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Ordovician NEWS

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CONTENTS

Notes for contributors	p. 1
Editor's note	p. 1
Chairman's and Secretary's addresses	p. 1
Chairman's Report	p. 2
Annual Report of the Ordovician Subcommission	p. 2
Subcommission membership	p. 7
Cambrian-Ordovician Boundary Working Group	p. 8
New IGCP project - patterns of Ordovician biodiversity	p. 9
Minutes of Titular Members' meeting, 13 June 1995, Las Vegas	p. 15
Minutes of Intra-Ordovician workshop, 13 June 1995, Las Vegas	p. 18
Minutes of Subcommission meetings, 14 June 1995, Las Vegas	p. 22
Minutes of Titular Members' meeting, 16 June 1995, Las Vegas	p. 26
ISOS Titular Members' questionnaire responses, May 1995	p. 30
Results of ISOS polling of Titular Members in April/May 1995	p. 37
Results of ISOS postal ballots, October-December 1995	p. 40
The Whiterock and base of the Middle Ordovician, by R. Fortey	p. 41
The voting process for global series, by A. Owen	p. 46
Discussion of Cow Head section, H. Williams & C. Barnes	p. 47
What is the base of the <i>gracilis</i> Zone?, by V. Jaanusson	p. 53
Reply to V. Jaanusson, by S. Finney	p. 55
Ladislav Marek 1928 - 1995 - in memoriam	p. 58
Camouflaged trilobites?, by V. Petr and P. Kácha	p. 58
3rd Baltic Stratigraphic Conference	p. 59
WOGOGO 1997	p. 59
Report of Seventh Ordovician Symposium, Las Vegas	p. 59
Report of Friends of the Ordovician meeting, New Orleans	p. 62
Russian literature on Arctic research	p. 63
New Victorian maps	p. 63
Seventh Ordovician Symposium publications	p. 64
<i>Palaeoworld</i> special issue - base of <i>austrodentatus</i> Zone	p. 71
News and current research of Ordovician workers	p. 71
Ordovician publications, 1995	p. 81
E-mail addresses	p. 89
<i>Ordovician News</i> address changes	p. 92

NOTES FOR CONTRIBUTORS

The continued health and survival of *Ordovician News* depends on YOU to send in items of Ordovician interest such as lists and reviews of recent publications, brief summaries of current research, notices of relevant local, national and international meetings, etc. As more geological software becomes available, details of this would also be welcomed by many of us. Also please ensure that I am notified of any changes in address, telephone or fax number and e-mail address. Submissions for inclusion in the next issue of *Ordovician News* should arrive before 31 January 1997; when providing lists of recent publications, please include only fully refereed articles and books (not abstracts) published during 1996.

Contributions should be in English, typed double space and sent to: S.H. Williams, Department of Earth Sciences, Memorial University of Newfoundland, St. John's, Newfoundland A1B 3X5, Canada, OR ideally via e-mail, as this saves a lot of retyping. For longer contributions, it would help if a copy was sent either on 3 1/2" diskette (either Macintosh or IBM, but please state operating system and software used) or via e-mail (preferably as encoded file).

EDITOR'S NOTE

This "bumper" issue includes a number of longer discussion contributions related to the definition of global series and stages which I hope you will find to be of interest, plus a revised directory of e-mail addresses (which includes over one third of all Subcommission members). I am now sending notices, requests for contributions, etc. via e-mail rather than by mail wherever possible, so please keep me informed of any new or revised addresses (send to williams@sparky2.esd.mun.ca). With the ever-decreasing availability of secretarial assistance, electronically-mailed contributions are very welcome, and I am extremely grateful to all people that helped me in this regards when providing material for the present issue.

Henry Williams

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CHAIRMAN'S REPORT

This will be my last report on behalf of the current 1992-96 Executive and Voting Membership of the Ordovician Subcommittee. Membership changes will take effect next August, coinciding with the IGC in Beijing. Stan Finney has been nominated as Chairman for the 1996-2000 term of office, and Chen Xu and Henry Williams will continue as Vice Chairman and Secretary, respectively.

I have reported elsewhere in this issue (adapted from my article in the December 1995 issue of *Episodes*) on the highly successful Seventh International Symposium on the Ordovician System held in Las Vegas from 12-16 June 1995, and the important accompanying workshop discussions, meeting and field trips.

The last Ordovician correlation chart, the twelfth in our current global series was published as IUGS Publication No. 31 in 1995. This concluded an important part of our work program, initiated by Rube Ross in 1980.

Significant progress has also been made in identifying most significant biohorizons for global correlation purposes, and in finding workable, standardized global Ordovician subdivisions into series and stages. Strong support has been given to adopting a tripartite, subdivision into formal Series, LOWER, MIDDLE and UPPER.

Details of recent progress are presented elsewhere in this issue, in (1) the Annual Report of the Subcommittee for 1995 to ICS, (2) the postal ballots and questionnaire responses from Voting Members, and (3) the minutes, both the general Ordovician workshop discussions, and the breakfast meetings of the Voting Members, held during the Las Vegas Symposium.

I conclude by thanking all Ordovician workers who have actively participated in the work of the Subcommittee over these past seven years. I wish the new membership under the Chairmanship of Stan Finney all the best as they go forward in search of the best solutions for boundary definitions, and I hope they can find a truly workable common language for all Ordovician geology.

Barry Webby

ISOS ANNUAL REPORT FOR 1995

1. Name of subcommission

Subcommission on Ordovician Stratigraphy (SOS)

2. Overall objectives

The Subcommittee aims to promote international cooperation in Ordovician stratigraphy. Specific objectives are:

a. To delimit and subdivide the Ordovician System (and Period) as a part of the overall ICS work to elaborate the standard global stratigraphic scale. This work aims to establish the boundaries (GSSPs), the correlation of the subdivisions (Stages and Series), and the nomenclature of the subdivisions.

b. To promote regular international meetings on aspects of Ordovician geology,

especially those devoted to clarifying stratigraphic procedures, nomenclature and methods for use in establishing a unified global time scale, and to prepare correlation charts with explanatory notes (this latter task now completed).

3. Organization

a. Subcommittee Executive:

*Chairperson, B.D. Webby (Australia)

Vicechairperson, Chen Xu (P.R. China)

Secretary, S.H. Williams (Canada)

18 other Voting Members

92 Corresponding Members

*S. Finney (U.S.A.) has been nominated by the Voting Membership as the next Chairperson, for the next 4-year period (1996-2000)

b. Cambrian/Ordovician Boundary Working Group:

Chairperson, R.A. Cooper (New Zealand)

Secretary, G.S. Nowlan (Canada)

11 other Voting Members

57 Corresponding Members

c. Informal intra-Ordovician Working Groups

Convenors of these groups are as follows:

(i) base of *approximatus* (base of "Arenig") - S.H. Williams, S. Bergström, C.R. Barnes

(ii) base of *laevis* (base of "Whiterock") - R.J. Ross Jr., S. Finney, R. Ethington

(iii) base of *austrodentatus* (base of "Darriwilian") - Chen Xu, C.E. Mitchell, S.M. Bergström

(iv) base of *gracilis* (base of "Caradoc") - S. Finney, S.M. Bergström, R. Fortey

4. Extent of national/regional/global support for projects

Independent support for projects comes mainly from individual Ordovician workers, through their employer organizations, and through individual to multidisciplinary, cooperative, team activities supported by grants from national/regional government-funded bodies.

SOS receives no formal support from international organizations outside IUGS/ICS.

5. Interface with other international projects

The membership of the Subcommittee both geographically and in terms of research interests effectively reflects available expertise in aspects of Ordovician stratigraphy.

The Subcommittee has no formal links with other global projects, though some individual Ordovician workers are members of IGCP projects, most notably the following:

Project 319: Global Palaeogeography of the Late Precambrian and Early Paleozoic (Lower Ordovician only)

- Project 321: Gondwana dispersion and Asian accretion
 Project 328: Palaeozoic microvertebrate biochronology and marine/nonmarine correlation
 Project 335: Biotic Recovery from Mass Extinction events - patterns, processes and implications
 Project 351: Early Paleozoic Evolution from the nucleus to the margins in Africa and South America

However, a new IGCP proposal is currently being submitted to the Secretariat of IGCP by B.D. Webby (Australia), M. Droser (USA) and F. Paris (France), entitled "The Great Ordovician biotic radiation: implications for global correlation and resources". Hopefully this project will be supported over the period 1996-2001.

6. Accomplishments and products generated in 1995

(a) The Seventh International Symposium on the Ordovician System was held on the campus of the University of Nevada - Las Vegas, USA, from 12-16 June 1995, and provided opportunities for an official business meeting of the Subcommittee, attended by about 40 persons, and for Cambrian-Ordovician Boundary and Intra-Ordovician workshop discussions, as well as separate meetings of the Voting Members. An impressive, 498-page, volume of "Short Papers", and a 151-page "Field Trip Guidebook" on the Ordovician geology of the Great Basin were published before the meeting.

(b) The last IUGS-supported Ordovician correlation chart and explanatory notes was printed. It comprised a 104-page, 82-column volume for China, compiled by Chen Xu, Rong Jia-yu, Wang Xiao-feng and others, and edited by Barry Webby, as *IUGS Publication No 31*. This completes our Ordovician correlation chart series, a major part of our activities since the late 1970s. The twelve volumes published since 1980 comprise an almost complete global coverage. Consequently they represent an invaluable data base, of great value in our current work of establishing global Ordovician correlations and events.

(c) Roger Cooper, Chairman of the Cambrian-Ordovician Boundary Working Group, reported that two circulars and a letter plus agenda had been sent to members since the inception of the group concerning work on the Dayangcha section. Nine of the 13 Voting Members attended meetings in Las Vegas in June 1995, and they unofficially concluded that an horizon based on conodont *Iapetognathus* would prove acceptable, but there were problems relating to the range of this genus at Green Point, Newfoundland. Carbon isotope stratigraphy was proving to have high correlation potential, and should be used in any choice of a stratotype. But the group recognised the need to achieve an early decision on the Dayangcha section. Also the group were also drawing up a shortlist of alternative sections with *Iapetognathus* in the event that the Dayangcha section was rejected.

(d) Late last year (1994) I circulated formal papers to Voting Members for the postal ballot on the boundary stratotype (GSSP) defining the base of the *Tetraraptus approximatus* Biozone, based on the Ledge section, Cow Head Peninsula, western Newfoundland. This proposal is based mainly on the work of S.H. Williams, C.R.

Barnes and W.B.N Berry. During the voting process a number of issues were raised by members, specifically: (1) that the vote was not clearly specified as defining a Series or a Stage boundary; (2) that the British name Arenig had been used rather than a less committed interim term, such as "second series"; (3) that there had been inadequate review of all potentially good sections across the particular interval (especially the Hunneberg section in southern Sweden); and (4) that stratigraphic discontinuities existed in the the critical interval of the Ledge section at Cow Head. For these reasons, a clear majority was not achieved and consequently I postponed the vote pending results of further work on the Ledge section, and on the new sections in the Hunneberg region.

In June 1995, these matters were again discussed in one of the Intra-Ordovician workshops, and it was recommended that two GSSP proposals should be prepared by the two groups of workers (separate submissions on the Ledge section by S. Henry Williams and co-workers, and on the best Hunneberg section by Stig Bergström and colleagues) by a deadline of **31 March 1996**. Then the position papers will be circulated to Voting Members for a decision. The preferred section will then be submitted as the proposed GSSP.

(e) On 22 March 1995 a position paper, set of ballot papers and questionnaire were circulated to the Voting Membership. Results of the postal ballots are as follows: **1.** That we adopt a set of guidelines for establishing global boundaries and subdivisions, first to select a level with global correlation potential, secondly to find the best possible section for definition of the GSSP, and finally to assign a formal name (with recommended level of hierarchy) to the overlying chronostratigraphic unit [**91% majority vote**]; **2.** That the base of the *Tripodus laevis* conodont Biozone be the base of the third chronostratigraphic division of the Ordovician System [**61% majority vote**]; **3.** That the base of the *Nemagraptus gracilis* graptolite Biozone be the base of the fifth chronostratigraphic division of the Ordovician System [**86% majority**]; **4.** That the base of the *Phragmodus undatus* conodont Biozone be the base of the sixth chronostratigraphic division of the Ordovician System [**53% majority - vote declared lost**]; and **5.** That the base of the *Dicellograptus complanatus* graptolite Biozone be the base of the seventh chronostratigraphic division [**75% majority vote**]. The results give a clear mandate to our continued, focussed, work program on the *laevis*, *gracilis* and *complanatus* levels for potential global Stage (and in some cases Series) boundaries.

(f) A second set of ballot papers was circulated to the Voting Members in October 1995. The first, arises from the earlier questionnaire and the workshop discussions in Las Vegas strongly favouring a tripartite subdivision of the Ordovician System with the formalized LOWER, MIDDLE and UPPER for used as the Series names, and the second, concerns the particular levels for establishing these Series boundaries, at the base of the *Tripodus laevis* Biozone, and the base of the *Nemagraptus gracilis* Biozone, respectively. Results should be known by late December 1995.

(g) Work has continued on a position paper for the adoption of the base of the *Undulograptus austrodentatus* Biozone as global stage boundary by Chen Xu, C.E.

Mitchell and S.M. Bergström. Their GSSP proposal details the base of the *austrudentatus* Biozone in the Huangnitang section of Zhejiang Province, SE China, with an auxiliary section documenting equivalent beds on the Yangtze Platform. This will be submitted by **31 March 1996**, then voted on by the Titular Members.

(h) Early in 1995 a 43-page issue of *Ordovician News*, No.12, was published. It was edited by S. Henry Williams.

7. Problems encountered in 1995 (if any)

None

8. Work plan for 1995

a. Operating budget request

(i) Support to publish *Ordovician News* issue No.13 in early 1996 prior to the 30th International Geological Congress in August 1996.

(ii) General administrative expenses for the Subcommission Chairman & Secretary, and the C/O Working Group Chairman & Secretary.

b. Publications

(i) A book entitled "Base of the *austrudentatus* Zone as a level for global subdivision of the Ordovician" (edited by Chen Xu, C.E. Mitchell and S.M. Bergstrom) will be published in Nanjing late 1995 or early 1996 (as No.5 in the *Palaeoworld* series).

(ii) A guide book for the pre-IGC field trip to the Tarim Basin will be prepared by Chen Xu, Zhou Zhi-yi and colleagues.

(iii) *Ordovician News* No. 13 will be assembled by S.H. Williams and published in early 1996.

c. Conferences

In August 1996 the 30th International Geological Congress is being held in Beijing, China. An official business meeting of the Ordovician Subcommission is being arranged, along with active participation in the Stratigraphy sessions.

d. Anticipated accomplishments:

Submit various proposals for GSSPs and subdivisions ratified by the Voting Membership for ICS/IUGS approval before the 30th International Geological Congress, to be held in Beijing, China. Specifically it is hoped to have two GSSP submissions (base of *approximatus* and base of *austrudentatus* biozones) presented for approval prior to the IGC.

A strong program of Ordovician discussions is proposed for the stratigraphy session of the IGC, with focus on the Ordovician time scale and its subdivisions (convenors Chen Xu and Barry Webby), and on patterns of Ordovician biodiversity. Also a pre-Congress field trip for Ordovician workers to the Tarim Basin of NW China is being organized by Chen Xu and Zhou Zhi-yi.

9. Potential funding sources outside IUGS

The Subcommission has no regular funding sources outside IUGS. Individual

members of the executive, Voting Members and Corresponding Members will all need to find their own financial support through their institutions to attend the Beijing IGC meeting. The Chair, who is now retired from a permanent teaching and administrative post at Sydney University, has an Honorary position at Macquarie University, and remains active in Ordovician research. He is willing to provide a large part of the support for travel and expenses from private funds, but would appreciate partial supplementation for his travel to attend the important Beijing IGC meeting.

10. Anticipated work plan for period 1997-2000

1997-2000. One may expect that priority will continue to be given by the new (post 1996) Executive to continuing focus on defining the boundary stratotypes for ALL the Stage and Series subdivisions of the Ordovician System, and of publishing the decisions of all these final recommendations.

The Eighth International Symposium on the Ordovician System will be held in Prague, Czech Republic, in August or September 1999, and there are plans for a post-session field trip to Spain and Morocco to study the cooler, peri-Gondwana successions (including the glacial deposits).

There will also be a WOGOGO (Working Group on Ordovician Geology of Baltoscandia) field meeting in St. Petersburg, Russia, probably in August 1997, with four days of field trips to examine the Lower Ordovician of the East European (Russian) Platform.

It may be expected that there will be field meetings in intervening years to examine prime candidate sections for stratotype boundaries, and field work related to the newly proposed IGCP project on "The Great Ordovician biotic radiation: implications for global correlation and resources".

Barry Webby

SUBCOMMISSION MEMBERSHIP

A number of changes to the Titular Membership which were suggested last year should be ratified at the upcoming IGC. Stan Finney will take over as new chair of the Subcommission. Bruno Baldis, Bill Berry, Bill Dean, Valdar Jaanusson, Igor Nikitin Rube Ross and Barry Webby will retire as Titular Members. New Titular Members who have confirmed their appointment include Gilberto Acenolaza (Argentina), Warren Huff (USA), Chuck Mitchell (USA), and Bob Nicoll (Australia). New Corresponding Members include Dave Harper (Ireland), Jorg Maletz (Germany), Arne Nielsen (Denmark), Anita Löfgren (Sweden) and David Rohr (USA). I welcome all new members and trust that they will continue to play an active role in our work. I also thank the retiring Titular Members for their invaluable contributions to Subcommission work over the past number of years.

Barry Webby

CAMBRIAN - ORDOVICIAN BOUNDARY WORKING GROUP

The International Cambrian - Ordovician Boundary Working Group has been busy working towards a resolution of the boundary question. Circulars dealing with progress on several fronts were mailed to about 60 voting and Corresponding Members in March and December 1995 and again, most recently, in May 1996. In addition, meetings were held at the Seventh International Symposium on the Ordovician System in Las Vegas in June 1995 including a public evening discussion. Nine of the thirteen Voting Members took part in a meeting of the Voting Members following the public discussion. In the course of their meeting they resolved to include two extra candidate sections, Lawson Cove and Green Point, in the final ballot. This resolution has subsequently been put to formal ballot, the result of which was an overwhelming yes.

The current Voting Members of the Working Group are: Roger Cooper (New Zealand, Chairman), Godfrey Nowlan (Secretary, Canada), Chen Jun-yuan (China), Svetlana Dubinina (Russia), Bernie Erdtmann (Germany), Ray Ethington (U.S.A.), Richard Fortey (U.K.), Dim Kaljo (Estonia), Bob Nicoll (Australia), Rob Ripperdan (U.S.A.), Adrian Rushton (U.K.), John Shergold (Australia), John Taylor (U.S.A.)

The Working Group is proceeding with the final ballot to choose the GSSP. The May 1996 Circular (84 pages long) contains the final briefing papers for the three candidate sections for GSSP and other relevant papers, including a discussion of the conodont species of *Iapetognathus*. The ballot form is being distributed to the Voting Members in late May 1996. The group has before it three candidate sections for GSSP - Lawson Cove (Utah, U.S.A.), Dayangcha (Jilin, China), and Green Point (Newfoundland, Canada). They represent the shallow shelf platform, outer shelf or deep shelf, and continental slope environments respectively, each with its own distinctive mix of fossil groups and physical characteristics. Each candidate has its own set of advantages. Each also has its disadvantages. None has all of the attributes desirable in a GSSP and the group is going to have to choose the best compromise.

The boundary interval in all three candidate sections is free from synsedimentary dislocations and structural complications other than small scale and readily identifiable faults, from threat of foreseeable damage or destruction, and from metamorphism and strong diagenetic alteration. All three candidate GSSP's lie within stratigraphically extensive sequences which range from well down in the Cambrian to well up in the Ordovician. Each is part of a geographically more extensive stratal succession which provides other nearby sections through the boundary interval. The rate of sedimentation varies greatly among the three sections, but in all three it is adequate to clearly separate the bioevents.

Godfrey Nowlan

LETTER OF INVITATION TO ORDOVICIAN COLLEAGUES TO PARTICIPATE IN THE PROPOSAL OF A NEW IGCP PROJECT - TEMPORAL AND SPATIAL PATTERNS OF ORDOVICIAN BIODIVERSITY: IMPLICATIONS FOR GLOBAL CORRELATION AND RESOURCES

We invite **all** Ordovician workers with interests in aspects of Ordovician biodiversity, global correlation problems and/or hydrocarbons to join us in establishing this proposal (see below) as a new IGCP project. Please regard this very much as a preliminary outline. We welcome constructive suggestions for improvement. We will submit the proposal through IGCP National Committees later this year, hopefully for establishment as a 5-year project early in 1997. We hope you will agree that it is essential to have one or more globally directed IGCP programs linked in a thoroughly cooperative way to the work of the Ordovician Subcommission.

General literature surveys of fossil diversity have been made, but what is now required is a more comprehensive stocktaking of Ordovician biotas, fully appraising spatial and temporal relationships in **all** areas of the world, not only in terms of the great Ordovician radiation event, but also in identifying more precisely what elements of these biotas may have significant global correlation potential.

Initially we are recommending the establishment of **seven regional teams** to commence work on the first stage of our program. We invite Ordovician workers to join in this program of work, especially those who would wish to be active in coordinating the work in their particular region of the world. Please advise Barry Webby as soon as possible if you feel you are able to participate in this IGCP project.

Barry Webby
Mary Droser
Florentin Paris

IGCP TITLE: TEMPORAL AND SPATIAL PATTERNS OF ORDOVICIAN BIODIVERSITY: IMPLICATIONS FOR GLOBAL CORRELATION AND RESOURCES

Proposed by:

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Brief outline and main objectives:

The most rapid, sustained, biotic diversification in the history of animal life on Earth occurred during the Ordovician Period, some 490-435 million years ago. Not only was there a tripling of diversity, but completion of the rise of the "modern" phyla. Dramatic changes took place in both pelagic and benthic realms, with entirely new groups

colonizing the oceans, and a wide variety of benthic organisms evolving to better utilize the habitat space above and below the sea floor (e. g., colonial growth, tiering), and in all latitudinal zones. This massive temporal and spatial diversification is, on the one hand, of great intrinsic interest in providing a window on a remarkably rich ancient global ecosystem and, on the other, of inestimable value as a high resolution global correlation tool, once its record of innumerable evolutionary (and extinction) bioevents has been properly integrated, first on a region-to-region basis, and then tied to a global standard.

Primary objective:

To survey the full global range of communities (and constituent species) in representative onshore-offshore profiles of each major region, and across all Ordovician latitudinal zones.

It is proposed that this main work be undertaken in three stages:

First, seven regional teams, based in North America, South America, Europe-North Africa, Baltoscandia-Russian Platform, Kazakhstan-Central Asia, China, and Australasia, will establish the temporal and spatial patterns of individual groups of organisms - benthic (epifaunal and infaunal) and pelagic - and the nature of representative onshore-offshore community profiles.

Secondly, region-to-region analyses of the biodiversity patterns will follow, with evaluation of significant event data, e.g., the main evolutionary (and extinction) bioevents.

The **third** part of the study will focus on establishing cross ties between this regional-to-global bioevent successional record and the available standardized pelagic fossil group zonal sequences (i.e., those based on graptolites, conodonts and organic-walled microfossils), leading to an integrated and unified global scheme.

Secondary objectives:

(1) In terms of the pelagic groups, given their great potential for establishing precise worldwide correlation, graphic correlation methods will be employed on further selected regional data sets (e.g., between Eastern Canada, the Baltic and northern Gondwana using the organic-walled microfossils). (2) These organic-walled microfossils (chitinozoans and acritarchs) will be given especial attention as they have proved so useful in correlating into high latitude regions. (3) Also, the paleontology of organic-rich shales, and their occurrences in contrasting shallow platform and deeper peripheral environments, will be investigated, owing to their economically significant hydrocarbon potential.

This new IGCP project aims to be collaborative with, and complementary to, the work being undertaken by the IUGS Subcommittee on Ordovician Stratigraphy, with its primary task the establishment of a global standard of international subdivisions (Series and Stages) bounded by GSSPs.

Estimated duration:

Five years (1997-2001)

Tentative work schedule:

Establishment of the seven regional teams will be undertaken during 1996, prior to submission of this application. Preliminary studies will be undertaken in **China**, in association with the International Geological Congress in August, and a pre-session field trip to the Tarim Basin, NW China.

1997. Program of field work and first workshop discussions will be held in **Scandinavia** and **Russia**. The workshop discussions will be held in St Peterburg during August 1997. The field work will focus on onshore-offshore profiles across the confacies belts of Jaanusson in Baltoscandian platform successions of mainly **temperate** settings. It is also planned to examine the oil shale deposits of Estonia.

1998. A field meeting and workshop discussions is planned to focus another very important region during the year, namely, **Kazakhstan** (and possibly neighbouring **Tazhikstan**), with Ordovician biotas occurring in various terranes including extensive volcanic island and archipelago-like complexes in **near-tropical to temperate** settings.

1999. A major IGCP meeting will be held in conjunction with the Eighth International Symposium on the Ordovician System in Prague, **Czech Republic**, in August-September 1999 with field trips to the Barrandean region near Prague, and an eleven-day field excursion to **Spain** and **Morocco**. Attempts will also be made to arrange a field trip to **Algeria** after this excursion. This will provide an opportunity to overview the **near polar**, peri-Gondwana successions and faunas (including the glacial deposits).

