are mostly represented by shelly-fauna with graptolites. The vitrinite reflectance versus depth curves exhibit values that provide additional consistent arguments for a high thermal regime. This interpretation is possibly supported by the present day oil resources that are exploited in the eastern part of the Moesian Platform where hydrocarbons are supposed to have migrated into carbonaceous Mesozoic reservoirs from deeper formations.

The biostratigraphy of new chitinozoans from the South of Romania

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Poster Presentation

The south of Romania is occupied by the Moesian tectonic block. New chitinozoan assemblages are described for the sediments of its eastern part. They contain Wenlock and Ludlow as well as Pridoli/Lochkovian chitinozoans, most of them in a good state of preservation. the *Conochitina pachycephala* biozone and some characteristic species, *e.g. Conochitina tuba, C. claviformis,* were recognized in the samples from boreholes. Also identified were Pridoli chitinozoans such as *Urnochitina urna, Eisenackitina lagenomorpha, Eisenackitina filifera, and Bursachitina krizi, etc.* The biozones *Eisenackitina bohemica* and *Urochitina simplex* together with accompanying species such as *Cingulochitina plusquelleci, C. ervensis, C. serrata, Angochitina filosa, Bursachitina oviformis,* etc. were also described, these being characteristic for Lochkovian age. Macrofauna are also present in the study area. In the western part of the Moesian terrane, the facies of "shelly fauna" without graptolites is present while, in the eastern part, the facies of "shelly fauna" that contains graptolites occurs. The *lundgreni, nilssoni-scanicus, bohemicus* and *ultimus-formosus* graptolite zones were identified. The *Icriodus woschmidti* conodont zone was recognised in the eastern part as well as in the western part of Moesia (Iordan, 1971). Supposing that affinities are not clearly indicated for the Wenlock-Ludlow by the chitinozoans assemblage, because they are cosmopolitan specimens, there is evidence that shows a North Gondwanan affinity for this part of Moesia for the Pridoli/Lochkovian. Moreover, the Pridoli/Lochkovian affinities are similar to those from Podolia, Ukraine (Paris & Grahn, 1996). Otherwise, the same palaeogeographical affinities are demonstrated for Moesia in Bulgaria by some authors (Haydoutov & Yanev, 1997; Gutiérez-Marco et al., 2003).

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Towards an Upper Ordovician chitinozoan biozonation on Avalonia? Research on historical type areas and other UK key sections.

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Poster Presentation

The recent study of the rich and diverse chitinozoan assemblages from the historical type area of the Ashgill Series in the Cautley District (Cumbria, Northern England) led to the recognition of several, both new as previously defined biozones, from bottom to top: the *Fungochitina fungiformis*, *Tanuchitina bergstroemi*?, *Conochitina rugata* (three Baltoscandian biozones), *Spinachitina fossensis*, *Bursachitina* sp. 1 n. sp. (two typical Avalonian biozones), *Ancyrochitina merga* (a Northern Gondwana biozone) and the *Belonechitina postrobusta* Zone (a global lower Silurian biozone). All biozones are well correlated with the graptolite (Rickards, 2002) and shelly fauna (Ingham, 1966) biozones described from the region. These data were already presented on several occasions (e.g. Vandenbroucke *et al.*, 2003), but are now consequently completed with data from other key sections in the U.K., such as the

Pus Gill section (Cross Fell Inlier, Cumbria, Northern England), which originally gave its name to the lowest stage of the Ashgill Series. The Baltoscandic *F. fungiformis* Zone (Nõlvak and Grahn, 1993) has been recognised in this section as well, thus quite easily allowing correlation between both sections, for the first time with a widely distributed planktonic fossil group. From the combined study of the sections, it is clear that the base of the Ashgill Series lies within the *F. fungiformis* Zone, rather than in the *T. bergstroemi* zone as previously written (thus, slightly lower in the chitinozoan biozonation).

In addition, the Baltoscandic chitinozoan zones mentioned above are now much better tied to the British chronostratigraphy, which has been and still is widely used in literature, although at present abandoned on a international level. Equally interesting, the occurrence of *Angochitina communis* in the Pus Gill section, below the FAD of *Fungochitina fungiformis*, is correlated with the topmost Onnian beds of the historical type Caradoc section in the Onny Valley (Shropshire, U.K.); this thus leaves the *F. fungiformis* bearing part of the Pus Gill Onnian absent from the type Caradoc area (see Jenkins, 1967). As far as we know, this is the first direct correlation between the two historical type areas.

