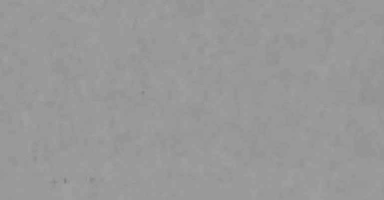
INTERNATIONAL UNION OF
GEOLOGICAL SCIENCES
COMMISSION ON STRATIGRAPHY

—S—D—S—

SUBCOMMISSION ON
DEVONIAN STRATIGRAPHY

NEWSLETTER No. 14

December 1997



I. U. G. S Subcommission on Devonian Stratigraphy

***Newsletter No. 14*, December 1997**

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The *Newsletter* appears annually following SDS meetings. Contributions may be sent to the Editor at any time during the year for inclusion in the next issue. Guidelines for consideration in the preparation of contributions are presented on the inside of the back cover.

The printing of this issue is 150 copies with 102 mailed to titular and corresponding members, 23 to honorary members, Chairmen of the Carboniferous and Silurian Subcommissions, IUGS and ICS officers, friends of the Devonian, and libraries. Remaining copies are available from the Chairman, Secretary, or Editor. The costs of preparation, printing and postage for the *Newsletter* are shared equally by SDS and The Department of Geology, University of Texas at Arlington.

The *Newsletter* can also be viewed in electronic published format via the SDS World Wide Web site at URL **http://geology.uta.edu/geoweb/sds**. The SDS anonyous ftp site at **ftp://geology.uta.edu/incoming** or **ftp://129.107.18.20/incoming** is maintained for the convenience of SDS members.

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EDITORIAL NOTES

Electronic SDS

The SDS web page is presently under construction and should be completed near the end of January 1997. The complete newsletter will be ready for viewing with a standard web browser (Netscape, Internet Explorer, or Cyberdog). If the web site does not appear properly with your current browser, you can download the most current versions of these browsers from the **SDS Anonymous ftp site**. The address of the SDS Anonymous ftp site remains **geology.uta.edu** if you use a standard file transfer program or **ftp://geology.uta.edu/incoming** if you use a web browser to connect to the site. If you have problems making a connection, contact me at **crick@uta.edu**.

I greatly appreciate all who used the ftp site to transfer contribution materials for the newsletter as well as those who have mastered the technique of attaching formatted text and graphics to e-mail messages. Your efforts greatly reduce my work load.

Registration Forms via E-mail

E-mail versions of the registration form for the IGCP 406 Warsaw Meeting and the registration form for the IGCP 421 Iran Meeting are available. The forms can be obtained automatically by sending an e-mail message to crick@uta.edu with the appropriate subject (WARSAW MEETING or IRAN MEETING) spelled as given here. See notes at the bottom of pages 23 & 28 for more information.

Digital Newsletter

Newsletter #14 is available as an Abode Acrobat Portable Document at http://geology.uta.edu/geoweb/sds/n14.pdf or by ftp at geology.uta.edu/incoming/sds/n14.pdf. Acrobat readers for Macintosh and Windows computers are available at http://www.adobe.com or http://geology.uta.edu/geoweb/sds.

MESSAGE FROM THE CHAIRMAN

On behalf of the SDS members attending the Symposium on Devonian Cyclicity and Sequence Stratigraphy at the University of Rochester last July, I thank the organizers Carlton E. BRETT and W.T. KIRCHGASSER especially for showing SDS members the applications of cyclicity and sequence stratigraphy in the Devonian of New York and for the hospitality given to our subcommission. The number of participants at the SDS annual meeting and the proposals made, clearly show the interest of SDS members in the subdivision of the 7 formally defined Devonian stages (see minutes enclosed in this Newsletter). Further discussion of the substage proposals will also be the main topic on the agenda of the next SDS business Meeting in Bologna, associated with the ECOS 7 conodont symposium (June 24-26, 1998). In order to have a successful discussion, please provide your proposals as soon as possible but no later than 31 May 1998, so they can be distributed in advance to participants. A last point of my message concerns SDS membership. At present there is no Canadian titular SDS member. Considering that Canada is a most important Devonian region, I am looking forward to receiving nominations for a Canadian titular membership.

P. Bultynck
E-mail: bultynck.pal@kbinirsnb.be

Minutes of the SDS Business Meeting, 21th July, Rochester

The annual business meeting was held during the evening of Monday 21th July, in the Susan B. Anthony Hall at Rochester University. The SDS meeting took place from 19th - 21th July in conjunction with the Amadeus Grabau Symposium on "Cyclicity and Bioevents in the Devonian System", organized by CM Carlton Brett et al. from Rochester and by TM Bill Kirchgasser from Potsdam. The symposium was followed from 22th to 27th July by exceedingly informative excursions to the splendid Devonian of western and eastern New York State and of northern Pennsylvania.

PRESENT: Chairman P. Bultynck, secretary TM R.T. Becker; TMs: Yu Chang-min, M.R. House, W. Ziegler, W.T. Kirchgasser, C.A.-Sandberg, J.A. Talent, K. Weddige; CMs: J. Hladil, W.A. Oliver jr., J. Over, H.P. Schönlaub, C.E. Brett, T.T. Uyeno, P. Sartenaer, M. Ginter, E. Schindler; guests: B. Ellwood, J. Ebert, F. Rogers, R. Metzger, J. Morrow, J. LeMenn, A. Antoshkina, C. Ver Straeten. The meeting was much better attended than the previous year.

1. Introduction

The Chairman, P. Bultynck, opened the meeting and thanked CM Carlton E. Brett and TM William T. Kirchgasser for the invitation to come to Rochester and for the perfect organization of the symposium that attracted such a high number of active SDS members, sixteen years after the last New York State SDS conference. The chairman also gave the warmest thanks of the whole subcommission to the past chairman TM M.R. House who finished his term which saw the ratification of the last Devonian GSSP.

Apologies for absence were recorded from vice-chairman CM R. Crick who had to leave the symposium early, from TMs Bai Shung-liang, A. Blieck, R. Feist, P. Morzadec, I. Chlupac, V. Menner, M. Streel, J.B. Richardson, E. A. Yolkin, and G. Klapper, and from CMs D. Brice, M. Bradshaw, D.K. Elliot, C.H. Holland, A. Kuz'min, R. Mawson, N. Ovnatanova, F. Paris, M. Rzhonsnitskaya, E. Turnau, S. Turner, S. Yatskov, and K. Zagora.

On various topics eight documents were distributed and these were numbered in the following order (texts included in this newsletter ***but*** not in the order presented below)

Document 1: Jansen, U. & Schindler, E. (eds.): Subdivision of the Emsian stage - state of discussion in the German Subcommission on Devonian Stratigraphy.

Document 2: Chlupac, I.: Comments to subdivision of the Emsian Stage.

Document 3: Carls, P. & Valenzuela-Ríos, J.I.: no title (concerning the *kitabicus*-boundary...).

Document 4: Ziegler, W. & Sandberg, C.A.: Proposal of boundaries for a Late Frasnian Substage and for subdivision of the Famennian Stage into three Substages.

Document 5: Sartenaer, P.: Is the term Strunian worth being properly defined, and thus kept?

Document 6: Weddige, K. (ed.): Devon-Korrelationstabelle (published in Senckenbergiana lethaea, 76 (1/2): 267-286).

Document 7: Schindler, E.: Report of the German Subcommission on Devonian Stratigraphy.

Document 8: Feist, R. & Talent, J.A.: International Geological Correlation Programme, IGCP 421.

2. Minutes of the Beijing Meeting 1996

The minutes of the Beijing meeting were circulated in SDS Newsletter No. 13. CM Susan Turner drew attention that her apologies had not been recorded and following suggestion of TM House, this correction is reported here.

3. Chairman's Business

The chairman reported the sad death of our former active SDS member Wolfgang Struve. Members held a minute of silence in honor of him. TM W. Ziegler gave a short review of his life and scientific work and an obituary shall be included in this newsletter. Also, the death of Curt Teichert had to be reported. His extraordinary contributions to geology, palaeontology and present day reef research, including many contributions to Devonian stratigraphy, was previously acknowledged in the Teichert-Festschrift published in Senckenbergiana lethaea.

4. Proposals for Devonian substages and additional stages

At the beginning there was a discussion on the formal procedure. It was suggested that substages should be defined in the same way as stages and official recognition of substages should be attempted. Doubts were raised whether the International Stratigraphical Commission would approve substages. However, there is no reason why the international scientific community should not recognize and follow unratified SDS substage recommendations. The secretary proposed to proceed first with certain stages where there is a common desire for subdivision.

4A: Results of the questionnaire

The chairman reported the results of the questionnaire but criticized that only thirteen forms were returned. These show the following ranking for the need of subdivision:

1. Emsian
2. Famennian
3. Givetian
4. Frasnian
5. Lochkovian

Nobody has yet suggested a subdivision of the Pragian and Eifelian.

4B. Proposals for a subdivision of the Emsian (Documents 1-3, Document 9)

TM Yu proposed to include the paper by Yu & Ruan (1989), Canadian Society of Petroleum Geology, Memoir 14, vol. III: 179-191 (vol. III of the 2nd Calgary Symposium on the Devonian System) in the discussion and submitted a copy to be recognized as Document 9. CM Schindler explained Document 1 and summarized that the German SDS recommends to investigate in more details levels close to the entry of *Nowakia cancellata* (in evolutionary transition from *N. elegans*) and of *Polygnathus inversus*. Studies of brachiopod faunas of this interval are under way by U. Jansen. Potential stratotype areas were outlined and data on Spanish sections were promised for to the newsletter. The chairman summarized Document 2 by TM Chlupac who considers both the base of the *inversus* Zone and of the *serotinus* Zone but gives preference to the first level. CM Sartenaer drew attention to the fact that G. Solle had already used a subdivision of the Emsian a long time ago. The base of the Ems Quarzite and the base of the Lauchbach Schichten may correspond with the base of the *N. richteri* and *serotinus* Zones which may be regarded as a good alternative for subdivision. TM House emphasized that in former discussions of pelagic successions neritic faunas were not considered enough and this should not be repeated in the future. The secretary raised the problem that the lower part of the *cancellata* Zone seems to have in South China (Luofo section, see Document 9) and in Central Asia (Dzaus Beds) still typical "Lower Emsian" ammonoid faunas with anetoceratids and relatives (*Erbenoceras, Teicherticeras, Mimosphinctes*). The base of the *serotinus* Zone, again, is too high and postdates according to current knowledge the entry of oldest anarcestids. TM Weddige commented that the *serotinus* Zone is present in the Lower Lahnstein Beds and the chairman added that *Po. serotinus* lies above the level of Solle's subdivision. CM Schindler proposed to look in the initial phase of more detailed investigation at a longer time span and CM Hladil urged SDS members to link conodont studies with studies of physical boundaries formed by sea level changes and with methods such as chemostratigraphy. Following a move by CM Oliver to finish the debate, the following declaration was agreed unanimously by all voting members. SDS decides to investigate for a twofold substage subdivision of the Emsian in detail, and using all available stratigraphical methods, the time interval from the start of the Dalejan transgression to the entry of *N. richteri* and of early anarcestids. Special attempts shall be made to correlate pelagic and neritic successions. All SDS members are asked to provide at the next meeting relevant data and detailed descriptions of sections, including potential stratotype candidates.

4C. Proposals for a subdivision of the Givetian

The chairman proposed to defer a Givetian subdivision for future meetings which was accepted.

4D. Proposals for a subdivision of the Famennian (Documents 4 and 5)

TM Ziegler gave a brief outline of the joint Document 4 with TM Sandberg and emphasized that the proposed levels for a threefold subdivision (boundaries at the base of the *marginifera* Zone and at the base of the *expansa* Zone) correlate with major transgressions. They would not recommend a possible alternative earlier level (base of Latest *crepida* Zone) since it would cut off a too short interval for a Lower Famennian. Attempts are being made to understand the classical German Stufen of the pelagic realm. The international *Pa. semichatovae* transgression is proposed as a possible level for the definition of an Upper Frasnian. CM Sartenaer explained Document 5 and stated that the Strunian has been, and still is, so widely used in the literature, that it cannot be ignored. He reminded SDS members that by giving up the Strunian, up to 2 ma have been added to the classical Famennian. He conceded that there are wide discrepancies in the international use of the term Strunian but the entry of *Quasiendothyra* may be a good time marker. TM House stressed that many other groups apart from conodonts still need detailed documentation in the Famennian. The secretary recommended to subdivide the Famennian into a lower, middle and upper part which follow to a large extent the classical pelagic German Stufen-subdivision (Nehden- and *Cheiloceras*-Stufe = Upper Devonian II = Lower Famennian; Hemberg- and *Platyclymenia*-Stufe = Upper Devonian III + IV = Middle Famennian, Dasberg- and Wocklum- or *Clymenia*- and *Wocklumeria*-Stufen = Upper Devonian V + VI = Upper Famennian). In conodont terms, the Middle Famennian should start somewhat below the entry of clymenids and the base of the old Lower *velifer* Zone (now Latest *marginifera* Zone) should be considered. The base of the *expansa* Zone may be an acceptable level but it may still correlate with last *Platyclymenia* faunas; this problem needs to be resolved by future work. TM Sandberg commented that the *velifer* Zone is hardly recognizable in North America and therefore of limited value. CM Ginter remarked that the shark teeth zonation could have relevance in the future discussion. Following the proposal by CM Oliver to close the discussion, the following declaration was decided: SDS asks its members to present proposals for a threefold subdivision of the Famennian in the light of submitted documents, with regards to the discussion reported here, and considering the Strunian as a potential upper Famennian substage. Investigations should pay special attention to the correlation with neritic and terrestrial successions.

5. A formatted correlation table with coordinates as a standard medium for international Devonian stratigraphical communications (Document 6)

TM Weddige gave an introduction to the published correlation charts and invited all SDS members to contribute biostratigraphical and regional geological columns which will be published every year in the Senckenbergiana lethaea. CM Sartenaer congratulated TM Weddige for his large effort and it is hoped that many SDS members will cooperate.

6. Devonian Marine/Non-Marine correlation

A report by TM Blieck on the final year of IGCP 328 (Palaeozoic Vertebrate Biochronology and Global Marine/Non-Marine Correlation) has been submitted and will be published in this Newsletter. Devonian work will continue in the frame of IGCP 406 (Circum-Arctic Lower to Middle Palaeozoic Vertebrate Palaeontology and Biostratigraphy, proposed by M.V.H. Wilson and T. Marss).

7. IGCP 421 "North Gondwana Mid-Paleozoic Bioevent/Biogeography Patterns in Relation to Crustal Dynamics (Document 8)

TM Talent gave an introduction to the new IGCP 421 which is intended to cover the period from the Silurian to the pre-Variscan part of the Carboniferous. It is hoped to fingerprint Gondwana crustal blocks by faunal and biostratigraphical characteristics. Cooperation with palaeomagnetic and structural research will be essential to reach improved palaeogeographical and plate tectonic reconstructions. The inaugural meeting of IGCP 421 was announced to be held in September in Vienna. It is aimed that future IGCP symposia take place in connection with annual SDS meetings. Further details will be given separately (Document 8) in the SDS Newsletter. The chairman declared that SDS will support IGCP 421 as much as possible and asked members to take part actively.

8. IUGS matters

The chairman reported that new GSSPs have been decided for the base of the Ordovician, and for the Piacenzian (uppermost Neogen, Upper Pliocene). The new statutes and revised guidelines have been published by Remane et al. in Episodes. The IUGS will continue with financial support of ICS.

9. Membership

9A. Withdrawals

TMs Streel and House declared to withdraw from titular membership but both wish to continue as CMs. Thanks for the service of TM House by the chairman was underlined by long applause. CM Holland declared in a written statement to the secretary that he agrees to decline from formal membership but wishes to be kept on the mailing list of the newsletter. CM Freyer has withdrawn from the German SDS and it is suspected that this also applies to the International Subcommission.

9B. Election of CMs

Written nominations of Charles A. Ver Straeten (Department of Geological Sciences, Northwestern University, Evanston) and Jean LeMenn (Laboratorie de PalÈontologie, Universite de Bretagne Occidentale, Brest) were approved unanimously.

9C. Election of TMs

Written nominations (by TMs M.R. House and P. Bultynck) of the vice-chairman R. Crick and of the secretary R.T. Becker were approved unanimously.

10. Reports

10A. Financial Report

	[in US $]	
Income for 1997		
— carried forward from 1996		144.05
— IUGS subvention for 1997		1,423.61
		1,567.66
Expenditure for 1997		
— attendance support Rochester meeting	355.00	
— participation in costs associated with the Rochester Meeting	500.00	
— secretary expenses	120.00	
— Newsletter allocation for No. 14.	250.00	
	1,225.00	
provisional balance July 1997		342.66

10B. [An announced report by CM Turner had not arrived]

10C. Report of the German Subcommission on Devonian Stratigraphy (Document 7)

CM Schindler gave a summary of German SDS activities of the last year. The annual meeting on the 1st of March was attended by forty participants. A Devonian bibliography has assembled 1,600 references which were checked thoroughly. Current activities aim at holostratigraphic correlations of the German Devonian, and the integration of modern stratigraphical techniques was generally recommended. A working group has been founded to revise and re-define the classical German Oberdevon-Stufen. The chairman requested other national subcommissions to submit reports to the business meetings or to the Newsletter.

10D. Progress in Radiometric Dating

TM Talent reported that work on Eastern Australian ashbeds is in progress in cooperation with Greg Dunning (Memorial University). SHRIMP dating of two dozens of samples by J. Claoue-Long, unfortunately, has not become available since processing of Palaeozoic samples was stopped. Because of the significant shortcomings of the Harland et al. timescale, a new chart is currently planned by Cambridge Press. J. Ebert reported on a new, much older age than previously thought (418 ma) for a level in the woschmidti Zone at the base of the Pragian. The Tioga Bentonite of New York gave a 391.6 ma age (Uranium-Lead-date). Further radiometric dates were announced for the 1997 meeting of the Geological Society of America and the abstract with these is included in this Newsletter.

11. SDS Publications

11A. Moscow Symposium Volume on "Devonian Eustatic Changes of the World Ocean Level".

TM Ziegler presented the cover and content of the volume which will be published as Courier Forschungsinstitut Senckenberg, vol. 199. It is edited jointly by TMs House & Ziegler and dedicated to CM Maria Rzhonsnitskaya. TM House drew attention to the fact that she will celebrate her 85. birthday in 1997. [the volume with 146 pages has been published in the meantime]

11B. Devonian Correlation Volume

The chairman reported that most contributions had arrived since the last meeting. The secretary commented that papers on the Col de Puech de la Suque and Coumiac Stratotypes have been practically finished. The manuscript on Wettelsdorf was still missing but the regional summary of Australia had just arrived. Unfortunately, there is no review at all of the North American Devonian and yet no contribution for Morocco. The Correlation Volume will be printed as a volume of the Courier series in the next year.

12. Future Meetings

12A. Meeting for 1998

Since original plans to hold a meeting in Morocco, in conjunction with a field trip to more neritic successions of the Dra Valley, did not materialize, it was proposed to convene at the ECOS VII symposium, from June 24-26 in Bologna and Modena (see details in this Newsletter). In association with ECOS VII (25. June), there will be a working meeting of IGCP 421. The organizers of ECOS VII have agreed in the meantime to host the 1998 SDS Business Meeting which will take place in the afternoon of the 23rd June in Bologna. For any information, please contact Dr. Maria Christina Perri, Dipartimento di Scienze della Terra e Geologico Ambientali, Universita di Bologna, Via Zamboni 67, I-40126 Bologna, Italy, Tel. 051-354569, Fax. 051-354522, e-mail perri@geomin.unibo.it

12B. Meeting for 1999

There is a previous invitation by TM Yolkin to hold a joint meeting with the Silurian Subcommission in Novosibirsk and to have an associated field trip to the Siberian Silurian/Devonian (see 1996 minutes). The chairman declared to inquire whether this offer is still valid. Alternatively, a business meeting can be linked in 1999 with IGCP 421 activities.

13. Any other business

Time had progressed considerably and no other business seems to have been regarded as urgent.