2000. A special IGCP session will be requested for inclusion in the program of the 31st IGC, to be held either in **South Africa**, or one or more **South American** countries. We also plan a series of field trips to study **tropical Australian** successions, specifically, onshore-offshore faunal gradients in platform sequences, and offshore volcanic island complexes, most complete pelagic record in the shaly facies, and Ordovician hydrocarbon distributions.

2001. A final, major, IGCP meeting will be held in **North America**, to review the achievements of our 5-year work program. Also, a book on global Ordovician biodiversity will be published at or near the conclusion of the project.

Concrete results expected of the project:

(a) In theoretical sciences

Temporal and spatial bioevent data will first be combined group-by-group for each region, then integrated with the best available global standard derived from the graphically correlated pelagic zonal schemes, tied to available physical and chemical markers

(radiometric dating, magnetic polarity, areally widespread ash layers, geochemical signatures and isotopic excursions). This will provide a much improved means of precise global correlation of Ordovician rocks, and a greatly improved understanding of the factors responsible for this great diversification of animal life.

(b) In applied science and technology

Comparative work on the organic-rich, anoxic, oil shales of comparatively shallow, intracratonic biofacies, and the deeper-water, peripheral, graptolitic biofacies should add important new data (and hopefully review of unpublished oil company data) bearing on the nature and origin of Ordovician oils. The practical results of this work should greatly benefit a number of participating countries.

The following short term results are expected

Significant progress may be expected by the end of the first year of the project (end of 1997), after field work has been completed in Baltoscandia and Russia. It will then be possible to make close comparisons of the Baltoscandian onshore-offshore faunal profiles with existing data for the North American platform, and compile the graphic correlation data sets for North Atlantic province conodonts, and chitinozoans from best available Baltoscandian sections. Field work on the faunal content, diversity and trophic strategies of the benthic communities associated with the oil shale biofacies in Estonia will also hopefully be completed in 1997.

In 1998, field work will be extended to the best available and well preserved onshore-offshore faunal profiles in the volcanic island and archipelagic and/or platform settings within the fold belts of Kazakhstan and neighbouring Tazhikstan, as a basis for further comparisons, for example, with the island biotas of eastern Australia. The discussions held in Alma Ata and Tashkent will include important training workshops on the approaches employed in this program of work, of benefit to local scientists.

Present state of activities in the field (include names of institutions and persons):

1. Work continues on the documentation of the entire Ordovician faunas and floras from the island-arc tectono-environmental settings of eastern Australia by Barry Webby (Macquarie University), Ian Percival (NSW Geological Survey), Zhen Yongyi (Macquarie University), Julie Trotter (C.S.I.R.O., North Ryde). Other work on the Ordovician faunas in the continental platform and shelf margin (warm water Gondwana) successions of central, northern and western Australia, as well as western New South Wales is continuing, mainly in cooperation with colleagues of the Australian Geological Survey, Canberra, in particular Bob Nicoll, John Shergold and John Laurie, and with Pierre Kruse (Northern Territory Geological Survey, Darwin).

2. Currently studies of the major Ordovician biodiversification event are being undertaken in the Basin and Range Province of the western United States (in warm water Laurasian successions) by Mary Droser (Univ. California, Riverside and Cincinnati), Peter

Sheehan (Milwaukee Public Museum) and others, with particular focus on understanding the nature of ecological shifts and changes associated with the great radiation event.

3. Florentin Paris is actively participating in three major programs of work, namely, on Ordovician-Devonian chitinozoans, on north Gondwanan palaeoenvironments, and on palaeogeographic reconstructions of the north Gondwanan, Laurentian and Baltoscandian regions. His work on Ordovician chitinozoans (with A. Achab, Y. Grahn, J. Nolvak, J. Verniers, G. Van Grootel) includes focus on their utility as "biostratigraphical tools", on their biological significance based on exceptionally well preserved specimens, and in building a series of comprehensively complete, illustrated data bases for all described taxa.

What countries and institutions likely to participate:

Algeria (Univ. Alger; SONATRACH R.&D); Argentina (Cordoba group); Australia (AGSO, Macquarie University, GS Vict., GS NSW; Univ. New England, Armidale); Austria (Wien, Geol. Surv.); Belgium (Univ. Liege; Univ. Gent); Canada (Univ. Victoria; Univ. Manitoba; Memorial Univ., Newfoundland; GSCan.; INRS Quebec); China (Acad. Sinica, Nanjing; Chinese Acad. Geol. Sci., Ichang & Beijing); Czech Republic (Karlova Univ.); Denmark, (Univ. Copenhagen; Geol. Surv. Greenland); Estonia (Acad. Sci. Est. SSR); France, (Univ. Rennes; Univ. Brest; BRGM - French Geol. Surv.), Germany (Tech. Univ. Berlin; Univ. Erlangen); Ireland (Univ. College, Galway); Italy (Modena Univ.; Univ. Pisa; Univ. Cagliari); Kazakhstan (Geol. Inst. Acad. Sci., Alma Ata); Morocco (Rabat); New Zealand (NZGS, Lower Hutt); Norway (Paleont. Inst., Oslo); Poland (Acad. Sci., Warsaw); South Africa (GS South Africa; Rhodes Univ.); Russia (VSEGEI, St Petersburg); Spain (Complutense Univ., Madrid; Univ. Oviedo; Univ. Zaragoza); Sweden (Uppsala Univ.; Lund Univ.; Riksmuseet, Stockholm); Tazhikstan (Geol. Inst., Acad. Sci., Tashkent); United Kingdom (Univ. Cardiff, Queen's Univ., Belfast; Sheffield Univ., Glasgow Univ., Brit. Mus. London); United States (Univ. of California, Riverside; Univ. Cincinnati; State Univ. Calif., Long Beach; Ohio State; Univ. California, Berkeley; Penn. State; Univ. Missouri, Columbia; Community College, Austin; State Univ. New York, Buffalo; USGS, Denver & Washington DC; Milwaukee State Museum; Univ. Texas; Brigham Young, Provo; Univ. Chicago; Univ. Alpine, Texas.

What countries or institutions (or individuals) have already:

(a) agreed to cooperate (*agreed to participate; others being contacted)

Cordoba (Astini et al); AGSO (Nicoll)*, GSVict (VandenBerg), GSNSW (Percival)*; Gent (Van Grootel, Verniers), Liege (Servais); Victoria (Barnes)*, Manitoba (Elias), Newfoundland (Williams)*, GSCan (Nowlan); Nanjing (Chen Xu, Rong, Zhou)*, Ichang (Wang Xiaofeng); Karlova, Prague (Fatka et al.); Copenhagen (Nielson, Rasmussen et al); Est. Acad. Sci (Kaljo, Nolvak, Bauert); Rennes (Paris et al.)*; Hamburg (Schallreuter), TU Berlin (Erdtmann, Maletz), Erlangen (Keller, Lehnert); Galway (Harper); Pisa (Tongiorgi, Albani), Modena (Serpagli); Alma Ata (Apollonov)*; Armidale (Metcalf); Rabat (Hamoumi, El Aouad); NZGS (Cooper)*; Oslo (Bruton); Sheffield (Romano);

G.S.S.Africa (Theron); VSEGEI (Koren, Popov); Madrid (Gutierrez Marco)*; Uppsala (Holmer, Peel), Stockholm (Grahn, Jaanusson); Tashkent (Kim); Cardiff (Dean), Belfast (A.D. Wright) Glasgow (Owen), Brit. Mus. (Fortey); Riverside/Cincinnati (Droser)*, Long Beach (Finney)*, Ohio State (Bergström, Sweet)*, Berkeley (Berry), Penn State (Cuffey, Patkowsky) Columbia (Ethington), Austin (Johns), Buffalo (Mitchell), USGS (Ross, R., Neuman, Repetski, Harris), Milwaukee (Sheehan)*, Texas (Sprinkle), Provo (Rigby), Chicago (Sepkoski), Alpine TX (Rohr)

(b) will be contacted

Algeria (K. Boumendjel R & D. SONATRACH); Bolivia (Mercedes di Pasquo) Brazil (Luis P. Quadro & J.H.G. de Melo, PETROBRAS, Rio de Janeiro), Iraq (Thamer K. Al-Ameri, Univ. Baghdad); Iran (Ghavidel-Syooki, National Iranian Oil Co, Teheran); Saudi Arabia (Said al Hajri, Saudi ARAMCO, R. & D, Dhahran); Vietnam (Ta Hoa Phuong, Univ. Hanoi)

Suggested location of major field activities:

We plan to have major field work concentrated each year in one or more continental platforms and associated peripheral regions; focus over the five years of the project will be on blocks in each main latitudinal zone (tropical, south temperate and south polar). This will involve work in platformal and peripheral regions of: (1) North America, Australia, Kazakhstan, N and NW China (tropical), (2) NW Europe, Baltoscandia and S China (south temperate) and (3) N Africa, Cordilleran S America and SE Europe (mainly south polar).

**Location of major laboratory research*
(expected or assured co-operation of laboratories)**

School of Earth Sciences, Macquarie University, North Ryde, NSW, 2109, Australia;
Australian Geological Survey Organization, P.O. Box 368, Canberra, ACT, 2601,
Australia

Department of Earth Sciences, University of California, Riverside, Riverside, CA. 92521,
USA; Department of Geology, University of Cincinnati, Cincinnati, Ohio 45221-0013,
USA

Giosciences, Institut de Géologie, Universiti de Rennes I, 35042 Rennes Cedex, **France**

*[We would hope that there would be at least **one major laboratory for our researches in each regional area**; please advise if you can help]

Barry Webby
Mary Droser
Florentin Paris

**SUBCOMMISSION ON ORDOVICIAN STRATIGRAPHY
TITULAR MEMBERS MEETING, 6.00AM, 13 JUNE 1995, LAS VEGAS**

Present: Appollonov, Barnes, Bergström, Berry, Chen, Cooper, Finney, Fortey, Gutierrez-Marco, Paris, Ross, Wang, Webby, Williams.

WEBBY noted that 15 of the 22 Titular Members were present at Las Vegas.

Membership. Webby would be stepping down as Chairman of SOS at 1996 IGC. Williams also would like to step down if possible. There should also be a turnover of Titular Members; ICS recommends 1/3 at each IGC, with maximum total of three terms (normally 12 years) for TM's. 10 present TM's have been in their positions since 1982. Also, 22 TM's exceeds the maximum permitted by 2, so the total needs to be reduced to 20.

Proposals for next ISOS. Two proposals received, for San Juan, Argentina in 1998 (proposed Baldis) and Prague, Czechoslovakia (proposed Fatka).

BARNES - Possibly few people would attend a meeting in Argentina because of expense?

BERGSTRÖM - Prices are about the same as the US, but air fares are higher. It might not be possible to remove fossil material from San Juan Province (provincial laws).

FINNEY - Baldis states that there would be no problem to change date to 1999, and there is the possibility of a special reduced air fare (ca. US\$1,000 from North America).

CHEN - Air fares still a problem from China and Europe.

WEBBY - There has not been a previous SOS meeting in an area with cool water/high latitude assemblage. If Argentina was part of Laurentia, then no problem; otherwise perhaps we should adopt proposal.

PARIS - In favour of cool water region; Czechoslovakia would also meet this criterion, but with advantage of easy access and organic-rich lithologies.

GUTIERREZ-MARCO - Bohemian rocks are similar to those in Spain, etc., typical of north Gondwana.

BERGSTRÖM - Czech sections are probably more important to visit than those in Argentina.

CHEN - Could the Ordovician and graptolite meetings be coordinated again?

WEBBY - Erdtmann suggests Berlin for the next graptolite meeting, but no related SOS meeting.

GUTIERREZ-MARCO - Propose the next graptolite meeting for Spain. It could have good coordination with Czech meeting and intervening excursion through southern France and northern Spain.

WEBBY - Any chance of an excursion to Morocco?

GUTIERREZ-MARCO - Would need to be at least five days; it would be complex to organize, but possible.

BARNES - Last three SOS meetings have disadvantaged researchers from former soviet bloc - Prague would be good for them and could run excursions to the east.

FINNEY - Personally don't favour more back-to-back symposiums; but many people seem to prefer this, and it produces better attendance on excursions.

BERRY - Agrees with Barnes.

WILLIAMS - Perhaps an attempt should be made to coordinate the graptolite meeting with a Silurian meeting next time?

WEBBY - On balance there appears to be a preference for W. Europe amongst TM's.

Executive membership. WEBBY - We are supposed to provide ICS details of membership changes (TM's and Executive) by end of June, so that they can be circulated to members of ICS before end of July and approved by early August (one year ahead of next IGC). This should also include any changes to the Cambrian-Ordovician Boundary Working Group. Webby previously asked Bergström to chair a Nominating Committee, also including Barnes, Chen, Dean and Paris. He had been unable to contact Dean, but the remainder of the Committee were in Las Vegas.

FORTEY - He had heard that Dean was currently unwell.

WEBBY - Suggests the Committee operate without Dean; they should meet immediately, and if possible have their suggestions for the meeting of TM's on Friday 16 June. The Committee had already proposed that Cooper and Nowlan remain as Chairman and Secretary of the COBWG. Changes in ICS rules mean that the Secretary of SOS may be chosen by the Chairman without vote by other TM's.

BERGSTRÖM - Must the new Chairman be selected from current TM's of SOS?

WEBBY - Apparently yes, although Corresponding Members could also perhaps be considered. New ICS rules allow for two alternate candidates to be put forward for voting, but he personally considers selection of a single candidate better.

Titular membership. WEBBY - Recommended rotation of 1/3 TM's every IGC has not been achieved by SOS. At least 7 TM's should move to CM status next year (10 is possible). We could ask for recommendations for replacements from retiring TM's. Webby wants to move to CM status. Should we ask Nominating Committee to examine this issue by Friday?

ROSS - Is retiring, would like John Taylor to be considered for his replacement.

BARNES - Need to look at the future agenda of SOS before making decisions. Need more non-paleontologists, etc.

FORTEY - Need to seek volunteers for stepping down. No justification for both Nikitin and Appollonov as TM's (same institution). Dean has not participated in SOS meetings or business for many years.

BERGSTRÖM - Need to rebalance membership.

WEBBY - Yes.

BARNES - Should get input from the general SOS membership and perhaps replace all 10 who have served three terms or more.

PARIS - Should new TM's already have been CM's?

WEBBY - Normally, but Corresponding Membership also needs to be looked at; there are currently almost 80, many of which are not active or who have not contributed to SOS work.

WILLIAMS - Worried about taking "unknown entities" for new TM's. Also the CM's should definitely be revised.

WEBBY - Should we leave structure for focussing of TM's to incoming chairman and executive?

ROSS - Yes.

BERGSTRÖM - Is current Corresponding Membership inadequate?

WEBBY - Yes.

ROSS - Doesn't want to be CM after retirement as TM.

WILLIAMS - CM's should be reduced to about 50 in total.

WEBBY - Harper, Maletz and Rohr will be new CM's.

WILLIAMS - Harper already accepted invitation.

BARNES - Should send form letter to all CM's asking for outline of recent Ordovician research, and if not adequate remove them [Williams - action, but decided against in subsequent consultation with Webby and Chairman elect: SHW].

Budget. WEBBY - 50% of IUGS funding currently used for printing of *Ordovician News*. Could charge in the future.

WILLIAMS - Prefer to keep it free to SOS members for now.

BARNES - Could move to electronic transmission.

Bergström - What is the cost of *Ordovician News*?

WILLIAMS - ca. \$1.25 per copy.

WEBBY - \$200 allotted for COBWG expenses. ICS has submitted complaint to IUGS re. reduced relative funding levels. Revision of funding is imminent. ICS has ca. \$24,000 total budget.

Publications. WILLIAMS - Brief summary of status of *Ordovician News*; no problems with financing, or (so far) with free mailing. He suspects that mailing will not be free for much longer, at which time we might consider charging a nominal subscription; at present the effort involved with such a scheme would not be worth the return. Doesn't mind sending via electronic transmission, but considers that most people would still want a hard copy (at least for the time being).

WEBBY - Correlation charts complete. Chinese chart now out, and cheap. 800 copies printed for AUS\$3,900 (ca. US\$3,000). Ross did great job on the chart series.

IGC, Beijing 1996. WEBBY - Special symposium on Ordovician stratigraphy now in place. Possibility for 6 presentations. Barnes, Bergström, Chen and Wang already agreed to give papers. Tarim field trip (to be organized independantly by Chen) has so far received limited response.

CHEN - Tarim excursion was originally proposed because of interest expressed in Sydney. Not much response; this is possibly related to cost (e.g., internal air fare alone is ca. \$1,000). Via rail the same trip would take 4 days, so impractical. Trip would be too difficult and time-consuming if less than 10 people are interested. Total estimated cost for excursion would be ca. \$2,000.

WEBBY - Let him and Chen know if any TM's are planning to attend IGC and/or excursion.

Postal ballot and questionnaire. WEBBY - several responses arrived only just before he left for Las Vegas, so he hasn't totally tallied the results. All ballots received a majority approval, most with >60% in favour:

Threefold approach to dividing the Ordovician - 91% in favour

Focus on *laevis/lunatus* as global boundary - 58% in favour

Focus on *gracilis* as global boundary - 86% in favour

Focus on *undatus* as global boundary - 59% in favour

Focus on *complanatus* as global boundary - 71% in favour

Still no clear direction on whether to use these as series or stage boundaries.

BERGSTRÖM - *undatus* not a good choice.

ROSS & COOPER - which level would be used for *complanatus*?

BARNES - Should use ballot for the basis of workshop discussions. If a tripartite division is favoured, concentrate on this first. Don't just focus on levels; sections are needed too.

WEBBY - From his suggestions in *Ordovician News* and based on discussions during the pre-meeting excursion, he feels that the bases *laevis/lunatus* and *gracilis* are the two most popular levels for the definition of tripartite division. These should receive priority during the workshops.

ROSS - *laevis/lunatus* gets better all the time...

FORTEY - The Ordovician keeps getting longer based on radiometric ages. A tripartite division would give series that were too long; better to use that for subsystems.

Meeting was adjourned 8 am.

Henry Williams

SUBCOMMISSION ON ORDOVICIAN STRATIGRAPHY: INTRA-ORDOVICIAN WORKSHOP, 7.30 PM, 13 JUNE, 1995, LAS VEGAS

Present: About 40 Ordovician members and friends were welcomed by Barry WEBBY (Chair). No apologies were received.

1) **Agenda** - focus on the tripartite subdivision of the Ordovician System. Barry WEBBY reviewed recent suggestions presented by Valdar JAANUSSON of the need for

primary focus on a tripartite subdivision - that we first needed to agree on the most practical tripartite subdivision, secondly to select suitable biostratigraphic levels for boundaries between the Series, and thirdly to assign formal names to the Series.

WEBBY illustrated three different, possible schemes for tripartite subdivision, and then suggested discussion should first centre on a suitable lower boundary level, namely at the base of the *laevis* conodont and *lunatus* graptolite biozones.

2) *laevis/lunatus* level

Stig BERGSTROM: this horizon can be recognised globally (not Siberia?) based on both conodonts and graptolites.

Bernie ERDTMANN: sought advice about the position of this level in Peri Gondwana.

Henry WILLIAMS: this level is well proved

Chuck MITCHELL: no one level is applicable worldwide - he suggested to separate *laevis* from *lunatus* - may not be strictly contemporaneous.

Barry WEBBY: *laevis* should be the marker.

Bernie ERDTMANN: Is this a highstand boundary, or a lowstand boundary, based on this morning's talks?

Charles ROSS: this boundary represents a worldwide drop in sea level - hence it is recognisable worldwide.

Richard FORTEY: but unrecognisable in the Far East.

Rube ROSS: a query on the worldwide extent of the isograptid biofacies.

Paul COPPER: comparison with the Devonian in which each level coincides with a stage boundary.

Jorg MALETZ: hard to distinguish these early isograptids.

Henry WILLIAMS: disagrees - this level is the first appearance of *Pseudotrigrionograptus ensiformis*.

Rube ROSS: Maybe then we should look at *laevis*.

Roger COOPER: *lunatus* is well recognisable over a wide area.

CHEN Xu: support *lunatus* - it occurs in two areas of China in which *I. victoriae* group is recognised but not very common. No exact co-occurrence of conodonts presently known.

WANG Xiaofeng: indicated problems in exact correlation between graptolites and conodonts at *triangularis* or *narvis* level

CHEN Xu: *A. suecicus* in South China is roughly equivalent to *victoriae* group.

Stig BERGSTROM: Yangtze Platform has rich and diverse faunas with *triangularis* and *narvis* over one metre [?sequence]. Graptolites not very practical in shallow carbonate platforms.

Oldrich FATKA: What about Bohemian cold-water basin without conodonts - how do you correlate without them?

Bernie ERDTMANN: Not recognisable in the Czech Republic; only recognisable in Spain, possibly also one level in Morocco. He sees this level as an oddity.

Florentin PARIS: the level does not have to occur everywhere, as long as the level is

recognisable.

Chuck MITCHELL: If the level is a lowstand, it should leave a physical record - enquiry re bentonites in the Whiterock section - possible potential.

Rube ROSS: does a boundary exist anywhere with all major groups present? (no answer).

Fons VANDENBERG: In the Tasman Fold Belt, base of the Ordovician cannot be defined within 100 m. Therefore no perfect boundary.

Roger COOPER: Can the level be correlated indirectly into the Bohemian Basin?

Tom DUTRO: Some combination of graptolites and conodonts is generally agreed, but the point of contention is the level.

Bernie ERDTMANN: *laevis/lunatus* is a good base for the Whiterockian - but sees a hidden North America agenda. Agrees with local/regional stages but not series.

Barry WEBBY: First step is to establish a level worthy of consideration, taking into account problems of correlation into cold-water faunas. We are not establishing a GSSP - merely an interregional tiepoint. Stages come later.

Chris BARNES: faunas strongly influenced by provincialism - this is a reality. Boundary should reflect major faunal turnovers. Are disadvantages for Peri Gondwana offset by choosing *austrudentatus*?

Chuck MITCHELL: Yes, indirect correlation possible at both levels; i.e., *laevis* and *austrudentatus*.

Richard FORTEY: *austrudentatus* better in Wales, than correlative with Bohemia.

Henry WILLIAMS: agrees that *austrudentatus* is good, but if *gracilis* is taken as the upper level, the Middle Ordovician is restricted to the Llanvirn which is very short.

Rube ROSS: referred to the charts and photographs displayed [on the blackboard], representing over 30 years of work in the Great Basin. He asked what other level in the Ordovician has four different phyla defining a level.

Barry WEBBY: Asked for comments from those representing areas such as Kazakhstan and Baltica.

Mischa APOLLONOV: *laevis/lunatus* is correlatable with Kazakhstan so is OK.

Dimitri KALJO: no one level will be in agreement everywhere; if you do not have graptolites, indirect correlation will have to do. If levels are defined clearly enough this will be possible. Best if three Series of Ordovician were more or less of the same size. If two levels are defined to best fit British and North American stratigraphy, this will please most people.

Chris BARNES: Lower, Middle Upper divisions should reflect major events, e.g., faunal turnover, flooding events, not just aesthetic divisions; i.e., choices between levels 3 and 4 [*laevis* & *austrudentatus*] (with more information available), and between levels 5 and 6 [*gracilis* & *undatus*], or the base of the Mohawkian.

CHEN Xu: difficult to make Lower and Middle Ordovician divisions the same duration.

Sven STOUGE: in Baltoscandia, base of the *evae* conodont Biozone may be a better level because it reflects a lower sea level. Worried that base of Whiterock may not be equivalent to *laevis*.

Charles ROSS: major drop in sea level at the base of the Whiterock.

Bob NICOLL: in Australia radiometric dates suggest 10-15 Ma for the Lower Ordovician, 16 Ma for the Middle Ordovician.

A straw vote was then taken, in favour of a Series boundary at the base of *laevis/lunatus*. On a show of hands, results were 18 For, 8 Against, and 10 Abstain.

3) *gracilis* level

Barry WEBBY then opened discussion on this higher level.

Henry WILLIAMS: issues a caution about the 'base' of *gracilis* - it is the true base in Scandinavia and North America but not in the British Isles.

Stan FINNEY: questions Henry's diagrams - showed other diagrams from the 1980 Oslo volume illustrative of Calera, Alabama, & Abington, Virginia, and other sections in the Appalachians illustrating consistent migration/invasion of *N. gracilis*.

Henry WILLIAMS: responded that he was not criticising Stan's work.

Florentin PARIS: no *gracilis* in North Africa and southern Europe - not a great problem, since indirect correlations possible.

Richard FORTEY: *gracilis* is a workable horizon.

Oldrich FATKA: agrees

Tatjana KOREN: in Arctic Russia - *gracilis* is a good marker in N. Zemlya, not so good in Kolyma.

CHEN Xu: *gracilis* is a good marker.

WANG Xiaofeng: *gracilis* does not appear at the beginning of the transgression but a little higher, but no problem with this level.

Stig BERGSTROM: problem that *gracilis* is not easy to correlate into shallow carbonate facies, e.g., Baltoscandia, Siberia.

Barry WEBBY: do any subzonal conodont levels coincide with *gracilis*? [unfortunately Stig's response is not recorded in the minutes]. There is a need for magnetic polarity studies at this level.

Stig BERGSTROM: in the late 1970's, three graduate students did detailed section collections for magnetic polarity reversals, but results were inconclusive.

Bill BERRY: What about the Woods Hollow conodonts (in Texas)?