Chitinozoan research in the Greenscoe section through the Kirkley Bank Formation in the Lake District (Dalton-in-Furness, Northern England) yielded abundant chitinozoans belonging to the *Fungochitina fungiformis* zone, stressing the usefulness of this biozone for correlation within Avalonia and between Avalonia and Baltica. The section also allows calibration with the *Amorphognathus superbus* conodont biozone (Smith, 1999).

The Caradoc succession between Fishgard and Cardigan (southwest Wales) has good potential to be correlated with the lower stratigraphical levels in Cautley and the Cross Fell inliers, according to preliminary chitinozoan results from 24 samples, the top ones tentatively assigned to the ?*Fungochitina fungiformis* and *Tanuchitina bergstroemi* zones. The samples were taken from graptolite slabs, collected during a recent BGS mapping project in the area (Williams *et al*., 2003); the chitinozoan results will thus be tightly correlated with the graptolite data (*Diplograptus multidens*, *Dicranograptus clingani* and *Pleurograptus linearis* biozones).

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Chitinozoans from the Upper Ordovician of the Fauquez area (Brabant Massif, Belgium)

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Poster Presentation

The biostratigraphy with chitinozoans of the Upper Ordovician rocks of the Fauquez area is studied in detail. The Chitinozoans of four recently defined formations, the Bornival, the Huet, the Fauquez and Madot Formations (Van Grootel *et al.,* 1997) are studied from 53 samples. Except for the Fauquez Formation, in which the *clingani* or *linearis* Graptolite Biozone was recognised (Maletz & Servais, 1998), the rocks are devoid of any graptolites or conodonts. The chitinozoans are poorly to moderately preserved but nevertheless several Baltoscandian biozones (Nõlvak & Grahn, 1993; Nõlvak, 1999) could be recognised. Also correlations with the Type Ashgill area (Vandenbroucke, in prep.) and the Belgian Condroz Inlier (Vanmeirhaeghe, in prep.) on Avalonia can be made.

The Bornival Formation, which is subdivided into three members, contains *Belonechitina robusta* and *Conochitina minnesotensis*, whereas *Lagenochitina baltica* was recovered from the second member. The presence of a few specimens of *Belonechitina hirsuta* is probaly due to reworking. The co-occurence of *B. robusta* and *L. baltica* indicates a Cheneyan or younger age. The Huet Formation contains *L. baltica, L . prussica,,* and *B. robusta*. These three species co-occur in Baltica in the late Caradoc and the early Ashgill. In the Fauquez Formation, these three species co-occur together with *Tanuchitina bergstroemi*?, indicating a late Caradoc to early Ashgill age, corroborated by the graptolite data. The Madot Formation contains the same chitinozoan assemblage. Trilobites, probably found in the Madot Formation (Richter & Richter, 1951) indicate an early Ashgill age. Martin & Rickards (1979) studied acritarchs in four samples in the Fauquez area and obtained a broad Caradoc to Llandovery age for the Madot Formation, not contradictory to our results.

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Palaeobiological and palaeoenvironmental significance of cryptospores and acritarchs from the Llanvirn of Saudi Arabia

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Poster Presentation

Core samples and cuttings from the shallow drillcore QSIM-801 in the Qasim region of central Saudi Arabia were investigated palynologically. The studied interval corresponds to the Qasim and Saq formations, and yielded well preserved and abundant palynomorph assemblages comprising cryptospores, acritarchs, and chitinozoans. Palynological dating (acritarchs and chitinozoans) points to a late Arenig to Llanvirn age for the investigated interval, as confirmed also by graptolite data.

The lowermost cored levels, consisting of marine, shallow water, fine grained sandstones are palynologically dominated by rich and diversified cryptospore assemblages comprising permanent tetrads, diads, monads, and possibly cuticle-like phytoclasts. These findings confirm previous reports of palynological evidence for early land plants in Saudi Arabia and the interest and importance of this area for the study of the evolution of primitive vegetation.

Palynological assemblages from the upper part of the drillcore are richer in marine elements (acritarchs and chitinozoans), although recurrences of cryptospore-dominated levels indicate shoreline proximity throughout the sequence. The acritarchs are very well preserved and comprise few examples of previously unreported morphologies, probably belonging to new taxa.