R. Thomas Becker (Berlin)

Documents Submitted to the Subcommission on Devonian Stratigraphy Rochester, NY 21 July 1997

The Chairman has indicated that proposals for the subdivision of Devonian stages will be discussed at the business Meeting in Bologna (24-26 June 1998). New and revised proposals should reach the Chairman no later than 31 May 1998 for dessemination to the membership. Please a copy to the Editor for posting on the SDS web site.

Conc: *kitabicus*-boundary; late original Pragian, Emsian, Zlichovian; *Pol. excavatus* Zone; intra-Emsian substage boundary.

CM Peter CARLS (Braunschweig) & José Ignacio VALENZUELA-RÍOS (Valencia)

1. The installation of the *pireneae*-Zone as the latest Pragian conodont zone was, though formally correct, the first one in a series of misleading procedures, because it only suggested the proximity of the end of the original Pragian without having demonstrated that it covers only a really late interval of the original Pragian (as delimited by the beginning of the Zlichovian). As a consequence, a succeeding zone is not necessarily close or posterior to the end of the original Pragian or to the beginning of the classical Emsian. Therefore, and combined to multiply erroneous concepts of *Polygnathus dehiscens* as a zonal index, the *kitabicus*-Zone could fall into a long interval of originally Pragian time.

2. Besides by the origin of its index *Pol. kitabicus,* the new *kitabicus* boundary of the Emsian is additionally correlatable by means of the following conodont occurrences slightly above the boundary in the Zinzilban Section (Yolkin, et al. 1989):

   Polygnathus pireneae (final range)
   Pelkysgnathus serr. serratus
   Pedavis mariannae
   Ozarkodina exe. excavate

   To our knowledge, none of these conodonts has ever been reported from strata that were definitely Emsian in the classical sense of the Rhine region. In Celtibera, *Pel. serratus* and *Oz. excavate* tote sp. do not rise above the Nogueras Fm., which ends with about the early half of the original Pragian and amid the classical Early Siegenian. Rather sporadic reports of the other two taxa from other regions are also amid the unshortened Pragian (e.g. Nevada, Pyrenees).

3. The official submission of the SDS to the IUGS of June 1993 concerning the Pragian-Emsian boundary comprises, in its Appendix A: Fig. 3, graptolite ranges in the Zinzilban Section, given by KIM & ERINA. As we are not graptolite experts, we would suggest to test how *Monograptus thomasi,* which is registered above the conodonts just mentioned and enters 46 m above the *kitabicus* boundary, correlates with its records from Nevada and Yukon. In Nevada it is recorded close to and even below some of the conodonts mentioned.

4. Final records of graptolites in the Zinzilban Section are about 170 m above the *kitabicus* boundary. In Bohemia, the last graptolites occur in a thin band within the dacryoconarid zone of *Guerichina strangulate.* The latter was (almost?) final Pragian in its original scope. We ignore the position of the G. *strangulate* Zone in the Zinzilban Section, but we have been told that it is found there somewhere above the *kitabicus* boundary. Is the originally final Pragian about 170 m above the *kitabicus* boundary? (Some upper ranges of dacryoconarids, identified in open nomenclature, would rather suggest late Zlichovian age near that level.)

5. In the Nogueras region of Celtiberia, there is the following succession:

   a. Member d3b of the Santa Cruz Fm. with a succession of brachiopod faunas that just reach the level, where the classical Middle Siegenian fauna began. Conodonts are abundant *Icriodus curvicauda* (late part of range) and few *Icr. ang. angustoides* (isolated last occurrence; reported at the Rade de Brest, France, in the same level). No *Polygnathus* has been obtained.

   b. Over 100 m of barren deltaic facies, member d3c of Santa Cruz Fm.

   c. Top bed of Santa Cruz Fm. with *Seilloucrinus verneuili* and *Diamenocrinus floreus,* correlating with top bed of unit F9 = set 44, 5 m below the top of the Le Faou Fm. in the Seillou Section, Rade de Brest; also coinciding in revised brachiopods. No exclusively classical Emsian brachiopods.

   d. Basal limestone bed of Mariposas Fm., type stratum of *Polygnathus excavatus*; the true origin may have been older, corresponding to somewhere in the barren interval b; the *excavatus* Zone begins late within the classical Siegenian - consequently, the entire conventional *kitabicus-Zone* is within the classical Siegenian. *Guerichina is* still absent.

   e. 1 m or 2 m above d, *Guerichina* sp. sp. and *Peneauia* sp. are found as steinkerns in conodont samples. *Acrospirifer fallax* is the first relevant post-Siegenian spiriferid and marks the oldest possible level for the beginning of the classical Emsian.

   f. According to exterior moulds, *Guerichina* cf. *infundibulum* exists up to about 1 m above the limestone set in the middle of submember d4a-beta. This still demonstrates the *Guerichina strangulate* Zone of the original (?almost) final Pragian. The uppermost tenth or so of the extension of this zone is, according to brachiopods *(Acrospirifer, Arduspirifer),* the equivalent of the Erbeloch Grauwacke (fauna see JAHNKE, 1971). Revision of conodonts, inclusive of those figured from Bohemia, results in that *Icriodus bilatericrescens multicos-*

tatus begins in the limestone set in the middle of submember d4a-beta, whereas *Icr. bil. bilatericrescens* is still lacking at this age.

g. According to the origin of *Icr. bil. bilatericrescens*, the beginning of the Zlichovian is within the basal metre of the shelly limestone-shale alternation submember d4a-gamma. *Pol. excavatus* still exists. A "Basal Zlichovian Event" can not be safely identified in Celtiberia. A possibly local process might be the cause for the interruption of the formerly rather steady deposition at the Rade de Brest, but the fauna coming in with the "Hercynian incursion" described by LE MENN et al. (1976, uppermost faunal layer of the Le Faou Fm.) is near the beginning of the original gronbergi Zone.

h. *Polygnathus excavatus* s. s. ends amid the submember d4a-gamma, *Polygnathus* with many ridges crossing the tongue appear shortly before its end. Posteriorly concave as well as flat basal cavities overlap in range. A revision is necessary. *Polygnathus* corresponding aborally to the concept of *Pol. gronbergi* enter towards the top of the submember d4a-gamma; that is where the traditional *gronbergi*-Zone would begin.

6. Also in the Nogueras Region of Celtiberia, within the submember d4b-alpha of the Mariposas-Fm., which is of distal, deeper neritic biofacies, the following successive entries have been observed up to now:

   a. *Icriodus latus* ranges across the base.

   b. *Icr. armoricanus* enters, and *Icr. sigwoidalis* possibly ends at 3 m. - *Nowakia (Dmitriella)* e. g. *praecursor* are the prevailing nowakiids.

   c. *Criteriognathus steinhornensis* s. s. enters at 5.5 m.

   d. *Polygnathus vigiereorum* enters at 12 m and indicates that the *inversus* Zone has begun.

   e. *Polygnathus inversus* is found with delay at 19 m. - This is the approximate level in which one *Augurites sp.* has been found from float as the oldest ammonoid in Celtiberia, still close to *Now. (Dm.)* e. g. *praecursor.* It is close to the middle of the Zlichovian.

   f. *Nowakia barrandei* occurs abundantly in only few beds around 27 m. *Anetoceras* sp. and *Mimagoniatites* co-occur with it.

   g. The local range of *Nowakia elegans* is not yet duely delimited, but it passes from submember d4b-alpha to d4b-beta, and in the basal 5 m or so of the latter it overlaps with first *Now. cancellata.*

Consequences of the above conditions and biostratigraphic successions are as follows:

A. The *kitabicus* boundary cuts the original Pragian near its middle.

B. The *excavatus* Zone begins before the *Guerichina strangulate* Zone. Its beginning is too old to be connected anyhow with the name of the Zlichovian. The range of its index ends rather early in the Zlichovian.

C. The original Pragian and the classical Emsian of the Rhine region overlap in good approximation by the *Guer. strangulate* Zone.

D. The ammonoid record from the Bundenbach shale correlates with the late Early Emsian of Stadtfeld, Germany, through *Anetoceras.* Both predate the beginning of the classical Late Emsian of the Rhine region. The Bundenbach ammonoids indicate late Zlichovian (CHLUPAC, 1976); this can be tied in with the uppermost part of submember d4b-alpha of the Mariposas Fm. The latter is closely followed by the Late Emsian *Rhenops lethaeae* (see GANDL, 1972) and by the initial Dalejian *Nowakia cancellata.* Therefore, the classical Early/Late Emsian boundary of the Rhine region and the beginning of the Dalejian of Bohemia coincide satisfactorily. A definition of an intra-Emsian substage boundary should define the Early/Late Emsian boundary so that a correlation by means of the origin of *Nowakia cancellata* is possible.

E. The *kitabicus*-Zone is a good zone in a merely definitive sense, but the *kitabicus* boundary is at an undesired level. Useful early occurrences of its index are not widely available. The application of the Name of the Emsian to strata as old as the *kitabicus*-Zone causes confusion. In the historical type region of the Siegenian, it converts some 4000 m of formerly Siegenian sediments into "Emsian". As soon as the rules permit, we will claim to redefine the beginning of the Emsian so as to be close to the classical boundary in the Rhine region and to the beginning of the *Guerichina strangulate* Zone.

F. If any alternative should concern the Zlichovian, its original beginning should not be changed.

Comments to subdivision of the Emsian Stage

TM Ivo CHLUPAC, Praha

The Emsian Stage should be subdivided into two chronostratigraphic units of a lower rank. The necessity of such a subdivision is generally known (comp. e.g. Solle 1972, Chlupac 1976) and is based especially on the following features:

1. The stratigraphic volume of the present Emsian Stage is markedly larger than that of all adjacent Devonian Stages. It includes 5 to 6 conodont Zones or 7 to 8 tentaculite zones, which contrast with 3 zones of Pragian and four zones of Eifelian in both fossil groups.

2. The faunistic differences between the lower and the upper parts of the Emsian Stage are very conspicuous. The upper part contains many younger elements, which were in the past traditionally regarded as Middle Devonian. This concerns particularly goniatites (onset of anarcestids), tentaculites (start of the wide distribution of *Nowakia cancellata*, later replaced by *N. richteri*), changes in lineages of brachiopods (particularly characteristic in the Rhenish facies, cf. e.g. Mittmeyer 1982, new data also in Garcia-Al-

calde et Truyols-Massoni 1994), numerous innovations in trilobites (review: Chlupac 1994).

3. The eustatic sea level variation and the global event-stratigraphy also support the subdivision (the Daleje Event, comp. e.g. the recent SDS Devonian stratigraphic scheme of TM R. Crick, 1994).

As for the limit between the both Emsian subdivisions, this should be in accordance with the conodont, and, if possible, also with other biostratigraphic zonations. In my view, two alternatives do exist:

1. The base of the *Polygnathus inversus* conodont Zone which may be roughly correlated with the base of the *Nowakia cancellata* or possibly *N. elegans* tentaculite Zones and is close to the culmination of the transgressive Daleje Event. This level is also supported by the goniatite biostratigraphy as the upper boundary of the *Anetoceras* fauna lies in close proximity.

2. The base of the *Polygnathus serotinus* Zone which is close to the base of the *Nowakia richteri* tentaculite Zone, and also close to the first worldwide distribution of anarcestid goniatites.

If compared the two candidate levels, the first choice, i.e. the base of the *Polygnathus inversus* conodont zone seems to have preference: it is easily distinguishable in different faunal groups and subdivides the Emsian into two substages of comparative volume.

When naming the Emsian subdivisions, the names Zlíchovian and Dalejan in slightly redefined sense may be adopted. They are widely used in international correlations of different parts of the world and the Zlíchovian/Dalejan boundary remained without substantial changes since its establishment.

The use of the names Lower and Upper Emsian as separate formal units is not advisable, as it would contradict the practice in naming chronostratigraphic units lower in rank than the Series: These should have specific names different from other units (comp. The International Stratigraphic Guide).

Subdivision of the Emsian stage – German Subcommission on Devonian Stratigraphy

U. JANSEN & CM E. SCHINDLER, Frankfurt (comps.)

After the 21st meeting of the German 'Subkommission für Devon-Stratigraphie' (SDS) a working group for a possible subdivision of the Emsian has been established. This group recently met for the first time. Besides the compilers, the following persons were participating at the meeting, held at Göttingen University on July 2, 1997: H. GROOS-UFFENORDE, O.H. WALLISER, W. RIEGEL, H. JAHNKE (Univ. Göttingen), P. CARLS (Univ. Braunschweig), H.-G. MITTMEYER, J. GAD (GLA Rheinland-Pfalz, Mainz), G. SCHRAUT (FIS, Frankfurt). - G.K.B. ALBERTI (Hamburg), G. BECKER and K. WEDDIGE (FIS Frankfurt) were not present, but had given statements in advance. The results shall be briefly presented and are open for discussion.

With regard to an international subdivision of the Emsian, the working group stated to favour the pelagic facies when discussing boundary proposals, due to the worldwide distribution of pelagic organisms. The classical pelagic sections (yielding dacryoconarids and conodonts as most important index fossils) are situated in the Barrandian area (Bohemia). The area of the Rheinisches Schiefergebirge, representing the type area of the Emsian, is developed in neritic facies. The classical subdivision of Lower and Upper Emsian strata (mainly based on brachiopod development) should be referred to as well. For it should be the aim to correlate the different biostratigraphic successions (based on different faunal groups in different facies), areas with interfingering facies developments are regarded as highly valuable in respect to future investigations (e.g. Armorican Massiv, Cantabrian Mountains, Celtiberian Chains, ? Moroccan Presahara).

Dacryoconarids, conodonts, brachiopods and goniatites have been considered as very important for subdividing the Emsian. On a worldwide scale, the dacryoconarids *Nowakia elegans* and *N. cancellata* have been proven as most useful. The evolutionary transition from the first to the latter can easily be identified (almost in the field). It represents the boundary between the Zlichovian and the Dalejian of the Barrandian succession and more or less matches the facies shift known as Daleje Event. Even in sections with dominating neritic facies, corresponding pelagic incursions documented by dacryoconarids-bearing rocks, can often be observed. Therefore, this level is especially suitable in respect to subdividing the Emsian and should be seriously considered. Despite minor taxonomic problems concerning the two nowakiid taxa – a revision has been proposed (G.K.B. ALBERTI, written comm., and O.H. WALLISER, oral contr.) – they may be candidates for the boundary definition. The conodonts, up to now applied for defining the Devonian stage boundaries, are not yet investigated in greater detail around this level. Therefore, the working group proposes to examine this level with regard to a phylogenetic transition in polygnathid conodont development. At the regular meeting of the German SDS earlier this year, K. WEDDIGE had already proposed to focus on the onset of *Polygnathus inversus*. Other faunal groups (e.g. brachiopods, goniatites, trilobites, ostracodes, etc.) or palynomorphs show increasing potential in biostratigraphy and therefore should also be taken into account in the future. This is of special interest when correlating between different facies. Concerning such correlations, first promising attempts are made within the brachiopods (relationships between Moroccan Presahara and the Rheinisches Schiefergebirge, U. JANSEN) as well as in the palynomorphs (e.g. STREEL et al. 1987). Regarding the goniatites, the proposed boundary level would lie closely to the disappearance of substantial parts of the anetoceratid goniatites. The trilobite succession is rather spotty up to now, but may also offer additional information (e.g. G. SCHRAUT, Presaharan sections). Ostracodes are not considered as highly valuable to date, but have not been satisfyingly studied so far.

With regard to an Emsian subdivision the working group favours the following regions:

Pelagic facies:

Barrandian area (Czech Republic), being predominantly pelagic.

Southern Cantabrian Mountains (Spain), e.g. the Villayandre section showing pelagic facies in the boundary interval.

Intercalation of pelagic and neritic facies:

In the following areas, the sections show faunal elements belonging to both, the neritic and pelagic facies. The state of investigation is different to date.

Presahara (Morocco).

Brittany (France).

Celtiberia (Spain).

Neritic facies:

Type area of the Emsian in the Rheinisches Schiefergebirge (Germany) as well as in the above mentioned areas.

In the course of the working group meeting, there have been discussed several problems of the late Early Devonian, particularly of the Pragian and the Emsian stages as well as the Zlichovian and the Dalejian (and of their boundaries, respectively). Especially the recently defined base of the Emsian has been strongly discredited by P. CARLS. For this part of the discussion only touches the subdivision of the Emsian with respect to nomenclature, this topic is referred to in a separate handout by P. CARLS & J.I. VALENZUELA-RÍOS.

In the discussion about the youngest stage of the Early Devonian, the question arose wether there should be established two formally new stages (instead of the Emsian) or if there should be a subdivision on the substage level. Independently of this question, the problems of the Pragian/Emsian boundary definition at the Zinzilban section have to be considered. As stressed by P. CARLS, the actual base of the boundary lies well down in Pragian strata of Barrandian stratigraphy. In case of a formal subdivision of the Emsian into two separate stages (and in the light of the 'basal problems'), the working group has been discussing possible names for the new stages. A suggestion of preliminarily naming the upper part "Dalejian" and leaving the lower part unnamed for the moment (until the problems concerning the base are solved) has been raised and declared to put forward. If there will be no support for this suggestion, the creation of new names would be another alternative.

Literature (mainly SDS proposals):

CARLS, P. & VALENZUELA-RÍOS, J.I. (1997): Conc.: *kitabicus*-boundary; late original Pragian, Emsian, Zlichovian; *Pol. excavatus* Zone; intra-Emsian substage boundary.- Submission to the SDS meeting at Rochester, July 1997: 3 pp.; Rochester.

JAHNKE, H. [comp.] (1994): Arbeitsunterlage zum TOP 5: Zweiteilung der Ems-Stufe.-Submission to the 20. Sitzung der Subkommission für Devon-Stratigraphie: 12 pp., 6 figs.; Frankfurt/M.

STREEL, M.; HIGGS, K.; LOBOZIAK, S.; RIEGEL, W. & STEEMANS, P. (1987): Spore stratigraphy and correlation with faunas and floras in the type marine Devonian of the Ardenne-Rhenish regions.- Rev. Palaeobot. Palynol., 50: 211-229, 14 figs.; Amsterdam.

Is the term Strunian worth being properly defined, and thus kept?

CM Paul SARTENAER (Bruxelles)

No month, no week, passes without the Etroeungt beds or the Strunian being mentioned in a publication, and still it is customary among geologists to state that nobody knows what the Strunian is. Some even call it a regional stage. This negative attitude is wrong and right at the same time.

It is wrong, because the Strunian rests upon solid foundations, the Etroeungt Limestone ("Calcaire d'Étroeungt"), of which the stratotype is the Parcq quarry in Etroeungt near Avesnes (Department of the North, France). The 24.05 m thick Etroeungt Limestone has been described bed by bed by GOSSELET (1857), - although formally named by the same author only in 1860 -, and updated by SARTENAER & MAMET (1964). GOSSELET never used the term Strunian, which was introduced by de LAPPARENT (1900, p. 860), and later considered as a stage by BARROIS (1913, p.16).

It is wrong, because the Strunian has been widely used, following GOSSELET's lead, for beds containing a transitional fauna between the late Devonian and early Carboniferous beds (as understood before the latest modification of the Devonian/Carboniferous boundary), i.e. beds containing species, part of them being declared Devonian, and the other part Carboniferous.

It is right, because the lack of an internationally accepted definition has been counterbalanced by such a great "plasticity" in the usage of the term Strunian that it makes it impossible for any geologist to prove that "his" Strunian is better than that of another geologist. Having become vague the term has become convenient. As a result there are quite a few dozens of Strunians.

The Strunian has been mentioned and investigated in 85 sedimentary basins, 25 countries, and 5 continents. Its fauna has been studied by various authors, and the expression "Etroeungt fauna" is commonly used in literature. GOSSELET (1879), DEHEE (1929), LE MAÎTRE (1933), LETHIERS (1974), to quote only some of the authors who worked in the type area, described brachiopods, stromatopores, and ostracods. Two recent publications by MISTIAEN (1997) and by BRICK et al. (presented at the 30th International Geological Congress in Beijing, 1996, in press) indicate that endeavour is not fading out. Beds assigned to the Strunian may reach great thicknesses, e.g. 180 to 430 m in Algeria or 100 to 260 m in Armenia, and in some regions they have been subdivided into two or three parts according to their faunal contents, e.g. in the Velbert Anticline (Bergisches Land, Germany) by PAUL (1939) or in N Devon (England) by GOLDRING (1957). Some scientists have even recognized a shaly, a sandy, and a limy Strunian in the type area.