Stig BERGSTROM: base of *gracilis* falls within *anserinus* conodont Zone.

Stan FINNEY: How do chitinozoans assist?

Florentin PARIS: Yes, useful for indirect correlations.

Mischa APOLLONOV: *gracilis* is one of the most important, easily seen levels in Kazakhstan; associated with facies change.

Dimitri KALJO: reminded that Valdar JAANUSSON said that 'nothing happens at this level'.

Chris BARNES: but remarkably strong strontium curve excursion at this level - something certainly happens.

Jan RASMUSSEN: in Sweden, 2-3 m of shale, 1.5 m of nodular limestone with *Pygodus anserinus*. *N. gracilis* found above this level, perhaps not below.

Stan FINNEY: *gracilis* in carbonate successions occurs just above *anserinus*.
 WANG Xiaofeng: first step to choose *gracilis*, next stage to correlate with conodonts.

4) Remaining straw votes

A straw vote was then taken in favour of a Series boundary at the base of the *gracilis* graptolite Biozone. Results: 35 For; 0 Against; 5 Abstain.

Then followed a further straw vote in favour of using a tripartite Series division (Lower, Middle and Upper) using base of *laevis/lunatus* biozones and base of *gracilis* as the boundaries. Results: 22 For, 3 Against; 16 Abstain.

A final straw vote was taken in favour of using a tripartite Series division (Lower, Middle and Upper) using the base of *austrodentatus* Biozone and the base of *gracilis* as the boundaries. Results: 9 For, 18 Against; 14 Abstain.

Only a few additional comments were raised after these results became known.

Dimitri KALJO noted *gracilis* was quite clear.

Barry WEBBY similarly mentioned *gracilis* was clearly supported, but more study was needed at lower levels.

Florentin PARIS referred to the problem for northern Gondwana.

Chris BARNES asked whether other levels were to be considered on Thursday evening?

Barry WEBBY confirmed this, and closed the meeting at 9.30pm.

[Minutes of this workshop were kindly recorded by Ian Percival]

SUBCOMMISSION ON ORDOVICIAN STRATIGRAPHY OFFICIAL MEETING, 7.30 PM, 14 JUNE 1995, LAS VEGAS

Present: 19 signed attendance sheet (but total number reached nearer 40 by end of meeting?).

1. Meeting opened by WEBBY. No apologies received.

2. No amendments to agenda requested.

3. Minutes of last two official meetings (Sydney, 1991 and Nanjing, 1994) approved (moved ROSS, seconded BARNES).

4. **Ordovician News.** WILLIAMS gave brief update on *Ordovician News*. Volume 12 was circulated in early May, with ca. 400 copies @ \$1.25 each. No costs for postage at present, but this situation is unlikely to continue for long. PARIS suggested that an internet server for Ordovician discussion could be established; WILLIAMS was unwilling to do this due to lack of expertise. A brief discussion did not give much support, and a few people were opposed to being exposed to additional unwanted mail.

5. **Ordovician Correlation Charts.** WEBBY reported that the latest and last correlation chart, namely on China by Chen et al., had now been published by IUGS. No more charts were planned.

ERDTMANN - A new German-organized chart will soon be produced individually, but initially only in German.

BARNES - Will there really not be any further charts?

WEBBY - Unless somebody is prepared to coordinate and edit; if so, fine. But new agreements for publication will have to be renegotiated with IUGS, etc.

BARNES - Need to decide on this, in order to inform IUGS of any likely future contributions.

WEBBY - Most people have very limited time available for Subcommittee work. With the present thrust in series/stage definitions, there is not enough capability for both this and new charts.

ERDTMANN - Could help a bit, but could not commit myself.

WILLIAMS - If anyone has an additional project in the future, bring it to the attention of the executive and they will see what can be done.

FORTEY - The new UK chart (Geol. Soc. London publication) will be available in 12 to 18 months.

6. **IGC, 1996.** WEBBY met with ICS Secretary General to request an Ordovician program at the next IGC. A session "Towards an integrated global Ordovician timescale - boundaries and subdivisions" has now been adopted. There will be approximately six contributions; Barnes, Bergström, Chen and Wang have already offered papers, and also probably Erdtmann. Anybody planning to attend IGC is asked to contact Webby so that he can coordinate the Ordovician meeting; there will also be an official Subcommittee meeting.

CHEN - In terms of the proposed unofficial pre-meeting excursion, a trip to the Tarim area is planned because most Ordovician workers have not been there before, it has a lot of ongoing hydrocarbon exploration with a lot of potential for Ordovician source and reservoir rocks, and there are both shelf and slope settings with a great variety of fossils. One of the main problems is the airfare from Beijing, which will be ca. US\$1,000 return. Other expenses will run at ca. US\$100 per day, giving a total cost of ca. US\$1,800 for the trip.

ERDTMANN - There are two official IGC trips to the Tarim region, which cost ca. US\$1,500 for 14 days; why are these so much cheaper and couldn't the agenda of one or both of this be altered to accommodate Ordovician workers?

CHEN - It would be difficult, as the trips are concentrating primarily on the Mesozoic.

BARNES - Will there be any restrictions on collecting?

CHEN - No. Because the government will not permit a foreign group to camp near the main localities, participants will have to stay in the nearest city each night; this will involve a 2 1/2 hour drive and 1 hour walk twice every day. Ideally 15-20 participants are needed for such an excursion, and 10 is the absolute minimum required.

WEBBY - Who is interested in attending? (an informal count seemed to suggest that 10 or more people might be interested).

WANG - I will check with IGC organization to see if there is any flexibility with their other trips.

WEBBY - Chen and Wang should draft the proposal; an original copy should be sent to Williams or Webby for duplication and circulation to potential participants within the next couple of months.

7. Proposals for next Ordovician meetings. BALDIS outlined the proposal to hold the nexts SOS in San Juan, Argentina in 1999. Parts of Argentina were "sandwiched" between Laurentia and Gondwana during the Ordovician, so it was important for study and discussion. There has been a lot of intensive work done recently, and a visit by the Subcommittee would be a big boost to research. Many potential academic and political sponsors existed for a future meeting; there would be a variety of both day and extended excursions possible, plus a chance to visit type specimen collections. He suggested September as a suitable time of year, but this was flexible.

FINNEY - Wasn't there a problem for taking fossil material out of the country?

BALDIS - Special arrangements would make this possible.

BERGSTRÖM - What would be the registration costs?

BALDIS - ca. \$200, and university residences could be used.

PERCIVAL - What was the current rate of inflation in Argentina?

BALDIS - ca. 0%.

FATKA then presented a proposal to hold the next SOS in Prague, Czechoslovakia sometime during July to September in 1998 or 1999. The last three SOS meetings had been held in temperate/warm water regions of the Ordovician world. Czechoslovakia was situated in cold water conditions during that time. There would be about five days of discussion with a half-day excursion in the Prague region and a half-day visit to the National Museum to see type material. Possible pre-symposium excursions could include Morocco or the Prague Basin, with a post-symposium trip running through SW Europe to France and Spain. A good cultural accompanying members program could be offered. Prices for campus residence would be ca. \$20 per night.

ERDTMANN - I could also offer an excursion to the Schwarzerbege antinclinorium in Germany (ca. 160 km from Prague).

BARNES - Are there any restrictions on the export of material from Czechoslovakia?

FATKA - No, if for official purposes such as the proposed meeting.

PARIS - It would be more difficult to remove material from Morocco. Is there a possibility of a national sponsor?

FATKA - None has been arranged at present.

PERCIVAL - Would a publication be produced for the meeting, and what format?

FATKA - Too early to say at present.

The vote for the two possible sites gave 7 in favour of Argentina, with 21 in favour of Czechoslovakia and 6 abstentions. The Eighth International Symposium on the Ordovician System will, therefore, be held in Prague, at a date to be announced.

KOREN - There will be a WOGOGOB meeting in St. Petersburg, probably in August 1997. All would be welcome. Four days of Lower Ordovician excursions are planned, plus two days of technical discussions and a cultural program.

8. Cambrian-Ordovician Boundary Working Group, Business Report.

COOPER - Two circulars and a letter plus agenda have been sent out since the inception of the new working group, re. a decision on Dyangcha. 9 of the 13 Titular Members attended official meetings on Monday and Tuesday of this week. The unofficial conclusion reached was that a horizon based on *Iapetognathus* would prove OK, although there were possible problems related to the ranges of this genus at Green Point. Carbon isotope stratigraphy apparently has high potential for correlation, and should be a parameter involved in the choice of stratotype. The working group recognizes the urgency for a final decision, and needs several options in the event that Dayangcha is rejected. If that section is approved as stratotype, fine; otherwise the Titular Members will have to make a selection of other sections to add to a shortlist and make a decision to accept one of these using the *Iapetognathus* horizon.

9. Membership matters. WEBBY - Under ICS rules, a chairman may only serve a maximum of two terms; thus a new chair will be needed from next year. A Nominating Committee has been established, and is currently discussing possible candidates. In terms of the Cambrian-Ordovician Boundary Working Group, it has recommended that Cooper continue as Chairman with Nowlan as Secretary. In terms of Titular Members, there should be a total of 20 people with a maximum of three terms (12 years), after which they revert to Corresponding Members. Presently 10 of 22 Titular Members have held their positions for longer than 12 years. There should be a 30% turnover at every IGC; therefore, at least 7 Titular Members should retire and 5 be replaced (bringing the total down to 20). Titular Members and the Nominating Committee are currently discussing the problem, and hopefully will make suggestions by the end of the week. Details of membership changes have to be forwarded to ICS 12 months before the next IGC. There are presently 80 Corresponding Members; they should provide good coverage in terms of expertise and geography, but there are no formal rules for this status. Anyone wishing to become a Corresponding Member should contact the executive.

10. Other business. None.

Meeting was adjourned at 9.55 pm.

Henry Williams

**SUBCOMMISSION ON ORDOVICIAN STRATIGRAPHY
TITULAR MEMBERS MEETING, 6.00AM, 16 JUNE 1995, LAS VEGAS**

Present: Appollonov, Baldis, Barnes, Bergström, Berry, Chen, Cooper, Finney, Fortey, Gutierrez-Marco, Paris, Ross, Wang, Webby, Williams.

Global series divisions for the Ordovician System. WEBBY - A proposal for GSSP's at base of *approximatus* Zone was circulated for voting. The book containing information on the JCY *austrodentatus* proposal will be published in September 1995 in *Palaeoworld*. Work is needed on correlation into the conodont-bearing Yangtze Platform before a final decision on locality and GSSP is made. A vote on *austrodentatus* vs. *artus* is probably needed first. In terms of the suggested tripartite division for the Ordovician, there appears to be general support for the base of *laevis* Zone as base of Middle Ordovician and base of *gracilis* Zone as base of Upper Ordovician. Could either have a formal vote now at this TM's meeting (15 of 22 members present) or could have an informal "test" vote.

ROSS - **MOTION: I move that a tripartite division be adopted for the Ordovician System, using the base of the *laevis* conodont Biozone for the base of the Middle Ordovician and base of the *gracilis* graptolite Biozone for the base of the Upper Ordovician** (seconded - BERGSTRÖM).

FORTEY - *laevis* Zone not recognizable in shelf Gondwana settings. Global divisions and boundaries should be recognizable in all parts of the world.

CHEN - Level has potential in two regions of China, but is a problem on the platform. Can't yet say whether correlation is definitely possible.

BERGSTRÖM - Level can be recognized on Yangtze Platform.

FINNEY - Are there any other horizons that would be more easily recognizable in the Gondwanan sequences?

FORTEY - base of *approximatus* and *austrodentatus*.

WEBBY - We should perhaps vote on two alternatives: *laevis/gracilis* and *austrodentatus/gracilis*.

WANG - Are there any good sections in the U.S. where the base of *lunatus* may be correlated precisely with the conodont zonation?

BERGSTRÖM - Yes, e.g., Texas, Marathon and to a lesser extent in Newfoundland. Also Roberts Mountains and in Baltic region.

FINNEY - Graptolites and conodonts occur together in parts of the Vinini.

FORTEY - Are the Marathon conodont studies published?

BERGSTRÖM - Yes and no. No formal publication on this particular interval. The level at Roberts Mountain will be described soon.

FORTEY - Are there any conodonts at this level in the Tøyen Fm.?

BERGSTRÖM - There are conodonts from about 2 m above the level. In Sweden there is good correlation both in outcrop and in the subsurface.

WEBBY - Is there any work on chitinozoans at this level in Gondwana?

PARIS - Not at the present time, and no ties.

BERRY - Has *austrodentatus* been found in N. Africa?

PARIS - No.

FORTEY - *austrodentatus* has been recorded from several localities in the British Isles.

BERGSTRÖM - Several records from the U.K. are probably other later *Undulograptus* species, rather than *austrodentatus* itself.

CHEN - No *austrodentatus* in Tarim and other platform regions.

ROSS - Has *austrodentatus* been recognized in the carbonate faunas of the Baltic?

BERGSTRÖM - Probably only at later levels, towards top of zone.

CHEN - There are six sections in the JCY area that may be used to create a composite section. It appears that the *austrodentatus* Zone is quite long - perhaps ca. 3.5 Ma.

BERGSTRÖM - Level is approximately equivalent to upper 1/3 of *altifrons* Zone.

PARIS - Only two places with potential for correlation at this level between warm and cold water settings: Turkey and China. There is good correlation between Turkey and the Baltic, but *austrodentatus* has not been described from Turkey.

FINNEY - We need more detailed species ranges through the *artus* Zone and outline of other levels.

FORTEY - These were published in 1987. Scandinavian sections have been studied for >100 years. If base of *artus* Zone is being considered, all data could easily be brought together. Whatever horizon is chosen as base of Middle Ordovician should have same sort of potential for worldwide correlation.

BERGSTRÖM (to Fortey) - Name one place where *artus* can be recognized in a continuous section. There are no graptolites within the interval at Öland, and coeval zonation is not very clear. The base of the Volkovian is approximately at the base of *laevis*.

GUTIERREZ-MARCO - Acritarchs from around this level have been published in *Pal. Ital.*

BARNES - The changeover from "Cambrian" to "Ordovician" faunas occurs approximately at the base of the Whiterock. If *austrodentatus* and *gracilis* are adopted as the lower and upper boundaries of the Middle Ordovician the division will be too short to be worth retaining.

PARIS - Any *lunatus* at Lévis?

BERRY - Yes, but not described.

WEBBY - **Call the vote: 11 For; 3 Against; 1 Abstain.**

WEBBY - In questionnaire circulated before Las Vegas, a tripartite division was generally favoured. Should we now have a formal vote on using the terms "Lower", "Middle" and "Upper" Ordovician for the series?

BARNES - **MOTION: The Ordovician System should be divided into three formal series, named Lower, Middle and Upper** (seconded - FINNEY).

BERGSTRÖM - There is so much variation in usage of these terms that any more will cause confusion. So proper names are needed.

WEBBY - Need the divisions, Lower, Middle and Upper formally defined first.

WILLIAMS - Support formal definition of these terms to make them usable by non-stratigraphers.

BARNES - Previous motion will result in suitable divisions. It is best not to have series names other than Lower, Middle and Upper in order to help unify geologists from different regions. Stages can have names.

CHEN - Different authors have different meanings for Lower, Middle and Upper.

WEBBY - **Call the vote: 12 For; 2 Against; 1 Abstain.**

COOPER - **MOTION: A tripartite division should be adopted for the Ordovician System, using the base of the *austrodentatus* graptolite Biozone for the base of the Middle Ordovician and base of the *gracilis* biozone for the base of the Upper Ordovician** (seconded - ROSS).

WEBBY - **Call the vote: 2 For; 9 Against; 4 Abstain.**

WEBBY - The two potential stage levels in the upper Ordovician (*tubuliferus* and *ordovicicus*) should be reexamined.

WILLIAMS - I suggest that graptolite levels around first appearance of *tubuliferus* are probably not very good. The *ordovicicus* horizon is probably better; but is *ordovicicus* reliably identifiable from other *Amorphognathus* species by all conodont workers?

BERGSTRÖM - Yes, but several cases of misidentification even recently.

BARNES - Showed range charts for Whitland section in South Wales, and correlation with southern Scotland using graptolite information from Zalasiewicz and Rushton. The upper shale section at Whitland contains endemic graptolites; *ordovicicus* occurs in nodular limestones directly above the *Normalograptus* interval.

BERGSTRÖM - The base of the *ordovicicus* Zone is about 1/3 the way down the *linearis* Zone in Sweden.

Membership. WEBBY - The Nominating Committee (Bergström, Barnes, Chen, Paris, minus Dean) has been discussing membership issues over the past few days, both in isolation and with other TM's.

BERGSTRÖM - There was disagreement on the committee re. candidates. Some suggested that Bergström himself be nominated; he declared himself a non-candidate but the rest of the committee supported his nomination. So no clear decision reached. The other main candidate being discussed was Finney.

CHEN - The committee clearly gave Bergström majority support, so if Finney is proposed the vote of the Nominating Committee has to be declared invalid.

BERGSTRÖM - Not true.

WEBBY - Is Finney prepared to take over as chairman?

FINNEY - I am thinking about it. It depends partly on whether funding for travel is available from UCLB.

COOPER - Are there any other candidates in the event of Finney not accepting?

BERGSTRÖM - Yes, Berry, Cooper and Paris.

ROSS - **MOTION: I nominate Stan Finney as Chairman Elect of the Ordovician Subcommittee, based on recommendation of Nominating**

Committee (seconded - COOPER).

WEBBY - **Call the vote: 13 For; 0 Against; 1 Abstain.**

WEBBY - **MOTION: I propose amendment to nomination of Stan Finney, naming Floretin Paris as alternate if Finney is unable to accept position** (seconded - ROSS).

WEBBY - **Call the vote: 14 For; 0 Against; 0 Abstain.**

WEBBY - Chen Xu will continue as vice chairman. The new chairman has the right to choose the next secretary of SOS. Reminder that there should be a turnover of TM's of about 1/3, with overall reduction in number of 2. Has the Nominating Committee considered this?

BERGSTRÖM - We have had several discussions. No specific members had yet been agreed upon for retrial, but there were certainly a number of less active members who should be replaced by younger, more active ones.

ROSS - Suggest that Dean and Jaanusson be transferred to CM status.

BARNES - Bergström has not really stated full results of Nominating Committee's deliberations. Up to 10 people could be removed as TM's. A number of younger people with non-paleontological interests (e.g., sedimentology, chemostratigraphy, etc.) had been recognized. What procedure should be followed?

WEBBY - Request Nominating Committee to discuss issue with incoming chairman once he is finally decided, then he can discuss problem with other members of the executive. The suggested changes are required at least 12 months before next IGC, so must be done quickly.

BARNES - Is the final decision on TM's made by the new chairman?

WEBBY - It will be made by the present chairman in consultation with the new chairman and vice-chairman.

WILLIAMS - What constitutes a Corresponding Member? Soon there could be over 100 in the SOS.

FORTEY - Could check list for people with no Ordovician publications in the last 5 years.

New SOS directions. BERRY - Discussed relationship of biodiversity with physical changes through the Ordovician, and suggested possible wholistic approaches to the basal Whiterock, etc. This might be an appropriate topic for a new working group within SOS.

FINNEY - Supports wholistic examination of Whiterock, Ordovician-Silurian boundary, etc., incorporating tools such as geochemistry, sedimentology, etc.

Meeting adjourned ca. 8.00 am.

Henry Williams

**IUGS SUBCOMMISSION ON ORDOVICIAN STRATIGRAPHY:
SUMMARY OF ISOS TITULAR MEMBERS QUESTIONNAIRE
RESPONSES MAY 1995**

[No responses were received from Berry, Dean and Nikitin]

nb., These responses were received prior to the Subcommittee meeting at Las Vegas.

1.

a. (for *artus*) - Bruton, Paris, Fortey, Owen

b. (for *austrodentatus*) - Baldis, Barnes, Chen, Cooper, Popov, Ross*, Wang, Webby, Williams, Zhou)

c. (abstain) - Apollonov**, Bergstrom, Gutierrez Marco***, Finney****, Jaanusson*****

*(Ross) Mitchell and Maletz have made a stronger case for *austrodentatus* than anyone has made for *artus*.

** (Apollonov) These levels are most uncertain for me in Kazakhstan - shelly faunas of "Arenig" and "Llanvirn" are very similar.

*** (Gutierrez Marco) Before taking a decision I prefer to know if Berry's opinion (*Newsl. Strat.* 32 1995) about a possible equivalency *artus* (Atlantic) - *austrodentatus* (Pacific) has wide support or not?

**** (Finney) I have concerns regarding isochrony and geographic extent of both

***** (Jaanusson) I do not know anywhere in Europe with a continuous, reasonably rich graptoliferous sequence from the *hirundo* to *artus* zones. There is no published information on how the transition from one zone to the other looks like in the graptoloid faunas. In Baltoscandia the boundary falls in a limestone sequence with the exception of south-western Scania where in a drill core the sequence is reported to be continuously in the shale facies, but no further information is available.

In the limestone sequence of northern Öland (Skevington 1964) the occurrence of *Holmograptus lentus* at the base of the Valastean Substage is generally taken as an indication of the base of the *artus* Zone. One metre lower down in the sequence, within the Hunderumian Substage, a varied graptoloid assemblage (some 10 species) has been isolated from the limestone. This assemblage is routinely referred to the *hirundo* Zone because it obviously does not belong to the *artus* Zone and in the standard classification *artus* Zone succeeds the *hirundo* Zone. However, this assemblage has little in common with the normal Atlantic *hirundo* fauna. The occurrence of *Oelandograptus austrodentatus oelandicus* and associated biserial forms rather suggests an equivalent to the Pacific *austrodentatus* Zone. A similar assemblage has recently been found in the Hunderumian limestones of eastern Ingria but I do not know any details. The base of *Eoplacognathus variabilis* Zone is very close to the base of the Hunderumian Substage (Löfgren 1985), and in the Ichang district of central China the base of the *austrodentatus* Zone is recorded to coincide roughly with (slightly above) that of the *E. variabilis* Zone. Thus in the Baltoscandian region an equivalent to at least the lower *austrodentatus* Zone may be recognisable, but it is a remarkably thin unit, roughly equivalent only to the Hunderumian Substage.

Examination of the graptoloid succession in the south-western Scania drill core, mentioned above, may contribute important facts to defining the boundaries under consideration.

Llanvirnian sections in Wales do not yield any decisive information. "The British faunas [are]

too poor to be correlated with other areas. The first occurrence of the pendent didymograptids is not in a succession of faunas and associated elements are rare if at all present. The base of the British Llanvirn cannot, therefore, be correlated with any level within the lower Llanvirn succession in Scandinavia" (Maletz, 1994).

At the present state of our knowledge it is difficult to understand how anybody would be able to form a well motivated opinion about the preference of the base of either *austrodentatus* or *artus* Zone as a major international boundary.

2 a. Do you support introduction of traditional British Series for the main Ordovician chronostratigraphic subdivisions?

YES - Apollonov*, Baldis, Bruton, Chen, Cooper**, Fortey, Owen, Williams, Zhou

NO - Barnes, Bergström, Finney, Gutierrez Marco, Jaanusson***, Paris, Popov, Ross, Wang, Webby

*(Apollonov) yes if introduction means conservation of names

** (Cooper) I would be happy with Tremadoc for the lowest unit as the scope of this unit and of the traditional Tremadoc (as currently defined, eg, by Fortey et al 1995) are very close or identical; this assumes of course that the base of the second unit will lie at FAD of *T. approximatus*.

For the remaining Ordovician units, I favour using the traditional British names PROVIDED that the upper and lower boundaries of the traditional unit approximate closely to those of the new units. This may work out for the Ashgill but does not look likely for other units.

Where the boundaries do not agree well, traditional names should only be used if a way can be found that distinguishes the new usage from previous usage. For example, if the new unit names were always used in some distinctive font, or with a Greek first letter, it would be clear that the new definition is implied. Unfortunately I can not think of a convenient way of doing this that would be acceptable to publishers, or does not at the same time break other publishing conventions.

*** (Jaanusson) I am unable to answer these questions. In my opinion, name is unimportant. What is important is the unit itself, the definition of the unit. If there is an agreement about the definition of the unit and there already exists a name for the unit so defined, whether from Great Britain or from elsewhere, why do not use it. If there is no previous acceptable name, a new name must be invented.

2 b. If NO do you prefer other regional Series names (modified or unmodified)?

YES - Barnes, Finney, Gutierrez Marco, Ross*, Wang

NO - Webby, Fortey, Paris

*(Ross) I prefer that regional Series be used in their own continental regions and then applied to parts of other continents or areas where similarity of faunas and/or lithologies requires their recognition. I prefer a global terminology limited to biozones, not series at all.

2 c. Would you prefer a new global Series terminology?

YES - Baldis, Bergström, Paris*, Popov, Wang, Webby

NO - Fortey, Gutierrez Marco

*(Paris) Would prefer new Subsystem divisions

3 a. Do you support the ICS directive that the Ordovician Subcommission now focus primarily on global Stages rather than Series?

YES - Apollonov, Bergström, Finney, Gutierrez Marco, Paris, Ross*, Wang

NO - Baldis, Barnes, Bruton, Chen, Cooper**, Fortey, Jaanusson, Owen, Popov, Webby, Williams, Zhou

*(Ross) If the ICS directive can be interpreted to equate stages to biozones I can go along with it. The concept of global series should be totally discarded.

** (Cooper) I prefer to call the primary (upper and lower) divisions *subsystemic* divisions, and use the term *series* for the next level (of 7 or so divisions). *Stages* then become essentially local correlation units, which they are at present.