The quantitative analysis of relative abundances and representativity of the main morphological groups of acritarchs and the calculation of t/m index are tentatively used to track changes in palaeoenvironmental conditions. Common occurrence of teratological forms, of cysts at various stages of maturity, and frequently observed local over-representation of specific form-groups (e.g., galeates, *Frankea*), are interpreted as evidence of highly stressed palaeoecological conditions, probably linked to coastal palaeoenvironmental dynamics. On the basis of this observations, we tentatively discuss the influence of fluctuations in hydrographic processes on acritarch cyst development.

High-latitude bryozoan-dominated communities as a major carbonate factory on mixed carbonate-siliciclastic platforms of the late Ordovician northern Gondwana

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Poster Presentation

The northern Gondwana platforms were adequate to record an anomalous peak of carbonate productivity during Ashgill times. Carbonate sedimentation was then characterized by temperate- to cold-water reefal and non-reefal limestones, in which a robust skeletal carbonate factory was episodically resilient to poisoning by terrigenous input. The Ashgillian sedimentary succession of the Erfoud area (eastern Anti-Atlas) corresponds to the bryozoan-rich Khabt el Hajar Formation. The succession consists of two mixed (siliciclastic-carbonate) units bounded by marls in distal areas and by a major discontinuity in proximal areas. A preliminary biostratigraphical study, based on echinoderms (*Herpetocystis destombesi*), trilobites (*Brongniartella platynota maroccana*), and brachiopods (*Paucicrura catalanica)* allows us to propose a mid Ashgill age, at least for the marls and the upper mixed unit.

The Ashgill sediments of the Erfoud area are arranged into two depositional sequences, up to 70 thick, respectively topped by two major stratigraphic discontinuities. The first sequence commences with a lower transgressive systems tract (TST1) characterized by a gradual increase in carbonate content representing a mid-ramp system dominated by storm-induced processes. TST1 is capped by a laterally correlatable flooding surface indicated by the widespread distribution of carbonate production. The high stand systems tract (HST1) has recorded a progradational trend on the whole ramp with the development of a bryozoan-rich biofacies in a front-delta system.

The second depositional sequence clearly onlaps the erosive surface capping the last HST1 (D1). The transgression (TST2) is marked in the proximal area by a fine-grained carbonate sedimentation rich in echinoderms and bryozoans passing basinward into marls where *in situ* delicate-branching bryozoan clusters developed. The upper highstand systems tract (HST2) shows a new progradation of bryozoan-rich sediments capped by a sharp erosive unconformity (D2) that marks the contact with Silurian iron-rich crusts. Neither the Hirnantian nor the lower stages of the Silurian have been identified in these sections.

Two bryozoan-dominated biofacies and one bryonoderm biofacies occur within the above-reported mixed carbonate-siliciclastic units. These biofacies change in a proximal-distal transect through the platform. The distal biofacies in sequence 2 (TST2) is composed of *in situ* delicate-branching bryozoans that formed metre-scale clusters embedded in a marly substrate developed on outer-ramp environments. The proximal biofacies are the bryozoan and bryonoderm ones. The bryozoan biofacies is dominated by encrusting bryozoans and secondary robust-branching bryozoans developed in a front-delta system (sequences 1 and 2), where an epibenthic community, which colonized and stabilized the siliciclastic substrates, is commonly observed at the top of sand shoals and on abandoned marginal channels. The bryonoderm biofacies (sequence 1), dominated by thick crinoids and robust-branching bryozoans, developed in mid-ramp settings and corresponds to pelmatozoan-bryozoan meadows degraded by wave activity and input of siliciclastic material. Three main bryozoan morphotypes have been identified: encrusting forms, erect-rigid and robust-branching forms, and delicate-branching forms. Each of them occupies different depositional settings from shallow-ramp settings dominated by siliciclastic sedimentation, carbonate mid-ramp settings rich in echinoderms, and deep-ramp settings dominated by a marly sedimentation.

From a paleogeographic point of view, the middle-Ashgill Erfoud ramp is characterized by episodic exclusion of carbonate productivity in nearshore environments related to an active shoreline source of siliciclastic sediments. Only centimetre-scale bryozoan clusters developed in this part of the northern Gondwana platform, differing from the carbonate mud-mound complexes preserved in the Iberian Chains (Spain). Was the higher latitudinal position of the Moroccan platform directly responsible for the lack of reefal development?

This paper is a contribution to projects BTE2002-0118, Eclipse and IGCP 503.