Should we keep the Strunian for historical reasons? Certainly not for historical reasons alone, although we must not disregard them and forget that the Strunian, the central point of discussions during a few international congresses, was an important Devonian component until 1928, and then again since 1937.

The purpose of this brief submission is not, at this stage, to recommend the acceptance of the Strunian as a formal substage. What is considered as highly desirable is, first, to start an open discussion leading to a clarification and a definition of the Strunian (MAMET MORTELMANS & SARTENAER suggested, in 1965, to accept the first appearance of Ouasiendothyra kobeitusana as the base of the Strunian), secondly, to face reality in accepting the fact that the Strunian, depending on the accepted definition, is not just a quiet period corresponding to a full recovery from the Dasberg event, but also an event in itself, including the Hangenberg event. The worse thing to do would be to pursue an ostrich policy - anyhow, research scientists would not - and to adopt a "ça va de soi" ("c'est la vie") attitude towards the some 2,000,000 years that have been added to the Famennian in increasing its span of time by about 30%. We have switched overnight from the late Famennian (i.e. the late "late" Famennian) to the late Famennian (i.e. the late "new" Famennian). It means that we have not changed our vocabulary although the contents of what we refer to have been drastically modified. In the time interval at stake, more than in the preceding and succeeding time intervals, the correlation between most of the "magic" zones are still rough approximations, the "correlation" between the conodont and foraminifer zones deserving a special mention.

As a concluding remark, it must be borne in mind that the words "to keep" and "acceptance" have been used in this short note, because, the Strunian existing already for a long time, no new name has to be eventually adopted.

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Comments on the revision of the Emsian Stage

CM O.H. WALLISER (Göttingen)

Ongoing discussions of the status of the Emsian Stage should consider not only a subdivision of the stage, but rather the possibility of dividing it into 2 stages. If this suggestion is followed we must also evaluate the position of the base of the lower of the two new stages.

The number of faunal changes and length of the Emsian Stage suggest that it would be appropriate to divide it into two stage-level stratigraphic units. If we do this, two new stage names are required. It would be advantageous to use Zlichovian and Dalejan as the upper two stages of the Lower Devonian. the logical next step is to choose boundary stratotypes for the new stages in the Barrandian, which action has the advantage that then all Lower Devonian boundary stratotypes are defined within a single magnafacies.

The base of the above proposed Dalejan Stage should coincide with the base of the regional Dalejan Stage as it is employed in recent publications, i.e. the appearance of *Nowakia cancellata*. The regional Dalejan basal boundary, also known as the *gracilis* (after *Gyroceratites gracilis*) or *cancellata* boundary, coincides with the global Dalejan Event which terminates the interval (*N. elegans* Zone) where most of the early goniatite lineages became extinct. Of course, intensive investigations of dacryoconarid and conodont faunas around the proposed boundary is needed before any decision is reached. For example, the transition from *N. elegans* to *N. cancellata* should be pinned down because *N. cancellata*, evolving from *N. elegans*, occurs already in faunas still dominated by *N. elegans*. The *cancellata* boundary then has to be integrated with the conodont stratigraphy. This boundary is within the *Po. laticostatus-Po. inversus* Zone, most likely at the appearance of *Po. gilberti* or at the boundary of Weddige's (1996) *Po. nothoperbonus* and *Po. inversus* Zones, respectively.

If we divide the Emsian Stage, the logical procedure would be to continue to use the appearance of *Po. citabicus* as the boundary criterion for the lower stage. However, this boundary is much lower than the subcommission assumed when it selected the *Po. dehiscens* criterion. Half, or perhaps more, of the classical Pragian has been transferred to the Emsian, thus totally changing the meaning of the regional Pragian Stage. Therefore, inspite of the rules, we should revise the lower boundary. I propose that we use the base of the regional Zlichovian as the lower boundary of the proposed Zlichovian Stage.

If this proposal is followed, it has the advantage that the global stage terminology and subdivision of the Lower Devonian more or less coincide with the terms and subdivision used for many decades within the pelagic to hemipelagic magnafacies. In addition, the terms Gedinnian, Siegenian, and Emsian, used for more than a century in the neritic magnafacies, may be applied there when correlation with the international standard is not yet possible.

I would like to thank M. Murphy for help in formulating this comment with which he agrees.

Proposal of boundaries for a Late Frasnian Substage and for subdivision of the Famennian Stage into three Substages

TM Willi ZIEGLER (Frankfurt) and TM Charles A. SANDBERG (Denver)

If subdivision of the Frasnian and Famennian Stages is to be achieved, the most appropriate boundaries should be based on conodonts and on the start of conodont zones that can be widely recognized not only by their zonal indicators, but also by their accompanying faunas. Such widely recognized zones are invariably related to major eustatic rises, as shown on the Devonian sealevel curve (Johnson, Klapper, and Sandberg, 1985). It seems appropriate to subdivide the Famennian Stage, which has a generally accepted duration of ~10 m.y., into three parts (see accompanying chart). The two globally most recognizable zones are the Early *marginifera* Zone and the Early *expansa* Zone. Such a tripartite subdivision would assign 9 zones having a duration of 4.0 m.y. to the Lower (Early) Famennian, 7 zones having a duration of 3.5 m.y. to the Middle Famennian, and 6 zones having a duration of 2.5 m.y. to the Late Famennian. The only equally recognizable zonal boundary, which might be substituted for the start of the Early *marginifera* Zone, is the start of the Latest *crepida* Zone.

The base of the Famennian Stage, of course, has already been defined by the SDS at the start of the Early *triangularis* Zone.

For the Frasnian Stage, which has a duration of only ~5 m.y., there is only one major eustatic rise that is recognized in shallow as well as deep environments. This is the *Palmatolepis semichatovae* transgression, which occurred within the Early *rhenana* Zone. We are unaware of any other Frasnian eustatic rise that is so widely recognizable.

Remarks on the German Late Devonian Stages (Stufen)

Willi ZIEGLER

The German Stages (Stufen) of the Late Devonian were developed between the late 19th century and the middle of the 20th century during the exploration of the Variscan Rhenish Mountains. Many famous German paleontologists were involved, for example, Kayser, Frech, Denckmann, Wedekind, Paeckelmann, H. Schmidt, and Schindewolf.

Although these Stages served as the stratigraphic frame for mapping projects of the former Prussian Geological Survey and later State Geological Surveys, none of them (except the Wocklum Stufe) were originally based on a single measured section but rather on partial sections from different facies realms, slates in the basinal and nodular cephalopod limestones of the submarine rises, which the authors thought would best represent their concept of the respective units. By about 1950, these Stufen were used officially in stratigraphic work and resulting maps, and despite the lack of good reference sections or stratotypes they represented an acceptable umbrella for Upper Devonian rock sequences, stratigraphy, facies, and paleontologic content.

The Stufen and their rocks from the beginning on were searched for fossils and hand in hand with the geological reconnaissance work a cephalopod succession came into usage. A correlation between the Stufen and the ammonoid development was accepted as follows:

Adorf Stufe= *Manticoceras* Stufe

Nehden Stufe= *Cheiloceras* Stufe

Hemberg Stufe= *Platyclymenia - Prolobites* Stufe

Dasberg Stufe= *Clymenia* Stufe

Wocklum Stufe= *Wocklumeria* Stufe

This correlation was rarely based on bed-by-bed and fossil successions, but rather on single tie points, perhaps with the exception of Wedekind's and Schindewolf's studies on ammonoids. Serious errors and miscorrelations resulted, as shown for the Adorf-*Manticoceras* Stufe by House and Ziegler (1977).

Since the 1950's, however, entomozoan ostracodes provided a refined biostratigraphic zonation for the basinal slates (Rabien, 1954, 1956) and conodonts were found to be the ultimate tool for high precision biostratigraphy (Bischoff, 1956; Ziegler, 1958, 1962). The previous classification was helpful for tie points, but the refining studies revealed that many old sections had gaps (Hemberg Stufe), were incomplete (Nehden Stufe), or even overlapped (Adorf and Nehden Stufen; the top of the former Adorf Limestone is within the Famennian Middle *crepida* Zone).

The presently known conodont ages of the boundaries of the German Stages (Stufen), which are still in use, are indicated on the accompanying chart. This positioning is the result of post-1960's studies, during which many of the older sections for all Stufen were revised and some new sections were excavated in type areas (Dasberg and Hemberg Stufen).

It is expected that the German Geological Surveys will continue using the old Stufen, therefore the German Subcommission on Devonian Stratigraphy has recently set up a Working Group to reevaluate and/or newly establish their reference sections.

EPOCH	STAGE	~Ma	STANDARD CONODONT ZONES		PROPOSED SUBSTAGE BOUNDARIES	GERMAN STUFEN
EARLY CARB.			*sulcata*			
LATE DEVONIAN	FAMENNIAN	354	*praesulcata*	Late	UPPER (LATE) FAMENNIAN	Wocklum (VI)
		354.5		Middle		
		354.6		Early		
		355	*expansa*	Late		Dasberg (V)
		356		Middle		
				Early		
			postera	Late	MIDDLE FAMENNIAN	*annulata* (IV)
		357		Early		Hemberg (III)
			trachytera	Late		
		358		Early		
			marginifera	Latest		
		359		Late		
				Early		Nehden (II)
		360	*rhomboidea*	Late	LOWER (EARLY) FAMENNIAN	
		360.2		Early		
		360.5	*crepida*	Latest		
		361		Late		
				Middle		
		362		Early		
			triangularis	Late		
		363		Middle		
				Early		
	FRASNIAN	364	*linguiformis*		UPPER (LATE) FRASNIAN	Adorf (I)
		364.3	*rhenana*	Late		
		365		Early		
		365.7	*jamieae*		(NO OPINION)	
		366	*hassi*	Late		
				Early		
		367	*punctata*			
			transitans			
		368	*falsiovalis*	Late		
				Early		
MIDDLE DEVONIAN		369	*disparilis*			

PROPOSED BOUNDARIES FOR FOUR UPPER DEVONIAN SUBSTAGES

(Conodont biochronology from Sandberg and Ziegler, 1996, Fig. 1a; German Stufen by Willi Ziegler)

Willi Ziegler and Charles A. Sandberg
Submission to Subcommission on
Devonian Stratigraphy
Rochester, NY
July 21, 1997

Minutes for the German SDS group

The German SDS group gathered for their yearly meeting at the Senckenberg Museum in Frankfurt on the 1st of March. 40 colleagues working on the Devonian system participated. Various topics were discussed during the meeting; among those, the following were of major importance: further subdivision of the Devonian stages, holostratigraphic aspects, Devonian correlation chart. Because some of these aspects have been already dealt with in the last newsletter and in a brief submission to the SDS meeting in Rochester, only a few main topics are reported where new developments have progressed.

Two main aspects of German SDS activities are the subdivisions of the Emsian and the Famennian stages. As already reported before (Newsletter No. 13), there has been set up a working group of the German SDS on the boundary between the Lower and the Upper Emsian. During a first meeting of this working group, it had been agreed to search for a boundary close to the *cancelata/elegans* boundary in terms of the dacryoconarid zonation or to look for a suitable 'conodont boundary' as close as possible. These suggestions have been presented in a submission to the SDS meeting in Rochester (U. Jansen & E. Schindler [comps.]), where the search for a suitable conodont boundary had been favoured (but also close to the dacryoconarid boundary). Connections concerning international efforts are under way by the coordinator of the German subgroup Ulrich Jansen (address see Newsletter No. 13). Any suggestions on that topic should be directed to him.

A second working group, concerned with a possible subdivision on the Famennian stage has been established during our yearly meeting. Matthias Piecha from the Geolocical Survey of Nordrhein-Westfalen in Krefeld (address at the end) took the coordination. In the meantime, there have already been held two meetings (one 'theoretical' gathering and one 'practical' field-trip). Briefly summarized, a division of the Famennian into three parts – similar to suggestions in a submission to the Rochester meeting by Willi Ziegler and Charlie Sandberg – have been taken into consideration. Most intense research shall be focused on detailed correlation between the different faunal groups and their various boundaries by close cooperation of the different specialists (here, the traditional German Stufen zonation has a major impact). Suggestions concernig the Famennian subdivision should be directed to Matthias Piecha directly.

Projects together with geochemically and/or geophysically working colleagues have been proceeding. More bentonites for radiometric dating (from stratigraphically well controlled sections, such as the GSSP section at the Lower/Middle Devonian boundary) have been forewarded; cooperations with colleagues working on these datings are in progress.

Two other examples for cooperations between biostratigraphers and other stratigraphers briefly shall be mentioned:

There is a new project (roughly translated as 'Evolution of the system Earth during the late Palaeozoic in the light of sedimentary geochemistry', supported by the German Science Foundation [DFG]) to which some SDS members are attached. CM's Wolfgang Buggisch and Michael Joachimski (both Erlangen) are mainly involved in this project; strongly involved are a group of chemists (organic chemistry) from Jülich and Jan Veizer (Bochum). Questions should be directed to the Erlangen workers (address at the end).

A very fruitful and active cooperation has started between German SDS members and the magnetic susceptibility workers (Brooks Ellwood and Rex Crick) from Arlington, Texas. Biostratigraphically well-known sections have been investigated; research will go on.

Many of the above mentioned activities may be regarded in the frame of the new IGCP project 421 on 'North Gondwanan mid-Palaeozoic biodynamics'(leaders: John Talent and Raimund Feist). German SDS participants at the initial meeting of the project in Wien have been Willi Ziegler, Thomas Becker, Dieter Korn, Gunnar Schraut, Eberhard Schindler. As an example for projects connected with the IGCP 421, TM Willi Ziegler gave a report about an already running cooperation project on the Devonian (mainly Lower Devonian) of the western Anti-Atlas in Morocco between the University of Marrakech and the Senckenberg Institute, Frankfurt. During recent field work, additionally the Arlington magnetic susceptibility group and the colleagues from Rabat, Morocco have been working jointly on a Lower Devonian section together with the teams mentioned above.

At the end of 1996, the first issue of the 'Devonian correlation chart', edited by TM Karsten Weddige (comp. SDS Newsletter No. 13), has been published in Senckenbergiana lethaea, 76: 267-286; Frankfurt/M. The next issue of the chart (updated and enlarged) is in press (Senckenbergiana lethaea, vol. 77). The chart should be checked, applied, and corrected by any interested colleagues. Suggestions should be directed to Karsten Weddige (address see SDS Newsletter No. 13).

Briefly, I want to announce a recent volume of the 'Courier Forschungsinstitut Senckenberg' (CFS) resulting from the SDS meeting on sea-level changes three years ago in Moscow. The volume dedicated in honour of Maria A. Rhzonsnitskaya (St. Petersburg), contains twelve articles on that topic, mostly from regions of the former Soviet Union and other eastern countries; two contributions are dealing with Australian examples. All articles are written in English. Citation of the volume: House, M.R. & Ziegler, W. [eds.] (1997): On sea-level fluctuations in the Devonian.– Cour. Forsch.-Inst. Senckenberg, 199: 146 pp., 70 figs., 3 tabs.; Frankfurt/M. For copies of the volume, the following address should be contacted: Mrs. Sabine Jessel, Forschungsinstitut und Naturmuseum Senckenberg, Schriftentausch, Senckenberganlage 25, D–60325 Frankfurt/M., Germany; Fax: ++49-69-746238; e-mail: sjessel@sng.uni-frankfurt.de

List of addresses of colleagues mentioned in the minutes – and not mentioned in the SDS Newsletter No. 13:

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Finally, there has to be made a sad announcement. Two well-known members of the German SDS died in 1997. Wolfgang Struve (TM of the German SDS and CM of the international SDS) and Heinrich Karl Erben (CM of the German SDS). The German and the international community of Devonian researchers have lost two of their outstanding workers.

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Report of the German Subcommission on Devonian Stratigraphy SDS meeting at Rochester, N.Y.; July 1997

Currently, the German SDS has 64 members. 40 gathered at our last meeting in Frankfurt on the 1 st of March.

The participants discussed various topics; among those the most prominent were: subdivision of Devonian stages, holostratigraphic aspects, Devonian correlation chart, monograph of the German Devonian, database of Devonian (and additional Rhenohercynian) literature.

Starting with the last: There exists a collection of more than 1,600 citations of Rhenohercynian (mainly Devonian) literature. Karsten Weddige initiated it and takes care of it. For the future it is planned to provide it online (to date it is saved on diskettes).

About the valuable Devonian correlation chart we have already heard by K. WEDDIGE.

One of the main aspects in the German SDS is (and will be) the application of holostra tigraphic methods. Obviously, the base has to be intensive biostratigraphic work, but other "stratigraphies" must also be taken into account. The following ones have been discussed in greater detail and may surely enhance stratigraphic knowledge.

Isotope and organic matter geochemistry: There are active working groups (e.g. M. JOACHIMSK! from the Univ. of Erlangen, who is present) or the group at the KFA in Julich.

Event stratigraphy already has - and will continue - to play a major role in Devonian stratigraphy. Many colleagues are working with this method for several years.

Graphic correlation and sequence stratigraphy have to be considered in the future. Discussion of this topic has been showing, that the application of these methods has to be conducted critically, and must be referred to basic biostratigraphic data wherever possible.

Magnetostratigraphy - where possible - will also be conducted (e.g. P. BUCHHOLZ, Braunschweig).

Radiometric dating shall be one of the focusses in the future. There are many bentonites in the German Devonian and - not known to some people - there are already studies from years ago that could be reactivated due to the modern methods (e.g. SHRIMP). I'd like to mention Prof. J. WTNTER at the Univ. of Frankfurt, who worked (differently from today) with bentonites and zirkons e.g. in the Eifel area. First efforts from well-dated sections by myself are under way together with TM J. TALENT and other colleagues.

Concerning the subdivision of Devonian stages there are interests namely for the Famennian and for the Emsian stages.

There has been set up a working group for the subdivison of the Famennian of which M. PIECHA (Geol. Survey in Krefeld) will be the convertor.

A similar group - as we already have shown earlier - exists for the subdivision of the Emsian, were U. JANSEN (FIS, Frankfurt) is the convertor.

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Revised guidelines for the establishment of global chronostratigraphic standards by the International Commission on Stratigraphy (ICS)

by Jurgen Remane, Michael G Bassett, John W Cowie, Klaus H Gohrbandt, H Richard Lane, Olaf Michelsen and Wang Naiwen, with the cooperation of members of ICS

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Background

These Revised Guidelines are the result of close cooperation between the Bureau and Subcommissions of ICS. A first provisional draft was prepared by J Remane, Chairman of ICS, taking into account proposals made by K H Gohrbandt, then Secretary General of ICS. A more formal draft was established on this basis by the Bureau of ICS at its meeting at Neuchatel (Switzerland) in March 1994. This was circulated to all Subcommissions for comments. That draft was also discussed at the International Symposium on Permian Stratigraphy at Guiyang (China) in September 1994, the 4th International Symposium on Jurassic Stratigraphy at Mendoza (Argentina) in October 1994, and at the 2nd International Symposium on Cretaceous Stratigraphy at Brussels (Belgium) in September 1995. The final version, incorporating as far as possible oral and written comments from members of ICS bodies, was worked out at the meeting of the Bureau of ICS at Neuchatel in April 1996, attended by J Remane (Chairman), M G Bassett (1st Vice- chairman), O Michelsen (Secretary General), and H R Lane (1st Vice-chairman elect), and was then submitted for vote to the full Commission of ICS (consisting of the five members of the Bureau of ICS and the 16 Chairpersons of ICS Subcommissions).