3 b. If NO would you prefer to establish global Series first, then once adopted, global Stages?

YES - Baldis, Barnes, Bruton, Chen, Fortey, Jaanusson, Owen, Popov, Webby, Zhou

NO - Cooper*, Williams

*(Cooper) I recommend we work from the smallest (7 or so) divisions upwards, rather than the reverse. We can then ensure that boundaries of large scale divisions coincide with those of the smaller scale divisions.

3 c. If NO to question 3.b., how would you establish the global Stages as required by ICS?

(Williams) I believe that we have a good, relatively stable and well known set of series. Finer scale global divisions would be impossible due to paleobiogeographical variation.

4 a. Do you support the use of British Series names for a global Stage terminology?

YES - Apollonov, Baldis, Chen, Cooper*, Fortey, Jaanusson**, Paris***, Webby*****, Zhou

NO - Barnes, Bergström, Bruton, Finney, Gutierrez Marco, Jaanusson**, Popov, Ross****, Wang, Webby*****, Williams*****

*(Cooper) with the proviso given in notes above (see question 2.a). Where British series boundaries do not coincide with those of the new divisions, I prefer the use of other regional names (with the same proviso given above), rather than introduce completely new names.

** (Jaanusson) The same answer given for question 2.a. (above) applies to this question.

*** (Paris) Yes but with additional new names when necessary.

**** (Ross) As noted by Mitchell the British terms would require so much alteration that confusion would result. In addition implications of faunal similarities could be totally misleading. I prefer global stages based on and named for biozones, without reference to existing Series.

***** (Williams) No, unless forced to do so by ICS.

***** (Webby) I have no difficulty with the global Stage divisions being chosen on merit,

from the areas where the GSSPs are to be located - they may be British, other regional, or new names.

4 b. If NO do you support the introduction of a completely new global Stage terminology?

YES - Bruton, Ross, Wang

NO - Barnes, Gutierrez Marco, Popov, Williams

4 c. Or do you support the introduction of a global Stage terminology using other existing (modified or unmodified) region Series and /or Stage nomenclatures?

YES - Baldis, Barnes, Bergström, Finney, Gutierrez Marco, Wang

5. Would you prefer use of a tripartite divisions of Lower, Middle and Upper (or bipartite Lower and Upper) as Series or Subsystem divisions?

In favour of SERIES: Apollonov, Barnes, Bergström, Chen, Finney, Jaanusson, Popov, Wang, Webby, Zhou

In favour of SUBSYSTEMS: Baldis, Bruton, Cooper, Finney, Gutierrez Marco, Owen, Paris, Ross, Williams

6. Would you prefer a tripartite or bipartite subdivision?

In favour of LOWER, MIDDLE and UPPER: Baldis, Barnes, Bergström Bruton, Chen Finney, Fortey, Gutierrez Marco, Jaanusson, Popov, Webby, Williams, Zhou

In favour of LOWER and UPPER: Apollonov, Cooper, Ross, Wang

7. Give a brief outline of your philosophy for global subdivision of the Ordovician System.

Apollonov: In the countries of the former USSR generally accepted stratigraphic practice follows from the decisions of the IGC in 1881 and 1900. We use such hierarchy of stratigraphic divisions: System - Series ("Otdel") - Stage. Subsystem is practically the same as Series. This is an unofficial division and is unnecessary. Ordovician must be subdivided in the same way as all other Systems of the Paleozoic. Different stratigraphic classifications of successive parts of the global chronostratigraphic scale may be compared with use of years for some epochs of the history of Mankind, and of months for other epochs. English Stages (=traditional Series: Tremadoc, Arenig etc) are natural divisions, corresponding to real historic epochs in the mobile belt. They are recognizable in Kazakhstan in general. And as chronostratigraphic units they can serve for correlation globally.

Barnes: 1. The System/Series/Stage subdivisions should represent 2nd, 3rd & 4th order geological events in Ordovician earth history.

2. These events should be defined by the closest, widely correlatable biozone.

3. New Series/Stage names will likely be required in some if not all cases. We should use

regional names reflecting the selected boundary stratotypes.

4. This ballot may cause confusion - too many chronostratigraphic levels for Series, probably too few for Stages; this has partly influenced my rejection of Ballots 2 and 3.

Bruton: I very much agree with what Alan Owen writes (not surprising since we have been brought up in the same tradition and have worked on the same stratigraphic problems), and following the new British stratigraphic scheme, prefer to continue with the use of Tremadoc, Arenig, Llanvirn, Caradoc and Ashgill divisions at SERIES level.

Local STAGE & SUBSTAGE divisions of these with all the various names in the world accommodate, problems connected with paleolatitudes, faunal provincialism, sedimentological regimes and important local patriotism!

There is something inherent that makes tripartite thinking attractive. The major faunal changes during the older and younger parts of the System with a transition between, makes this easier to explain (in conversations, lectures and displays) if one can refer to LOWER, MIDDLE & UPPER. I'm all in favour of making these of SUBSYSTEM rank with a new nomenclature, and defining these with global boundaries (*Iapetognathus-laevis-gracilis*). We should not necessarily strive to make these subdivisions of approximately equal time length.

Chen: Tremadocian is a long time-interval (30 m.y.) in Ordovician and should be subdivided into substages. I would like to suggest that 3 substages for Tremadocian are practical. The boundary of the lower and middle substages may coincide with the base of 'hunnebergensis' or *deltifer*. The middle-upper substage boundary may coincide with the base of 'Hunneberg' or *proteus*, or the CRE event of Erdtmann.

My philosophy about the other subdivisions has been expressed in responses to the accompanying postal ballots and in this questionnaire.

Cooper: 1. About 6-7 international correlation units seems about the right number for the Ordovician.

2. I prefer to call these series rather than stages. This leaves stages as essentially regional correlation units which is very much what they traditionally have been.

3. The boundaries of the series should be based on globally correlatable biohorizons. In practise, for the Ordovician, this will generally mean choosing either conodonts, graptolites, or both, as the primary group for boundary definition.

4. Where possible, magnetostratigraphic, chemostratigraphic and sequence stratigraphic events should be utilised in choosing series boundaries.

5. As a general rule, I favour using existing names for the new series where the boundaries of the new units coincide reasonably closely with those of the existing named units. However, where the old unit boundaries differ significantly from the new, continued use of the old names is a recipe for confusion and ambiguity and other names should be selected.

Finney: 1. Identify levels with global correlation potential.

2. Select best possible GSSP for each.

3. Then consider each one as a potential stage boundary or series (& by definition Stage) boundary.

4. Then name units using modified region nomenclature where appropriate.

Fortey: A widely recognised biostratigraphic signal - based on conodonts and/or graptolites - is the primary reference. This should be linked to a familiar naming system to prevent confusion among non-specialists. Reference sections should include the possibility for refinement using magnetostratigraphy, isotope stratigraphy etc., but this should not be mandatory (too much time is wasted in the pursuit of ideal sections which do not exist). Practical solutions require that priorities of global areas are considered - for example, graptolites should be favoured as a primary reference if large parts of the world lack conodonts.

Gutierrez Marco: Unfortunately, the history of the subdivisions of the British Ordovician is twisted from its origin, and its "propping-up" will be a new source for discord. Fortey et al., (1995) turned to divide, and divide, and divide .. (an r-strategy?)

It is necessary to adopt a completely different philosophy, following the democratic principle of the great majority advantage and adequacy. In this sense, it shall be to find new stratotypes in other sequences which provide higher precision and continuity, as are the well established sequence of Australasia (with many correspondences with other Pacific schemes) or, concerning Europe, the graptolitic-conodont sequences of Baltoscandia. At the same time, regional subdivisions should be promoted, when they can be applied to wide palaeogeographical areas.

Owen: My views on series and subsystems are as outlined on my letter of July 94 reproduced (with a lot of typos!) in your circular of 22 March. All of the levels currently under study have some virtue for wide (if not global) correlation and I don't think any of these on the voting forms should be abandoned although alternatively we may chose to recognise the units they define at a mixture of levels [series and (?more local) stages]. I feel that the questionnaire may not prove as helpful as you had hoped. Question 5 assumes 6a, 4 depends on 3 and 5 & 6 affect the interpretation of 2-4. I found it very difficult to maintain a consistent thread! I think Valdar's suggestion of circulating the correlation chart for amendment (backed by evidence) is an excellent idea. It will sharpen our ideas on the target levels and the intervening units. Do you mind doing this?

Paris: I am in favour of a tripartite subdivision of the Ordovician System (Lower, Middle, Upper, regarded as subsystems instead of Series) with 7 to 9 Stages, using the name of previous British Series when appropriate (i.e., when the base of the new defined Stage will be close to the base of an existing British Series) and using a totally new name when the base of the new Stage is located somewhere within an English Series.

In addition, I believe it is of prime importance: 1) to select the GSSP in an area located at medium latitude during the Ordovician (in order to restrict too high provincialism effects on the composition of the fauna, induced by too cold or too warm water if GSSP selected either on very low or very paleolatitudes); 2) to select type sections where other fossil groups with correlation potential (e.g., chitinozoans, brachiopods, trilobites . . .) are represented together with graptolites and/or conodonts; 3) to select type sections where a continuous and accurate record of different fossil groups can be documented (this precludes sections with too sporadic occurrences of conodonts, graptolites, chitinozoans . . .). I realise that most of these are normal requests for GSSP!!

Popov: I suppose that the primary task is to achieve a general agreement about the most practical subdivision of the Ordovician System on the Series (British, three-fold or two-fold). A three-fold subdivision of the Ordovician System seems to be the best solution as well as it is widely used.

If the three-fold subdivision of the Ordovician will be formally established, definition of the boundaries between Series represent a second task. I suppose that the base of the *austrudentatus* graptolite Zone as a potential lower boundary of the Middle Ordovician and the base of *undatus/americanus* biozones as the potential lower boundary of the Upper Ordovician may be considered at this stage. The base of *gracilis* Biozone is good as a Stage boundary, however, it is unsuitable as the Series boundary, because there are no significant biotic and environmental changes at this level.

Subdivision of the Ordovician on global stages create many problems, which cannot be solved simply by the selection of one or another level in the base of graptolite or conodont zone. Graptolite zones in the Ordovician are the best instruments for long range correlation, however, their boundaries may be recognized precisely mostly in the marginal lithofacies and in many cases they are poorly defined in the cratonic sequences. Therefore a chronostratigraphic subdivision of the Ordovician can not be solved simply by the definition of a number of critical levels with a significant correlation potential and by the following nomination of the selected stratigraphic intervals. It is important to achieve agreement about the definition of stages as the practical units based on several criteria. The definition of the boundaries is only the important part of the procedure. There are several potentially important biohorizons, which never been discussed as possible Stage boundaries (e.g., base of *A. victoriae* and *P. proteus* zones and base of *linearis* Zone). It is reasonable also to use some of the British Series names (Tremadoc, Arenig, Ashgill) in global Stage terminology in a modified sense.

Ross: Our purpose in subdividing the Ordovician System/Period is to provide a means of correlating geologic historical events between oil fields, between mining districts, between counties, between states or provinces, between nations, between continents, or between tectonic terrains. CORRELATION IS THE PURPOSE of subdivision, that is telling time.

The fundamental unit for correlation is the biozone, i.e., concurrent range zone (a refined assemblage zone). Accuracy is more important than precision. The two are not necessarily the same. Therefore the concurrent range zone is more accurate than the lowest occurrence (or first appearance) of a single taxon. The 15 Ordovician graptolitic concurrent range zones of Elles & Wood are a good example. They, however, were/are useful in the black shale facies, seldom of any use in shallow water carbonates. Every effort must be made to broaden the concurrent range zone to include taxa of as many genera, classes, or phyla as possible. A good example is the *T. laevis* conodont Zone, the base of which coincides with *I. v. lunatus* graptolite Zone, the *Orthidiella* brachiopod zone (generally indicated by the lowest occurrence of *O. subalata*), and by certain bathyurid trilobites (Fortey in press).

It is probable that additional biozones will be established as work proceeds. Once a reasonable number of biozones has been established, it is likely that they may be bundled. The bundles will probably reflect allegiances to one or more regional series. Popular usage will probably determine the naming of each bundle. The fewer the rules governing this process the greater likelihood that it will represent the geologic events that are being correlated.

The relative positions of radiometric dates and of geochemical signatures are governed by

biozones, not the reverse.

Williams: I believe that we should attempt to use a well-defined, only slightly modified version of the currently and historically most widely-used schemes - this is without doubt the British series. US workers like their own chronostratigraphy but hardly anyone else does, so they are merely a vocal minority. Any divisions finer than the UK series would be impossible to define globally - look at the problems we have already had!

Zhou: All chronostratigraphic units are artificially defined. To subdivide the Ordovician into three series and eight or nine stages is preferred: the lower, the Tremadoc (including 2 or 3 stages), the middle, the Arenig + Llanvirn (3 stages) and the upper, the Caradoc + Ashgill (3 stages). Any graptolite or conodont biozone of which the base is selected as boundary between two chronostratigraphic units should be world-wide distributed. Biozones established in slope areas are of more global correlation potential than those in shallower or deeper facies belts.

Barry Webby

IUGS SUBCOMMISSION ON ORDOVICIAN STRATIGRAPHY: RESULTS OF ISOS POLLING OF TITULAR MEMBERS IN APRIL/MAY 1995

Note that two members did not respond to the postal vote (Dean, Nikitin); their votes consequently, following ICS guidelines, are registered as YES votes.

nb., This voting process was held prior to the Subcommittee meeting at Las Vegas.

Postal Ballot 1 (Formal proposal for adoption of a set of guidelines for establishing Ordovician global boundaries and subdivisions).

YES - 20 (Apollonov, Baldis, Barnes, Bergström, Berry, Bruton, Chen, Dean, Cooper, Finney, Fortey, Gutierrez Marco, Owen, Nikitin, Paris, Ross*, Wang, Webby, Williams, Zhou)

ABSTENTION - 0

NO - 2 (Jaanusson, Popov)

Result: 91% majority vote

*(Ross) Global series. In American usage series are time-rock terms. It is very unlikely that a rock unit could circle, girdle, or enwrap the Earth. As I have noted previously the recognition, discrimination, and preservation of regional Series is essential to the interpretation of global history. As an example - currently there is great interest in the previous domain of western Argentina around San Juan. Many are convinced that its Late Cambrian through Middle Ordovician faunas and rocks ally it to northeastern Laurentia and that a North American terminology fits the bill. If the old British series are applied a totally incorrect paleotectonic history is implied. I have been informed that RF insists that the presence of *Neseuretus* indicates that that area is Gondwanan terrain. Because that is a late Ordovician genus it may be significant in showing that the subject microplate had assumed its present position by late Ordovician time. I find the mixing of regional series terms to be enlightening, whereas the use

of a uniform global terminology hides history, almost irresponsibly.

Postal Ballot 2 (Vote on the base of the *Tripodus laevis* conodont zone as the base of the third chronostratigraphic division of the Ordovician System)

YES - 11 (Baldis, Bergström, Berry, Bruton, Cooper, Dean, Finney, Gutierrez Marco, Nikitin, Ross*, Webby)

ABSTENTION - 4 (Apollonov, Paris, Owen, Wang)

NO - 7 (Barnes, Chen, Fortey, Jaanusson, Popov, Williams, Zhou)

Result: 61% majority vote

*(Ross) Yes, but suggested that the wording should be amended to read ". .as a base of a chronostratigraphic . ." The units should not be numbered.

Postal Ballot 3 (Vote on the base of the *Nemagraptus gracilis* graptolite zone as the base of the fifth chronostratigraphic division of the Ordovician System)

YES - 19 (Apollonov, Baldis, Bergström, Berry, Bruton, Chen, Cooper, Dean, Finney, Fortey, Gutierrez Marco, Owen, Nikitin, Paris, Ross*, Wang, Webby, Williams**, Zhou)

ABSTENTION - 0

NO - 3 (Barnes, Jaanusson, Popov)

Result: 86% majority vote

*(Ross) Yes, but suggested that the wording should be amended to read ". .as a base of a chronostratigraphic . ." The units should not be numbered.

** (Williams) With reservations given the current usage of the "base" in many regions.

Postal Ballot 4 (Vote on the base of the *Phragmodus undatus* conodont zone as the base of the sixth chronostratigraphic division of the Ordovician System)

YES - 8 (Apollonov, Barnes, Berry, Bruton, Dean, Gutierrez Marco, Finney, Nikitin)

ABSTENTION - 7 (Paris, Chen, Cooper, Owen, Ross*, Wang, Webby)

NO - 7 (Baldis, Bergström, Fortey, Jaanusson, Popov, Williams, Zhou)

Result: 53% majority vote (less than a required majority)

*(Ross) I should prefer the base of the *aculeata* conodont zone.

Postal Ballot 5 (Vote of the base of the *Dicellograptus complanatus* graptolite zone as the base of the seventh chronostratigraphic division of the Ordovician System)

YES- 12 (Apollonov, Barnes, Berry, Bruton, Chen, Dean, Finney, Fortey, Gutierrez Marco, Nikitin, Wang, Zhou)

ABSTENTION - 6 (Baldis, Cooper, Owen*, Paris, Ross, Webby)

NO - 4 (Bergström, Jaanusson, Popov, Williams)

Result: 75% majority vote

*Owen notes that the base of the *ordovicicus* conodont biozone needs to be clarified first.

Additional comments about these postal ballots were contributed by the following Voting Members:

Bergström: I strongly believe that it is premature to vote on the various bases of the major units in view of the fact that much new and significant information will shortly be presented at the Las Vegas meeting and that the Voting Members of the Subcommittee should have access to those data in order to make a wise decision. I would advise you strongly to regard this as a *straw* vote, and not a formal vote because much more discussion is needed. For instance, little has been published about the *austrodentatus* Zone and the *Phragmodus undatus* Zone; new data (in press) drastically changes the position of the base of the latter zone, and there is also new information in press on the base of the *complanatus* Zone and its international correlation. Furthermore, I do not think there has been enough discussion regarding the possibility of tracing these horizons into shelly (non-graptolitic) facies, an extremely important point. We should not repeat the Ordovician/Silurian boundary mistake, and we must keep in mind that shelly facies is far more widespread on the major continental plates than graptolite facies.

Cooper: I am not entirely happy about voting on the base of a biostratigraphic zone (i.e. on a biohorizon) for defining the base of a chronostratigraphic unit such as series because of the possible implication that the base of the zone, everywhere it is found, will coincide with the base of the series. We all know that, although in practise a zone base will be taken by many to indicate the series base, it need not do so away from the type section, and it is likely that truly isochronous events such as magnetic polarity reversals will eventually be able to show that some Ordovician biohorizons used for series definition are diachronous, as has already happened in some Cenozoic series and stages. This is the reason why a GSSP is used from chronostratigraphic unit definition rather than a zone base.

The problem is highlighted in ballot 5, on the base of the 7th unit. The base of the *complanatus* zone is recommended, but this may not mean the same thing in all sequences. I have voted in ballots 2-5 on the understanding that selection of a particular biohorizon (or zone base) for series (or stage) definition implies only that the biohorizon *indicates the series boundary in the type section*.

Jaanusson: As to the Ballots 2-5 my objection is not the levels themselves but the numbering of the chronostratigraphic divisions (third, fifth, etc.). This is incompatible with a three-fold subdivision of the System.

I would hesitate to treat the bases of graptolite zones as if they were well defined levels. According to my experience there are problems with defining the bases of almost every Atlantic graptolite zone. The main body of a zone is readily recognisable but at the boundaries there is commonly a "grey zone" of varying extent where the level of the boundary is unclear. In my experience this complicates the correlation of the graptolitic and shelly sequences because the "grey zone" may correspond to a substantial unit in the shelly facies. Definition of the base of a graptolite zone in terms of appearance of an index species is illusory in practice. Such a level is correlatable only if a number of conditions are satisfied, and the probability that all these conditions are fulfilled is so low that, based only on biostratigraphic evidence, the level is hardly recognisable even in another section of the area (I have been studying this problem for some time, based on probability theory). It is useful to be aware that what we are dealing with are rough but in practice workable approximations.

Owen: [Please note Dr Owen's important relevant, earlier comments of 29 July 1994 were quoted unfortunately with a few typing errors in the position paper (dated 22 March 1995) circulated previously to all Voting Members].

Dr Owen has added the following comments in his response to these ballots and questionnaire:

"I found Valdar's [Jaanusson] recent circular interesting - although his unsupported allusions to the trinucleids at the base of the Ashgill being 'misinterpreted' were naughty to say the least. The relationship between the *linearis* Zone and the shelly base of the Ashgill is clear (it straddles that boundary). Classification of the base of the *ordovicicus* Zone is still needed both in terms of how it is defined and its position relative to the base of the *complanatus* Zone (see Valdar's comment) and the shelly base of the Ashgill.

Popov: I support your proposal to introduce a tripartite subdivision of the Ordovician (*Ordovician News*, no.11), because it is, actually, widely used in practise, and gives a frame for the following subdivision of the Ordovician into global stages. I would like to note, for instance, that subdivision of the Ordovician into the Lower, Middle and Upper Series is widely accepted in Russia and Kazakhstan, as well as in Baltoscandia.

There are also important unpublished data which affect correlation proposed in your chart [attached to the position paper] of March 22. Particularly, the base of the Castlemainian and, possibly, Whiterockian more likely correspond to the base of the *originalis* conodont Biozone of Baltoscandia, and placed above the base of the Volkov Regional Stage. Some new data on the correlation of the base of the Harju Series and *ordovicicus* conodont Biozone were discussed in details by Valdar Jaanusson in his letter of May 5th, 1995.

I regard ballots 2-5 as premature, because significance of some proposed correlation levels depends strongly on the subdivisions of the Ordovician System into Series, which are not formally established. The proposed final postal ballot in favour of the base of *austrudentatus* or *artus* biozones as a base of a global Ordovician Stage (or Series) boundary level gives also a good opportunity to make a formal decision on principles of the subdivision of the Ordovician System into Series.

B.D. Webby
Declared 11 October 1995

IUGS SUBCOMMISSION ON ORDOVICIAN STRATIGRAPHY: RESULTS OF ISOS POSTAL BALLOTS, OCTOBER-DECEMBER 1995

1. Should the Ordovician System should be divided into three formal Series, named LOWER, MIDDLE and UPPER?

YES: 18 (Apollonov, Baldis, Barnes, Bergström, Berry, Chen, Cooper, Finney, Gutierrez Marco, Jaanusson, Nikitin, Paris, Popov, Ross, Webby, Williams, Zhou)

NO: 2 (Fortey, Owen)

ABSTAIN: 1 (Wang)

This resulted in a **90% majority** in favour of the ballot.

2. Should a tripartite division of the Ordovician System be adopted using the base of *Tripodus laevis* conodont Biozone for the base of the Middle Ordovician System, and the base of the *Nemagraptus gracilis* graptolite Biozone for the base of the Upper Ordovician System?

YES: 14 (Apollonov, Baldis, Barnes, Bergström, Berry, Bruton, Chen, Finney, Jaanusson, Nikitin, Popov, Ross, Webby, Williams)

NO: 3 (Fortey, Owen, Wang)

ABSTAIN: 4 (Cooper, Gutierrez Marco, Paris, Zhou)

This represented an **82% majority** in favour of the ballot.

As these specific votes are not linked to GSSP proposals they are in effect straw votes, but they do provide a clear mandate for the current primary focus of our Subcommittee work to establish a tripartite subdivision, with GSSPs defining the bases of the Middle, and the Upper Ordovician, Series, respectively.

Barry Webby
Declared 7 February 1996

IS THE BASE OF THE WHITEROCK SERIES A SUITABLE GLOBAL HORIZON FOR THE BASE OF THE MIDDLE ORDOVICIAN?

Richard Fortey

At the Las Vegas meeting in 1995 there was considerable enthusiasm for a base of the Middle Ordovician at what has been termed the base of the Whiterock Series. This base was formally defined by Ross and others at Whiterock Canyon, Nevada. The proposed base for international correlation purposes was at a combined *Tripodus laevis/Isograptus lunatus* horizon, recognised in the Vinini Formation as equivalent to the base of the Whiterock (Finney and Ethington 1992). It was my belief that other possibilities had not been aired sufficiently at the meeting concerning an INTERNATIONAL base for the Middle Ordovician. These other bases are the classical Llanvirn base in Wales (base of *D. artus* Biozone) and the base of the *Undulograptus austrodentatus* Biozone. The purpose of this discussion paper is to get some way towards defining criteria for international utility. I start with the assumption that scientists of goodwill shall agree on horizons which are most useful, as calibrated on some objective measure. I shall also briefly look at some specific problems relating to the Whiterockian.

Tests for international utility in correlation

If a base for the Middle Ordovician is to be defined in such a manner as to be useful globally there are a number of simple criteria which it must pass before it can be considered for practical utility. For a period of continental dispersal like the Ordovician a suitable test is whether a given horizon can be recognised in each of the main

palaeocontinents and in the most important successions within each one. This can be established simply by a table listing (1) the palaeocontinents, and (2) countries within each palaeocontinent from which good successions have been established. While historical factors are not necessarily paramount, it is obvious that historically important areas should be included in any such system, if for no other reason than they will have successions that have been collected for a long time and are thoroughly documented. We consider below three possibilities for this base, each of which has been advanced as a global horizon for correlation. These are, in ascending stratigraphic order:

1. The base of the Whiterock Series.
2. The base of the *Undulograptus austrodentatus* Biozone.
3. The base of the *Didymograptus artus* Biozone.