Modelling the Hirnantian eustatic fall and its related Gondwanan ice-sheet growth time

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Oral Presentation

Actualistic interpolations allow the inference of past glacial conditions by applying glacial isostatic adjustment (GIA) models. The processes and effects of the Hirnantian (latest Ordovician) glaciation can therefore be analysed by comparison with analogous Quaternary glaciation episodes. One of the main unresolved questions of the Hirnantian glaciation is its related eustatic fall, a key parameter, which is required to explain the associated major extinction event. Previous estimates of this sea-level drop have been advanced based on evidence of the subaerial exposure of pre-Hirnantian siliciclastic and carbonate platforms and their subsequent erosion and karstification. These analyses have usually been made in subtropical- and temperate-water platforms, postulating an eustatic drop of 50 to 100 m related to the Hirnantian sea-level draw-down (Brenchley & Newall, 1980).

New data from the Moroccan Anti-Atlas related to the relative-sea level drop associated with glacioeustacism and the isostatic depression driven by ice loading on the northernmost glaciated Gondwana (Alnif area; Álvaro et al., this volume) allow estimates to be made on the maximum ice volume accumulated, as well as on the growth rate of the ice sheet. A recorded valley-glacier incision of at least 180 m, eroding the pre-Hirnantian platform sediments of the Alnif area, is interpreted as a directly induced glacioeustatic draw-drown driven by the accumulation of the Hirnantian ice-sheet on high-latitude Gondwana. To estimate the eustatic drop in sea level in this area, it is necessary to add to the 180 m of erosion, the estimated bathymetry of the youngest Ashgill (pre-Hirnantian) marine sediments (the shales of the Upper-Ktaoua Formation that were deposited in offshore settings: ca. 60 m deep).

Recent palaeogeographical reconstructions depict the Hirnantian South Pole close to the Guinean Gulf surrounded by an ice cap that reached the southern Sahara, Saudi Arabia, South Africa, South America, and even the eastern Anti-Atlas in Morocco (Álvaro et al., this volume). As a result, a continuous polar ice sheet reaching southern latitudes of 60° (radius of ca. 3 300 km) can be postulated for the Hirnantian glaciation peak. According to the known relationships between radius (L) and volume (V) of Quaternary ice sheets (Paterson, 1972: $L = k\ V^{5/2}$), an Hirnantian ice-sheet volume of about 120 10^6 km^3 can be estimated, which would imply an eustatic drop of ca. 250 m. This estimate greatly increases the highest probable values proposed in previous-reported eustatic drops and fits well with the value envisaged in the Alnif case-study. The Hirnantian maximum ice-sheet volume and sea-level drop would have surpassed by nearly 25% the maximum Quaternary values, representing the largest-known Phanerozoic glaciation.

With our GIA model, the adjustment between the estimated curves of eustatic, isostatic and relative sea-level fluctuations observed in Alnif has only been possible for an ice-sheet growth time of the order of 10 000 years. Thus, a total glaciation time span of no more than 20 000 years is estimated, reducing considerably the previouslyreported time span of ca. 500 000 years. In the light of this new estimate, the primary causes that controlled the growth and decay of the Hirnantian ice cap must be re-evaluated. The extremely short time span of this glaciation and its huge sea-level change will permit a better understanding of the importance of its related extinction event.

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Ordovician conulariid diversity in the periGondwana and Baltica regions – a summary with a special view to the Ordovician of Barrandian

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Poster Presentation

High biodiversity of the suborder *Conulariina* Miller and Gurley, 1896 is exhibited globally at the Middle-Upper Ordovician. In the contrast to the Cambrian from which no genera is described, first occurences of eight genera are documented from the Middle-Upper Ordovician of the periGondwana and Baltica regions.

The periGondwana is characterised by the cool-water EAP (*Exoconularia-Archaeoconularia-Pseudoconularia*) conulariid province (Van Iten – Brabcová, 2004) typical of following other species: *Anaconularia, Conularia, Conulariella, Eoconularia,* and *Metaconularia*. Host rocks of these generas are usually fine-grained sandstones and shales, exceptional preservation is in iron ores. All the forms are medium to big conulariids with well-developed sculpture. The genus *Conulariella*, typical for its rectangular cross-section and smooth transversal ribs is characteristic only for the Arenigian of Bohemia. The EAP Province includes France, Bohemia, Thuringia, Sardinia, Morroco, Turkey and, probably, Jordan.