In this vote, the Revised Guidelines were approved by the full Commission with an overwhelming majority, with only one opposing vote. The Revised Guidelines are thus a formal and mandatory document regulating the procedure to be followed in the definition of chronostratigraphic boundaries. The particular importance of this text lies also in the fact that this is the first document on stratigraphic procedure issued by ICS which represents a voted formal agreement.

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1 Introduction

The Silurian-Devonian Boundary Committee was the first to put into practice (in 1960) the principle to define chronostratigraphic units by their lower boundary only, which thus becomes automatically the upper boundary of the underlying unit. The Silurian-Devonian boundary-stratotype at Klonk in the Czech Republic was ratified at the 24th International Geological Congress (IGC) at Montreal, 1972. During this process, the committee developed the principles of chronostratigraphic boundary definition. These 'lessons learned' (McLaren, 1977:23) constituted the basis of the first Guidelines of ICS, where the concept of the Global Standard Stratotype-section and Point (GSSP) was introduced:

> *This Boundary Stratotype Section and Point is the designated type of a stratigraphic boundary identified in published form and marked in the section as a specific point in a specific sequence of rock strata and constituting the standard for the definition and recognition of the stratigraphic boundary between two named global stratigraphic (chronostratigraphic) units* (Cowie and others, 1986:5).

This definition is still valid for the Phanerozoic. A GSSP voted by the Full Commission of ICS (the Bureau of ICS and Chairpersons of all ICS Subcommissions, see also Bassett, 1990) and confirmed by the Executive of the International Union of Geological Sciences (IUGS) represents a ratified boundary definition.

The necessity for a precise global chronostratigraphic scale is obvious. Research on global events means comparison of stratigraphic documents from distant regions—but how can we be sure to deal with the same event throughout, without having a precise and reliable chronostratigraphic scale? The same is true for the establishment of eustatic sea-level curves or the reconstitution of global climatic changes in the past. Progress in these and many other fields of geological research is only possible if progress is also made in the definition of chronostratigraphic units.

2 Aims and principles

2.1 Aims of the revision

The original Guidelines were issued by the Bureau of ICS (Cowie and others, 1986) and summarised by Cowie (1986) in *Episodes*, the official publication of IUGS, and by Cowie (199O, 1991). They have guided uniformity of definition for 20 chronostratigraphic boundaries during ten years of successful application. The experience gained in this process has confirmed the basic principles of the original Guidelines. Nevertheless, a cautious revision of the Guidelines appears useful for different reasons:

1 The Precambrian Subcommission of ICS has proposed a global stratigraphic subdivision for the Proterozoic where boundaries are defined in terms of absolute ages (see section 2.2), with entirely new names for the nine Proterozoic systems created on this basis. The resultant new subdivision of the Proterozoic was voted by ICS and ratified by IUGS at the 28th IGC in Washington, 1989: it is thus formalized (and should therefore not have been omitted in the 2nd edition of the ISG).

2 During the last years, great progress has been made in the field of non-biostratigraphic methods of correlation (see section 3.1). These should therefore be given more weight in the choice of boundary levels and type-sections.

3 Certain problems concerning the philosophy of boundary definition came up repeatedly in recent discussions of GSSP candidates, such as the necessity to respect priority, to have natural boundaries (see section 2.4), the role of fossils in boundary definition (see section 3.1), and the degree to which global correlation has to be exact before defining a boundary (see section 2.3)

4 Since the publication of the original Guidelines (Cowie et al.,1986), important publications on the principles of stratigraphy have appeared, especially the 2nd edition of the International Stratigraphic Guide (ISG) (Salvador, 1994). or Harland (1992). The position of the Guidelines in this new context had to be clarified.

The role of the Guidelines remains, however, unchanged. They regulate the procedures of boundary definition, the selection of an appropriate boundary level, and the corresponding voting procedures (also partly dealt with in articles 3 and 7.1 of the statutes of ICS). They further define the requirements to be fulfilled by the stratotype-section housing the boundary point.

2.2 The Precambrian Standard

The new boundary-type definition, first introduced for the Proterozoic in 1989, was necessitated by the lack of adequate fossils in most of the Precambrian. It is termed herein the Global Standard Stratigraphic Age (GSSA). Defining boundaries in terms of absolute apes means that the numerical value of the boundary age is a theoretical postulate, independent of the method applied to obtain numerical ages. But, as in the case of boundaries defined by a GSSP, an explicit motivation for the choice of the proposed numerical value should be given, clarifying, at the same time, its relation to traditional boundary definitions. GSSAs have the same status for boundary definition in the Precambrian as GSSPs have in the Phanerozoic.

2.3 Correlation precedes definition

Except for the Precambrian, this principle is still valid. To define a boundary first and then evaluate its potential for long-range correlation (as has been proposed in some cases) will mostly lead to boundary definitions of limited practical value. On the other hand, it would be unrealistic to demand that a given boundary be recognisable all over the world before it can be formally defined. In each case we must find the best possible compromise, otherwise the search for the Holy Grail of the perfect GSSP will never end.

2.4 Priority and natural boundaries

Our main task for a number of years will be to develop precise boundary definitions for traditional chronostratigraphic units. Most of them were defined in the last century by their characteristic fossil contents, and their boundaries coincided with spectacular biostratigraphic and lithologic changes. These were 'natural' boundaries, in perfect agreement with the catastrophist philosophy of that time. In reality, rapid faunal turnovers are to a certain extent artefacts due to stratigraphic gaps or condensation. Most of the classic type-localities are thus unsuitable for a precise boundary definition: we have to look for new sections where sedimentation is continuous across the boundary interval; but then boundaries will rarely correspond to a lithologic change.

The idea that chronostratigraphic boundaries should always correspond to something 'visible' has also led to conflicting regional 'definitions' of international chronostratigraphic boundaries, which were adapted to regional lithostratigraphic boundaries of different ages.

There is no formal priority regulation in stratigraphy. Therefore, in redefining boundaries, priority can be given to the level with the best correlation potential. The redefinition will give us the opportunity to use fossil groups (such as conodonts) and methods of chronocorrelation (such as magnetostratigraphy) which were unknown or poorly developed at the time of the original definition. This does not mean that priority should be totally neglected. Practical considerations will incite us to limit changes to the necessary minimum. If, however, the interregional correlation potential of a traditional boundary does not correspond to the needs of modern stratigraphy, its position has to be changed.

Chronostratigraphic boundaries are conventional boundaries. They are a matter of normative science and can be decided by a majority vote (Cowie and others, 1986). To a certain degree, this principle can be reconciled with the demand for natural houndaries. As stated above, most of the classical boundaries are not clear cut but correspond to critical biotic and/or climatic transitions. Placing a boundary within such an interval will preserve the advantage of having successive units which are distinguished by their contents. But where exactly the boundary is to be placed, are matters of convention and practical considerations.

Once a boundary is (re)defined by a GSSP or a GSSA, it should be used in all published figures and tables. Such an obligation will not hinder any authors from expressing their personal opinions.

2.5 Boundary-stratotypes instead of unit-stratotypes

If chronostratigraphic units were defined by unit-stratotypes, the boundary between two adjacent units would be defined by two separate GSSPs: as the upper boundary of the lower unit in one unit-stratotype and as the lower boundary of the succeeding unit in the other. The Global Chronostratigraphic Scale must, however, comprise strictly contiguous units, without overlaps and with no gaps between them. But there is no method of correlation which would guarantee a perfect isochrony of two separate boundary points, even at a short distance apart (Harland, 1992).

This problem was already recognised in the first edition of the ISG (Hedherg, 1976), but unit-stratotypes for chronostratigraphic units were still admitted as an alternative possibility. In the second edition (Salvador, 1994). boundary-stratotypes are given a stronger preference, but as a whole, the position remains ambiguous: 'Since the only record of geologic time . . . lies in the rocks themselves, the best standard for a chronostratigraphic unit is a body of rocks formed between two designated instants of geologic time.' (Salvador, 1994: 88).

The Guidelines of ICS are unambiguous: **Chronostratigraphic units of the Phanerozoic Global Standard can only be defined through boundary stratotypes**. Even should the situation arise (e.g. as in the Silurian stratotypes in Britain) that the GSSPs defining the lower and upper boundaries of one-and-the-same unit are located in the same section, this does not imply that the stratigraphic interval and its biota between the two GSSPs represent a unit stratotype.

For several systems, upper and lower boundaries are now defined by GSSPs. Following the choice of the best type-section these are located in distant regions: the base of the Silurian in Scotland. UK; that of the Devonian in the Czech Republic; that of the Carboniferous in the Montagne Noire, France; of the Permian in Kazakhstan; and the base of the Quaternary in Italy.

The lower boundaries of chronostratigraphic units of higher rank (series, systems etc.) are automatically defined by the base of their lowermost stage. In other words: the lower boundary of a system is always also a series and it stage boundary.

A GSSP cannot be compared to the holotype of Zoological Nomenclature; it corresponds rather to a standard of measure in physics (Harland, 1992). The use of terms like holostratotype, parastratotype etc. should therefore be avoided (Cowie and others, 1986). If reference sections and points seem necessary in order to give a better understanding of the boundary in another facies or paleobiogeographic context, an auxiliary stratotype point may be defined. Such auxiliary points are subordinate to a GSSP.

3 The choice of the best boundary level

3.1 Some general considerations about chronostratigraphic methods

Chronostratigraphy and chronocorrelation have been discussed at length in the ISG (Salvador, 1994). We may thus limit the following discussion to selected topics which are of particular importance for the choice of the boundary level.

Considerable progress has been made in the last few years in developing and improving methods of non-biostratigraphic chronocorrelation. Some of them are based on geochemical signals, like the famous Ir-spike used as guidance for the definition of the Cretaceous-Paleogene boundary, or on shifts of stable isotopes which should be helpful in the definition of the Permian-Triassic boundary (Baud and others, 1989).

Reversals of the Earth's magnetic field are important, because they are a worldwide phenomenon and practically instantaneous, thus providing a precise and reliable means of chronocorrelation. Late Jurassic to Recent reversals have been calibrated to the Magnetic Polarity Time Scale based on oceanic anomalies (Hailwood, 1989).

Geophysical and geochemical events are, however, repetitive and do not allow an unequivocal determination of the age. They need calibration through radioisotopic or biostratigraphic dating. Unfortunately, radioactive isotopes are rarely available where needed so that stratigraphic routine work depends mostly on other methods. But radioisotopic datings are very important for the quantitative calibration of relative ages.

Biostratigraphic boundaries, i.e. the boundaries of the material stratigraphic occurrence of species, are diachronous (ISG). This fact has, however, been overstated. A species exists for a finite span of time and is therefore characteristic of a certain geologic interval. In rapidly evolving lineages this may be less than one million years, so that most biostratigraphic datings attain a higher degree of resolution than the use of radioisotopes.

The use of fossils for calibrating chronostratigraphic units does not only involve tracing of biostratigraphic boundaries. It is indeed less a matter of correlation than of determining relative ages within a biochronologic standard of reference. Biochronology is the reconstruction of the succession of species in time through the synthesis of local and regional biostratigraphic data (for a recent overview, *see* Remane, 1991). The chronostratigraphic reliability of biostratigraphic boundaries can thus be tested by comparing data from different species. In this process, mathematical approaches (Quantitative Stratigraphy) play an increasingly important role (Gradstein and others, 1985; Guex, 1991; Mann and Lane, 1995).

Fossil species depend on the environment and are biogeographically limited. An appropriate choice of widespread species may diminish but never totally eliminate these shortcomings. Radioactive isotopes do not suffer from these geographical restrictions; but their resolution diminishes with increasing age. Therefore, non-biostratigraphic markers like magnetic reversals and stable isotopes have gained increasing importance in long-range lateral correlation.

3.2 The best boundary level

With the above considerations in mind, the correlation potential of any boundary level should be tested through a detailed study of several continuous successions covering the critical interval, if possible on different continents. The most suitable of these sections can then be selected for definition of the GSSP. If two boundary levels of equal correlation potential are available, the better candidate (see chapter 4) will decide the choice of the boundary level.

This implies the integration of data from different facies and paleogeographic provinces in a global synthesis. The perfect GSSP, where all elements of such a synthesis are well represented, will often not be available. Flexibility is therefore necessary in order to make a timely decision.

The boundary definition will normally start from the identification of a level which can be characterised by a marker event of optimal correlation potential. This marker event may be a magnetic reversal, some kind of geochemical or isotopic signal, or the first appearance or last occurrence of a fossil species. However, only the boundary point in the section, the GSSP (Cowie et al., 1986) formally defines the boundary. This means that an occurrence of the primary marker does not automatically determine the boundary. Other markers should therefore be available near the critical level, in order to support chronostratigraphic correlation in sections other than the GSSP. If the primary marker is a fossil species, first appearances are generally more reliable than extinction events, especially if the gradual transition between the marker and its ancestor can be observed.

4 The requirements for a GSSP

The danger of eternalizing the search for the best type-section has already been addressed in section 2.2. The stratotype- section should contain the best possible record of the relevant marker events. In this sense, the requirements listed below characterize the ideal section. Not all of them can be fulfilled in every case, but the fact that all GSSPs are voted by ICS in accordance with the present Guidelines insures that flexibility will not degenerate to arbitrariness.

4.1 Geological requirements

- **Exposure over an adequate thickness** of sediments is one requirement to guarantee that a sufficient time interval is represented by the section, so that the boundary can also be determined by interpolation, using auxiliary markers close to the boundary.
- **Continuous sedimentation**: no gaps, no condensation in proximity of the boundary level.
- **The rate of sedimentation** should be sufficient that successive events can be easily separated
- **Absence of synsedimentary and tectonic disturbances.**
- **Absence of metamorphism and strong diagenetic alteration** (identification of magnetic and geochemical signals).

4.2 Biostratigraphic requirements

- **Abundance and diversity of well-preserved fossils** throughout the critical interval. Diversified biotas will offer the best possibility of precise correlations.
- **Absence of vertical facies changes** at or near the boundary. A change of litho- or biofacies reflects a change of ecologic conditions which may have controlled the appearance of a given species at the boundary level. A sharp lithofacial change may also correspond to a hiatus. 'An obvious boundary should be suspect' (Cowie and others, 1986).
- **Favourable facies for long-range biostratigraphic correlations**; this will normally correspond to an open marine environment where species with a wide geographic range will be more common than in coastal and continental settings. The latter should therefore be avoided.

4.3 Other methods

Magnetostratigraphy, sequence stratigraphy, cyclostratigraphy, analysis of stable isotopes should be given due weight in the selection of a GSSP. If a choice has to be made between candidates having more or less the same biostratigraphic qualities, the one offering the better applications of non-biostratigraphic methods should be preferred.

- **Radioisotopic dating**. Whenever possible, it is important to achieve direct quantitative calibration (numerical age) of a chronostratigraphic boundary at the GSSP.
- **Magnetostratigraphy**. A reproducible magnetic reversal stratigraphy is a desirable requirement in order to know where in the magnetostratigraphic sequence the GSSP is located.
- **Chemostratigraphy**, including the study of vertical changes of the proportions of stable isotopes, which may be indicative of global events.
- The regional paleogeographical context and the facies relationships of the stratotype-section should be clarified. Knowledge of the sequence stratigraphy will contribute to an understanding of these relations.

4.4 Other requirements

- The GSSP should be indicated by a permanently fixed marker.
- Accessibility: candidate sections in remote regions which can only be visited by organizing costly expeditions should normally be excluded from the selection.
- Free access for research to the type-section for all stratigraphers regardless of their nationality.
- When making a formal submission to ICS, the concerned Subcommission should try to obtain guarantees from the respective authority concerning free access for research and permanent protection of the site.

5 Procedure for the submission of a GSSP

5.1 Editing of the submission

Submissions must be in English. In order to provide a clear picture of the qualities of the proposed GSSP candidate, the formal submission to ICS or to the concerned Subcommission should give the following information:

1 name of the boundary;

2 indication of the exact location (coordinates) of the stratotype-section on a detailed topographic map or aerial photograph, if possible at a scale not less than 1: 50.000;

3 location on a detailed geologic map;

4 detailed description of the stratotype-section including a litholog and photos of the section, indicating the bed in which the boundary-point is defined and the key-levels for all physical and biostratigraphic markers;

5 motivation for the choice of the boundary level and the stratotype-section, with a discussion of failed candidates and their ease of intercontinental correlation;

6 any comparison with former usage should be discussed fully;

7 discussion of all markers used in the determination of the boundary level;

8 illustration of important fossils;

9 results of radioisotopie dating, indicating clearly what method has been used;

10 results of all votes within the Working Group and the Subcommission.

Note: Within these procedures, only items 1, 6, 7, 9, 10, and the motivation for the choice of the boundary-level are relevant to the establishment of a GSSA.

Following acceptance of the submission within these Guidelines, the Chairperson or the Secretary of ICS will arrange a vote by the full Commission within a period of no more than 60 days.

5.2 Voting procedure

In accordance with the ICS statutes, all formal voting must be conducted by post, giving a deadline of 60 days for the receipt of votes. Voting members (of the Working Group, Subcommission or full Commission) may vote 'YES', 'NO', or 'ABSTAIN'. The last step in the selection of a final candidate for a boundary level and/or a GSSP should always be a vote on one single candidate (Cowie et al., 1 986).

In outline, this procedure includes the following steps:

1 Successive voting by members of the concerned Working Group leading to the choice of a boundary level and the final selection of a single GSSP or GSSA candidate.

2 If this obtains the statutory working majority in the Working Group, members of the respective Subcommission will vote on whether or not the candidate be approved.

3 In the case of a statutory majority being in favor, formal submission of the candidate to ICS for approval.

4 Again, in the case of a statutory majority, submission of the GSSP or GSSA candidate to the IUGS Executive Committee for ratification, together with an abstract of tile submission. prepared by the responsible ICS body.

ICS should attempt to finalize, within three years after IUGS ratification, any remaining official steps for the protection of the site with the authorities of the country in which the GSSP is located.

6 Revision of a GSSP

A GSSP or GSSA can be changed if a strong demand arises out of research subsequent to its establishment. But in the meantime it will give a stable point of reference. Normally, this stability should be maintained and the practical value of the boundary definition tested for a minimum period of ten years. Revisions for other reasons should be made only in exceptional circumstances, such as:

1 The permanent destruction or inaccessibility of an established GSSP,

2 a violation of accepted stratigraphic principles discovered only after the ratification of a GSSP.

7 Selected references

The 2nd edition of the ISG (Salvador, 1994) contains a comprehensive list of publications dealing with the principles and techniques of stratigraphy. The present list of references is therefore limited to papers providing further information on the principles underlying these Guidelines, adding some titles not mentioned in the ISG.

Bassett. M 1990. International Commission on Stratigraphy, in Briggs, D E G and Crowther, P C, eds., Paleobiology, a synthesis: Blackwell, pp.468-469.

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McLaren, D J, 1977, The Silurian-Devonian Boundary Committee a final report, in Martinsson, A, ed., The Silurian-Devonian Boundary: Stuttgart: IUGS Series A, no. 5, pp.1-34.

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Annual Meeting of the German Palaeontological Society, Daun, 21.-28. Sep. 1997

This year's Annual Meeting took place in the heart of the Eifel Mountains and, therefore, much of the programm and the excursions was devoted to Devonian topics and localities. The conference was held in the modern conference centre next to the GEO Zentrum Vulkaneifel (Leopoldstr. 9, D-54550 Daun) which focusses on the Tertiary and Quarternary basaltic volcanism but the Deutsche Palaeontologische Gesellschaft was exceedingly well hosted by the organizers I. Eschghi and Mrs. H. Rudolf. A reception was held on the evening of the 24th in the Natural History Museum of Gerolstein which displays a good collection of the famous local Devonian fauna.

Seven excursions led to the Lower Devonian clastic sequences of the southern Eifel Mountains and of the Hunsr,ck as well as to the fossiliferous Eifelkalkmulden. Two excursions dealt with the industrial exploitation of Middle Devonian carbonates and with hydrogeological aspects of the southern Eifel synclines. Stratigraphy and regional paleontology were during tours to:

Excursion B: Stratigraphy and facies in the Lower Emsian of the Manderscheid Uplift (led by H.-G. Mittmeyer).