In terms of historical usage, the Whiterock Series was proposed by Cooper (1956) as a brachiopod - based stage for use in North American and cratonic sequences. It was later used in the stage sense by Whittington (1963-1970) but more recently as a series to subsume certain historically prior usages such as Chazy and Tableheadian (see Ross et al 1982). The *D. artus* Biozone corresponds with the classical base of the Llanvirn Series known as the *D. bifidus* zone, an appellation due to a misconception about the identity of the common pendent zonal graptolite. This confusion over the species name was resolved by Cooper and Fortey (1982) and confirmed by Williams and Stevens (1987). The renaming of the biozone was made by Fortey and Owens (1987).

The *austrodentatus* Biozone was recognised in China as being somewhat lower than the base of the classic Llanvirn (Mu et. al 1979). It marks a profound change in graptolite faunas, not least because it is the level at which biserial graptolites became abundant and widespread. In China it is underlain by the Zone of *U. sinodentatus*, which Mitchell (1995) claims to include the direct ancestors of subsequent biserial graptolites.

Regions of the World at which the base of the Middle Ordovician should be recognisable

Ideally, the boundary should be immediately recognisable in every section spanning the interval. In practice, this is scarcely possible but it is important that it should be identifiable with comparative ease in sections within major palaeogeographic entities, such as palaeocontinents or major terrains, in sections with classical status by virtue of having been studied for many years, or any countries where the system is particularly well represented in outcrop.

For the Ordovician I identify the following as important areas for correlation; although inevitably this selection is something of a compromise between palaeogeography and politics. Anyone is free to produce their own list.

1. Laurentia - by which is meant the area embraced by the USA, Canada, Greenland and Spitzbergen. This entity was persistent as a palaeocontinent throughout the Ordovician, and has classical status from studies going back to James Hall. Western Newfoundland has particular importance as a sub-area because of the exceptional relevance of the Cow

Head Group for international correlation.

2. Great Britain. This area includes the type sections of all the major divisions that, up until now, had been used to subdivide the Ordovician. While it is not a *sine qua none* to define stratotype horizons in the Anglo-Welsh area, it would be difficult to leave this area out of consideration. Anglo-Wales was probably on the Avalonian micro-continent which drifted northwards from Gondwana towards Laurentia through the Ordovician.

3. Baltica, Norway, Sweden, Estonia and the Russian platform have the classical development of "condensed" Ordovician sequences. Their history of research goes back as far as it does in Great Britain.

4. Bohemia. This is the area made famous by J. Barrande, and has been as intensively studied as Baltica. It may or may not be another microcontinent, "Perunica" (see Havlicek et al 1994) or may have been attached to Gondwana. It cannot be left out of any global consideration of the Ordovician.

5. "Western Gondwana". This is used broadly for the vast area embraced by Armorica, the South of France, Spain, Portugal, Morocco - and to Libya and the rest of North Africa. We are aware that this is lumping together what may be more than one terrane, and that there are clearly regional differences even within this area (Henry, Hammann etc). However, the problems are likely to be soluble by careful application of local correlation studies, as witness the recent use of acritarchs and chitinozoa over a wide area for correlation purposes. Nonetheless, this does represent a huge area of Ordovician rocks and for this reason any base of the Middle Ordovician which cannot be recognised over this area must be regarded as flawed.

6. South America. South American Ordovician sections are being recognised as some of the best in the world, although many are still at an early stage of knowledge. While South America was part of the Ordovician Gondwana continent, there is evidence that a wider range of facies and continental climatic zones were present in Argentina than Armonica, for example. The Precordillera Terrane may be a special case - having started as Laurentian and finished as Gondwanan! I do not score it here.

7. China. Chinese sections divide into two major realms: the North China platform and the Yangtze Platform. Thanks to very intensive work by Chinese palaeontologists over the last 20 years these successions are now well known, and they are important for showing rich variation in facies and faunas. The North China platform succession is less varied. We take the South China sections as more important in this analysis.

8. Australia/New Zealand. The thick sections of the Amadeus and Georgina Basins are under study at the moment. Graptolitic successions in Victoria are well-known (recently ably summarised by Vandenberg and Cooper), while the succession in New Zealand is essentially similar.

It is my view that the best horizon chosen as a chronostratigraphic standard should be recognisable in as many of these areas as possible. This is a practical way of providing a definition of "global".

Global scores for the three Middle Ordovician horizons

All three horizons are recognisable in several sections. I have summarised the scores in a table, ticking (y=yes) those places where a given horizon can be recognised by direct evidence; n = definitely not possible at the moment; ? signifies real doubt. Obviously there is no room here to detail the evidence, and I may have missed some, but since I have worked in many of the areas I think it must be broadly right.

TABLE

Area	1.....	2.....	3.....	4.....	5.....	6.....	7.....	8.....
Base of:								
<i>artus</i> Biozone	?	y	y	y	y	y	y	y?
<i>austrodentatus</i>	y	y	y	y?	n	y	y	y
<i>laevis/lunatus</i>	y	n	y	n	n	n?	y	y

If the critic agrees with the eight desirable areas of correlation listed above then both *austrodentatus* and *artus* are superior to the base of the Whiterock horizon on the basis of the scores shown in the table.

It seems to me, therefore, that on the present state of knowledge it would be better to choose a horizon for this important major division which will be recognisable in as many of the major areas of importance as possible. It is superfluous to point out the the Whiterockian ticks were mostly on the Ordovician palaeoequator. We need to have an horizon recognisable as well in Ordovician Gondwana, and the Ordovician type area.

Sequence stratigraphy and the base of the Middle Ordovician

Fortey (1984) pointed out the basal Middle Ordovician coincided with a global eustatic event. It was originally claimed that this interval, broadly corresponding with the *austrodentatus* Biozone, was regressive globally; and it remains true that in most stable platform successions there is a striking facies change at the base of this horizon, usually accompanied by a marked shallowing. Nielsen (1992) has studied the interval in great detail and has produced a complex eustatic curve which he claims may be correlated between the stable platforms of Central Australia and that of Baltica. Both regressive and transgressive events produce signals with chronostratigraphic potential. Their study is not, perhaps, in a sufficiently advanced state to evaluate all sections, but preliminary suggestions can be made.

1. The base of the Whiterock is marked by a sequence break in many sections in the type area of the Western USA. In the Ibex section (Ross et al 1993), the type section of the Ibexian series, there is a thin sandstone bed 1.2 m above the "Zone K" coquina comprising a true shell bed of the brachiopod *Hesperonomiella minor*. The Whiterock series as defined by conodonts starts immediately above this bed (Ross et al. 1993). At

the paratype section of Meiklejohn Peak (Ross 1970) there is a major encrinite at the same horizon, followed by at least 3 m of a (birdseye) limestone lacking fossils.

2. The *austrodentatus* Biozone is less clearly marked, having been recognised for the most part in deeper facies. However, the appearance of biserial graptolites is a widespread event and presumably represents a flooding surface, post - sequence break at the base of the Whiterock. It corresponds with the appearance of graptolite shales with *Xiphograptus svalbardensis* in Utah, and in the Russian Platform (T. Koren pers. comm. 1992). In Nielsen's interpretation it is followed by one or more regressive pulses.

3. The *artus* Biozone is a maximum flooding surface postdating the complex regressive-transgressive sequences below. This is shown well by the appearance in many sections in platform Gondwana of deeper water shales bearing pendent didymograptids, after a long period of coarser clastic deposition: eg, in France, Saudi Arabia, Southern Spain and Morocco. There is also evidence of a deepening on the Laurentian craton at this level although international correlation has certain problems. However, the facies change between the Table Head and Black Cove formations in western Newfoundland approximates to the base of the *artus* Biozone.

Hence all three horizons are either already, or potentially, related to changes in sequence. Of the three, the basal Whiterockian is probably a global low-stand, the *artus* Biozone the maximum flooding surface, while the status of the *austrodentatus* base is regarded by Nielsen as a transgression also, although of lesser magnitude than the *artus*.

Is the base of the Whiterockian the base of *laevis/lunatus*?

Briefly, I would conclude with a few remarks on the actual field definition of Whiterockian. In the type section at Whiterock Canyon the spike is driven in at a facies change at the local base of the Antelope Valley Formation (see Ross, Ethington and Mitchell 1991), essentially a change from graptolite shale to shelly limestone, where G A Cooper's "Middle" Ordovician brachiopod assemblage appears. The graptolite fauna from the underlying shales is poor in species and does not include *lunatus*, nor, I believe, any isograptids. Comparison with published conodont charts at the Ibex section (Ross et al. 1993) and in the Vinini Formation (Finney and Ethington 1992) suggests that the conodonts associated with this Whiterock base actually appear several metres BELOW the spike in some limestone stingers within the graptolite shales. Furthermore, I have recovered trilobites (which are in press in *Journal of Paleontology*) from the basal Whiterock Canyon limestones which only appear ten metres or so above the conodont-recognised base in the Ibex section, Utah (Ethington in Ross et al 1993). This actually overlies a distinctive and underlying shelly fauna, so the difference is stratigraphically significant.

This leads me to wonder whether *laevis/lunatus* is earlier than basal Whiterockian as it is formally defined on the "spike". The correlation of the real Whiterockian base is open to discussion. It may even prove to be close to *austrodentatus*.

Conclusions

A full consideration of the various horizons possible for defining the base of the Middle Ordovician show that a claimed Whiterock base at *laevis/lunatus* is not as widely recognisable as two other alternatives, at *austrodentatus* or *artus*. Furthermore, there is evidence that the base of the Whiterock as defined formally lies stratigraphically above the base of *laevis/lunatus*.

A RESPONSE RE. VOTING PROCESS FOR GLOBAL SERIES

Alan Owen

I'm sorry if I seem very negative, but I can only vote on the proposals as stated on the form. I have no basic problem with a tripartite division (if that is the best way of grouping things) but I think this should be at subsystem level. I fear we are being railroaded by the ICS into producing a scheme which will force widely (if not globally) acceptable chronostratigraphical units into inappropriately low levels in the stratigraphical hierarchy.

As stated by others far more elegantly than I can, one of the scientific attractions of the Ordovician is that it was a time of complex and changing biogeography which in turn produces problems and challenges for stratigraphical correlation. At the end of the day, there will be a need for some regional bio- and hence chronostratigraphical units to provide greater local refinement and/or to reflect local difficulties in using some part of the global scheme. Neither of these is trivial yet such units may have to be defined at a level below substage if we define the L, M and U Ordovician as series. Whilst it is clear that there is a strong measure of agreement on using the base of the *N. gracilis* Biozone to define a global chronostratigraphical level (which I support) there is less agreement on defining a base to the middle 'series' which would give it (or the lower 'series') an 'acceptably long' duration.

What then for the next level down in the hierarchy? Will we be forced into rejecting some possible global boundaries because the 'stages' they might define would be too short in relation to the controversial boundary defined by the base of the *T. laevis* Biozone? Conversely, do we run the risk of having a set of global stages which is partly decoupled from the series boundaries - i.e. with a series boundary lying within a stage? Might we *de facto* abandon the international approach and leave it to the various regions of the world to develop their local chronostratigraphies fitting them as best they can to the overall tripartite division of the Ordovician? I fear we are storing up trouble for ourselves by forcing an artificial constraint on the way we divide the System. Our original approach of defining widely (ideally globally) acceptable series, without reference to the actual number was a far more 'natural classification' from which we could then see if larger groupings were realistic. If the present ballot proves indecisive or rejects the motions as stated, I would urge that we return to that approach.

DISCUSSION OF THE LEDGE SECTION, WESTERN NEWFOUNDLAND, AS A SUITABLE GSSP SECTION FOR AN EARLY ORDOVICIAN STAGE/SUBSERIES BOUNDARY

S. Henry Williams and Christopher R. Barnes

In 1994, we published a paper proposing the Ledge section on the Cow Head Peninsula, western Newfoundland as the stratotype for the base of the "second series of the Ordovician System" (Williams et al., 1994). Our documentation was subsequently employed by Barry Webby as the basis for one of a number of suggestions circulated to Titular Members of the Ordovician Subcommittee for approval later in 1994. During this process, criticisms were made by a number of Subcommittee members, most notably Bernd Erdtmann and Stig Bergström, regarding our assessment and correlation of the western Newfoundland section. These criticisms were subsequently repeated in presentations given at the Seventh International Symposium on the Ordovician System in Las Vegas during June 1995 and summaries published in the symposium volume *Ordovician Odyssey* (Erdtmann and Maletz, 1995; Maletz et al., 1995) (see Fig. 1). We believe that their objections to the Ledge section are based in large part on flawed taxonomic interpretation of the graptolites in this "late Tremadoc-early Arenig" boundary interval (herein referred to as TAB), and that their proposed alternative section at Diabasbrottet, Mt. Hunneberg in Sweden is far more deficient in terms of a proposed stratotype section.

The importance of the decision regarding this boundary would appear to be rather less than what it was prior to the Subcommittee meetings at Las Vegas and subsequent formal vote, as it has now been decided by a large majority to use a threefold series division for the Ordovician System with the names Lower, Middle and Upper (see Webby, this volume). As the boundary between the Lower and Middle Ordovician series will be placed at the base of the *Tripodus laevis* conodont Zone, a level close to the base of the *Isograptus victoriae lunatus* graptolite Zone, the first occurrence of *Tetragraptus approximatus approximatus* (the FAD agreed upon for defining the boundary treated in the present discussion) now falls within the middle of the Lower Ordovician Series. If a two-fold global subdivision of the series employing this level is subsequently adopted by the Subcommittee, the divisions of the Lower Ordovician Series will approximate to what have been accepted by many researchers as the Tremadoc and the lower half of the Arenig.

Response to objections of the Cow Head Ledge section as GSSP

Erdtmann (1994, unpubl.) made a number of serious criticisms related to our documentation of the Ledge section across the TAB including our taxonomic identifications, species ranges and correlation with other regions. We would here like to respond. Firstly (point B3), he criticised the section for containing only *Aorograptus victoriae* and "*Adelograptus* sp." in the interval directly below the boundary. These two forms are, however, present together with a far more diverse assemblage only 0.5 m below in an unbroken sedimentary sequence. Furthermore, it is the FAD of *T.*

approximatus, not the last occurrence of any earlier species, that has been accepted for defining the TAB.

Secondly (point B4), he claimed that all graptolites described and figured from the pre-*T. approximatus* interval by Williams and Stevens (1991) possessed alternating bithecae and lateral stolothecae throughout their rhabdosomes, showing them to belong to an early Tremadoc ("pre-Hunnebergian") interval. We agree that certain taxa do contain more than one bitheca (e.g., *Aorograptus victoriae*, *Paratemnograptus isolatus*), but the majority of simple rhabdosomes only contain a sicular bitheca. As no graptolites with only one bitheca have been recorded from the pre-Hunneberg strata of Scandinavia, it is clear that the TAB interval must be latest Tremadoc (i.e., middle "Hunnebergian") in age. Erdtmann (point B4, fig. A; revised zones in Erdtmann and Maletz, 1995, fig. 1) further claims that the presence of *Kiaerograptus bulmani* indicates a correlation with the *A. victoriae* Zone or lower part of the *K. supremus* Zone of the Mt. Hunneberg region and demonstrates that the following *A. murrayi* and *H. copiosus* zones, which there lie between the *K. supremus* Zone and the FAD of *T. approximatus*, are absent. Part of the problem with these comparisons is that there is a great deal of variation in rhabdosome form and development within the graptolites present in the TAB interval, making taxonomic distinction difficult. Thus, if the faunal assemblages from Sweden published by Lindholm (1991) and from western Newfoundland by Williams and Stevens (1991) are compared, there appears to be a large difference in faunal composition. If the figured material of the two papers is compared critically there is, however, far more similarity (such an exercise was not originally possible for either paper as both were prepared and submitted almost simultaneously). Of particular importance are the following points:

1. *Tetragraptus longus* sp. nov. of Lindholm (1991), which is restricted to the *H. copiosus* Zone of Mt. Hunneberg, is similar or identical to *Kiaerograptus bulmani* of Williams and Stevens (1991) which was found at Green Point, Martin Point and St. Paul's Inlet in addition to the Ledge section. We therefore believe that (what we at least call) *K. bulmani* ranges from the *A. victoriae* to the *H. copiosus* zones of Mt. Hunneberg.
2. *Kiaerograptus supremus* of Lindholm (1991), which is restricted to the *K. supremus* and *A. murrayi* zones of Mt. Hunneberg, may well be synonymous with *Kiaerograptus* cf. *K. taylori* of Williams and Stevens (1991) which was found at Martin Point.
3. *Hunnegraptus copiosus* of Lindholm (1991), which is restricted to the *H. copiosus* Zone of Mt. Hunneberg, is identical to *Kiaerograptus pritchardi* of Williams and Stevens (1991) which was found at Green Point and Martin Point North.
4. *Tetragraptus krapperrupensis* sp. nov. of Lindholm (1991), which is found in the *A. murrayi* Zone and possibly *H. copiosus* Zone of Mt. Hunneberg, is similar or identical to *Kiaerograptus magnus* sp. nov. of Williams and Stevens (1991) which was found at Green Point, Martin Point and St. Paul's Inlet.

If the above observations are correct, they show that the collecting levels at Green Point (GP38), Martin Point (MP42), St. Paul's Inlet (SPI43) and Cow Head (CH34) of western Newfoundland, which yielded both flattened and isolated material, contain taxa

supposedly diagnostic of at least the *H. copiosus* and *A. murrayi* zones. This suggests that the ranges of these taxa are considerably longer than claimed by Lindholm (1991), Erdtmann (1994, unpubl.) and Erdtmann and Maletz (1995) and casts doubt on the widescale validity of their TAB graptolite zones which are essentially single species range or regional acme zones. It furthermore indicates that the claim by Erdtmann (1994, unpubl.) and Erdtmann and Maletz (1995) of a hiatus within the Cow Head Group at this level based on graptolite evidence (Fig. 1) is unfounded.

Erdtmann's (1994, unpubl., point B7) last principal objection to the Ledge section was that we recorded the first occurrence of the conodont *Prioniodus elegans* at the same level as the FAD of *T. approximatus*, whereas at the Diabasbrottet and Mossebo sections *T. approximatus* first occurs well below *P. elegans* (Löfgren, 1993). We believe that the reason for this (also discussed in the next section) is that the "*T. approximatus*" of Mt. Hunneberg does not actually belong to this species. We believe that it has far more in common with *T. acclinans*, which is restricted to the middle and upper parts of the *T. approximatus* Zone in the Cow Head Group sections. Furthermore, the conodonts recorded by Maletz et al. (1995, fig. 1) indicate the presence of *Prioniodus* cf. *P. elegans* rather than *P. elegans* itself, casting some doubt on whether the first occurrence of this taxon is of critical importance in correlating between the two regions.

Problems with the Diabasbrottet section as a GSSP

The Diabasbrottet section is clearly an excellent, fossiliferous locality that is easily accessible and meets many of the general requirements for a GSSP. The conodonts have been documented thoroughly by Löfgren (1993), with graptolite and trilobite work by Jörg Maletz supplementing Lindholm's (1991) earlier graptolite study on other localities from the area. The section is documented in detail by Maletz et al. (1995) in their recommendation of Diabasbrottet for GSSP. We do, however, have a number of reservations about the suitability of the section, including apparent faunal deficiencies and potential for non-paleontological study. The most serious problems appear to be:

1. There are no graptolites in the lower part of the section (Maletz et al., 1995, fig. 1); the first two species to appear are "*T. approximatus*" and *T. phyllograptoides*. It is thus, impossible, to know whether we are dealing with a true FAD for *T. approximatus* and to know which of Lindholm's zones would be present immediately below the FAD. This problem is apparently alleviated somewhat by the presence of other sections in the area (such as those studied by Lindholm, 1991), which contain earlier graptolite assemblages (J. Maletz, pers. comm., 1995) but we do not believe this to be a reasonable solution for what would become a globally recognized standard section. Furthermore, it was clear from the presentation given at Las Vegas in June, 1995, that the graptolites identified as "*T. approximatus*" had a much more rounded, open proximal structure than the angular "H-shaped" funicular region of typical *T. approximatus*. Those specimens from Mt. Hunneberg seemed to be far more similar to the species *T. acclinans*, first described from Australia, which Williams and Stevens (1988) found to be restricted to the middle and upper parts of the *T. approximatus* Zone in western Newfoundland. It therefore seems

likely that the true FAD of *T. approximatus* in the Cow Head Group correlates with somewhere in the non-graptolitic interval or in the lower part of the Diabasbrottet section, and that it is actually the Scandinavian rather than the Newfoundland sequence which contains a significant hiatus around this level (see Fig. 2).

2. In terms of continuity of sedimentation based on conodont evidence, Bergström (1988) noted that the base of the *P. elegans* Zone in Sweden usually occurs at a lag deposit, and represents a time of peak regression. Löfgren's (1993) four-fold subdivision of the underlying *Paroistodus proteus* Zone has only local application and most likely represents ecologic shifts rather than biostratigraphically useful change; it may, however, be useful in parts of the Baltic region.

3. The Diabasbrottet section is in reality four sections (Löfgren, 1993, fig.3) exposed along a quarried escarpment. Although Maletz et al. (1995) claim that individual beds can be traced for 100's of metres and even kilometres, this is not evident within the four sections published by Löfgren (1993, fig.3). Critical examination of figs. 3 and 7 of Löfgren (1993), suggests that relatively few conodonts occur in the main section. The most productive samples are derived from limestones in the small lateral sections which then need to be correlated into the main section.

4. As noted by Maletz et al. (1995), the Diabasbrottet section has been extensively heated by dolerite sills, making the section unamenable to paleomagnetic and chemostratigraphic work. Löfgren (1993) reports conodont CAI values of 5-8 (i.e., 300-600+°C) We agree that exceptions have been made to the general ICS guidelines for recommending a GSSP, but consider that this combined with the shortcomings outlined above render the Swedish section unsuitable for consideration.

Other possible GSSP sections in the world

In his discussion of the Cow Head section, Erdtmann (1994, unpubl.) suggested a number of other TAB sections that might be considered for GSSP based on the FAD of *T. approximatus*. We believe that none of them have the potential to be a GSSP and certainly none compare to the quality offered by Ledge section for the following reasons:

1. The section at Quebrada Agua y Toro/Cieneguillas (south Bolivia) has yet to be documented thoroughly, so clearly should not be considered at this stage. Only graptolites have been noted in the provisional reports.
2. The Anthill Creek section in the Aorangi Mine district of New Zealand has been superbly documented by Cooper (1979). We agree with Erdtmann (1994, unpubl.) that there is, indeed, an apparently unbroken section of black shale and chert between La2 (late Tremadoc) and La3 with *T. approximatus*. A short (unpublished) study by Henry Williams and Roger Cooper in 1993 showed, however, that the section was only sporadically graptolitic and that preservation was generally too poor for critical taxonomic determination. Furthermore, no carbonates are available for conodont extraction and the section has suffered from regional deformation; we are unsure of the exact (low grade metamorphic?) level of deformation in the area, but are certain that it has been heated too

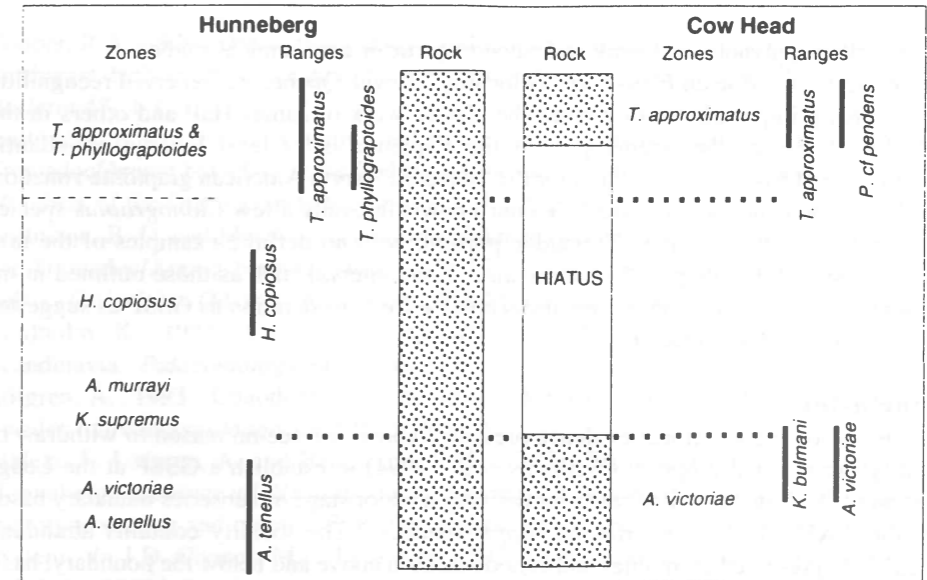


Fig. 1. Correlation of Hunneberg and Cow Head sections after Erdtmann and Maletz (1995, fig. 1)

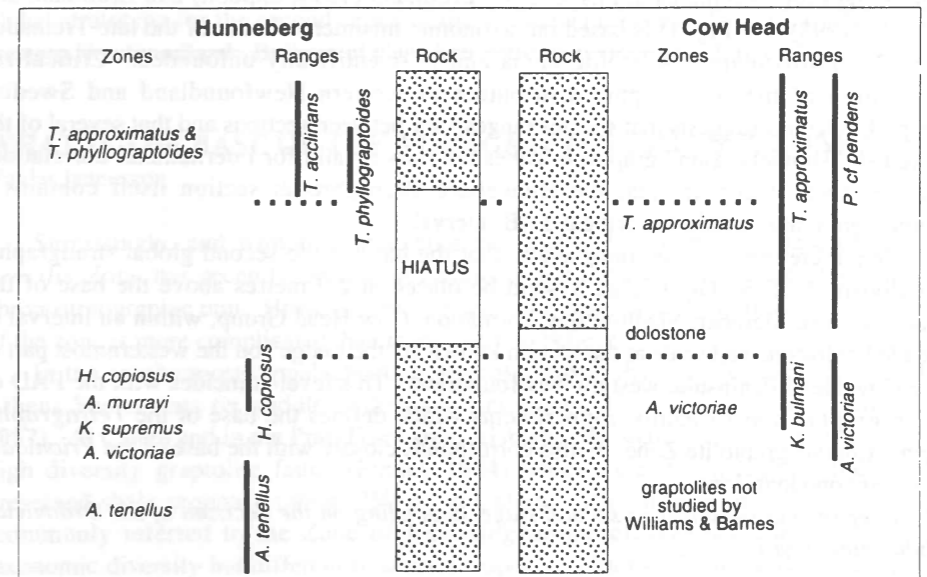


Fig. 2. Revised correlation of Hunneberg and Cow Head sections based on this paper

far for critical palynological work and paleomagnetic or geochemical studies.