The palaeocontinet Baltica is assigned to the warm-water CC (*Conularia* – *Climacoconus*) conularid province with following other representatives: *Archaeoconularia*, *Conularina*, *Ctenoconularia*, *Eoconularia*, *Exoconularia*, *Glyptoconularia*, *Metaconularia,* and *Pseudoconularia*. Host rocks are most often carbonates or cratonic basin shales. The CC province representatives are small to medium conulariid forms characteristic for its simple sculpture.

In the Prague Basin (Bohemia), all the Ordovician forms, except for the species *Conularia (Plectoconularia) proteica* Barrande, 1854; are not recorded in the younger stages. High specialization of the Ordovician species indicated by complicated sculpture did not allow to these form adapt to new climate conditions after the Hirnantian glaciation. Close similarities in morphology were studied at the species *Pseudoconularia grandissima, Exoconularia pyramidata, Anaconularia anomala* and *Conularia rugulosa* occuring in the Prague Basin (Bohemia), France and Morroco regions, and *Metaconularia bilineata* occuring in the Prague Basin (Bohemia) and Gotland (Sweden).

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The Ordovician Baltic epeiric sea – taphonomy and early diagenesis of its carbonate sediments

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Poster Presentation

Shallow water carbonate sedimentation persisted in the Ordovician Baltoscandian epeiric sea from the Tremadocian. 'Cephalopod limestones' are the typical limestones preserved today in Jämtland, Östergötland, Västergötland, Öland (central-southern Sweden), Estonia, and Denmark. As well as these distinctive sequences, reefs and limestone-shale alternations are known from Norway, and carbonate mud mounds are documented from the Caradoc and Ashgill of Siljan District Sweden (Kullberg and Boda mounds), Gotland, the Baltic and Russia. This dynamic carbonate deposystem was the setting for much of Ordovician Baltoscandian biodiversification, yet the exact environmental controls on sedimentation, and particularly processes of early diagenesis are poorly understood. Developing a taphonomic and early diagenetic model is critical for fully appreciating the spatial and temporal trends of Ordovician biodiversification for Baltica, particularly for taphonomically vulnerable groups such as molluscs.

Research on the cephalopod limestone of Jämtland has revealed that these are largely a product of an extensive destructive taphonomic system, similar to that seen in Cenozoic temperate carbonates. Early diagenetic characteristics indicating extensive syndepositional dissolution include a calcite-biased bioclastic fraction, partly to completely dissolved shells, contrasts in preservation of originally aragonitic nautiloid cephalopods, pores overprinted by dissolution and the possible presence of pitted microspars. Evidence for bioturbation is ubiquitous and is closely related to early remobilisation of carbonate – a *Thalassinoides*/*Chondrites* suite is commonly documented, as is a finer scale sediment retexturing. 'Micritic' nodular limestones and 'diagenetic beds' are interpreted as features of early carbonate remobilisation and lithification. The micritic limestones are composed of extensively comminuted bioclasts, as well as micrite/microspar cements displaying displacive clay cages. An aragonite mud precursor is a possibility, yet no obvious source is preserved (bearing in mind this is a 'calcite sea') that could have provided sufficiently large volumes to source diagenetic limestone; a skeletal source is more likely. The apparent slow accumulation rate for the cephalopod limestone can be interpreted as evidence for a diagenetically open system rather than low carbonate production.

This diagenetic regime has implications for the nature of biodiversity trends for molluscs. For example, the second major radiation of bivalves in the Upper Ordovician has been linked to the development of low latitude carbonate platforms on Baltica and Laurentia. However, the cephalopod limestone facies existed from the Tremadocian in Baltica, yet contains hardly any fossil record for bivalves among a normal marine fauna. Recently compiled bivalve data for Baltica shows that many of these bivalves are known from the Boda limestone mud mounds and siliciclastic facies elsewhere in Baltica that have a contrasting early diagenetic history compared to the cephalopod limestones. The paucity of bivalves then from cephalopod limestones is likely to be taphonomic rather than ecological and may well be obscuring the true timing and nature of bivalve radiation. Studies on the Silurian carbonates from Gotland have proven that early diagenetic dissolution of bivalves occurred on a previously unrecognised large scale for diversity and abundance; there is no reason to assume the case was any different in the Ordovician for bivalves (cephalopods and gastropods).

Depositional environments and sequence stratigraphy of the Jigunsan Formation (Middle Ordovician), Taebaeksan Basin, Mideast Korea

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Poster Presentation

The Jigunsan Formation (Middle Ordovician) in the eastern Taebaeksan Basin, mideast Korea, is an extensive fine-grained deposit of mixed carbonate-siliciclastic platform that is correlated for long distances. This study focuses on the depositional processes and sequence stratigraphic implications of the siliciclastic-dominant mixed carbonate-siliciclastic succession. The deposits of the Jigunsan and the juxtaposed formations can be classified into eleven sedimentary facies and six successive facies associations.