Excursion C: The Lower Devonian of the Osteifeler Hauptsattel (led by W. Meyer).

Excursion D: Middle Devonian Eifelkalkmulden, I and II (led by W. Haas & A. Braun).

Excursion H: Biostratigraphical stage boundaries and events in the Pr,m and Hillesheim Synclines (led by G. Plodowski & K. Weddige).

Excursion K: Bundenbach and the Lower Devonian of the Mosel Syncline (led by C. Bartels, W. Blind, M. Wuttke, H. Ristedt, A. Braun, J. Gad & H. Elkholy)

All excursion guides are published in Terra Nostra, 97/7: 202 p., ISSN 0946-8978.

During the sessions the following Devonian talks and poster contributions were presented (titles translated, all published in Terra Nostra, 97/6; page numbers given in square brackets):

Bartels, C. & Wuttke, M.: Project Nahecaris: The Hunsrückslate and its fossils. [24-25]

Becker, R.T.: Origin and evolution of triangular clymenids and their relatives (Wocklumeriina n. suborder; oberes Oberdevon). [28-29]

Brühl, D.: Fauna and facies of Middle Devonian reef carbonates (Upper Eifelian) of the Middle Dollendorf Syncline/Eifel (Rhenish Slate Mountains). [40]

Brühl, D. & Pohler, SD.: Tabulate corals of the Moore Creek Limestone (Middle Devonian/Eifelian) of the Tamworth Belt (Moore Creek, New South Wales, Australia). [137, poster]

Elkholy, H., Ristedt, H. & Gad, J.: Lithofacies and biofacies investigations in the middle part of the Upper Emsian of the Koblenz area. [47]

Gudo, M.: Attempt of an anatomical reconstruction of Calceola sandalina. [60-61]

Haas, W. & Bruton, D.: On the enrolling mechanism of Phacops (Trilobita). [62]

Hampe, O.: On the histology of some elasmobranchiate teeth from the Middle/Upper Devonian of Antarctica. [64]

Jansen, U.: Problems of the brachiopod stratigraphy in the Rhenish Lower Devonian, examples from the genus Schizophoria. [68]

Kauffmann, G.: Calcareous Algae from the Middle Devonian of the Lahn and Dill Synclines. [150, poster]

May, A.: Stromatoporoids from the Lower Devonian reef of Koneprusy (Bohemia) - first research results. [83]

Otto, M.: The vertebrate fauna of the Brandenberg Formation in the Eifelian of the northern Rhenish Slate Mountains.[90]

Pohler, S.: The influence of sealevel changes on biostromal developments - a case study from Emsian and Eifelian limestones from Eastern Australia. [93]

Requadt, H.: Lithostratigraphy in the Devonian of Rhienland-Pfalz. [158-159]

Salerno, C., Nose, M. & Schröder, S.: Facies and palaeoecological studies in the Middle Devonian (Givetian) of the Sötenich Syncline (Eifel). [162]

Schöne, B.R.: The otomari Event on the Rhenohercynian Schelf (northern Rhenish Slate Mountains). [107]

Schraut, G.: Stratigraphical and palaeobiogeographical analyses of trilobites from the Lower Devonian of the Anti-Atlas (Morocco). [108-110]

Schröder, S.: The rugose fauna of the Eilenbergium of the Dollendorf Syncline (Middle Devonian/Upper Eifelian; Rhenish Slate Mountains/Eifel). [111]

Schölke, I.: The Nehden Event in the Rhenish Slate Mountains and in the Montagne Noire - a comparison. [112]

Schultze, H.-P.: Upper Devonian fishes of Colorado and their palaeoecology. [113]

Weddige, K.: The Devon-Korrelationstabelle (DK) - an uniformly formatted correlation chart with coordinates as a standardized stratigraphical communication agent. [128]

Ziegler, W.: The significance of the Eifel region for scientific stratigraphy. [131-132]

R. Thomas Becker
Secretary

Meeting of the IGCP 406 project "Circum-Arctic Lower-Middle Palaeozoic Vertebrate Palaeontology and Biostratigraphy"

The meeting: "Palaeozoic Strata and Fossils of the Eurasian Arctic" was held from 23 to 26 September 1997 at the St. Petersburg University, Geological Faculty, Department of Palaeontology. The meeting was organised by A. Ivanov, I. Evdokimova, T. Modzalevskaya, S. Snigirevskiy and A. Zhuravlev. More than 35 participants from 12 countries (Australia, Estonia, France, Germany, Ireland, Latvia, Lithuania, the Netherlands, Poland, Russia Sweden, UK) have attended with various contributions. They embraced the studies of the whole Palaeozoic but most oral and poster presentations were associated with the Devonian biostratigraphy: the stratigraphic position of reefs and the vertebrate and conodont assemblages in the Timan-Pechora Province; ostracod, bivalves and fossil plant distribution and palaeogeography of the Eurasian Arctic region; vertebrates and other fossils of Severnaya Zemlya; vertebrate microremains from the Canadian Arctic. The project business meeting and workshop on Severnaya Zemlya monographs took place during the meeting. Dr Peep Mannik (Tallinn, Estonia) was elected as a third co-leader of the project apart from Tiiu Marss and Mark Wilson. The meeting of the project are planned for next year in Warsaw, Poland. As well the project is going to finish the preparing of two monographs on Severnaya Zemlya. The first of them concerned the Silurian-Devonian stratigraphy of the archipelago will be published in Russian, in Novosibirsk Press, R. G. Matukhin & V. V. Menner, eds.; a second one with the palaeontological descriptions will be printed in English, in Geodiversitas, Paris, D. Goujet & H. Lelievre, eds.

The abstract volume published by the St. Petersburg University as Ichthyolith Issues Special Publication 3 (A. Ivanov, M.V.H. Wilson & A. Zhuravlev, eds.) are available on the Web site:

http://www.wplus.net/pp/Stratigr

Contents of Ichthyolith Issues Special Publication 3:

MARSS, T. & WILSON, M.: Introduction

ABUSHIK, A. F. & EVDOKIMOVA, I. O.: Key intervals for ostracod correlation in different facies of the lower Devonian of the Eurasian Arctic

ANTOSHKINA, A. I.: Stratigraphic position of reefs in the Lower Palaeozoic succession of the Timan-Pechora region

BURROW, C. J., VERGOOSSEN, J. M. J. & TURNER, S. : Microvertebrate assemblages from the Late Silurian of Cornwallis Island, Arctic Canada

ERMOLAEW, W. & IVANOV, A.O.: Middle Devonian vertebrates from the Mimer Valley Basin of Vestspitsbergen

FEDOSEYEV, A. V.: Biostratigraphic trilobite-based subdivision of Cambrian deposits of Sukharikha River (Igarka Region)

GINTER, M. & TURNER, S.: New Early Famennian phoebodont shark from Melville Island, Arctic Canada

GOUJET, D. F.: Placoderms from Lower Devonian borings of Timan-Pechora

ISAKOVA, T. N. & AGAFONOVA, G. V.: Fusulinid biostratigraphy of Lower Permian deposits of the Kolva swell, north Timan-Pechora province

KARATAJUTE-TALIMAA, V. N. & MARSS, T.: Thelodonts from the Silurian and Lower Devonian of the Severnaya Zemlya Archipelago, Russian Arctic

KARATAJUTE-TALIMAA, V., VALIUKEVIÈIUS, J., JURIEVA, Z. & MENNER, V. : Vertebrate assemblages and correlation of Lower Devonian deposits of different facies in the northern Timan-Pechora province

KISSELEV, G. N.: Brief review of Silurian cephalopods of Severnaya Zemlya Archipelago and Novosibirsk Islands

KOROVNIKOV, I. V.: Lower Cambrian trilobite assemblages from the northeastern Siberian Platform

KOSSOVAYA, O. L.: Upper Palaeozoic rugose coral biostratigraphy of northern European Russia: key reliable levels

KULIKOVA, V. F. & SINITSINA, I. N.: Silurian - Devonian bivalvia from the Eurasian Arctic

KURSS, V. & PUPILS, M.: On paleogeography of eastern blocks of the Devonian Euramerican supercontinent

KUZMIN, A. V.: Aspects of the Frasnian conodont stratigraphy of the Timan-Pechora province

LAZARENKO, N. P., PEGEL, T. V. & ABAIMOVA, G. P. : Biostratigraphy of open marine Upper Cambrian deposits of Northern Siberia (from reference sections of Kharaulakh Ridge and Southwestern Prianabar'e)

LUKSEVICS, E.: Preliminary report on Middle/Upper Devonian fishes from Severnaya Zemlya (Placodermi, Bothriolepididae)

MANNIK, P: Silurian conodonts from Severnaya Zemlya

MATUKHIN, R., KARATAJUTE-TALIMAA, V., MARK-KURIK, E., CHERKESOVA, S. & MENNER , V.: Comparison of Upper Silurian and Lower Devonian facies and vertebrate assemblages of Severnaya Zemlya, Taimyr and the Northwestern Siberian Craton

MATUKHIN, R., MENNER, V., ABUSHIK, A., KARATAJUTE-TALIMAA, V., LUKSEVICS, E., MANNIK, P., MARK-KURIK, E, MARSS, T., MODZALEVSKAYA, T., NESTOR, H., SOBOLEV, N., STUKALINA, G. & VALIUKEVIÈIUS, J. : Dating of the Silurian and Devonian formations on Severnaya Zemlya

MILLER, C. G. & ADRAIN, J. M.: Conodonts from the Cape Phillips Formation (Wenlock, Silurian) of Arctic Canada

MODZALEVSKAYA, T. L: Ordovician and Silurian brachiopod succession of the Timan-Pechora region

NEKHOROSHEVA, L. V. & PATRUNOV, D. K.: Silurian paleobiogeographic provinciality of northern parts of the Baltica and Siberia paleocontinents: Southern Novaya Zemlya, Severnaya Zemlya, Taimyr

PATRUNOV, D. K.: Southern Novaya Zemlya basin in the Middle Paleozoic: from Yapetus system to Paleo-Uralian ocean system

SIPIN, D. P.: Small shelly fossil zonal assemblages of the Tommotian - Atdabanian on the northwestern Siberian Platform

SNIGIREVSKY, S. M.: Some Lower Carboniferous floras of the Arctic

SNIGIREVSKY, S. M.: Upper Devonian floras of the Arctic

STUKALINA, G. A.: Correlation of the Lower Silurian in Arctic regions and the Siberian Platform

SUKHOV, S. S. & PEGEL, T. V.: Daldin-Markha reef bank: depositional reconstruction and trilobite assemblage evolution for Cambrian stratigraphy on the Siberian Platform

TURNER, S.: Late Silurian microvertebrates from Cresswell Bay District, Somerset Island, Canada

TURNER, S. & BURROW, C. J.: Lower and Middle Devonian microvertebrate samples from the Canadian Arctic

VERGOOSSEN, J. M. J.: Revision of poracanthodid acanthodians

YOUNG, V. T.: Early Palaeozoic acanthodians in the collection of the Natural History Museum, London

ZHURAVLEV, A. V.: Environmental control on conodont micro-ornamentation: preliminary results from the Upper Devonian and Lower Carboniferous

ZHURAVLEV, A. V.: Tournaisian (Lower Carboniferous) conodont natural assemblages (Northern Urals).

Dr. Alexander Ivanov

St. Petersburg

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IGCP 406
Circum-Arctic Palaeozoic Vertebrates Meeting
"Circum-Arctic Palaeozoic Faunas and Facies"
Warsaw, Poland, September 3-8, 1998
FIRST CIRCULAR

Invitation

All interested Palaeozoic workers are invited to attend the 1998 meeting of IGCP 406 which will be held at the Faculty of Geology, Warsaw University in Warsaw, Poland, from September 3 to 8, 1998.

Conference topics

Biodiversity of Palaeozoic vertebrates and invertebrates of Circum-Arctic regions, in connection with palaeocology, stratigraphy and palaeogeography. Contributions on plants or palynomorphs are welcome.

Workshops: during the meeting a special symposium/workshop on Palaeozoic chondrichthyans from all over the world will be held. The workshop will be particularly focused on chondrichthyan microfossils, but any presentation dealing with sharks, both from the biostratigraphic or the morphological/phylogenetic aspect, is welcome. We invite suggestions on topics of other conference workshops.

Available equipment: Slide and overhead projectors.

Abstracts

Abstracts of conference papers should be submitted before April 1, 1998.

The text (in English, no more than 2 pages, including references) should be sent by e-mail as ASCII files. If you use special or national letters, or you want to add illustrations, please send a hard copy separately.

Estimated costs

Registration fee: 50 US$

The fee will be collected during the meeting at the registration desk.

Accommodation: 30 US$/night at the Academy hotel. The cost of living in Warsaw is ca. 10-20 US$/day.

Limited financial support from IGCP, as well as considerable reduction of accommodation/registra-tion costs are possible. If you are interested, please inform us as soon as you can.

Excursion

A two-day (7-8.09.) post-conference excursion to the most exciting Devonian outcrops of the Holy Cross Mountains is planned. Estimated cost: 50 US$.

Deadlines:

Preliminary registration - February 15, 1998 Abstracts - April 1, 1998

Please let us know if you need an official invitation.

Address

Michal Ginter, Institute of Geology, Warsaw University, Zwirki i Wigury 93

02-089 Warszawa, POLAND, e-mail: fiszbit@geo.uw.edu.pl, fax: (48 22) 22-02-48

IGCP 406

Circum-Arctic Palaeozoic Vertebrates

Warsaw Meeting, September 3-8, 1998

REGISTRATION FORM

Last name:

First name(s):

Title:

Sex (M/F)

Institution:

Address:

E-mail:

Fax:

My attendance is:

probable _ definite _

I will present a paper:

yes _ no _

Title of presentation (coauthors' names) :

Type of presentation:

oral _ poster _

I intend to submit an abstract(s) entitled:

I wish to take part in:

conference sessions _

workshop _

conference dinner _

post-conference excursion _

I need reservation at the hotel:

yes _ no _

a single room _ a bed in a double room _

I wish to make my own arrangements for accommodation _

I need official invitation:

yes _ no _

Please complete and return by e-mail (if it is possible) before February 15, 1998

E-mail: fiszbit@geo.uw.edu.pl

Michal Ginter, Institute of Geology, Warsaw University, Zwirki i Wigury 93, 02-089 Warszawa, Poland

NOTE: A version of this form suitable for submittal via e-mail may be obtained by sending a blank message with the subject "WARSAW MEETING" to crick@uta.edu. The form will be sent to you automatically via return e-mail. You may then use your e-mail editor to complete the information and forward it to Michal.

NEW IGCP PROJECT

NORTH GONDWANA MID-PALAEOZOIC BIOEVENT/BIOGEOGRAPHY PATTERNS IN RELATION TO CRUSTAL DYNAMICS

Objectives:

Analysis of bioevents (especially global extinctions and recoveries), major variation in biodiversity, and change in biogeographic differentiation along the North Gondwana continental margin during the mid-Palaeozoic. Integration of these data with the biofacies & lithofacies database for the region will be undertaken in pursuit of increased precision in stratigraphic alignments and improved palaeogeographic and palaeoclimatologic syntheses. Important (even constraining) implications are predicted as regards relative positioning of crustal blocks at the beginning of the mid-Palaeozoic, and for inferring geodynamic events during the crucial period leading to the Pangaea assembly.

The principal foci of the project are:

1. Close examination of major bioevents (especially global extinctions and recoveries) and biodiversity (including isotopic indicators thereof), and the extent to which these events and their "evolution" can be discriminated from crustal block to crustal block through the region.
2. Quantitative analysis of change in biogeographic differentiation laterally as well as changing patterns through time of biogeographic similarity & dissimilarity (believed to reflect, primarily, the relative positioning of the crustal blocks through time).
3. Integration of these data with the biofacies & lithofacies database for the region to provide:
4. Increased precision in stratigraphic alignments for the time-interval on which the project is focussed, and:
5. Best possible palaeogeographic and palaeoclimatologic syntheses, time-slice by time-slice. Biofacies and lithofacies data are sparse or not readily available for the mid-Palaeozoic for more than three-quarters of the region. It is anticipated that this initiative will lead to such data being sought out and made available for regional syntheses, and that the latter will reveal patterns of change in gross sedimentary geometry and palaeogeography with important (even constraining) implications for:
6. Interpreting evolution of the palaeoceanographic setting (with attention to possible isotopic indicators of patterns in ocean chemistry), relative disposition of crustal blocks along the northern Gondwana margin at the beginning of the mid-Palaeozoic, and for inferring events during fragmentation and dispersal of the blocks - at least for the time-interval in question.

Duration of project: 5 years: 1997-2001

Relationship to other IGCP projects:

A good chronologic framework for effective prosecution of the project has crystallized as a result of activities by the IUGS subcommissions on Silurian and Devonian stratigraphy (and associated system-boundary working groups), and by the former **IGCP 216** *Global biological events in Earth history*. The new project may be viewed as having some linkage to the former **IGCP 5** *Correlation of Prevariscan and Variscan events of the Alpine-Mediterranean mountain belt* (1978-1982), and **IGCP 321** *Gondwana dispersion and Asian accretion* (1991-1996). The first of these concerned tectonics (along 8 geotraverses) of the western portion of the area on which the project is focussed, and the second had a primarily Devonian and younger focus. The project includes the heart areas of the above projects, but extends across crustal blocks between them. There are obvious links to the former **IGCP 306** *Stratigraphic correlation in southeast Asia* (1992-1995) and, through the event aspects of the project, **IGCP 293** *Geochemical event markers in the Phanerozoic* (1990-1993) and **IGCP 335** *Biotic recovery from mass extinctions* (1993-1997). The project will build in a minor (biogeographic) way on **IGCP 328** *Palaeozoic microvertebrates*. It has an "end-on" relationship with **IGCP 351** *Early Palaeozoic evolution in northwest Gondwana* (1993-1997), and the new **IGCP 410** *Temporal and spatial patterns of Ordovician biodiversity* (1997-2001).

Tentative work schedule:

1997-1999: Establishment of biofacies & lithofacies database: Defining regional entities (crustal blocks), compilation of palaeobiologic data (taxonomically consistent) for individual crustal blocks, interregional biostratigraphic correlation; discrimination of bioevent intervals and interregional comparison & contrast.

late 1999-early 2000: Quantitative analysis of biogeographic patterns in time and space; inferred dynamic evolution (from biodata) of the North Gondwana continental margin.

2000-2001: Interaction with data from other areas of earth sciences and refining of inter-linked bio- & geodynamic model.

The initial database compilation (1997-1999), a mandatory prerequisite for the project, will be useful in itself: providing nomenclatorial consistency (biofacies, bioevent, taxonomic) across all crustal blocks of the former North Gondwana continental margin. This will have obvious relevance for communication among everyone involved, and utility for making comparison with patterns along the various segments of the former continental margin. Though it is not an articulated thrust of the project, it is anticipated that IGCP 421 will contribute in a modest way to improving the framework within which mineral exploration strategies might be developed.

Present state of activities

A vast amount of recent tectonic work has focused on the southern European region, especially the Ibero-Armorican and Alpine chains, and the Himalaya-Karakoram region and Tyan' Shan in relation to plate tectonics. Several of the mid-Palaeozoic boundary stratotypes, incidentally, have been established within the region on which this project will focus.

Geographic focus:

The swathe of countries through southern Eurasia (Portugal and Spain to southern China) having crustal blocks (or regions) hypothesized as having been part of or adjacent to the Gondwana margin during mid-Palaeozoic times. Many institutions outside this belt (e.g. in Belgium, Canada, Germany, Russia, the United Kingdom, USA) have researchers whose principal interests concern stratigraphic sequences and tectonic problems within the area in question. Interest is anticipated from scientists concerned with notionally allochthonous terranes in central America, and with relevant biostratigraphic interests (e.g. palynology) based on sequences deeper within the former Gondwana mega-continent.