3. The section at Rue du Fleuve, or "G-locality", Levis, Quebec has received recognition as a globally important locality since the classic work of James Hall and others in the 1860's. Although the Arenig part of the sequence is, at least locally, abundantly graptolitic and has formed the basis for the "standard" North American graptolite zonation, the Tremadoc is not well exposed. To our knowledge, only a few *Clonograptus* species are common in the so-called Tremadoc portion, with no definite examples of the taxa characteristic of the late pre-*T. approximatus* Zone interval such as those outlined in the present discussion. It is, therefore, unacceptable for consideration as GSSP as suggested by Erdtmann (1994, unpubl.).

Conclusions

Based on the additional evidence presented above, we see no reason to withdraw or modify our original proposal (Williams et al., 1994) to establish a GSSP at the Ledge section of the Cow Head Peninsula for defining a major stage or subseries boundary based on the FAD of *T. approximatus approximatus*. The locality contains abundant, exquisitely preserved graptolites and conodonts both above and below the boundary, has a low thermal maturity (CAI 1-1.5) and good potential for magneto- and chemostratigraphic studies. The critical interval may be correlated precisely with several other complete sections of the Cow Head Group developed in more distal facies. The suggestion of a hiatus at this level by Erdtmann (1994, unpubl.) and Erdtmann and Maletz (1995) (see Fig. 1) is based on taxonomic misinterpretation of the late Tremadoc (pre-*T. approximatus*) graptolite fauna and is scientifically unfounded. Critical re-evaluation of the stratigraphic distribution of western Newfoundland and Swedish graptolite faunas suggests that species ranges vary between sections and that several of the Swedish "Hunnebergian" graptolite zones are thus invalid for international correlation. Furthermore, it appears that the Hunneberg Diabasbrottet section itself contains a significant hiatus within the critical TAB interval.

We therefore propose, once again, that the base of the second global stratigraphic subdivision* of the Ordovician System be placed at 2.9 metres above the base of the Factory Cove Member, Shallow Bay Formation, Cow Head Group, within an interval of bedded dolostone and shale at the section known as "the Ledge" on the westernmost part of the Cow Head Peninsula, western Newfoundland. This level coincides with the FAD of *Tetragraptus approximatus approximatus* which defines the base of the *Tetragraptus approximatus* graptolite Zone. It also corresponds closely with the base of the *Prioniodus elegans* conodont Zone.

*(either second subseries or second stage, depending on the decision of the Ordovician Subcommission)

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WHAT IS THE BASE OF THE NEMAGRAPTUS GRACILIS ZONE?

Valdar Jaanusson

Surprisingly, and without a preceding exhaustive discussion, the base of the *N. gracilis* Zone has recently become a candidate for the base of a major Ordovician chronostratigraphic unit. However, the problem with regards to the definition of the base of the zone is more complicated than many seem to believe.

In the southernmost Appalachians a graptoliferous shale, collectively termed the Athens Shale, rests on middle Ordovician limestones (for a summary see Hall et al. 1987). At Calera and in the Pratt Ferry area, Alabama, the shale contains a fairly uniform high diversity graptolite fauna (Finney 1984) which extends throughout the whole preserved shale sequence (about 250 m at Calera). An earlier graptolite assemblage (commonly referred to the Zone of *Hustedograptus cf. teretiusculus*), with a low taxonomic diversity but different in several respects, is known from the Rockmart Slate of Georgia (Berry in Cressler 1970), but in the southern Appalachians no section is known in which these two assemblages occur in a continuous succession.

A characteristic constituent of the Athens Shale fauna is *Nemagraptus gracilis*, which

in the Calera section (Finney 1984, fig. 2) appears some 5 m above and in the Pratt Ferry area (Finney 1984, fig. 3) at the base of the graptoliferous beds. In the Calera section the level of the first appearance of this species has been taken as the base of the *N. gracilis* Zone (Finney 1984; Finney and Bergström 1986), but it is questionable whether this level really coincides with the introduction of that species within the region. Finney's (1984, fig. 2) faunal log shows a stepwise ascending appearance of various species from the base of the graptoliferous sequence, a pattern displayed by many faunal logs and normally caused by variations in local or regional densities in the occurrence of individual species, stochastic features relative to sample size and some other factors (see also Jaanusson 1976, text-figs. 1-4). In the Calera log the lowermost finds of *N. gracilis* are in the middle of such a scalariform pattern.

At Calera the boundary between the *Pygodus serra* and *P. anserinus* conodont zones is slightly above the base of the graptoliferous sequence (Hall et al. 1987, text-fig. 2). The published information from the Pratt Ferry area is somewhat conflicting. According to Finney (1984, fig. 3) the *serrus/anserinus* boundary is somewhat below the graptoliferous beds at which *N. gracilis* also appears, whereas data from ranges of conodonts (Hall et al. 1987, fig. 4) indicate a slightly lower level. However, it would be an unlikely coincidence if there the change from limestone to shale would happen to coincide with the regional level of the first appearance of *N. gracilis*. At the top of the limestone sequence, in the Pratt Ferry Limestone, Finney (1985) recorded the occurrence of fragments of *Nemagraptus*, not specifically identifiable but associated with *Pygodus serra*.

In the Baltoscandian region the *serrus/anserinus* boundary is situated near the middle of the *Hustedograptus teretiusculus* Zone (Bergström 1971), as the zone is currently defined within the region (Jaanusson and Strachan 1954). Thus, there appears to be a conspicuous discrepancy between Alabama and Baltoscandia with regard to the level of first appearance of *N. gracilis* relative to the *serrus/anserinus* zonal boundary. In Alabama *N. gracilis* seems to appear substantially earlier than in Baltoscandia, low down within the Baltoscandian *H. teretiusculus* zone. The difference is not surprising because we are dealing with two different biogeographic graptoloid provinces. The available information from the Anglo-Welsh region (see also Hughes 1989) seems to indicate that there the corresponding graptoloid succession is roughly comparable with that in Baltoscandia.

There is also a discrepancy with regard to temporal ranges of some species. Species which in Baltoscandia and the Anglo-Welsh region are restricted to the *H. teretiusculus* Zone range in the Calera section above the local level of the first appearance of *N. gracilis* (*Dicranograptus irregularis*, *Dicellograptus geniculatus*, *Azygograptus incurvus*). Several different explanations of the discrepancy are possible, but at present the possibility cannot be excluded that the range of these species in Alabama roughly indicates the portion of the regional *N. gracilis* Zone that corresponds to the upper part of the *H. teretiusculus* Zone in Baltoscandia and the Anglo-Welsh region.

Thus, the published evidence indicates that the first appearance of *N. gracilis* may be diachronous, and for this reason the level is hardly suitable for defining a global

chronostratigraphic boundary. A serious contributing difficulty is the lack of a known section which exposes an undoubted transition, without an intervening break in the sequence, from earlier graptoliferous beds to those containing the *N. gracilis* assemblage. Attention should be paid also to Hughes' (1989) opinion that "*N. gracilis* may be identified with certainty only from complete mature rhabdosomes" and that "this effectively means that a large amount of graptolite material which previously may have been identified as *N. gracilis* is specifically indeterminate".

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REPLY TO: "WHAT IS THE BASE OF THE NEMAGRAPTUS GRACILIS ZONE? BY VALDAR JAANUSSON"

Stan Finney

Valdar Jaanusson raises several important points with regard to definition of the base of the *N. gracilis* Zone and its candidacy as the base of a Middle Ordovician Series. Some of his concerns are addressed by recently published information with which he was not familiar. One of his concerns led me to discover a critical mistake in one of my published illustrations. Others require further consideration. Sections in Middle Ordovician shales at several localities in the Southern Appalachians provide expanded,

continuous stratigraphic records of the boundary between the *teretiusculus* and *gracilis* zones. Those at Calera and Pratt Ferry/Pratt Syncline are documented in the literature (Finney, 1984) and it is to those that most of Valdar's comments are directed. Recently, range charts for other important sections, such as Denton Valley, Tennessee and Abingdon, Virginia, have been published in Grubb and Finney (1995) and Finney and others (1996); the latter publication has a GSA Data Repository file with graptolite range data from more than 40 additional localities in the Southern Appalachians. Grubb and Finney (1995) and Finney and others (1996) also include a summary (synthetic) range chart and a composite standard reference section that illustrate graptolite distributions through the Middle Ordovician shales throughout the Southern Appalachians.

Stepwise ascending appearance of species: Valdar is concerned that the pattern of first appearance of species in the Calera section (Finney, 1984, fig. 2; Finney and others, 1996, fig. 7) may not be a true record of the introduction of species into the region; instead it may represent a stochastic feature of sample size or local variations in occurrences. This troubled me when I first plotted the ranges long ago, in part because the successive appearances coincide with an onlapping (deepening) depositional system and might represent facies control. Evidence from many other sections, however, indicates otherwise. Nearly identical patterns of successive appearances are illustrated for Denton Valley (Grubb and Finney, 1995, fig. 6) and Abingdon (Finney and others, 1996, fig. 8). Because the tectonically induced subsidence of the foreland basin migrated cratonward during the upper *murchisoni* to *bicornis* zones, the stratigraphic base of the shale is diachronous and the stratigraphic level at which *N. gracilis* and associated species appear varies between sections (e.g., 10 m at Calera, 40 m at Denton Valley). Nevertheless, the same successive appearances are associated with the first appearance of *N. gracilis* whether it is at the base, in the middle, or at the top of the shale succession. Where the base of the graptolitic facies is above the base of the *gracilis* Zone, *N. gracilis* and associated species appear together in the lowest collection as, for example, in the lowest collections at the base of the shale in the Pratt Ferry/Pratt Syncline section (Finney, 1994, fig. 3). The high degree of homotaxy of species characterizing the base of the *gracilis* Zone at various stratigraphic levels in the shale sequence in several widely separated sections is strong evidence that the successive appearances are a reliable representation of the order in which species first migrated into the region and that the first appearance of *N. gracilis*, when it occurs within a succession of key first appearances, is isochronous throughout the region.

Occurrence of both *teretiusculus* and *gracilis* assemblages in same section: On the basis of published information (Finney, 1984), it is reasonable to question the existence of a section in which both assemblages occur in succession. As mentioned above, several sections with substantial graptolitic intervals below the first appearance of *N. gracilis* have now been documented in Grubb and Finney (1995) and Finney and others (1996). In all of these, the assemblage is of low diversity and

characteristic of the *teretiusculus* Zone. Earliest species of *Dicellograptus* appear in, and characterize the upper part of the *teretiusculus* Zone.

Level of *P. serra*/*P. anserinus* conodont zone boundary: There are drafting errors in my illustration of the Pratt Ferry/Pratt Syncline section (Finney, 1984, fig. 3), which is a composite of two separate but nearby sections. At Pratt Ferry, the *serra/anserinus* zonal boundary is 0.3 m below the top the upper Pratt Ferry Beds. The lowest graptolite collections in the Athens Shale are from 4 m and 5 m above the top of the Pratt Ferry Beds at Pratt Ferry and Pratt Syncline, respectively. Accordingly the level at which the conodont zone boundary and the base of the Athens Shale are shown in fig. 3 is incorrect. The conodont boundary actually is well below the first appearance of *N. gracilis* as it is at Calera; however, the lowest stratigraphic level at which graptolites are preserved (collected) in the PF/PS section correlates with a level above the base of the *N. gracilis* Zone. For that reason, the range bases in the PF/PS section are truncated. My reported (Finney, 1995) fragments of *Nemagraptus* from the top of the Pratt Ferry Beds might represent *N. subtilis* but are indeterminate specifically.

Global homotaxy: Given an actualistic model in which the location and relative timing of species evolution and dispersal is dependent on the vagaries of local contingencies, perfect homotaxy is not to be expected. There clearly are variations in the relative ranges of species in the boundary interval of the base of the *gracilis* Zone, and heterotaxy in successive first appearances. In addition, there are still taxonomic misidentifications of species in the boundary interval because considerable information in my PhD dissertation (Finney, 1977) that is critical for resolving many of these has yet to be formally published. On the basis of my knowledge of these species and my analysis of their relative ranges worldwide, I conclude that the potential isochrony of the first appearance of *N. gracilis* is far better than that of any other species in the boundary interval, or for that matter at any other level in the *teretiusculus* and *gracilis* zones. However, that is a topic to be addressed in a more substantial proposal from Stig Bergström and myself and any others who can and wish to contribute.

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LADISLAV MAREK 1928 - 1995 - IN MEMORIAM

It is with great regret that we report the death of Ladislav Marek, one of the leaders of Ordovician research of trilobites and hyoliths. He studied geology and palaeontology at Charles University. Since 1961 he worked in the Geological Institute of the Czechoslovak Academy of Science and several years headed the Department of Macropalaeontology. For a long period he was the Secretary of the International Palaeontological Committee and coordinator of palaeontological research in Czechoslovakia. He specialized on Ordovician faunas and biostratigraphy, originally with trilobites and then on hyoliths. He became the world's leading specialist who was invited to describe hyolithid faunas from many localities in Europe, Africa, South America, and the U.S.A. The results of Ladislav's investigation on the Ordovician are published in nearly thirty papers. Many of these papers belong to pioneer studies in a number of different aspects, including bohemiid and cyclopygid trilobites and hyolithids. Together with V. Havlicek and M. Snajdr he dealt with modern investigations of the Ordovician in the Prague Basin, which resulted in the proposal of "Mediterranean" (peri-Gondwanan) chronostratigraphical units.

Olda Fatka and Petr Kraft

CAMOUFLAGED TRILOBITES?

Václav Petr (Charles University, Prague) and Petr Kácha (National Museum, Prague)

We have recently completed a preliminary study on the interesting possibility of frequent occurrence of camouflage and mimicry among Barrandian Ordovician trilobites. Curiously, to date, most of the articles on fossil camouflage and mimicry have been concentrated on finding colours or colour patterns in the fossil record. Other characteristics of camouflage and mimicry (including those best observable in the fossil record, i.e., morphological ones) do not play an important role in the paleontological research. While it is generally accepted that there are many examples of similarities in the fossil record resulting from close relationship (i.e., because of common ancestry), there has been less enthusiasm for the notion that two similar species at the same place and time were related as a "model" and its "mimic" or that they were camouflaged in the same manner. It is possible that many examples of species diversity in the fossil record and even the so-called "ecophenotypic" variations in a single fossil species have resulted from camouflage!

Paleontologists have traditionally searched only for the distinction of

"environmental" from "genetic" variations but ancient animals did not live in a sort of "abiological laboratory" environment. We have found, for example, that specimens of trilobites coming from fine-grained sediments bear dense, soft granulation on their carapaces (in extremely fine-grained sediments the carapax may be smooth), while those from coarse-grained ones are provided with large granules scattered on the outer surface of the exoskeletons. Such interesting correlations are found in many other Barrandian trilobites, including several common species such as the Ordovician dalmanitid *Dalmanitina socialis* (Barrande). The fact that the more ontogenetically younger trilobite individuals have coarser and more sparse granules on their exoskeleton indicates relatively stable diameter of the granules and points to a close connection of the granulation with the grain size of substrate. There are possibilities of many types of camouflage and mimicry in trilobites and several ones have been discussed previously by Lamont (1967, 1969). Unfortunately, the conclusions of the latter author have been typically ignored and never followed in the works of other specialists.

3rd BALTIC STRATIGRAPHIC CONFERENCE

The 3rd Baltic Stratigraphic Conference will be held in Tallinn, Estonia 8-12 October 1996 including an early Paleozoic excursion (two days). The main topic of the conference is high resolution biostratigraphy and Baltic regional stratigraphy. There are nearly 100 preliminary registrants from outside Estonia. The second circular is available from D. Kaljo (address and fax see Ordovician News No 12, e-mail kaljo@pzgeol.gi.ee). Deadline for final registration and abstracts is 1 June 1996.

D. Kaljo

WOGOGO, 1997

Next year, WOGOGO will be held in St. Petersburg during late August. If you have any questions regarding the organization, please contact Tatyana Koren.

Tatjana Koren

REPORT: SEVENTH INTERNATIONAL SYMPOSIUM ON THE ORDOVICIAN SYSTEM, LAS VEGAS, U.S.A., 12-16 JUNE 1995

Last June, some 140 people from 19 different countries attended the Seventh ISOS at the University of Nevada in Las Vegas. Despite the fact that the region includes some of the world's most spectacular scenery and an area of exceptional Ordovician rocks in the Basin Ranges, this was the first major international meeting on Ordovician geology to be held in western North America. Over 100 talks were presented in the four days of the technical sessions, plus a number of illuminating posters; almost too much to digest in the few days of the meeting. The organization of the program with a single, thematic set of talks each morning, worked very well. Afternoon sessions were concurrent, presented

in adjacent lecture rooms to accommodate the large number of volunteered talks.

Short papers of the talks and posters were published by the Pacific Section of the Society for Sedimentary Geology (SEPM) on 12 June, in a massive, 498-page compilation of the scientific content of the meeting, edited by John Cooper and others (1995). This report will therefore focus mainly on the organization of this important meeting, highlights of the technical program, the field trips to the Great Basin, and the workshops conducted by the International Subcommittee on Ordovician Stratigraphy.

First, we owe a debt to four persons, Stan Finney and Margaret (Peg) Rees as Co-Chairs, John Cooper as Publications Editor, and Mary Droser as Technical Program Co-ordinator. Each made major contributions towards the smooth running of the meeting. Additionally, Peg acted as Correspondence Secretary and Treasurer. The University of Nevada in Las Vegas was an excellent choice of venue, with good, inexpensive accommodation in a student residence (Tonopah Hall), easy access to meals at the student Dining Commons and nearby restaurants, and first-class adjoining lecture theatres in the Bigelow Physics Building for the technical sessions.

The two Honorary Co-Chairs presented important keynote talks, Lehi Hintze on the history of Ordovician research in western Utah, and Reuben J. Ross Jr., a paper entitled "The New World, Glass Slippers and Red Tape". Another highlight involved the presentation of the theme entitled "Paleogeography and Basin Analysis: Argentina and other areas of South America". It included papers by Riccardo Astini and others documenting the movement of the Argentine Precordilleran exotic terrane across the Iapetus Ocean, from a low-latitude position at the edge of Laurentia in the early Ordovician to the high latitudes of the South American margins of Gondwana by late Ordovician time.

Of the various social events, most notable and enjoyable were the welcoming reception in the Marjorie Barrick Museum of Natural History on the Las Vegas campus, and the cruise and Symposium Dinner early evening Thursday on Lake Mead aboard the "Desert Princess".

The five field trips were comprehensive in their coverage of the Ordovician geology of the Basin Ranges, including: (1) a seven day, pre-Symposium transect of the Central Great Basin (leaders Ray Ethington, Stan Finney, Jim Miller, Reuben (Rube) Ross, Lehi Hintze and Chris Valdes-Camin); (2) a one-day mid-Symposium excursion to study the large carbonate mud mound at Meikeljohn Peak (leader Rube Ross); then the first of the post-Symposium field trips, (3) a six-day excursion focusing on the patterns of the Ordovician radiation and the end-of-Ordovician extinction events as depicted in the Great Basin (leaders Mary Droser and Peter Sheehan); (4) a five-day examination of the Great Basin graptolitic succession (leaders Stan Finney, Bill Berry and Mike Murphy; and (5) a two-day study of the transition between the Lower Ordovician rocks of the cratonic margin (Spring Mountain, Nevada, and Mohawk Hill, California), and the inner miogeocline (Nopah Range, California) with leaders John Cooper and Martin Keller. Details of these field trips are contained in the well-illustrated, 151-page, guidebook, edited by John Cooper (1995), and also published prior to the meeting by the Pacific

Section of the Society for Sedimentary Geology (SEPM). This volume provides the most complete, up-to-date treatment of the highlights of Ordovician geology in the Great Basin, as emphasized by John Cooper in his Preface, "everything from graptolites to mudmounds to paleokarst to faunal communities to stratotypes, and shallow-marine to deep basin facies".

The last group of Ordovician workers to attend an official, internationally sponsored, field excursion to the Great Basin was in 1977, in the lead up to the Third International Symposium on the Ordovician System at Ohio State University. As a member of that select group 18 years ago, I long cherished the memories of seeing for the first time, under the expert guidance of Rube Ross, Lehi Hintze and Jim Miller, the magnificent sections in the Ibex area of western Utah, and in Whiterock Canyon, Ibex Canyon, Martins Ridge and in the Roberts Mountains area of Nevada. I enjoyed revisiting these sections on the pre-Symposium excursion, but the real bonus was to be able to fully appreciate the significance of the scientific achievements of our leaders, Rube, Lehi, Jim, Ray Ethington, Stan Finney and colleagues. In less than two decades, they have made tremendous advances in the understanding of the complex Ordovician biostratigraphic, paleoenvironmental, paleogeographic and paleotectonic histories of the Great Basin, and also significant progress towards completing the documentation of the type-Ibexian and type-Whiterockian stratotype successions.

A number of important International Subcommittee on Ordovician Stratigraphy workshops on boundaries and subdivisions and business meetings were also scheduled, unfortunately, because of the large numbers of volunteered talks in the technical program, limited to time slots in the evenings and the early mornings (with accompanying breakfast). First, there was a meeting of the Cambrian-Ordovician Boundary Working Group, chaired by Roger Cooper, on the evening of 12 June. Fifty people attended this 2-hour meeting which mainly focused on discussion of ways the new Working Group should evaluate the prime candidate section at Dayangcha, N. China. Rob Ripperdan expressed doubts, based on the record of carbon isotope signatures, on the continuity (or was it condensation) of the Dayangcha section. Bob Nicoll indicated that work was currently progressing on the description of a new species of *Iapetognathus* as a possible defining species. The nine Voting Members of the Working Group also met independently on a number of separate occasions to discuss their future work program.

Two Intra-Ordovician Workshops were also scheduled. The first on the evening of the 13 June focused on establishing a tripartite Series subdivision (formally named Lower, Middle and Upper) for the Ordovician System. Straw votes showed preference for a tripartite subdivision using the base of *laevis* conodont Biozone/*lunatus* graptolite Biozone, rather than the base of the *austrodentatus* graptolite Biozone, to mark the boundary between the Lower and Middle Series, and the base of the *gracilis* graptolite Biozone to mark the boundary between the Middle and Upper Series. The *gracilis* Biozone achieved particularly strong support (35 for; 0 against; 5 abstain).

The second Intra-Ordovician Workshop, held after the banquet on the evening of 15 June, was principally concerned with discussion of two potential stage boundary levels,

namely, at the base of the *approximatus* graptolite Biozone, and at the base of the *austrodentatus* Biozone. The first was approved for further consideration in a postal ballot in 1992 (approximating to the base of the British Arenig Series), with an horizon in the Ledge section at Cow Head, Newfoundland, proposed as a GSSP in 1994. However the formal vote was postponed when no clear majority was achieved and a number of issues were raised for further consideration during the voting process. A particularly important, alternative section in southern Sweden has since been proposed. Consequently two submissions, a revised proposal from Henry Williams and colleagues for the Cow Head section, and a new proposal from Stig Bergström and others for the Swedish section, will be submitted by 31 March 1996, as the basis for a further postal ballot. Chen Xu, Chuck Mitchell and others, are preparing a second, independent, GSSP proposal, also for submission by 31 March 1996, detailing the base of the *austrodentatus* graptolite Biozone in the Huangnitang section of Zhejiang Province, SE China, and an auxiliary section documenting equivalent beds on the Yantgtze Platform, as the basis for another global Stage division.

The main business meeting of the Subcommittee on Ordovician Stratigraphy was held on the evening of the 14 June, following the mid-Symposium field trip to Meikeljohn Peak. It was attended by about 40 persons. The fifteen Voting Members of the Subcommittee attending the Las Vegas meeting also met twice in early morning discussions on 13 and 16 June. Highlights of the business meeting included: (1) a decision to actively participate in the program of the 30th IGC in Beijing, August 1996, specifically in the Stratigraphy Symposium on the topic "Towards an Integrated Global Ordovician Time Scale: Boundaries and Subdivisions" (convenors Chen Xu and Barry Webby), and to organize a pre-IGC field trip to examine Ordovician sections to the Tarim Basin of NW China (organizers Chen Xu and Zhou Zhi-yi); (2) a report of the Nominating Committee on its task to find a person (or persons) to act as the next Chair of the Ordovician Subcommittee, from August 1996 (Stan Finney was subsequently nominated as Chairman Elect by the Voting Members; his acceptance of the nomination now awaits ratification by the International Commission on Stratigraphy); and (3) the meeting voted in favour of the next (the eighth) International Symposium on the Ordovician System being held in Prague, between July and September, 1999.