Facies association (FA) 1 consists of a shallowing-upward successional assemblage of peloidal grainstone, crudely laminated lime mudstone, bioturbated wackestone, and finely laminated lime mudstone that occur in the upper part of the Makgol Formation. It represents low-energy peritidal environments. FA2 consists predominantly of dark gray mudstone alternating with crudely laminated lime mudstone, resulting from hemipeagic settling in deep subtidal to basinal environments. FA3 is characterized by frequent alternation of laminated calcisiltite and dark gray mudstone or greenish gray siltstone representing storm-influenced deep subtidal platform. FA4 consists of greenish gray siltstone, massive grainstone and limestone conglomerate and is interpreted as deposit of local slope environments in storm-influenced shallow subtidal platform. FA5 consists of greenish gray siltstone and massive pack-grainstone, reflecting shallow subtidal platform environments. FA6 consists mainly of massive pack-grainstone and oolitic grainstone, deposited in shallow subtidal platform and shoal.

The facies sequence reflects an overall development of carbonate platform that was inundated during initial transgression (lower part of FA1) in the early Darriwilian and formed deep subtidal to basinal environments where storm-induced density and turbidity currents prevailed (FA2, 3 and 4). During sea-level still-stand, shallow platform sediments (FA 5 and 6) prograded over the deep subtidal to basinal area. The initial inundation surface of the platform, where a peloidal grainstone bed overlies a paleosol horizon, is interpreted as a sequence boundary/transgressive surface. The maximum flooding zone, representing a transition from transgression to regression, occurs in the upper part of facies association 2 which is characterized by a mudstone interval without carbonate sediment. According to biostratigraphic time scale, the entire sequence represents a cycle of third-order (3–10 Myr) sea-level rise and fall.

Gondwanan provenance of the Łysogóry block (Holy Cross Mountains, Poland) supported by Upper Ordovician chitinozoans from the Pobroszyn section

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Poster Presentation

Chitinozoans have been discovered in the carbonate-phosphorite lithofacies assigned to the Ordovician Bukowiany Limestone Formation of the Pobroszyn section in the Łysogóry Terrane, Holy Cross Mountains, central Poland (Trela et al. 2001). This tectonostratigraphic unit is emplaced between the East European Craton (EEC) and Małopolska Massif in southern Poland, and together with the Pomerania unit in northern Poland belongs to a mosaic of exotic terranes separating the old Precambrian craton of Baltica from the Phanerozoic western Europe along the prominent tectonic suture - the Trans-European Suture Zone (TESZ). The Łysogóry Unit together with Małopolska Massif in the Holy Cross Mountains are the only units where the Ordovician rocks crop out at the EEC margin. Recovered chitinozoan species, including *Belonechitina capitata*, *B. micracantha*, *Conochitina primitiva*, *C.* cf. *dolosa*, *Cyathochitina campanulaeformis*, *Cy. calix*, *Cy. sebyensis*, *Desmochitina minor ovulum*, *D. m. amphorea*, *D. m. erinacea*, *D. m. minor*, *D. nodosa*, *D. lacaniella, D. acollarea*, *D. juglandiformis*, *D. rugosa*, *Eisenackitina rhenana*, *Euconochitina* sp., *Lagenochitina deunffi*, *Pistillachitina pistillifrons*, *P. elegans*, *P. capitata*, *Laufeldochitina stentor,* and *L. striata*, are restricted to the upper Llanvirn-lower Caradoc. The chitinozoan assemblages document standard zones of Baltoscandian domain (Nõlvak & Grahn 1993). The stratigraphic occurrence of this assemblage extend from *L. striata - stentor* Biozone up to *L. deunffi-dalbyensis* (Aseri to Nabala Baltoscandian stages) with subzones: *sebyensis, clavaherculi, tuberculata,* and *rhenana*. Some of the identified chitinozoans are regarded as biogeographically significant and are characteristic for high palaeolatitudes (Paris 1999), in particular the discovered index species *L. deunffi*. This chitinozoan palaeobiogeographic evidence, as well as lithological similarities between the investigated strata and their equivalents from Buçaco, Portugal (Central Iberian Terrane) indicate that the Łysogóry Unit could have been situated at fairly high latitudes before the Late Ordovician. These observations together with previous palaeontological, palaeomagnetic and geochronologic (Belka *et al.* 2002) results obtained from the older (Cambriana) strata, support a hypothesis that the Łysogóry Unit was a terrane derived from Gondwana and accreted before the Late Ordovician to the south-western margin of the East European Craton (Baltica).