Regional and other groups:

Regional and national stratigraphic scales within the North Gondwana belt are often appreciably out of alignment with each other and with the criteria for series and stage boundaries agreed to in recent years by the relevant stratigraphic subcommissions and boundary working groups. Ratification of these recommendations by the International Commission on Stratigraphy has produced stability as regards an international standard scale for the time-interval with which the project is concerned. The time is therefore ripe for a broad-scale exercise in re-correlation of the stratigraphic sequences through the North Gondwana crustal blocks. Such an exercise is necessary to provide a sufficiently rigorous basis from which to investigate anoxic and extinction events and interregional transgression-regression patterns. In order to facilitate data compilation and interpretation, there will be 9 working groups (6 of them regional groups), each with 2 or more leaders entrusted with bringing together material for syntheses of pre-Variscan palaeontologic data and stratigraphic correlations:

1. Northern Africa
2. Ibero-Armorican arc
3. Southern France-Sardinia-Carnic Alps-Thuringia-Czech regions
4. Southern Asia from Turkey-Armenia-Azerbaijan-southern Central Asia (including Afghanistan and northern Pakistan) to the Tibet-Baoshan regions of China
5. South China and southeast Asian blocks
6. Australia and New Zealand. A special focus here will be palaeogeographic & palaeobiogeographic evolution of eastern Australia during the Middle Palaeozoic - testing whether or not a strike-slip model can explain what appear to be interregional mid-Palaeozoic lithofacies & biofacies anomalies
7. Biogeographic statistical techniques
8. Isotopic signatures of global extinction events
9. Geodynamics

   In anticipation that palaeomagnetic "inscrutability" may remain "a fact of life" as regards the mid-Palaeozoic for most crustal blocks in the region, it is proposed, as *part* of the program, to probe whether or not quantitative palaeobiogeographic data will assist in providing some constraint on the relative positioning of some of the blocks of this region during the mid-Palaeozoic. In order that the data might not be constrained by particular models, it has been proposed that the data-compilation will be undertaken, initially, without reference to (or preference for) previous geodynamic models. At a later stage (years 4 and 5, see below years 2000 and 2001) it is planned to invite a broad spectrum of colleagues with palaeomagnetic and other geodynamic skills to become involved in discussion of how their data may illuminate or impose constraints on the emerging syntheses.

Organizing the project for effectiveness

The project has been structured around a series of at least 10 international seminars and workshops. Wherever possible, for increased viability, these have been or will be associated with international or regional conventions on themes linked in some way with the project, e.g. with ECOS-7 (Seventh European Conodont Symposium, Italy, mid-1998), PAFF (Palaeogeography of Australasian Faunas and Floras, Australia, December 1997), AUSCOS-2 (Second Australasian Conodont Symposium, August 2000), the XXX IGC (Brazil, 2000), and meetings of the principal relevant subcommissions: on Silurian and Devonian stratigraphy. Regional workshops are encouraged; one of these has already taken place in France.

Impetus will be maintained by a sustained pattern of thematically relevant questions for building the database; these will be directed towards regional group leaders and individual participants (reporting back through group leaders). For instance, a "best possible" zonal scheme (graptolite, conodont, ammonoid, chitinozoan) will be distributed to all participants for compiling biostratigraphic data. The project already has a dedicated home-page on the Internet (see end of this report). As work progresses, a series of progress reports will be published in an IGCP 421 Newsletter to be distributed to all workers expressing interest in the project. These progress reports will include discussion of general principles, alignment of stratigraphic scales, taxonomic procedures (and temporarily critical taxonomic problems), and inferred transgression-regression patterns. Some of these matters were discussed at the two initial meetings of IGCP 421. It is the coordinators intention to provide a key to the literature of the region: stratigraphic, taxonomic, tectonic. At all stages emphasis will be on publication of results, culminating in publication of a comprehensive, multi-authored volume devoted to North Gondwanan mid-Palaeozoic bioevent & biogeography patterns in relation to crustal dynamics. Because of wide geographic spread of countries involved we the two initial meetings were scheduled at the "poles" of the region. It is planned to have generally 2 meetings per year. The following meetings & workshops are planned to foster accumulation of relevant data, and continuous evaluation of the emerging databases:

1997

1. September 17-21 - Vienna, a highly successful inaugural meeting was hosted by the Geologische Bundesanstalt (Wien).

Principal themes: a. Setting the agenda: procedures. b. Preliminary faunal, floral and tectonic data, principally for the southern European and north African crustal blocks. c. Correlation framework. A corpus of papers from this meeting will be published by the Geologische Bundesanstalt.

Excursion: mid-Palaeozoics of the Carnic Alps

2. 9-11 December - Wollongong (Australia) - in conjunction with the meeting on Palaeobiogeography of Australasian Faunas and Floras hosted by the University of Wollongong

Principal themes: a. Faunal and floral data principally of the Australian, New Zealand and southeast Asian crustal blocks. b. Correlation framework. It is anticipated that papers from this meeting will be published in Historical Biology, or as chapters in a volume, "Palaeobiogeography of Australasian Faunas and Floras" (Oxford University Press), now being compiled.

Excursion: Post-conference (12-12 December) to Palaeozoics of the Snowy Mountains region

1998

1. 24-26 June - Modena & Bologna, Italy - in conjunction with the 7th European Conodont Symposium ECOS-7, organisers E. Serpagli [Modena] & M.-C. Perri [Bologna] and their colleagues, and meeting of Subcommission on the Devonian System. Contact: Dr. M. Cristina Perri, fax: (39.51) 354522; e-mail: perri @geomin.unibo.it

Principal themes: a. Faunal and floral data from mid-Palaeozoics, especially of southern Europe and North Africa (continued). b. Correlation framework for mid-Palaeozoics especially of southern Europe and North Africa (continued)

Excursion: Pre- and post-conference excursions to mid-Palaeozoics of Sardinia (18-23 June) and Southern Alps (27 June-2 July).

2. 6-20 December - Isfahan, Iran - hosted by Department of Geology, University of Isfahan (see separate entry)

Principal themes: a. Mid-Palaeozoic faunas and floras from the entire North Gondwana region, with some emphasis on faunas and floras from south and southeast Asian crustal blocks. b. North Gondwana global extinction event patterns (initial session)

Excursions: Mid-Palaeozoics of eastern and central Iran (see separate entry)

1999

1. September (timed for late summer) - Peshawar, Pakistan

Principal themes: a. Faunal and floral data for central and south Asian crustal blocks. b. Correlation framework for central and south Asian crustal blocks

Excursions: Possible initial excursion across the Karakoram from Kashgar (Xinjiang) through Hunza and Gilgit to Peshawar. Post-conference: Mid-Palaeozoics of Khyber Agency, Nowshera and Chitral. Possibility of brief excursion to the famed Salt Range succession.

2. Location of second meeting for 1999 not yet formalised

2000

Note: A broad spectrum of colleagues with palaeomagnetic skills and geodynamic interests in the North Gondwana terranes will be invited to these and subsequent meetings to participate in discussion of how their data may impact on the emerging syntheses. Possibly 3 meetings will take place in 2000:

1. February. Location not yet formalised (?Morocco)

Principal theme: First multi-disciplinary confrontation of palaeobiogeographic and palaeoenvironmental (including palaeoclimatologic) data and syntheses with geotectonic & geophysical data bearing on mid-Palaeozoic crustal dynamics of the former North Gondwana region, with particular emphasis on crustal blocks in North Africa and southern Europe.

2. Meeting in conjunction with the International Geological Congress in Brazil

3. August-September at Macquarie University, Sydney [immediately following or immediately preceding the Olympic Games] - to be held concurrently with AUSCOS-2 (Second Australasian Conodont Symposium), and joined with the Third International Symposium on the Silurian System.

Principal theme: Sutures & faunas & floras with some emphasis on the mid-Palaeozoic of Australia and southeast Asia with respect to geotectonic & geophysical data

Excursions (pre- and post-conference): Focussed on biogeographic & ecologic patterns in relation to Palaeozoic sutures in eastern Australia

2001

Note: Both meetings for this year will be are timed to occur during climatically optimal periods for field work in the respective regions

1. Still to be formally arranged, but hope that it will take place in China.

Principal themes: a. Sutures & faunas & floras in the mid-Palaeozoic of southeast Asia. b.

Excursion: Key mid-Palaeozoic sequences of South China.

2. late August - *Final meeting* in Montpellier, France.

Principal theme: Final multi-disciplinary confrontation of palaeobiogeographic and palaeoenvironmental (including palaeoclimatologic) data and syntheses with geotectonic & geophysical data bearing on mid-Palaeozoic crustal dynamics of the former North Gondwana region

Excursion: Pyrenees & Montagne Noire mid-Palaeozoic sequences

Our aim is that this final event should be a major international congress to be sponsored, we hope, by the Société géologique de France and the IGCP, with cosponsorship by organizations such as the IUGS Silurian and Devonian subcommissions, and the International Palaeontological Association. For this congress we visualize parallel and joint sessions on plate tectonic movements along the former North Gondwanan margin, and on palaeobiogeographic and palaeoenvironmental data and syntheses.

International Geological Correlation Program (IGCP) Project 421: "North Gondwana mid-Palaeozoic biogeography\bioevent patterns in relation to crustal dynamics"

International meeting, December 1998, Isfahan, Iran

Sponsored by the University of Isfahan and supported by various Iranian organizations

First Circular

The fourth international meeting of IGCP 421 will take place in Isfahan, Iran, on 11-13 December 1998. The field excursions connected with the meeting will focus primarily on Silurian-Permian sequences, with special emphasis on Devonian-Carboniferous sequences which have provided new biostratigraphic data. The combination of events will include visits to renowned centres of Iranian culture: Isfahan, Shiraz, Yazd and Persepolis. The most convenient route for the majority of foreign participants is via Teheran from which there are frequent flights; there are less frequent flights from Dubai.

Program

5 December 1998 - arrival in Isfahan and registration

6-10 December - pre-conference excursion (overland to Isfahan-Tabas) to key Silurian-Permian sections in the Shotori Range, eastern Iran, based on Tabas, returning overland via Yazd. Leaders: Dr M. Yazdi et al.

11-13 December - conference in Isfahan, including cultural tour of Isfahan

14 December - Zefreh and Chahriseh sections (Devonian-Permian), north-east of Isfahan

15-16 December - visit to Shiraz and Persepolis

17-20 December - post-conference excursion to Palaeozoic sequences in the Kerman area (Isfahan-Kerman by air)

Costs

Because it may not be convenient for some participants to take part in all activities, costs are presented for each segment of the program:

Registration fee: US$ 100 (includes abstract book and excursion guide-book)

Accommodation in Isfahan: 4 star hotel US$ 80-100 per night (payment in US$ only); 2 star hotel US$ 50-80; government\university guest-house $40 or less

Pre-conference excursion (Tabas): approximately US$ 300

Zefreh and Chahriseh excursion: US$ 100

Shiraz and Persepolis excursion: US$ 200

Post-conference excursion (Kerman): US$ 400

The entire package (16 nights), including all excursions, will therefore amount to US$1,100 in addition to 4 nights accommodation in Isfahan during the conference. A vigorous effort is being made to obtain funding to reduce the quoted costs.

Guide-book

Dr M. Yazdi will coordinate preparation of the guide-book for the excursions.

Abstracts Book

Abstracts of papers and posters to be presented at the conference should be sent to Prof. John Talent for editing and preparation of the abstracts volume. They should be not more than 2 pages in length (including references), and should be submitted by 30 August on a DOS- or MACINTOSH-formatted diskette, preferably in Word, and should be accompanied by a printed copy.

Presentations

One or two presentations per person, poster or oral, the latter of 15 minutes duration followed by 5 minutes for discussion.

Publication

We will be seeking a medium for publication of manuscripts (refereed) presented at the conference.

Deadlines

Registration fee, deposits (25%) for excursions, and passport details: 30 June 1998

Abstracts: 30 August 1998

Payments

Iranian banks and larger businesses accept major credit cards; Visa and Mastercard are most widely accepted. Methods of payment for the conference have yet to be finalised. Those interested in participating in the conference should contact one of the undersigned who will provide necessary information on the best procedure for doing so as soon as this has been clarified.

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REGISTRATION FORM FOR IGCP421 MEETING IN IRAN, DECEMBER, 1997

Note: Updated information will be available on the IGCP421 Home Page early January, 1997. Point your browser to:
http://www.es.mq.edu.au/MUCEP/igcp421.htm

First name:

Surname:

Title:

Address:

(City) (State)

(Post or Zip code) (Country)

Phone: (Office) (home:)

E-mail address:

Fax:

I will attend the IGCP421 Meeting in Isfahan (US$100 plus accommodation)	Yes	No	Probably	
I will present a paper(s)	Yes	No		
I will present a poster(s)	Yes	No		
I intend to publish the papers(s) in the symposium volume		Yes	No	
I am interested in participating in the pre-conference excursion		Yes	No	(Isfahan-Tabas US$300)
I am interested in participating in the Zefreh and Chahriseh excursion		Yes	No	(US$100)
I am interested in participating in the Shiraz-Persepolis excursion		Yes	No	(US$200)
I am interested in participating in the post-conference excursion		Yes	No	(Kerman - US$400)

As well as updated information being posted on the Web, those people who reply to this circular will receive a hard copy of the Second Circular in March-April. Please reply promptly.

NOTE: A version of this form suitable for submittal via e-mail may be obtained by sending a blank message with the subject "IRAN MEETING" to crick@uta.edu. The form will be sent to you automatically via return e-mail. You may then use your e-mail editor to complete the information and forward it to John Talent.

Devonian Correlation Table

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Objectives

The tried and trusty correlation chart in its basic function as a communication medium should be so modernised and normed, that through permanent updates and revisions an adaptive standard for stratigraphic colleagues should be realised. Therefore the German Subcommission on Devonian Stratigraphy seconded the edition of a mandatory and continuously updatable Devonian correlation table (DC) which should be technically easy to amend and reproduce. Updates and supplements to the DC should be published sporadically in the Senckenbergiana lethaea journal.

Guidelines

Principle: Only the methodology of data collection and communication should be normed and standardized, but not the actual information itself.

Specifically, norms and standards can only be applied to technology, methodology, measuring institutions (cf. "Parisian standard metre", industry norms), however not to the content of scientific interpretations, which, through permanent search for actual truth, should be available for review and revision just after their publication. Therefore concepts of GSSPs or orthobiochrons are critical because methods such as commissionary institutions, "Golden Spike" or zone-orthochronology on the one hand and scientific contents of taxonomy, dating or correlation on the other hand are dependent on each other and thus, at least, the former could block the review and revision of the latter..

(1) Each Devonian vertical data sequence is subdivided into three equal DC columns of Lower-, Middle- and Upper Devonian.

This subdivision is due to printing and technical considerations, because each column height of 20 cm will not exceed standard page type-face format. (The equal heights of Lower-, Middle- and Upper Devonian column is not necessarily proportional to the same periods of absolute time.)

(2) Each DC column should be an independent, freely combinable time parameter. (Differentiating of contents).

It should be attempted to create columns independent from each other as freely combinable elements, e. g. the brachiopod stratigraphies from the Hillesheim and from the PrUm Syncline of the Eifel Mountains would be assigned to two different DC columns despite any similarities, provided that both columns are differentiated by at least one date. If data from both columns are combined within a new column afterwards, then this act will already represent a scientific evaluation as an application of the DC.

(3) Each DC column represents an independent element at the moment of publication. (Differentiating versions).

The updated version of a column represents a new column provided that old and new versions are distinguished from each other by at least one date. Such versions are separated into annual groups.

There will only be complete columns published in the DC. Single new datings must be assigned to a whole column. For example, if an author revised Moroccan brachiopod stratigraphy of Emsian stage only, he can achieve DC publication under his name by combining his new data with compiled brachiopod data from the whole Lower Devonian of a Moroccan region within one column.

(4) Each DC column, which, in accordance with (1) to (3), is an independent, freely combinable element, is assigned a registration number.

The code of a registration number (at the top and bottom of each column) distinguishes between stratigraphies (O = absolute timescale, A = chronostratigraphy, B = biostratigraphy, H = holostratigraphy, R = regional lithostratigraphy), consecutive numbers of vertical data sequences (whereby di, dm and ds indicate Lower, Middle and Upper Devonian of the same sequence).

At the lower end of the column, the registration number is enlarged by the year of publication (96 = 1996) and the CorelDRAW Graphic program suffix (.cdr) and indicates thereby the CorelDRAW filename of the column, since each column is assigned to one specific file.

Registration numbering and files are supervised and archived by the editor under strict curatorial control.

(5) The compiler is responsible for each column.

Compilers are not necessarily identical with authors, e. g. of an index fossil zonation. As competent experts they have judiciously reviewed, refined or revised the compiled data. (If, however, data were uncritically taken over, the source must be cited by "according to ...")

Commentaries may be published, but not necessarily for the initial DC installments. Later, in an advanced stage, the DC columns, particularly the biostratigraphic columns, should be completed by concise reference lists which mention each date of a column.

The column is the intellectual property of the compiler. A published column must be cited like any other published item, e. g. "CARLS, P. (1996): Brachiopoden, Spiriferen-"Schritte", Keltiberien;; Unterdevon. - In: K. WEDDIGE [ed.], Devon-Korrelationstabelle. - Senckenbergiana lethaea, 76 (1/2): 277, column B121di96; Frankfurt am Main.".

(6) Each stratigraphic date can be determined by DC coordinates, i. e. by column registration number plus time-ruler height.

A 20 cm. ruler is put of each column on the left hand margin (the adjoining right hand ruler belongs to the neighbouring column)). The co-ordinates allow the representation of each stratigraphic date in any printed publication or electronic communication media to be independent of synoptically combined scales, e. g. chronostratigraphic scales. Generally all data can be reproduced via coordinates, without for example the necessity of transmitting a graphical reproduction.

Examples for reading DC co-ordinates:

(B030di96: 6.55) = base of Lower Devonian *sulcatus* Conodont zone.

(di: 6.55) = point of time at Lochkovian/Pragian boundary.

(di96: 6.55) = all data concerning Lochkovian/Pragian boundary published until 1996.

(B030ds) = all recent global Conodont zones of the Upper Devonian.

(A010) = chronostratigraphy of Lower-, Middle- and Upper Devonian series in total.

The year of publication distinctly demonstrates, as when citing anyscientific reference, the scientific- and/or table time-ruler status towhich it refers. For example, the time level (di99: 6.55) until 1999 may be positioned above the Lochkovian/Pragian boundary because of new stratigraphical correlations.

The DC data are one-dimensional, i. e. only time-controlled. The DC co-ordinates do not indicate the lateral spatial distribution of data at each point of time since that is a matter of another scientific evaluation (of palaeoecology, biofacies-, bathymetry-, provicialism interpretations, palaeogeography, etc).

The time-ruler values &from 0 to 20 cm. are relative values, which reflect the "portion of the whole", i.e. the "portion of 20" (cm. of the time-ruler) in a manner analogous to the "portion of 100" by percentage calculations (per cent = per 100). Therefore 1 cm. (of the time-ruler) represents 5 % - the corresponding cm/% values can be compared at the left hand margins of the (A010) columns (cf pp. 274, 278, 282).

The naked eye may be able to recognize characters up to 0.25 mm. on a professional print-out of a column (scale = 1 cm: 1 cm). This means that in a Devonian table of 60 cm. height 2400 time periods can be differentiated which corresponds, (according to a 46 m. y. absolute time for the total Devonian), with a resolution of approximately 20,000 years absolute time per 0.25 mm of the time ruler scale. The computer allows zooming and printing out of details without magnification limits and thus increase the resolution without any restrictions (cf the magnifying-glass symbol in the column and the corresponding detail enlargements on p. 285).

Prospect

The consequent formatting of the correlation table should lea to a standardization of stratigraphical data transfer. The def nition of the DC column as an independent, freely combi able basic element allows stratigraphic colleagues a relative simple aid, to be used either as a hard- and/or a soft copy, as card-index and/or as a computer file. This means th card-indexes could be combined to any synoptic correlatio chart and that the data of the DC columns can be positione formatted and proportioned by the attributes of a comput graphics programme (CorelDRAW). In my opinion, a sui able compromise has been found between traditional ar modern methods of stratigraphic data processing. What important is maintaining the simplicity of use of card-indexe and of the synoptic overview of chart representation. The da is nevertheless available for the future construction of com plex stratigraphical data-bases and for processing. The mear to do this is provided by the co-ordinates of the time rule Differentiating annual versions of the co-ordinates allow bi liographical processing, i. e. correlation of past, present ar future stratigraphical data.