Barry D. Webby

(This report is modified from an original published in the December 1995 issue of *Episodes*)

REPORT: FRIENDS OF THE ORDOVICIAN MEETING

The Friends of the Ordovician convened at 5:30 PM on November 7, 1995, in the Doubletree Hotel in New Orleans during the annual meeting of the Geological Society of America. All of the sixteen assembled Friends introduced themselves to other members of the group and summarized their current interests and research on matters Ordovician. A diversity of geographic, stratigraphic, and taxonomic specialties was represented within

the group, and the inclusion of a goodly number of graduate students suggests that the Ordovician will continue to have Friends in the US for some years to come. Mary Droser called attention to a symposium on Ordovician Radiation and Extinction that she and Peter Sheehan are organizing for the forthcoming North American Paleontological Convention in Washington, D. C. Ray Ethington mentioned the on-going efforts of the Cambrian/Ordovician Boundary Working Group to reach closure on a boundary stratotype for the base of the Ordovician System.

Ray Ethington

RUSSIAN LITERATURE ON ARCTIC RESEARCH

EcoShelf, has begun to issue monthly reviews of Russian literature on Arctic Research. The review will comprise abstracts of newly published Russian literature. The abstracts translated into English will be grouped into Biology; Ecology; Geology; Glaciology; Meteorology; Oceanography and hydrochemistry; Offshore industry; Remote sensing; Sea ice. The most interesting or important news in Russian Arctic activity will be given. The review will be distributed in printed and/or via E-mail copies. Both institutions and individuals are welcome to subscribe for 1996. The cost of the annual subscription is \$90 (postage/e-mail cost not included). If you are interested, please, contact EcoShelf; indicate whether you would prefer printed or electronic copy (E-mail).

Nikolay Doronin

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NEW VICTORIAN MAPS

The Geological Survey of Victoria has now published 1:10,000 scale maps of the Bendigo goldfield (three in all) and Castlemaine (two maps), each with the tightly folded Ordovician shown subdivided into graptolite ZONES, with each zone individually coloured! The mapping at Bendigo is based on more than three thousand graptolite localities and supported by a great deal of lithological mapping (tracing of turbidite bands etc.). The Bendigo maps are contained in Geological Survey Report 93 entitled "Bendigo Goldfield (Spring Gully, Golden Square, Eaglehawk) 1:10,000 Maps Geological Report" by C.E. Willman and H.E. Wilkinson, cost A\$34.00. The Castlemaine maps are packaged in GSV Report 106, entitled "Castlemaine Goldfield (Castlemaine-Chewton and Fryers Creek) 1:10,000 Maps Geological Report" by C.E. Willman (A\$30.00). The Kilmore map plus report costs A\$26.00. The reports are available from: Business Centre, Dept of Agriculture, Energy & Minerals, P.O. Box 2145, MDC.

Fons VandenBerg

PUBLICATIONS FROM THE SEVENTH ORDOVICIAN SYMPOSIUM, LAS VEGAS

John Cooper and coauthors produced two magnificent volumes for the Las Vegas meeting, which are still available at bargain prices. Contents of *Ordovician Odyssey* are listed below (many thanks to Mary Droser for supplying this to me electronically). Both books are available for purchase from John Cooper, managing editor, Pacific Section, SEPM, at Dept. of Geological Sciences, California State University-Fullerton, Fullerton, CA 92634, USA. Prices in US dollars are - Book 77, \$40; Book 78, \$15; and postage for both volumes, \$6.25; contact John Cooper if you wish to pay by credit card.

Cooper, J.D., Droser M.L. and Finney, S.C. (eds), 1995. *Ordovician Odyssey: Short Papers for the Seventh International Symposium on the Ordovician System. Las Vegas, Nevada, USA*. The Pacific Section of the Society for Sedimentary Geology (SEPM), Fullerton, California. Book 77, x+498 pp.

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ORDOVICIAN ODYSSEY: TABLE OF CONTENTS

Biostratigraphy I: the Ordovician big picture

The New World, glass slippers, and red tape, *Reuben J. Ross, Jr*

Towards an Ordovician time scale, *Barry. D. Webby*

The Ordovician Series of the historical type area: revision as a contribution to their utility in international correlation, *Richard A. Fortey*

A conodont-based composite standard for the North American Ordovician: progress report, *Walter C. Sweet*

Correlation of Ordovician rocks of northern Alaska, *Anita G. Harris, Julie A. Dumoulin, John E. Repetski, Claire Carter*

Ordovician trilobite zonation in western Argentina, *Bruno A.J. Baldis*

Review of Ordovician conodont-graptolite biostratigraphy of the Argentine Precordillera, *Guillermo L. Albanesi, Mario A. Hünicken, Gladys Ortega*

Biostratigraphy II: series and stages around the World

Ibexian: a unique interval in the Ordovician, *William B. N. Berry*

Ozarkian and Canadian systems: gone and nearly forgotten, *Malcolm P. Weiss, Ellis L. Yochelson*

An affirmation of the Jeffersonian Stage (Ibexian) of North America and a proposed boundary stratotype, *James D. Loch*

Revision of the North American late Middle Ordovician standard stage classification and timing of the Trenton transgression based on K-bentonite bed correlation, *Stephen A. Leslie, Stig M. Bergström*

Oretanian and Dobrotivian stages vs. "Llanvirn-Llandeilo" series in the Ordovician of the Iberian Peninsula, *J.C. Gutiérrez-Marco, I. Rábano, M.A. San Jose, P. Herranz, G.N. Sarmiento*

A biostratigraphical approach to the Middle Ordovician conodonts from Spain, *G. N. Sarmiento, J. C. Gutiérrez-Marco, I. Rábano*

Oelandian (early Ordovician) biostratigraphy on the basis of Öland sections, Baltica, *Svend Stouge, G. Bagnoli, A. T. Nielsen, C. Ribecai, M. Tongiorgi*

Biostratigraphy III: the regional story

Ordovician basin dynamics and new graptolite data from the Tarija region, Eastern Cordillera, south Bolivia, *B-D Erdtmann, J. Kley, J. Müller, V. Jacobshagen*

Geodynamic processes in the Ordovician of the Argentine Precordillera: new biostratigraphic constraints, *Oliver Lehnert*

Facies relationships and conodont biostratigraphy of the upper McKay Group (Lower Ordovician), southern Canadian Rocky Mountains, *L. McKenzie McAnally, Christopher R. Barnes*

Biostratigraphy of the Advance Formation, a new upper Middle Ordovician unit, northern Rocky Mountains, *Brian S. Norford, G. S. Nowlan, Thomas E. Bolton, Robert J. Elias, Jisuo Jin, P. A. Johnston, David M. Rohr*

Correlation of selected late Lancefieldian-Bendigonian (early Ordovician) successions, *John H. Shergold, John R. Laurie, Robert S. Nicoll*

Biostratigraphy of the Prices Creek Group (early Ordovician, late Lancefieldian-Bendigonian), on the Lennard Shelf, Canning Basin, western Australia, *John H. Shergold, John R. Laurie, Robert S. Nicoll*

Stratigraphical significance of the *Svobodaina* species (Brachiopoda, Heterorthidae) range in the Upper Ordovician of south-western Europe, *Enrique Villas, David A. T. Harper, Michel Mélou, Daniel Vizcaino*

Acid insoluble residues, regressive-transgressive events, and conodont biostratigraphy in the Upper Cambrian and Lower Ordovician of western Utah and central Texas, *James F. Miller*

Stratigraphic position and significance of *Jujuyaspis* and *Iapetognathus* in the Wilberns Formation, Texas, *James F. Miller, James H. Stitt*

Biostratigraphic significance of *Iapetognathus* (Conodonta) and *Jujuyaspis* (Trilobita) in the House Limestone, Ibexarea, Utah, *James F. Miller, Michael E. Taylor*

Re-examination of the conodont biostratigraphy at the Cambro-Ordovician Xiaoyangqiao section, Dayangcha, Jilin Province, China, *Godfrey S. Nowlan, Robert S. Nicoll*

Distribution of brachiopods across the Cambrian-Ordovician boundary on the East European Plate and adjacent areas, *Leonid E. Popov, Lars E. Holmer*

Conodont distribution in a deep-water Cambrian-Ordovician boundary sequence from south-central Kazakhstan, *Leonid E. Popov, Tatjana Ju. Tolmacheva*

Conodont biostratigraphy of the Cambrian-Ordovician boundary in the northwestern of Argentina, *Raquel I. Rao, Mario A. Hunicken*

Correlation and definition of boundaries

Carbon isotope ratios from the Cambrian-Ordovician boundary section at Lawson Cove, Wah Wah Mountains, Utah, *Robert L. Ripperdan, James F. Miller*

High-resolution trilobite and conodont biostratigraphy across the Cambrian-Ordovician boundary in south-central New Mexico, *John F. Taylor, John E. Repetski*

The Diabasbrottet section at Mt. Hunneberg, province of Västergötland, Sweden: a proposed candidate for a Global Stratotype Section and Point (GSSP) for the base of the second series of the Ordovician System, *Jörg Maletz, Anita Löfgren, Stig M. Bergström*

Conodonts from the Cambrian-Ordovician boundary interval of Greenland, *Maxine Y. Huselbee*

The Tremadoc/Arenig transition in the Argentine Precordillera, *Oliver Lehnert*

The search for global biostratigraphic reference levels in the Ordovician System: regional correlation potential of the base of the North American Whiterockian Series, *Stig M. Bergström*

Base of Whiterock Series correlates with base of *Isograptus victoriae lunatus* Zone in Vinini Formation, Roberts Mountains, Nevada, *Stanley C. Finney, Raymond L. Ethington*

Graptolite species succession across the base of the *Undulograptus austrodentatus* Zone at Hunagnitang, south-central China, and its prospects for use as a global stage stratotype, *Chen Xu, Charles E. Mitchell, Zhang Yuan-dong, Stig M. Bergström, Donald Winston, Wang Zhi-hao, Jörg Maletz*

An important Ordovician-Silurian boundary interval section in the Vinini Formation, Roberts Mountains, Nevada, *Stan C. Finney, William B. N. Berry, W.C. Sweet*

Evidence and concerns with regard to the Late Ordovician glaciation in North Africa, *Phillipe Legrand*

Chitinozoans and Late Ordovician glacial events on Gondwana, *Florentin Paris, Z. Elaouad-Debbaj, J. C. Jaglin, D. Massa, L. Oulebsir*

Paleogeography and paleobiogeography

Paleoclimates and paleogeographic paths of the Argentine Precordillera during the Ordovician: evidence from climatically sensitive lithofacies, *Ricardo A. Astini*

The evolution of faunal provincialism in the Argentine Precordillera during the Ordovician: new evidence and paleogeographic implications, *Juan L. Benedetto, Marcelo Carrera, Teresa M. Sánchez, Norberto E. Vaccari*

Preliminary analysis of the distribution of early Ordovician graptolites from the Argentine Precordillera, *Edsel Daniel Brussa*

Ordovician graptolites of South America: palaeogeographic implications, *Jörg Maletz, Gladys Ortega*

Early Ordovician trilobite biogeography of Precordillera and Famatina, western Argentina: preliminary results, *N. Emilio Vaccari*

Simpson paleogeography, southern Midcontinent, U.S.A., *Raymond W. Suhm*

Ordovician palaeogeography and biogeography in China, *Wang Xiaofeng, Chen Xiaohong*

Outline of Ordovician palaeogeography, Tarim, northwest China, *Zhou Zhiyi, Ni Yunan, Yuan Wenwei*

Ordovician basins

Continental slope deposits in the Argentine Precordillera: sediments and geotectonic significance, *Martin Keller*

Geologic meaning of Arenig-Llanvirn diachronous black shales (Gualcamayo Alloformation) in the Argentine Precordillera, tectonic or eustatic? *Richardo A. Astini*

Early Ordovician carbonate platform facies of the Argentine Precordillera: restricted shelf to open platform evolution, *Fernando Cañas*

Middle and Late Ordovician sea level change in the northern margin of Yangtze platform, P. R. China, *Jianqin Chen, Christopher R. Barnes*

Biotic response to volcanic and sedimentologic processes in a Gondwanic active plate margin basin: the Arenig-Llanvirn Suri Formation, Famatina Basin, northwest Argentina, *Maria G. Mángano, Luis A. Buatois*

The eastern end of Avalonia: continuation into northern central Europe, *Gerhard Katzung, Uwe Giese, Jörg Maletz, Thomas Servais, Geert Van Grootel*

Tremadoc of the East European Platform: stratigraphy, confacies regions, correlation and basin dynamics, *Bernd-Dietrich Erdtmann*

Ordovician of the Prague Basin: stratigraphy and development, *Oldrich Fatka, Jaroslav Kraft, Petr Kraft, Michal Mergl, Radek Mikulá, Petr Storch*

Ordovician basin analysis of China, *Chen Xu, Z. Yuan-dong, Li Yue*

Mid-Upper Ordovician flysch deposition, northern Gaspé Peninsula, Quebec: a synthesis with implications for foreland and successor basin evolution in the Northern Appalachian Orogen, *L. G. Kessler, II, A. R. Prave, Michel Malo, W. V. Bloechi*

Using rapid, multidimensional, graphic correlation to evaluate chronostratigraphic models for the mid-Ordovician of the Mohawk Valley, New York, *Peter M. Sadler, William G. Kemple*

Structural-tectonic control on Middle-Late Ordovician deposition of the Lexington Limestone, central Kentucky, *Frank R. Etensohn, Mark A. Kulp*

Depositional facies and sequences of Upper Ordovician shelf and shallow ramp carbonates of the eastern Great Basin (Utah and Nevada), U.S.A., *Mark T. Harris, Lora A. Sexton, Peter M. Sheehan*

Ordovician carbonate-shelf rocks of Sonora, Mexico, *Forrest G. Poole, J. H. Stewart, J. E. Repetski, A. G. Harris, R. J. Ross, Jr., K. B. Ketner, R. Amaya-Martinez, J. M. Morales-Ramirez*

Ordovician ocean-basin rocks of Sonora, Mexico, *Forrest G. Poole, J. H. Stewart, William B. N. Berry, Anita G. Harris, J. E. Repetski, R. J. Madrid, K. B. Ketner, Claire Carter, J. M. Morales-Ramirez*

Geological reconnaissance of Ordovician deep-marine sequences in central Sonora, Mexico, *Claudio Bartolini, Mariano Morales, Edgardo Barrera, Jose Dominguez, Luis Navarro, Luis Soto, Stanley Finney, Claire Carter*

Ordovician oceans and climates

Ibexian and post-Ibexian paleogeography based on climatically sensitive sediments and biogeographic data, *Arthur J. Boucot, Chen Xu, C. R. Scotese*

Model sensitivity of the Late Ordovician climate to atmospheric $p\text{CO}_2$, *Mark T. Gibbs, Eric J. Barron, Thomas J. Crowley, Lee R. Kump*

Hirnantian glaciation and the carbon cycle, *Lee R. Kump, Mark T. Gigg, Michael A. Arthur, Mark E. Patzkowsky, Peter M. Sheehan*

Nd isotopic composition of Early Paleozoic oceans: testing global models of paleogeography and paleoceanography, *Cynthia A. Wright, Christopher R. Barnes, Stein B. Jacobsen*

Gloeocapsomorpha prisca-driven organic carbon isotope excursion, late Middle Ordovician (Rocklandian), North American Mid-continent: new data from Nevada and Iowa, *Stephen R. Jacobson, Stanley C. Finney, Joseph R. Hatch, Gregory A. Ludvigson*

Sea level changes

North American Ordovician depositional sequences and correlations, *Charles A. Ross, June R. P. Ross*

Ordovician events and sea level changes on the western margin of Gondwana: the Argentine Precordillera, *Susana Heredia, Matilde Beresi*

Uppermost Cambrian and Lower Ordovician in northwestern Russia: sequence stratigraphy, sea level changes and bio-events, *Andrej V. Dronov, Tatjana N. Koren, Leonid E. Popov, Tatjana Ju. Tolmacheva, Lars E. Holmer*

Paleokarst in the lower Middle Ordovician of southeastern California and adjacent Nevada and its bearing on the Sauk-Tippecanoe boundary problem, *Martin Keller, John Cooper*

Middle Ordovician (Llanvirnian) sea level change recorded in shallow-water carbonates (Yeongheung Formation), Korea, *Chan Min Yoo, Tong Il Lee*

Sequences and meter-scale cyclicity of Middle to Late Ordovician cool water carbonates and clastics of Kentucky, *Mike Pope, J. F. Read*

Sea-level changes and correlation of Ordovician-Silurian boundary sections in Appalachian Basin and Anticosti Island based on cumulative aggradation plots, *Richard J. Diecchio*

K-bentonites: the explosive record

Middle Ordovician K-Bentonites discovered in the Precordillera of Argentina: geochemical and paleogeographical implications, *Warren D. Huff, Stig M. Bergström, Dennis R. Kolata, Carlos Cingolani, D. W. Davis*

Southern and Central Appalachian stratigraphy interpreted with the use of the Middle Ordovician Deicke and Millbrig K-bentonite beds, *Douglas E. McVey, Warren D. Huff*

Mineralogy and grain characteristics of Middle Ordovician K-bentonites from the Precordillera of Argentina, *Mark P. S. Krekeler, Warren D. Huff, Dennis R. Kolata, Stig Bergström, Carlos Cingolani*

Grain size variation in the Millbrig K-bentonite: an investigation of Ordovician eruption dynamics using image analysis, *Y-S. Zhang, Warren D. Huff*

Sedimentology

New stratigraphic contributions from reappraisal of the Middle Ordovician (Chazy and Black Riverian) lithostratigraphy of the Ottawa Embayment, eastern Ontario, Canada, *Osman S. Hersi, George R. Dix*

Origin of the Arenigian terrigenous rocks in the subpolar Urals, *Alexandra B. Ludina*

Depositional history of a Middle Ordovician, mixed-carbonate-clastic unit - the Kanosh Formation, eastern Great Basin, U.S.A., *Ronald R. McDowell*

Flat-pebble conglomerate: a characteristic lithology of Upper Cambrian and Lower Ordovician shallow-water carbonate sequences, *Jeong C. Kim, Young I. Lee*

Cambro-Ordovician proximal shelf deposits of Colorado, *Paul M. Myrow, Ray L. Ethington, James F. Miller*

Early/Middle Ordovician condensation in the Polish part of the Baltic Basin, *Teresa Podhalaska*

Meiklejohn Peak's fibrous calcite: implications for the Ordovician marine record, *Kenneth J. Tobin, Kenneth R. Walker*

Widespread "Bighorn Facies", Upper Ordovician, North America, *Donald H. Zenger, David V. LeMone*

Paleobiology: evolution and diversity

The Ordovician radiations: diversification and extinction shown by global genus-level taxonomic data, *J. John Sepkoski, Jr.*

Do eocrinoids belong to the Cambrian or to the Paleozoic evolutionary fauna?, *James Sprinkle*

Evolutionary origins of the Diplograptina, *Charles E. Mitchell, Jörg Maletz, Zhang Yuan-dong*

The nature of diversification and paleoecology of the Ordovician radiation with evidence from the Great Basin, *Mary L. Droser, Peter M. Sheehan, Richard A. Fortey, Xing Li*

Benthic assemblages in the northwestern of Gondwana: a test of the Ordovician evolutionary radiation model, *Teresa M. Sánchez, Beatriz G. Waisfeld*

Ecologic aspects of the Ordovician radiation of articulate brachiopods, *Mark E. Patzkowsky*

Ordovician microfossil diversity patterns in the Rapla section, northern Estonia, *D. Kaljo, J. Nõlvak, A. Uutela*

Sexual dimorphism in trilobites, with an Ordovician case study, *Nigel C. Hughes, Richard A. Fortey*

Ordovician buildups, biofacies and ecology

Lower Ordovician reefs of Hubei, China, and the western United States, *J. Keith Rigby, Mathew H. Nitecki, Zhu Zhongde, Liu Bingli, Jiang Yangwen*

Paleoecology of late Tremadocian reef-bearing strata in western Hubei Province of China, *Zhu Zhongde, Jiang Yanwen, Liu Bingli*

The good, the bad, and the ugly: the paleoecology of Ordovician sponge/algal reef

mounds, *Ronald A. Johns*

Late Ordovician sponge-dominated, island-slope biofacies, eastern Australia, *Barry D. Webby, Ian G. Percival*

Ordovician cephalopods: data from Siberia, *Olga K. Bogolepova*

The Chickasaw bryozoan reef in the Middle Ordovician of south-central Oklahoma, *Clifford A. Cuffey, Roger J. Cuffey*

Origin and relationship of the Late Ordovician Red River-Stony Mountain and Richmond solitary rugose coral provinces in North America, *Robert J. Elias*

Late Arenig - early Llanvirn conodont biofacies across the Iapetus Ocean, *Jan A. Rasmussen, Svend Stouge*

Early Ordovician trilobite biofacies in the Argentine Cordillera Oriental, southwestern Gondwana: paleoecologic and paleobiogeographic significance, *Beatriz G. Waisfeld*

Ordovician gastropods of New South Wales - ecologic and biogeographic relationships, *Ian G. Percival*

Paleobiogeography of Ordovician acritarchs: some general considerations, *Thomas Servais*

Paleobiogeography of the Macluritidae (Ordovician-Gastropoda), *A.P. Gubanov, David M. Rohr*

The evolution of tectonic structure, environments and communities of fauna in the Ordovician of Kazakhstan, *Mark K. Apollonov*

Infaunal communities and tiering in Ordovician shallow marine terrigenous clastic and carbonate settings: ichnofabric and trace fossil evidence, *Mary L. Droser, Nigel C. Hughes*

Late Ashgillian brachiopod communities of the subpolar Urals, *Tatyana M. Beznosova*

Stratigraphic paleontology

First appearance of selected Early Ordovician acritarch taxa from peri-Gondwana, *Rainer Brockel, Oldrich Fatka, Stewart G. Molyneus, Thomas Servais*

Ordovician nautiloid cephalopod faunas from southeastern British Columbia: biostratigraphic and biogeographic significance, *R. C. Frey, Brian S. Norford*

Trilobite ecophenotypes: examples from the Lower Ordovician of Baltica, *Arne T. Nielsen*

A new occurrence of the genus *Euzonosoma* (Echinodermata: Ophiuroidea) from the Middle Ordovician Gull River Formation (Cardocian) of Ontario - first North American record of the Encrinasteridae, *F.H.C. Hotchkiss, D.K. Armstrong, D.M. Rudkin*

Stratigraphically significant Early and Middle Ordovician gastropod occurrences, western and northwestern Canada, *David M. Rohr, Brian S. Norford, Ellis L. Yochelson*

The initial Ordovician bivalve molluscs radiations on the western Gondwanan shelves, *Claude Babin*

PALAEOWORLD SPECIAL ISSUE ON THE BASE OF THE AUSTRUDENTATUS ZONE

Chen Xu and Stig Bergström have edited the summary of this interval which has received much attention recently as a possible level for defining the lower boundary of a global subdivision of the Ordovician System. The full reference is:

CHEN, X., and BERGSTRÖM, S.M. 1995. The base of the *austrudentatus* Zone as a level for global subdivision of the Ordovician System. *Palaeoworld* 5, 117 p. 5 pls, 39 figures.

The volume includes the following papers:

Regional stratigraphy and paleogeography (CHEN, X.)

Introduction-historical review (CHEN, X., and BERGSTRÖM, S.M.)

Lithological description of the sections (ZHANG, Y-D and WINSTON, D.)

Sedimentary rocks and depositional environments (WINSTON, D. and ZHANG, Y-D.)

Castlemainian to Darriwilian (late Yushanian to early Zhejiangian) graptolite faunas (CHEN, X., ZHANG, Y-D, and MITCHELL, C.E.)

Graptolite Composite Standard Sequence (GCSS) (ZHANG, Y-D.)

International correlation of the *Undulograptus austrudentatus* Zone (MITCHELL, C.E. and CHEN, X.)

Castlemainian (Late Yushanian) to Darriwilian (Zhejiangian) conodont faunas (WANG, Z-H, and BERGSTRÖM, S.M.)

Global correlation of Castlemainian to Darriwilian conodont faunas and their relations to the graptolite zone succession (BERGSTRÖM, S.M. and WANG, Z.)

Early Ordovician chitinozoans from the Huangnitang section and nearby localities in the Jiangshan-Changshan-Yushan (JCY) area (PARIS, F, and CHEN, X.)

Castlemainian K-bentonite beds in the Ningkuo Formation of the Jiangshan County - The first Lower Ordovician K-bentonites found in China (HUFF, W.D. and BERGSTRÖM, S.M.)

A proposal-the base of the *austrudentatus* Zone as a level for global subdivision of the Ordovician system (CHEN, X. and MITCHELL, C.E.)

CURRENT RESEARCH

AICHA ACHAB, Esther Asselin and Denis Lavoie (Canada) are presently undertaking a chitinozoan study of Ordovician strata from Saguenay-Lac Saint Jean regions to determine the relationship with colder microfauna of the Saint Lawrence Lowlands.