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Brief introduction of the Ordovician and Silurian in Northwest Zhejiang

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Poster Presentation

The Ordovician and Silurian in Northwest Zhejiang is a continuous marine succession, which can be divided into 2 litho-series approximately by the upper surface of Caradocian. The lower part is mainly composed of slope-basin sediments, and the upper of flyschs and flyschoids.

1. The lower series

The lower and middle part of Tremadocian is composed of argillaceous limestones, mudstones, and shales, in which some graptolite and trilobite fossils are found. The lithofacies then were replaced by neritic calcitic mudstones, which changed into red and grey knollenkalks at the end. The transgression in the afternoon of Early Ordovician brought on the famous graptolite shales in Northwest Zhejiang. It distributed from *D.(C.) deflexus* Zone to *N. gracillis* Zone in "JCY area" which was near a certain detached island, and a little longer inside the Zhe-Wan basin. The recession after the *N. gracillis* Zone resulted in great changes of lithofacies. Limestones containing cephalopoda and trilobite fossils of the upper part of Caradocian replaced the black shales. The litho-units of the series, which lasted around 50Ma and only formed hundreds of meter thick strata, can be traced in a large range. It indicates the steadiness of the local crustal block. However the "JCY detached island" and bentonites found at Hangnitang foreshowed the crustal activity. The SHRIMP age of zircons picked out from the bentonites is about 460Ma.

2. The upper series

After the finish of the low-speed aggradation, the high-speed progradation began in Ashgillian, and lasted to early Wenlock for about 15Ma. In such a short time thousands of meter thick strata composed of grey flyschs and flyschoids (interweaved red hue) formed, which records a high frequency of depositional changes. It obviously shows the crustal unsteadiness in that period. The flyschs were sediments of fluidified grain flows, while the flyschoids were mainly the result of tidal currents. The lithofacies and thickness vary in Northwest Zhejiang, mostly caused by synsedimentary. In the early Ashgillian flyschoids almost covered the whole Northwest Zhejiang, and flyschs, generally containing graptolite fossils, mainly sedimented in the northwest. At same time, the JCY area was a carbonate platform, on which an exented reef was built mainly by algae. Except these evidences of the crustal activity, even a slumping event was recorded as olistostromes in the JCY area. Though the regression in late Ashgillian was likely to be caused by the glacier event, there are no obvious phenomena indicating the cool climate. Around the boundary of the Ordovician and Silurian a brachiopod fauna (*Isorthis-Leptaena* fauna) spread over the Northwest Zhejiang, which is the latest bloom of brachiopods in the Early Paleozoic. In this fossil bed and the shales above some graptolite fossils (*N. persculptus* Zone and *A. ascensus* Zone) were found. In the upper part of the Llandovery, there are only 2 thin fossil beds mainly made up of brachiopods species. A set of very thick littoral sandstones, probably sedimented in early Wenlock, is the latest strata of the Early Paleozoic in Northwest Zhejiang. In these sandstones a 3-5 meter thick sedimentary tuff was found, which should have a great value on geotectology and stratigraphy.

Making a comprehensive survey on the whole Early Paleozoic, the sedimentary difference between the mentioned two series is the most obvious characteristic. We think the end of Caradocian is the period that Caledonian Movement started in Northwest Zhejiang.

Endemic thelodonts (Agnatha) of the Silurian of Central Asia and the Siberian platform

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Oral Presentation

Unique material from outcrops of Central Asia (Tuva and North West Mongolia) and five subregions of the Siberian Platform were analysed. Material is stored in the Institute of Geology and Geography, Vilnius, Lithuania.

The Lower Silurian samples (Llandovery and Wenlock) of North West Mongolia and the Siberian Platform were examined and yielded numerous vertebrate microremains, as well as samples from the entire Silurian (Llandovery to Pridoli) of Central Tuva. All the thelodont micromaterial (dentine scales) were ascribed to three genera - *Angaralepis* Karatajute-Talimaa, 1997, *Loganellia* Turner, 1991, and *Talimaalepis* Zigaite, 2004, gen. nov.