The fundamental problem with scientific EDP data transmi sion and data-bases is surely the anonymity of authorship The proposed concept however guarantees intellectual pro erty rights! It now forces the author to obey a new standar ized form of publication (but does not exclude comprehe sive syntheses and explanations elsewhere!). The column as combined card-index/file contributes to the reputation of author since it is citable, similar to a multi-paged publicatio It is more or less his business card as a stratigraphic expe his sign-board of his stratigraphic work. Compilers (not on authors), specifically engaged for the DC project guarant the respect of existing intellectual properties of others whi are to be treated fairly and in a professional manner. Surely future versions of the DC, compilership and authorship w increasingly tend to be identical. (Actually, the present D installment has already verified such a process since the m jority of the present columns were mainly compiled by t intellectual property owners of the column data themselves

Stratigraphy uses the time-scale as an unequivocal guideli to structure the multiplicity of historical data. The time-rul as a definite substitute of the time-scale. is therefore also t guiding reference for norms and standards for the dissemin tion of stratigraphic data. Any Devonian date, once produc by an author, can be definitely reproduced by means of t DC time-ruler co-ordinates. Whether or not GSSPs and orth chrons will become obsolete, time and practice will tell. Co odonts as index fossils will maintain their precedence, the ("standard") zonation however, could loose their role as a sta dardizing time-scale. On the contrary, the time-ruler shou (which as a scale does not contain any fossil names) indepe dently adjudicate between the argumentations and data of fossil groups and stratigraphies. Consequently, the critic feed-back contains a broader (more democratic) basis, again which GSSPs and orthochronologic zones must prove ther selves as standards.

As well as such a scientific feed-back the normed DC for transmits also a neutral, graphical-calculating feed-back! Wit in the graphically and mathematically fixed startand end-points of the time-ruler, the data must according to evolutionary survival principles adhere to their position with every DC amendment due to storage restrictions. Condensation and dispersion of data lead to harmonizing of the vertical data density, which can affect an individual or multiple column(s). For example in CARL5 5 column (B121di:) the spiriferid evolution provokes a vertical extension of the column level (B121di: 9.3-9.9) to the detriment of the lower and/or upper adjacent intervals (all: 89.3 resp. 9.9-10.85). This leads to the shrinking of the Middle Siegenian in the adjoining column (RI5O).

Such successive harmonizing leads ultimately to an adaptive feed-back, until an ideal compromise is achieved. Provided that enough big-, litho- and holo-stratigraphical data has been synthesized by such a graphical (and actually mathematical) iterative process, then a proportional copy of the real absolute time should be evolved on the 20 cm. time ruler. This kind of calibration process which is now called "Absolute time proportioning of stratigraphic correlation tables by feed-back harmonizing (AFH)" can naturally be applied to other time intervals, e.g. to the 60 cm. total Devonian time-scale, or one of the Devonian (or e. g. Tertiary) stages, or substages, or zones, or to any other stratigraphic resolution.

Call for column contributions

Anyone may submit Devonian data, independent of commissions and nations, and independent of the classical Devonian regions in Germany.

Biostratigraphic column have to be created, prior to the mass of lithostratigraphic column reflecting regional geology (from the German Devonian survey geologists, a commission has already been organised under the auspices of Dr. K. H. RIBBERT, Geol. Survey Krefeld). For preliminary orientations on the datings, columns on Devonian event-stratigraphy have been outlined just for this DC edition in order to stimulate revisions. According to the above guidelines (cf. (2)), the event parameters must be clearly differentiated - and thus the time-ruler will be a great aid to function such as a numerical x-axis for plotting T-R-, anoxia-logs and other measurements (e.g. thicknesses, cyclicities, sequences, evolutionary or sedimentation rates, etc.). Generally, the event- and/or holostratigraphy as well as absolute time chronology in combination with the new DC provides a well-founded basis for further investigations.

Karsten WEDDIGE
Frankfurt am Main, November 1996

REPORTS FROM THE MEMBERSHIP

G.K.B. ALBERTI (Grosshansdorf)

Continued study of sequences rich in planktonic tentaculitid assemblages from several Lower and Middle Devonian sections in North Africa (Morocco,Algeria), in Australia (Victoria) and in several regions of Europe (Upper Franconia/Thuringia, Harz Mountains, Carnic Alps etc.) (the Lower Devonian sections with special regard to the Pragian/Emsian boundary interval), among them:

1. Pragian and "Earliest Emsian" aged portions of Bou Tscharafine and Amlane sections in the Tafilalt (samples from the sixties and seventies) (see fig.1 herein), furthermore of Rabat-Tiflet sections in northwestern Morocco (ALBERTI 1969,1993,1997a), of Ben Zireg/Marhouma sections in South Algeria (ALBERTI 1981,1993,1997a) and of Neumuhle sections (with "*P. pireneae*", compare HUSKEN 1993 and ALBERTI 1997a) through the Triebenreuth Limestone (Upper Franconia) were in need of refining their biostratigraphical dating and subdivision. Apart from a few occurrences in Upper Franconia, in South Algeria etc. diagnostic conodonts are very rare or have not been found in the planktonic tentaculitids bearing samples and for this reason less helpful. Attempts to correlate conodont/pl. tentaculitid (e.g. *Guerichina*) ranges go on.

   Unfortunately, modern taxonomic and biostratigraphical research on planktonic tentaculitids from the Zinzilban section is still lacking (even though repeatedly announced in the SDS-Newsletters in the past by two authors), especially with regard to comparisons with the conodont ranges (particularly in the Pragian/Emsian boundary interval), so that precise biostiatigraphical dating only by means of planktonic tentaculitids may become not quite unproblematically in some cases.

   Two new results: In the aforementioned Tafilalt and Ben Zireg sections *Nowakia acuaria prisca* and *N. acuaria acuaria* certainly start before the entry of *N. (Alaina) anteacuaria.* The upper range of *N. acuarla acuária* overlaps with the lower range of *N. (Alaina) anteacuaria.* In other words: *N. acuaria* precedes *N. (Alaina) anteacuaria.*

   First find of a possibly phylogenetic ancestor of *N. barrandei* in the latest Pragian or at most in the boundary interval Pragian/Zlichovian (before the entry of *N. zlichovensis*), probably still in the *Guerichina infundibulum* Zone.

2. Lower Devonian portion of Late Emsian age of "Kieselgallenschiefer" sections (basin facies sequence), recently exposed by country water pipe trenches in the area Trautenstein - Hasselfelde, Lower Harz Mountains. The brand new finds of the zonal taxa *Nowakia richteri* (very abundant) and *N. aff. maureri* (extremely rare) in successive "beds" (beige-coloured silicous styliolinid concretions or silicified nodules, like the stratigraphically underlaying ones with *N. cancellata*, and in small quartzitic "phacoids") near the assumed top of the "Harzgerode Formation" would suggest a stratigraphical extension of the latter one near to the (theoretical) stratigraphical onset of the Wissenbach Shales facies: In fact, in the western "Harzgerode Zone" (Benneckenstein,Trautenstein) as well as in the eastern "Harzgerode Zone" (pit of the "New brick yard Harzgerode") in the Lower Harz Mountains (see ALBERTI & ALBERTI 1996a: fig.1 in SDS-Newsletter 13). The Asteropyginae of the "Harzgerode Formation" require special study.

3. Late Middle Devonian, mainly styliolinid and/or goniatite limestone sections (mainly *varcus*-Zone) in the central-Sahara (east of the mole d'Amguid in the external northwestern Tassili-n-Ajjer, called "Mouydir-NE" in ALBERTI 1997b). These sections probably were not known to PETTER 1959.

   Continuation and completion of the planktonic tentaculitid studies,based on self sampled material in the eighties (see ALBERTI 1997b,1998).

   Plan on doing research (together with co-authors) on the recovered conodonts, goniatites (among them probably: *Sobolewia, Archoceras/Atlantoceras, Maenioceras* s.l., *Agoniatites* and *Pharciceras* ?) and trilobites (with Buchenberg/Harz affinities). Comparative studies of Givetian planktonic tentaculitids from northwestern Sahara (Marhouma, etc.) and from Europe.

   The revision of ALBERTI & SALAH's collection of Givetian planktonic tentaculitids from the Lauthental section (Harz) could not verify the record of *Nowakia bianulifera* in bed 1 (nodule) from here (ALBERTI & SALAH 1980: Fig.l). In reality instead of that *Viriatellina* ? cf. *postotomari* occurs abundantly (exclusively) in bed 1. Dominant in the *Stringocephalus* Limestone at this locality is *Viriatellina (para) minuta.*

4. Brand new is the first finding of coiled planktonic tentaculitids (*Corniculinoides*) in the Lowermost Pragian of North Africa (Rabat-Tiflet section, North Morocco).

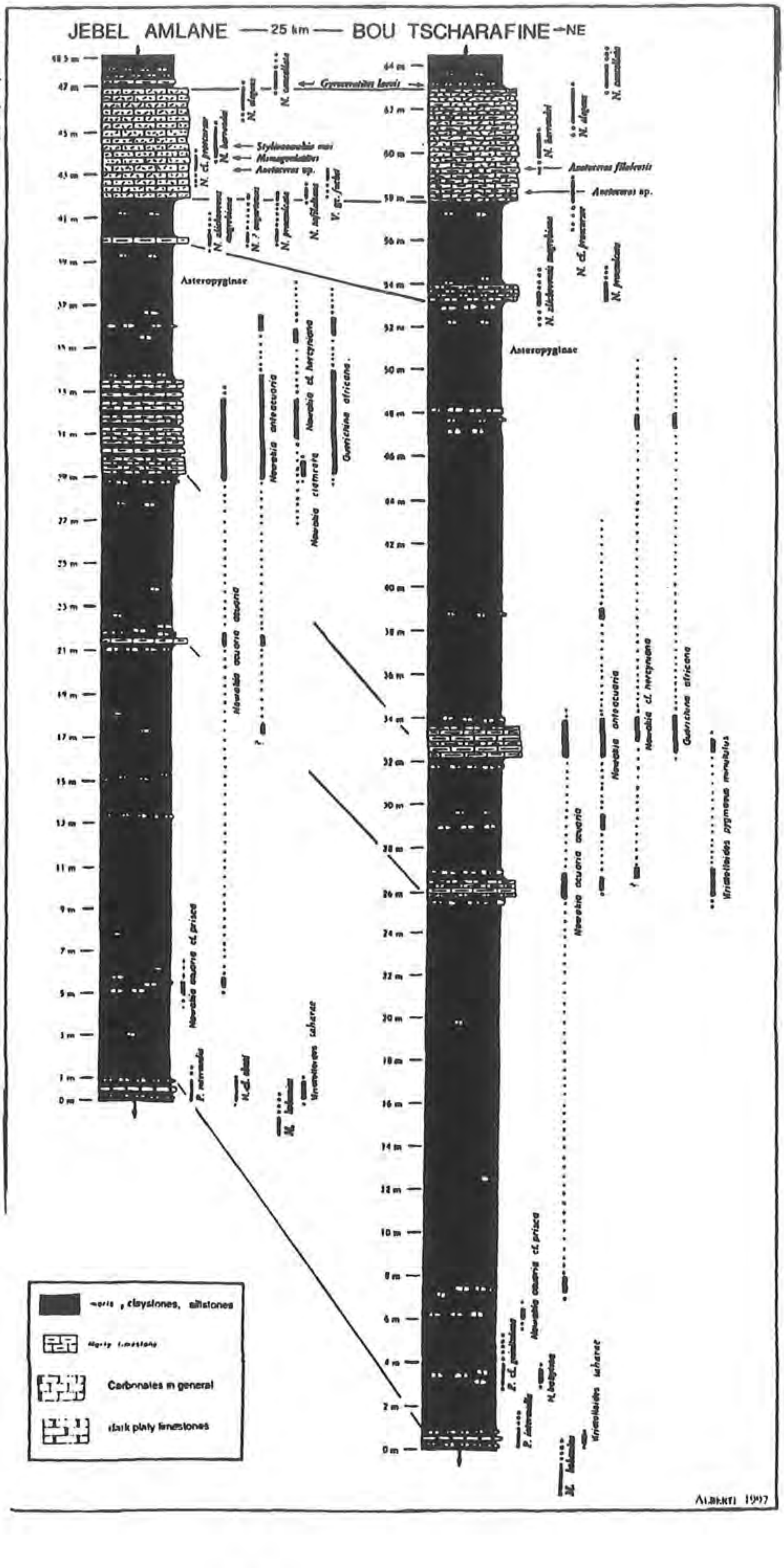
Recent publications

ALBERTI,G.K.B. (1997a) : Planktonische Tentakuliten des Devon. I. Homoctenida BOUCEK 1964 und Dacryoconarida FISHER 1962 aus dem Unter- bis Ober-Devon.—Palaeontographica, Abt.A, 244 (46): 85-142,22 figs.,2 tabs.,15 pls.; Frankfurt/M. ,, ~

ALBERTI,G.K.B. (1997b) : Planktonische Tentakuliten des Devon.II. Dacryoconarida FISHER 1962 aus dem Unter- und Mittel-Devon. Mit einem fuziellen Beitrag von T.C.HUSKEN.— Palaeontographica, Abt.A.,246 (1-2): 1-32,5 figs., 15 pls.; Frankfurt/M.

ALBERTI,G.K.B. : Planktonische Tentakuliten des Devon. III. Dacryoconarida FISHER 1962 aus dem Unter- und Mittel-Devon.— Palaeontographica,Abt.A., 15 pls.; Frankfurt/M. Ms in final stage of preparation for going to press.

Figure 1. Stratigraphical columns of the Lower Devonian at Jbel Amelane and at Bou Tchrafine (Tafilalt, southeastern Morocco) with the (tentative) ranges of selected planktonic tentaculitid taxa (after G. Alberti, 1981: Fig. 2, modified and completed.



R. Thomas BECKER (Berlin)

1997 was another busy year with a lot field work, conferences, excursions and curatorial work in the huge Devonian collection of the Museum für Naturkunde. Together with M.R. House, V. Ebbighausen, J. Bockwinkel and the American team accompanying Royal Mapes from Ohio, detailed stratigraphical work was continued in southern Morocco. Special attention was given to the famous pharciceratid successions of Hassi Nebech in the Southern Tafilalt, to the Mrakeb and Rich Bou Kourazia sections in the Southern Maider, and to the easternmost Tafilalt just at the Moroccan-Algerian border. Hightlights include the discovery of rich haematized goniatite faunas from a level between the two Kellwasser limestones at Ouidane Chebbi, haematized Chotec Event faunas with Pinacites, first North African karaclymeniids, synwocklumeriids and possibly *Kielcensia* (the latter two groups were purchased) and the discovery in the northern Maider of a Cymaclymenia-imitoceratid interval sandwiched between latest Famennian quarzites which are supposed to correlate with the Hangenberg Event interval. Exciting is also a Middle Famenian colonial rugose coral from ammonoid biofacies which may represent an important link in rugosan evolution and recovery after the Kellwasser Crisis. Collaborative work on this colonial coral is under way with D. Weyer from Magdeburg.

In the Rhenish Slate Mountains, field work and ammonoid studies proceeded in various ways. In relation to the attempts of the German SDS to redefine the German standard Upper Devonian "Stufen" (Adorf, Nehden, Hemberg, Dasberg, Wocklum), old museum collections and new faunas from the Hemberg type locality (N of Iserlohn) were revised. The Nie Brickwork section of the northern Sauerland was resampled and yielded some precisely horizonted *Flexiclymenia* and the "*Rectoclymenia*" *retrusa* Group which were formerly described from the Holy Cross Mountains. M. Piecha from the Krefeld Survey (GLA-NRW) started intensive conodont collecting of this important Hemberg/Dasberg section. An oldest glatziellid (Upper Devonian IV) and associated ammonoids have been described in a small paper which is in print. Conodont sampling for isotope studies continued together with T. Steuber (Erlangen) at the D/C boundary. Sampling, as a joint project with G. Klapper, was also completed to allow the application of Frasnian Montagne Noire conodont zones (Klapper, 1989) to German standard reference sections. Results hopefully will be presented at the Bologna ECOS meeting.

In the final phase of the INTAS project on the Timan Upper Devonian and comparisons with Middle Europe (jointly with M.R. House, V. Menner, P. Bultynck, N. Ovnatanova, A. Kuz¥min & S. Yatskov) excursions led to South Devon and the Belgian Upper Devonian reef complexes. Ammonoid localities in North Cornwall proved to be still productive. Following the Rochester SDS meeting, work on the Frasnian-Famennian boundary of New York was conducted with the good company of E. Schindler and Michael House are we were guided by J. Over and Bill Kirchgasser. Subsequently, Gil Klapper kindly showed me the Frasnian of Iowa including the Kellwasser Event beds (black shales) at famous Sweetland Creek. Ammonoid collecting, however, is not an easy job in Iowa. The US tour finished with visits to the ammonoid-stuffed lunatic asylum of Royal Mapes and to Susan Klofak and Neal Landman at the New York Museum.

In the museum, the search for old types of Devonian ammonoids has continued and was exceedingly succesful. Apart from Berlin originals of Paeckelmann (1913), Schmidt (1924), Schindewolf (1937, 1938) and Müller (1956), types of Lange (1929) were discovered and, as a consequence of a pre-war loan, also figured specimens (holo- and lectotypes, e.g., the lost monotype of *Alpinites kayseri*) of Schindewolf (1923) could be located.

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Alain BLIECK (Paris)

Recent Devonian activities

1 February 25 - March 3, 1997, Universidade do Algarve, UCTRA (Unidade de Ciencias e Tecnologias dos Recursos Aquaticos), Faro, Portugal.

Constança BEXIGA has defended her "licenciatura" thesis on "Pteraspidiformes (Agnatha, Heterostraci) of the Lower Devonian, Fraenkelryggen Formation of Spitsbergen: morphology and biometrics" on February 26 in Faro. The jury was composed of Prs J.P. Andrade and T.C. Borges, and A. Blieck. The defence was successful. The main conclusion of the work deals with the systematics of a sample of small pteraspids from a yet unpublished sandstone layer in the middle of the Fraenkelryggen Formation, east of the Raudfjord, NW Spitsbergen island. This sample is composed of individuals (dorsal and ventral shields of the head carapace) which morphologically may be divided in two lots: one of shorter, wider shields; one of longer, narrower shields. However, the biometrical analysis has shown that they correspond to a single "population". This population is considered to represent a new sample of *Protopteraspis aquilonia* (Bexiga, 1997).

After this defence A. Blieck, C. Derycke and C. Bexiga have been during four days in the field in SE Alenteje (Pomarao region) and W Algarve (Bordeira region), looking after Upper Devonian-Lower Carboniferous vertebrate microremains of the South Portuguese Zone, where chondrichthyan ichthyoliths had been mentioned in conodont-bearing beds (Oliveira, 1983; Van den Boogaard, 1990). Several limy sandstone layers have been sampled for acid leaching.

2 July 4-6, 1997, Buckow (Berlin), Germany: IGCP 406 meeting "Circum-Arctic Palaeozoic vertebrates — biological and geological significance".

Oral communication of C. BEXIGA & A. BLIECK (speaker) on "New data on pteraspids (Pteraspidomorphi, Heterostraci) of the Lower Devonian, Fraenkelryggen Formation of Spitsbergen" [see above]; and report of the activities of the French Working Group of IGCP 406 on the Russian (Severnaya Zemlya), European (Spitsbergen) and Canadian Arctic.

3 July 10-21, 1997, Vilnius, Lithuania: IGCP 406 workshop on Lower and Middle Devonian heterostracans of the Russian Arctic (Severnaya Zemlya) — A. BLIECK & V.N. KARATAJUTE-TALIMAA.