DICK ALDRIDGE (UK) reports continued work with Hannes Theron (South Africa) and Sarah Gabbott (UK) on the Soom Shale Conservation Lagerstätte in South Africa; new funding means that this project will continue for at least two more years. A project is also under way with Viive Viira (Estonia) on Ordovician conodont apparatuses, primarily prionodontids.

CHRIS BARNES' (Canada) overall aim in life at present is to understand Lower Paleozoic paleogeography, paleobiogeography and global bioevents using conodonts. Platform to basin transects in northern Laurentia are being undertaken in several areas; work on the Newfoundland Appalachians is nearing completion with several studies recently published, or in final preparation (with **D. Johnston** and **F. O'Brien**); comprehensive field programs have been completed in the southern Canadian Cordillera (with **Z. Ji** and **L. McKenzie McNally**) and new ones are in progress in the northern Cordillera (with **L. Pyle**). Other regional projects by students include those of **J. Chen** on the Ordovician faunas of North and South China and by **G. Albanesi** (co-supervised with **M. Hunicken**) on the Ordovician faunas from the Argentine Precordillera. Studies of strontium and neodymium isotope geochemistry using Lower Paleozoic conodonts are now being prepared for publication (with **C. Wright**, **J. Veizer** and **S. Jacobsen**). Papers in press include those on Ashgill conodonts from the Kalkbank Limestone of Germany (with **A. Ferretti**; in *Palaeontology*) and on Uppermost Cambrian and Lower Ordovician conodonts of the Survey Peak Formation from southern Alberta (with **Z. Ji**; in *Journal of Paleontology*). Projects in final publication phase during the current sabbatical leave include Ashgill conodonts from the Shoalshook Limestone of Wales (with **A. Ferretti**).

BRUNO BALDIS (Argentina) is continuing his studies on trilobite faunas of Argentina and other parts of South America, paying particular attention to the evidence provided in terms of characterizing the biogeographic changes related to the isolation, drift and docking of the Precordillera during the Ordovician.

MICHAEL BASSETT (UK) is working on a number of Ordovician brachiopod faunas from various parts of Britain and Baltoscandia - all in differing states of progress but with one or two close to completion. The main topics are on craniids from Estonia and Sweden, an Hirnantian fauna from subsurface Lithuania, Caradoc-Ashgill material from Dalarna (Sweden) and Hadeland (Norway), Arenig 'articulates' from South Wales, and Tremadoc lingulates from Shropshire (with Ph.D student **Mark Sutton, Cardiff**). Work on higher level brachiopod classification continues with his colleagues in Sweden (**Lars Holmer** and **Leonid Popov**), all involving discussion of some Ordovician taxa. With **Lesley Cherns (Cardiff)** he is analysing all Ordovician - Silurian boundary sequences throughout the Scandinavian Caledonides as a means of building a picture of dynamic sedimentary facies evolution throughout this critical interval when Iapetus closure exerted major control on the Scandinavian foreland basin development and on the pattern of facies across the adjacent Baltoscandian Platform.

RICHARD BATCHELOR (UK) is working on the geochemistry of Lower Paleozoic bentonites to aid correlation and to understand petrogenetic associations of contemporary magmatism. In collaboration with **Tony Weir (St Andrews)** and **Nils Spjeldnaes (Oslo)**, he is currently working on a suite of Ordovician metabentonites

from the Oslo region, with a view to describing a petrogenetic history of the source magmas. In addition, these metabentonites will be compared chemically with a similar suite from Sweden in the hope of correlating them. Detailed work on Scottish metabentonites is continuing.

STIG BERGSTRÖM (US) has been continuing his studies on Ordovician rocks and faunas, especially in Baltoscandia, Argentina and China. He presently has a number of papers in press or review, including a study with **Dan Goldman** of Upper Ordovician graptolites from the North American Midcontinent. Much of his time during 1995 has been spent on Ordovician K-bentonites and his cooperative efforts with **Warren Huff** and **Dennis Kolata** have resulted in several papers, including a large monograph of North American Ordovician K-bentonites that has been approved for publication as a *GSA Special Paper*. A major undertaking last year was the 117 page *austrodentatus* Zone monograph recently published as a separate volume of *Palaeoworld*, for which he served as co-editor in addition to being co-author on four of the papers.

PETR BUDIL (Czech Republic) is continuing his study of Bohemian dalmanitid trilobites. A revision of the earliest (Arenigian) representatives of genus *Ormathops* in Barrandian area has been published, while a revision of the Bohemian representatives of genera *Mucronaspis* and *Songxites* from the Upper Ordovician is in press. A short paper with **R. Saric** has also been published about the discovery of a cemented crinoid on the exoskeleton of the selenopeltid trilobite.

ROBIN COCKS (UK) is working on a late Ashgill brachiopod fauna from the Taimyr Peninsula, Siberia, jointly with **Tanya Modzalevskaya of VSEGEI, St Petersburg**; on an Hirnantian fauna from Thailand, jointly with **Richard Fortey**; and on the Avalonian palaeocontinent, jointly with **Stuart McKerrow**.

ROGER COOPER (New Zealand) is trying to make sense of the *Rhabdinopora* complex, and to get a globally applicable set of zones or biohorizons for correlation. So far he has visited Berlin (for 2 months), Estonia, and St Petersburg in Russia in the attempt. He thinks that a model can be devised that works well and involves both biofacies and time in the distribution of the so-called zones.

JOHN COPE (UK) is beginning work on the Ordovician once again, following a break to write up some Jurassic ammonite faunas. He has just completed a large paper on Arenig bivalve species (including twenty species from eighteen genera in a single quarry), and has several other bivalve projects in the works.

MARY DROSER (US) is continuing her work examining the nature of the ecology of the Ordovician radiation with **Peter Sheehan** primarily through field work on the Ordovician of the Great Basin. Work is progressing with **Richard Fortey** on the

Whiterockian trilobites of the Great Basin. PhD student **Xing Li** is finishing up his dissertation on Cambrian and Ordovician shell beds of the Great Basin. PhD student **Jan Arnett** is beginning a thesis on the taphonomy and paleoecology of outer shelf Ordovician faunas of the Great Basin. Mary is also working on the trace fossils and ichnofabric of the type Cincinnati in Ohio - specifically examining how the ichnological record relates to the distribution of body fossils and high resolution stratigraphic framework being worked on by **Arnie Miller** and **Dave Meyer (Univ. of Cincinnati)** and **Steve Holland (Univ. Georgia)**. Work also continues with **Nigel Hughes (Cincinnati Museum of Natural History)** on the early Paleozoic distribution of *Rusophycus*.

JAN OUVÉ EBBESTAD (Sweden) is investigating Upper Ordovician gastropods across the Baltic Shield for a Ph.D. with **John Peel** as his supervisor, with consideration of taxonomy, biostratigraphy, functional morphology and palaeoecology. His masters thesis on a revision of the Lower Ordovician (Tremadoc) trilobites of the Bjørksholmen Formation (formerly the Ceratopyge Limestone) of the Oslo Region was finished in Oslo 1993 under the supervision of **David Bruton**; this is now being prepared for publication.

BOB ELIAS (Canada) is studying various aspects of corals during the Ordovician radiation, mass extinction and Early Silurian recovery. Research with **Graham Young** focuses on the diversity, distribution and organizational complexity of latest Ordovician to earliest Silurian coral faunas. Doctoral student **Adam Melzak** is working on rugose corals from the Upper Ordovician to lowermost Silurian of Anticosti Island, Quebec.

BERND ERDTMANN (Germany) started a new project on the Riphean to Ordovician stratigraphy in the southern Urals in cooperation with colleagues **Kirill Ivanov** and **Andrei Maslov** and **Ivo Paalits**. Currently investigations are focussed on a sharp angular unconformity between Vendian and ?Arenigian rocks (pre-Caledonian!) in Bashkiria. The (graptolite supported) biostratigraphic work in the Eastern Cordillera of southern Bolivia will now be extended into neighbouring northern Argentina. Together with colleagues from the **University of Salta (Cristina Moya et al.)**, **Thomas Heuse** and a new TUB doctoral student the three distinct structural-depositional Ordovician "segments" of the Eastern Cordillera will be subjected to intensive sequence analysis based on graptolite and chitinozoan supported reference sections. These data will be correlated with event-derived chemo-indicators for the Tremadoc-Hunneberg-Arenig (Yuncharß Segment), Arenig-Llanvirn (Mocharß Segment) and Llandeilo-Caradoc (Atocha Segment) dominated basins from east to west. Field work in the Atocha region in August 1995 confirmed a Llandeilo to middle Caradoc age for that volcanoclastic forearc sequence (northern extension of Argentine "Puna"). A third project with **Roger Cooper**, **Jörg Maletz** and **Wang Haifeng (Nanjing)** is dealing with a redescription of *Rhabdinopora* and *Staurograptus* form groups and their precise ranges in

the Dayangcha and Green Point sections.

RAY ETHINGTON (US) has spent the year depressurizing from the ISOS pre-symposium field trip and will spend the coming months preparing a detailed report (with **Stan Finney**) on the graptolite/conodont biostratigraphy of the Vinini Formation in the Roberts Mountains, Nevada.

OLDRICH FATKA (Czech Republic) is continuing studies on Lower and Middle Ordovician acritarchs and chitinozoan of Bohemia. He organized a conference of the Acritarch Subcommittee of the C.I.M.P. in April 1996 in Prague in cooperation with **T. Servais**. Together with **Rainer Brocke (Germany)** and **Thomas Servais (Bergium)**, revisions of selected acritarch taxa are continuing.

ANNALISA FERRETTI (Italy) continues her work on Upper Ordovician European conodont faunas. A joint study with **Chris Barnes** on Ashgill conodonts from the Kalkbank Formation of Germany will be published soon. She has recently also completed a study of a small Ashgill conodont fauna from Bohemia.

JIM FLOYD (UK) is continuing to work on the Ordovician of the Southern Uplands of Scotland. Much of the southwestern part of the Southern Uplands is now covered by new 1:50 000 geological maps from BGS. Remapping continues towards the north-east and has almost reached the line of the River Nith. A revision of the Ordovician lithostratigraphy of the region (mostly the Northern Belt) is due to be published in early 1996. Work continues, with **A. Owen** and **H. Armstrong**, on the chert successions in the Southern Uplands.

BOB FREY (US) is currently working on the systematic description of a diverse Ordovician nautiloid fauna from southeastern British Columbia with **Brian Norford (Canada)**. He has also submitted a paper on the paleoecology of a distinctive, recurrent bivalve fauna from the Upper Ordovician of the Cincinnati Arch region for inclusion in a symposium volume on the paleobiology of bivalves (edited by Paul Johnston, Royal Tyrrell Museum of Paleontology in Canada). Bob continues to sort through much of the material inherited from Rousseau Flower and hopes to be restoring some of the "lost" material back to their proper repositories in the near future.

YNGVE GRAHN (Sweden) continues to work with **Jaak Nõlvak (Estonia)** on Ordovician climate in Baltoscandia, and on the lateral effects of the middle Ordovician asteroid impacts in the same region.

DAVE HARPER (Ireland) reports that work continues on the Ireland chapter for the Geological Society of London revised correlation of the Ordovician rocks of the British Isles. Various projects continue on Ordovician brachiopod faunas in Ireland (with

Matthew Parkes (Scotland) (with **Euan Clarkson** and **Alan Owen**), Poland and Spain (with **Enrique Villas**) together with Newfoundland (with **Henry Williams**). Research student **Yves Candela** has started monographic description of a new mid Ordovician brachiopod fauna from the Pomeroy inlier, Northern Ireland. The Palaeontological Association will shortly publish its field guide to Upper Ordovician Fossils (edited by Harper, D.A.T. and Owen, A.W.).

THOMAS HEUSE (Germany) is continuing biostratigraphic work on Ordovician palynomorphs (acritarchs, chitinozoans) in the Eastern Cordillera of S-Bolivia and N-Argentina.

LINDA HINTS (Estonia) is taking part in the new project (1996-1998) "Correlation and ecological interpretation of geo-events based on lithology, chemistry, fossil and isotope contents of early Palaeozoic rocks of the Baltic basin" (P.I. **Prof. D. Kaljo**). Objectives of this project are to learn about palaeoclimatic characters of time preceding and following the latest Ordovician glaciation, ecosystem dynamics and exact dating of different events. Linda is also continuing her studies of later Ordovician brachiopods, taxonomic composition, distribution, associations.

OLE ANDREAS HOEL (Norway) is nearing the end of his research project on trilobites from the Hunneberg Substage in Norway. It is quite certain that there is a hiatus in Norway between the uppermost Tremadoc and Lowermost Arenig, where the Zone of *Megistaspis (Ekeraspis) armata* is missing. The trilobites present in Norway seem to mostly belong to the lower part of the *M.(E.) planilimbata* Zone, and include 21 species belonging to 18 genera. The fauna of this interval in Norway was for long considered to belong to the *Ceratopyge*-fauna, but the present work has shown that of the 18 genera and 21 species in the younger beds studied by me, only 8 genera and only 3 species are in common with the *Ceratopyge*-fauna.

LARS HOLMER (Sweden) is still mostly working with **Leonid Popov** and **Svetlana Koneva** on the Cambrian and Early Ordovician brachiopods and stratigraphy of Malyi Karatau Range in southern Kazakhstan. He is also studying Late Ordovician brachiopod assemblages of the Hiberno-Salairian type from Central Kazakhstan together with **Igor Nikitin** and **Leonid Popov**. Lars and **Mike Bassett** are also continuing their investigations into the phylogeny of the "inarticulated" brachs - in particular, the trimerellids and other calcareous-shelled ones.

DIMITRI KALJO (Estonia) with a team of colleagues has begun a project on integrating the late Ordovician stable isotope record of the Baltic region with the biostratigraphy. They are starting with Caradoc strata, but special attention will be paid to the Pirgu-Porkuni interval and its rugose corals (in cooperation with **B. Neuman, Bergen**).

MARTIN KELLER (Germany) is still working in the Ordovician of the Southern Great Basin together with **John Cooper** (sedimentology, sequence stratigraphy). In Argentina, **Oliver Lehrnert** and he are continuing with their studies in the Precordillera, but together with **Oswaldo Bordonaro** he will in the future include the other Ordovician carbonates further south.

TATJANA KOREN (Russia) is continuing her work on the Lower Ordovician of north-eastern Russia, with special attention being paid to the further biostratigraphic refinement and correlation of Tremadoc-Arenig eustatic events of different orders within the sequence stratigraphy. The working team includes **A. Dronov** (sequence stratigraphy), **T. Koren** (graptolites), **L. Popov** (brachiopods) and **T. Tolmacheva** (conodonts). Tatjana is also involved with **R. Sobolevskaya** in systematically describing Early to Late Ordovician graptolite faunas collected by her from the Northern Island of the Novaya Zemlja Archipelego of Arctic Russia during the 1980's.

JAROSLAV KRAFT (Czech Republic) is preparing a monograph on Bohemian Ordovician graptolites, and together with **Petr Kraft** is preparing a detailed study on selected aspects of the Arenig/Llanvirn boundary interval graptolites.

PETR KRAFT (Czech Republic) continues systematic and stratigraphic research in the Arenig and Llanvirn (together with **Jaroslav Kraft**). His studies are extending partly also into the Tremadoc, dealing with graptolites, worm-like fossils and problematica..

ED LANDING (US) reports that a report on conodont biostratigraphy and revised lithostratigraphy of the Tribes Hill Formation (Lower Ordovician) is in press; the Tribes Hill is another Laurentian lower Tremadocian-equivalent unit that unconformably overlies the Upper Cambrian *Cordylodus proavus* Zone. A project with **S.R. Westrop** and **A.J. Boucot** deals with discovery of the youngest Ordovician (Arenigian-Llanvirnian) conodont-trilobite-brachiopod faunas from Avalonian New Brunswick. The faunas come from limestone clasts in a Triassic conglomerate.

JOHN LAURIE (Australia) is awaiting publication of a two part monograph (with **John Shergold**) on the Early Ordovician trilobites of the Emanuel Formation and a paper on the trilobite and brachiopod faunas of the overlying Gap Creek Formation. Short papers detailing the biostratigraphy and correlation of these successions were presented at the Ordovician Symposium in Las Vegas.

OLIVER LEHNERT (Germany) continues to work on Cambrian and Ordovician conodonts from the Precordilleran Terrane in western Argentina. Together with **John Cooper** and **Martin Keller** he is investigating the Cambro-Ordovician conodont faunas from the inner miogeocline (Nopah Range/California) to the craton margin (Spring Mountains/Nevada) in the Southern Great Basin with respect to sequence boundaries.

ALF LENZ (Canada) reports that one of his students, **Mark Obermajer**, is nearing the completion of his doctoral thesis on "Thermal maturity and petroleum generation in Paleozoic (Ordovician to Devonian) rocks of southern Ontario"

PIERRE LESPERANCE (Canada) has begun systematic descriptions of selected Ashgill trilobites from the Percé area, Quebec, predominantly from the Pabos Formation (a sandstone unit below the White Head Formation).

JÖRG MALETZ (Germany) has moved once again back to Germany and has started work on a project dealing with the paleogeography of northern Germany, using mostly subsurface graptolite material from northern Germany (Island of Rügen) and Sweden (Scania). Two publications with **Thomas Servais** on Ordovician and Lower Silurian graptolites from Belgium are in progress. Further work on the Bolivian graptolite faunas is planned together with **Bernd Erdtmann**. Jörg is also studying the evolution and biostratigraphy of the lowermost Tremadoc graptolite faunas based on isolated material of *Rhabdinopora*, *Staurogaptus* and *Anisogaptus*.

SANDY MCCRACKEN (Canada) reports that work continues on Ordovician conodonts of Baffin Island. This is part of a project that includes work by **Tom Bolton**, **Bruce Sanford** and **John Riva**. New research will be on conodonts of the Devonian Period, but there is still unfinished work on Ordovician-Silurian conodonts from the Arctic Islands (especially Cornwallis Island), and Lake Timiskaming area of Ontario.

TONU MEIDLA (Estonia) is continuing work on the following topics: (1) late Ordovician ostracodes in Baltoscandia, (2) the Ordovician-Silurian boundary event and (3) early Ordovician ostracodes and sea-level changes.

JAAK NOLVAK (Estonia) continues work on Ordovician chitinozoans and stratigraphy from the Baltoscandia, together with colleagues **Linda Hints** and **Tonu Meidla** and in cooperation with **Yngve Grahn (Sweden)** and **Florentin Paris (France)** on chitinozoan dating of some key Ordovician events.

GODFREY NOWLAN (Canada) is currently working on: 1, Cambrian - Devonian biostratigraphy of the subsurface of the Western Canada Basin, Alberta; 2, Ordovician-Silurian boundary biostratigraphy and geochemistry; 3, Silurian conodonts from Canadian Appalachians; 4, CAI: regional evaluations and economic deposits; 5, Ordovician conodonts from Canadian Appalachians; 6, Cambro-Ordovician boundary.

FLORENTIN PARIS (France) continues his investigations on Ordovician chitinozoans. The processing of 85 samples collected by **Chen Xu** around the base of the *austrodentatus* Zone in the JCY area (South China) is now completed. In spite of their fairly poor preservation, these chitinozoans should provide useful ties with Gondwanan

assemblages. Other projects with **Jacques Verniers** and **Geert Van Grootel** (correlation based on chitinozoans between Brabant and northern Gondwana regions), and with **Yngve Grahn** and **Jaak Nolvak** (biological signification of chitinozoans), are in progress. Investigations with **Christophe Lecuyer** on the $\delta^{13}C$ of organic walled microfossils, including Ordovician chitinozoans, are continuing. The last issue of *Chitinozoan Newsletter* November 1995), edited by F. Paris and S. Sutherland, is available, preferably by E-Mail, upon request (contact F. Paris).

IAN PERCIVAL (Australia) finally has a permanent position, as Paleontologist in the Geological Survey of New South Wales. His job there includes providing biostratigraphic support for the Survey's regional mapping program (much of which is currently concentrating on the Ordovician to Devonian of the Lachlan Fold Belt). He is also curator of the State's paleontological collections. Ian continues to collaborate with **Barry Webby** on research into Late Ordovician island faunas from central NSW.

TERESA PODHALANSKA (Poland) is continuing her work on the stratigraphy and sedimentology of the low to mid-Ordovician transition in the Polish part of the Baltic Basin. New investigations are also carried out concerning the biological and chemical processes in condensed beds and also ultrastructure analysis of the microbial fabric and microbialites.

IVAR PUURA (Estonia) is working on the aspects of taxonomy, biostratigraphy, biomineralization and taphonomy of the Cambrian-Ordovician lingulate brachiopods from Baltoscandia.

JAN RASMUSSEN (Denmark) is currently working on Ordovician and Early Silurian conodont biostratigraphy and paleoecology of eastern North Greenland (with **Paul Smith, Birmingham**). Although difficult to admit, he is also spending a little time on Permo-Carboniferous conodonts from Peary Land, North Greenland.

KEITH RIGBY (US) is continuing his work on Ordovician sponges, together with sponges from other geological periods. Most emphasis is placed on North American faunas, but he is also involved with researchers in China looking at Lower and Middle Ordovician sponges. As part of that study, they are also concerned with comparisons of Ordovician reefs, particularly from Hubei Province, with those of the western US.

JOHN RIVA (Canada) left Laval University in the fall of 1995 and he is now a Visiting Professor at the Quebec Geoscience Centre in Ste-Foy, Quebec, a cooperative enterprise formed by the union of the geological section of the Research Institute of the University of Quebec (INRS-Georessources) and the Quebec branch of the Geological Survey of Canada (GSC-Quebec).

THOMAS SERVAIS (Belgium) continues work on the Ordovician of Belgium. He will be finishing a two year project concerning the study of Upper Ordovician rugose and tabulate corals (with **Eddy Poty** and **Francis Tourneur**) and graptolites (with **Jörg Maletz**) in September 1996. In October he will move to Berlin, Germany to work in **Bernd Erdtmann's** department (funded by a Humboldt Foundation Fellowship) on Ordovician acritarchs from East Avalonia. In spring 1997, he plans a three month stay with **Stewart Molyneux** at the British Geological Survey. A number of papers concerning Ordovician acritarchs and graptolites (in conjunction with **Olda Fatka**, **Rainer Brocke** and **Jörg Maletz**) are currently in press, while the "Annotated bibliographic index of Ordovician acritarchs" will finally be published in 1996.

JOHN SHERGOLD (Australia) is currently working on the late Cambrian and initial Ordovician trilobite faunas of the Bonaparte Basin in the north of Western Australia. Virtually all of the genera are previously known from south-central or northeastern China. A significant, and totally unexpected occurrence of the Cambrian-Ordovician boundary index trilobite *Jujuyaspis*, in coarse glauconitic sandstone, is reported. A more advanced project is that describing the Warendan (earliest Ordovician) trilobites of the Datson Member of the Ninmaroo Formation, Georgina Basin, western Queensland. This fauna is also of east Asian aspect, being most closely related to south-central China. A monograph on the Early Ordovician trilobites of the Emanuel Formation, Canning Basin, Western Australia, co-authored with **John Laurie**, remains in press with *Palaeontographica*.

JIM SPRINKLE (US) is still working with **Tom Guensburg** on Early Ordovician echinoderms from the Rocky Mountains and the transition between Late Cambrian and Early Ordovician echinoderms at the start of the Ordovician Radiation. A joint chapter on life modes of Cambro-Ordovician echinoderms has been written for a forthcoming book, and two joint papers are in progress describing new rhombiferan cystoids and camerate crinoids from the Fillmore and Wah Wah Formations of western Utah.

FONS VANDENBERG (Australia) still has a supply of the Vandenberg & Cooper (Ordovician graptolite sequence of Australasia) and is willing to send it to anyone on request.

VIIVE VIIRA (Estonia) continues her work on conodonts across the Cambrian-Ordovician boundary beds in Estonia.

HENRY WILLIAMS (Canada) seems to be looking at everything apart from graptolites! Recent research has been dominated by plants and other remains in fluvial Devonian and Carboniferous sequences, although he has also been able to apply his "academic research" background on Ordovician stratigraphy and paleontology to the intensive hydrocarbon exploration presently taking place in western Newfoundland.

Henry, Elliott Burden, Helen Gillespie, Grace Parsons and Felicity O'Brien are now being kept fully occupied with providing biostratigraphic and thermal maturation data to a number of oil companies for both subsurface drilling and surficial studies. Helen is also receiving industry funding for an M.Sc. on Late Ordovician acritarchs; **James Carter** has just begun graduate study on the structure, sedimentology and geochemistry of the Middle Ordovician Lawrence Harbour Formation of central Newfoundland (the equivalent of the Moffat Shale Group of southern Scotland).

YIN GONGZHENG (China), Zhou Zhiyi and Ron Tripp recently completed a one year study of trilobites from the Pagoda Formation of Sunyi, Guizhou Province. Twenty one species (including three new), assigned to eighteen genera (including one new) and fourteen families of trilobite are described.

GRAHAM YOUNG (Canada) is examining Late Ordovician colonial corals, with a focus on faunas from the Red River and Stony Mountain formations of Manitoba. Graham and **Bob Elias** have recently published a monographic treatment of latest Ordovician and earliest Silurian colonial corals from the east-central US. They are continuing to do collaborative work, looking at diversity, distribution, paleoenvironmental significance, and organizational complexity of latest Ordovician to earliest Silurian coral faunas.

ORDOVICIAN PUBLICATIONS, 1995

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