L. sibirica (Karatajute-Talimaa, 1978) was found in the Llandovery series of North West Mongolia and the Siberian Platform. The case reflects the statement that these terranes were part of the unite Early Silurian palaeobasin (Fortey & Cocks, 2003). The *L. sibirica* biozone of the Lower and Middle Llandovery was distinguished in the region.

L. tuvaensis (Karatajute-Talimaa, 1978) is restricted to Silurian deposits of Central Tuva (Wenlock to Pridoli series). This fact points Tuva being situated more or less separate from the main Siberian palaeocraton (Fortey & Cocks, 2003). *L.* cf. *L. tuvaensis* is described in the Upper Silurian of North Greenland (Blom, 1999), which was a North East Laurentia, facing and approaching Siberian palaeocontinent in the Silurian time (Cocks & Torsvik, 2002). Such a finding may attribute to Early Palaeozoic continent relationship.

Talimaalepis rimae Zigaite 2004, gen. et sp. nov., first described in Llandovery series of Central Asia, joins the Early Silurian palaeobasins of the region, as it is common in North West Mongolia, the Siberian Platform and Tuva as well.

The abundance of endemic thelodont taxa in Silurian sections of the region, indicates it as a proper place for genesis and radiation of early thelodont species. This consideration refers to warm and productive basins, which existed on the Siberian palaeocontinent during its supposed crossing of the Equator during the Silurian (Cocks & Torsvik 2002).

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Platystrophia-like brachiopods: their potential use in biostratigraphy, palaeoecology and palaeogeography

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Poster Presentation

Rhynchonelliformean brachiopods usually identified as *Platystrophia* (s.l.) belong to one of the most easily recognizable and widespread brachiopod groups in the Middle - Upper Ordovician and Early Silurian of Baltoscandia together with the Upper Ordovician of Laurentia. Moreover they are also reported from Avalonia and China. Only the Baltoscandian successions, however, contain the most complete record of the evolutionary history of *Platystrophia* (s.l.), corresponding to the whole known stratigraphic range of this genus. *Platystrophia* (s.l.) is thus also an important paleobiogeographical indicator of provincial affinity through time (Williams 1973) and moreover is useful for biostratigraphy. In particular, the Ordovician deposits of Lithuania (Lithuanian Confacies Belt) were subdivided by Paskevicius (2000) into twenty biostratigraphical units based on brachiopods; six of them were based on species of *Platystrophia* (s.l.). The biostratigraphical significance of platystrophiids in the North Estonian Confacies Belt (Estonia, St. Petersburg region, north-western Moscow basin) is also well established (Alichova 1953, 1960).

Unfortunately, most of the species within the '*Platystrophia*' plexus were defined on external morphology, whereas interiors and especially the morphology of dorsal cardinalia for most are inadequately known. A recent review of Baltoscandian, Avalonian and Laurentian *Platystrophia* (s.l.) has led to an improved understanding of their morphology, taxonomy, and systematics (Zuykov 2003, Zuykov & Egerquist in press, Zuykov & Harper in press). In the revised diagnosis of the genus, the term *Platystrophia* (s.s.) is confined to a large group of Arenig to Late Caradoc species from Baltoscandia and Avalonia, whereas the Ashgill and lower Silurian taxa from these regions and from Laurentia are assigned to three new genera.

We report results of the analysis of species diversity of *Platystrophia*-like brachiopod genera through the Ordovician and Silurian and provide an outline of their stratigraphical and geographical distribution together with a new phylogenetic scheme. We support Schuchert & Cooper's (1932) proposed biphyletic origin of the *Platystrophia*-like taxa: "The American forms arising out of the stock that gave rise to *Plectorthis* and the European forms independently out of some unknown stock." However, ancestry of both lineages is uncertain and needs further evaluation. Our revision suggests that *Platystrophia* s.s. is no longer a cosmopolitan taxon (cf. Williams & Harper 2000, p. 775), but its distribution is limited to the shallow-water biofacies of the Baltoscandian and Avalonian palaeobasins. Baltoscandia is defined as a major center of diversification and subsequent dispersion of the genus during the Ordovician. Many are short-lived species potentially useful as a basis for the biostratigraphical zonal schemes in the shallow-water sequences of the Baltoscandian basin. Brachiopod shells from the East Baltic are not affected by any significant alteration and usually have well-preserved shell structures. Baltic *Platystrophia*-like brachiopods represent a homogenous group ranging through nearly all Middle and Upper Ordovician and are thus ideal for isotopic investigation.

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