This joint project is part of a collaborative work on the Silurian-Devonian series of Severnaya Zemlya. A first memoir on the stratigraphy will be published in Russian (R.G. Matukhin & V.V. Menner coord.); a second memoir on the palaeontology will be published in English in *Geodiversitas* (ex *Bull. Mus. natn. Hist. nat.*, Paris; D. Goujet & H. Lelièvre coord.). The main aim of the workshop held in Vilnius was to study the Early and Middle Devonian heterostracan assemblages of the October Revolution Island (except psammosteids which E. Mark-Kurik is in charge of) (heterostracans are unknown in the Silurian of this island). A preliminary result of this workshop is the following list of taxa:

Tesseraspis mosaica, *T.* sp., *Corvaspis* sp. cf. *C. kingi*, *C.* sp., *C.*? sp., *C.* sp. cf. *C. graticulata*, *Phialaspis* sp., *P.*? sp., Traquairaspidiformes indet., *Poraspis* sp. cf. *P. polaris*, *P.* sp., *Homalaspidella* sp., *Irregulareaspis* sp., *I.*? sp., *Anglaspis* nov. sp., *Ctenaspis* nov. sp., *Ct.* sp., *Putoranaspis*? sp., Amphiaspidiformes indet., Amphiaspidiformes? indet., *Unarkaspis*? sp., *Protopteraspis*? sp., *Miltaspis*? sp., Protopteraspididae nov. gen. et sp. 1, Protopteraspididae nov. gen. et sp. 2, *Gigantaspis*? sp., Pteraspidiformes indet.

The taxon provisionally named Protopteraspididae nov. gen. et sp. 2, from the red detrital Vstrechnaya Formation, is dated Middle Devonian (Eifelian *in* Karatajute-Talimaa & Matukhin, 1997) after its associated vertebrate fauna (placoderms, sarcopterygians, psammosteids). It is one of the rare Middle Devonian Pteraspidiformes (*sensu* Blieck, 1984).

Other subjects of interest were about Siluro-Devonian heterostracans of eastern Europe (Podolia, East Baltic, Timan-Pechora) and Spitsbergen, as well as about Ordovician-Silurian microremains of Siberia and Mongolia, and Silurian-Devonian acanthodians (with J.J. VALIUKEVICIUS).

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4 List of recent publications

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CM Carlton Brett (Rochester)

During the first half of 1997 a good deal of my attention was, of course, devoted to preparations for the SDS International Meeting on Cyclicity and Bioevents in the Devonian System. This meeting, which I dedicated to Amadeus Grabau, the great local western New York paleontologist, was held July 20-27 here in Rochester and in Devonian outcrops across New York State. Over 50 scientists participated in the formal talk sessions and some 25 made the full six day field trip from Lake Erie to the Catskill Front. I learned a good deal from the meeting and enjoyed interacting with many Devonian workers. (But, having organized the Silurian and Devonian symposia, for the respective subcommissions in the past two years, I'm not inclined to run another international symposium for a year or two!). I am in the process of making slight corrections to the field trip guidebook ("Devonian Cyclicity and Sequence Stratigraphy in New York State", C. E. Brett and C.A. Ver Straeten, editors, 369 p.) and, within the next month, I will reprint more copies of this book and the abstracts volume ("The Amadeus Grabau Symposium: International Meeting on Cyclcity and Bioevents in the Devonian System", 49 p.) I would be like to compile a list of mebers of SDS who might be interested in obtaining copies of either booklet.

On other fronts, Gordon Baird (SUNY College at Fredonia) and I have continued our work on the detailed cycle and event stratigraphy of the upper Givetian Tully Formation in central New York and central Pennsylvania and have been able to extend a number of tie-lines and event beds east and south of the region of Phil Heckel's classic work on the Tully. Chuck Ver Straeten (post-doctotal student at Northwestern University) and I have also begun work on the microstratigraphy and correlation of the Eifelian Columbus and Delaware limestones of Ohio into the New York equivalents. Notably, we believe that we can recognize equivalents of the upper Union Springs Formation (Chestnut Street beds) and Cherry Valley Limestone within the upper Delaware Formation. We hope to integrate these studies with work already underway by Jed Day, Bill Koch, and Art Boucot on stratigraphy, paleontology, and bioevents in the upper Eifelian of the mid-continent. I have also just received National Science Foundation funding for collaborative research with Brad Sageman, Dave Hollander,and Charles Ver Straeten of Northwestern University on a project entitled "Organic Carbon Burial Anoxia, and Ecological-Evolutionary Events in the Appalachian Basin During the Middle and Late Devonian (Givetian-Famennian)"; this research involves comparative microstratigraphy, paleontology, and geochemistry of drill cores through the Middle and Upper Devonian in western and central New York State.

Relevant Publications:

Brett, C.E. and Baird, G.C.(eds.) 1997. Paleontological Events: Stratigraphic, Ecological, and Evolutionary Implications. Columbia University Press, New York, 604 p.

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Rex E. CRICK & Brooks ELLWOOD (Texas)

This past year has seen a good deal of refinement and application of magnetic susceptibility to event-stratigraphy and cyclostratigraphy. We now refer to what we do as MSEC (MagnetoSusceptibility Event and Cyclostratigraphy). We have been exceptionally fortunate in being able to collaborate with a number of SDS and otherwise Devonian oriented colleagues. Without their assistance our work could not have progressed to its present level. Our thanks go to

R. Thomas Becker (Berlin), Pierre Bultynck (Bruxelles), Roland Dreesen (Mol, Belgium), Ahmed El Hassani (Rabat), Raimund Feist (Montpellier), Michael House (Southampton, UK), Jindra Hladil (Praha), Jeff Over (Geneseo, New York), Gerhard Plodowski (Frankfurt), Bradley B. Sageman (Evanston, Illinois), Eberhard Schindler (Frankfurt), Hans P. Schönlaub (Wien), Charles Ver Straeten (Evanston, Illinois), John Talent (North Ryde, N.S.W.), Otto Walliser (Göttingen), Karsten Weddige (Frankfurt), Willi Ziegler (Frankfurt).

Figure 1 shows the stratigraphic range of the MSEC work for the various areas we have worked. The only GSSP sequence yet to be sampled is that for the Pragian/Emsian boundary in Uzbechistan. The Silurian/Devonian boundary sequence shown for Australia was analyzed using samples supplied by TM John Talent. The original work on the Frasnian/Famennian GSSP was done using samples supplied by TM Raimund Feist. We have expanded sampling with visits to the Montagne Noire in collaboration with TM Feist. With the exceptions of Morocco where work began a few years ago and the Frasnian/Famennian sections in France, the vast majority of the sequences of Figure 1 have been completed in the past 12 months. The Moroccan sequences are the most complete due in part to the time spent there but also because of the exception exposures. We are in the process of preparing a composite MSEC curve for Anti-Atlas Morocco. It remains to complete the remainder of the Famennian and to document the overlap of the Emsian between the Ma'der and Tafilalt basins. We hope to complete this work in 1998.

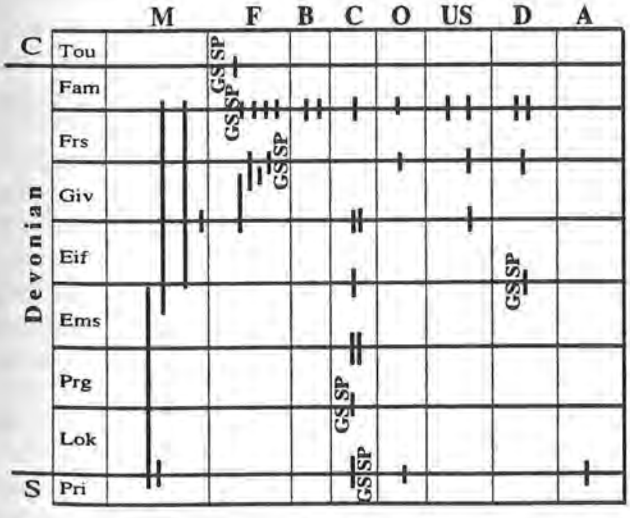

Figure 1 – Geographic and stratigraphic range of Devonian sequences sampled for magnetic susceptibility. Moroccan (M), French (F), Austria (O), German (D), Czech (C), Belgium (B), United States (US), and Australia (A).

Update on MSEC

MS is basically a proxy for the lithogenic or detrital fraction of marine sediment. Roughly, it is a quantitative measure of the amount of iron-bearing minerals in a sample (Ellwood, 1988; Ellwood et al., 1996). It is important to note that MS data are very different from the magnetic polarities that record the magnetic properties of Earth's magnetic field in rocks. Like magnetic polarities that depend on the conservation of iron in rocks, MS also depends on the preservation of iron. However, unlike magnetic polarities that can be easily remagnetized by heating, MS is largely unaffected by low to moderate thermal processes. Because the magnitude of MS varies inversely to the carbonate content of marine sediment as it tracks the lithogenic:biogenic ratio (Ellwood and Ledbetter, 1977), MS has also proven useful as a paleoclimatic indicator (Curry et al., 1995; Robinson, 1993).

Mineral contributors to the MSEC signature

Optical studies on residues extracted from samples of limestone used in this study show detrital magnetite. Remanent magnetic studies on samples collected for paleomagnetic work also show thermal demagnetization curves with magnetite Curie temperatures at about 580° C (Fig. 2). While these samples are remagnetized and exhibit a Carboniferous direction,

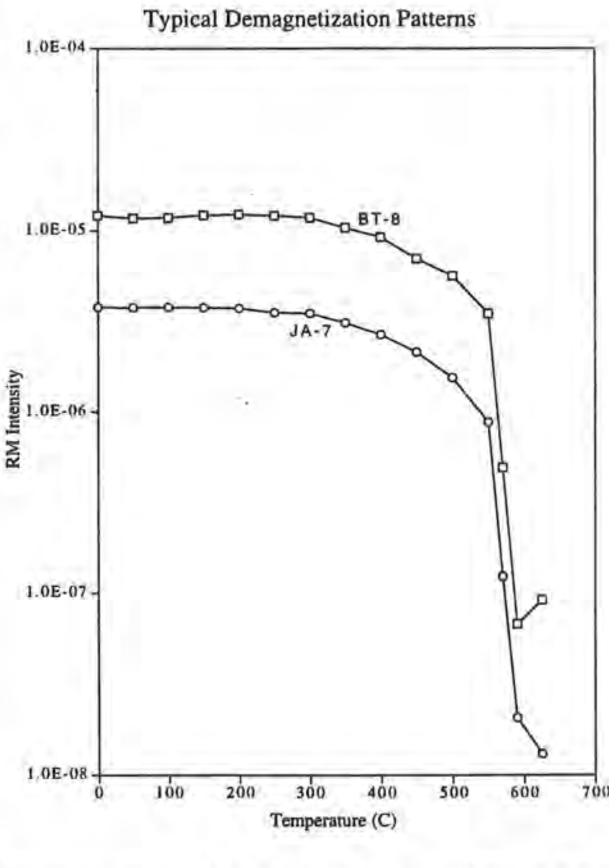

Figure 2 – Typical RM demagnetization patterns for limestone samples from the Tafilalt Basin in Morocco, showing magnetite Curie points. Samples from the same limestone bed from both Bou Tchrafine and Jebel Amelane are shown.

the magnetite still persists and is the dominant contributor to the MS.

The role of iron stains and pyritization

The effect on MS of hematite staining and pyritization is low. Both hematite and pyrite exhibit a low MS value unless in high concentration, and such zones are avoided during sampling. Furthermore, MS measurement of red/gray banded limestones show no MS difference between beds.

The effect on MSEC of single large volcanic eruptions or bolide impacts

On a global basis, both bolide impacts and single large eruptions are essentially geologically instantaneous events. The iron-rich component of these events is diluted and localized when incorporated into marine sediments, mixed by organisms in the marine environment, and lithified. The resulting layer is usually less than 10 cm thick and in sampling, even at 5 cm intervals, may only yield a single MS high value. Due to dilution, that value will not generally be substantially higher than other values. Furthermore, where the material is from a granitic or andesitic magma, magnetite is generally low or absent. The result in such cases can be MS values significantly lower than might be expected. As an example, the Tioga B k-bentonite in the Onondaga limestone has MS values only slightly higher than those of the Onondaga limestone (3.38 x 10^{-9} m^3/kg versus 1.45 x 10^{-9} m^3/kg for the Onondaga), values that are significantly lower than most rocks we have examined from Morocco.

The less common flood-type basaltic erosions may make a significant, long-term contribution to the detrital input of marine sediments. However, this effect may be more local or regional than global, and it needs to be tested. Such events may turn out to be excellent MSEC markers.

Controls on MSEC signatures

The primary controls on the MSEC signatures in marine rocks are sea level (base level) changes and climate. MSEC events can result from global sea-level fluctuations causing (1) base level changes and therefore corresponding changes in detrital influx into the world's oceans, (2) changes in global climate, or (3) result from local small-scale tectonic effects. Regional events can be differentiated from global events by comparing MSEC composite reference sections (CRSs) between regions and identifying those events that are not observed in both data sets (regional) versus those that are observed in both (global). Local MSEC events are high-frequency in nature and may do not extend beyond one section. During times of regression, base level is lowered and increased erosion increases the detrital contribution into the marine system, primarily from rivers. This material is then dispersed by bottom currents throughout ocean basins (Sachs and Ellwood, 1988) and MS magnitudes increase accordingly. Locally, sections sampled in marine strata deposited proximal to points of discharge or paleo-deltas of ancient river systems will have elevated MS magnitudes relative to sections distal from these points. While the MS magnitudes will be different among such sections, variations resulting from erosional events will be identifiable in all sections within basins, providing that the sections are reasonably complete, hence the value of hemipelagic/pelagic sequences for the development of MSEC CRSs. If the event is global, then the MS effects will be global. In the case of transgression, base level rises and MS magnitudes are reduced as a result.

Several factors have been proposed as causal mechanisms for global sea-level fluctuations. These factors cause base-level changes that in turn result in changes in detrital influx into the worlds oceans. They include (1) ocean spreading rate changes and corresponding ocean basin volume changes (Hays and Pitman, 1973), (2) mass redistribution due to mantle convection (Gurnis, 1990), (3) isostatic crustal balance, (4) orogenesis and short-wavelength uncompensated topography, (5) epeirogeny driven by dynamic topography effects and including post-glacial rebound and tectonic uplift (Lithgow-Bertelloni and Gurnis, 1997), and (6) subduction (Piromallo et al., 1997). In addition, $d^{18}O$ variations, related to long-term variations in continental ice volume, have also been shown to arise from variations in Earth's orbit through the influence of orbital forcing cycles (Imbrie et al., 1984). These climate fluctuations, then, produce long-term changes in detrital input into ocean basins. Observed oscillations in oxygen isotopic data have been tied directly to the MS signal in marine sediments, indicating that MSEC data sets for marine sedimentary samples are, at least in part, controlled by climatic variations.

Climate has two effects. First, changes in rainfall associated with variations in climate increase MS magnitudes during periods of high rainfall and increased rates of continental erosion, while lower rainfall results in lower erosion rates and decreased MS magnitudes. Second, glacial advances and associated lowering of base-level result in increased erosion and increased MS magnitudes. A second effect, erosion by glaciers, also produces an increase in detrital input into the marine system. This effect, causing elevated MS magnitudes due to detrital input into the South Atlantic Ocean, can be seen today coming from glacial erosion of Antarctica and the dispersal of this material northward into ocean basins by bottom currents (Sachs and Ellwood, 1988).

Another climatic effect is pedogenesis. Long-term, climate-driven pedogenesis results in the cyclic production of magnetite and maghemite in soils, which in turn are eroded and transported into ocean basins. These cycles persist through diagenesis. This is clear from the fact that even though MS magnitudes are significantly reduced in limestones and shales, by as much as two orders of magnitude from those of unlithified marine sediments (Sachs and Ellwood, 1988), MS trends still remain.

Secondary effects on the MSEC data set are weathering, alteration and iron migration and concentration. In sampling we choose sections that exhibit low weathering magnitudes and clean samples as much as possible of weathering rines. Obvious areas of alteration and areas of structural complexity are avoided during sampling, as are areas of iron concentration, such as pyrite nodules. However, the effect of hematite staining, often present in sections, is minimal because of the low MS carried in hematite stains.

Evidence that MSEC works

Several factors indicate that the MSEC method works. First, polarity studies on the same rocks indicate that an ac-

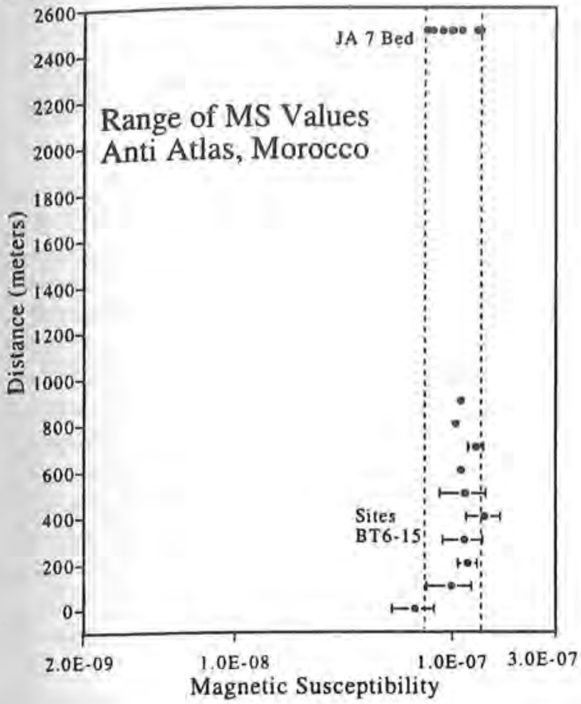

Figure 3 – MS values for samples from 11 sites in the same limestone bed from both Bou Tchrafine (BT6 to BT15) and Jebel Amelane (JA7 Bed). Each BT data point represents the mean and standard deviation of MS values for six samples. The JA data points represent MS data for individual samples taken from the base to the top of the bed and showing the variation within a single limestone bed. Dashed lines represent the highest and lowest MS values for bed JA7. Distance represents the site separation distance in meters. Magnetic susceptibility is given as m^3/kg and the range reported is the entire range of MS values from the Tafilalt Basin, Morocco.

quired remanence has persisted since the Paleozoic. In some instances this may be a remagnetized remanence, but in others the remanence is clearly primary. The carrier of remanence in such rocks is fine-grained (<1 mm), usually magnetite. Such grains are more easily mobilized than are the larger detrital grains (>7 mm) responsible for the MS signature. Therefore, because polarity studies work in limestones, so must MS studies, and in fact when polarity studies do not work, the simplicity of MS measurement virtually insures that MSEC studies on the same sample sets will work.

Second, multiple samples (6 each) from the same bed at single sites, from the same bed at 10 sites separated by 100 m intervals over a distance of 1 km, and from the same bed at sites separated by 25 km, give essentially the same values. This is illustrated by the data in Figure 3. Bed JA7 at Jebel Amelane is the same bed as that containing samples BT 6 to 15 at Bou Tchrafine. The data for JA7 are for eight samples collected consecutively from the bottom to the top of the bed and illustrate the variations that may be expected from a single bed. The variations within sites BT-6 to BT-15 and for JA7, while statistically identical can be attributed to within-site variability and to weathering.

Third, empirical results from sections separated by over 500 km document essentially identical MSEC trends (Crick et al., 1997). This includes Eifelian/Givetian boundary sequences from Morocco (including the GSSP), the Czech Republic and France. Other work shows the same trends in Frasnian/Famennian boundary sequences in France (including the GSSP), Belgium, Germany, France, Morocco, and southern Oklahoma.

Fourth, replicate measurements of the same samples using different methods yield essentially the same results. Figure 4 gives the Jebel Amelane data set for samples measured *in situ*, using a portable Bartington susceptibility instrument (open symbols in Fig. 4), and in the laboratory on samples collected from as near as possible to the place measured using the field instrument. In the main, the results are very similar. Possible reasons for the differences include: (1) weathering products in field samples that were removed or reduced in collected samples; (2) slightly different locations of samples that have a slight amount of within bed variability (see Fig. 3); (3) the Bartington field instrument is not as sensitive as the laboratory instrument and typically loses resolution for samples with very low MS magnitudes; and (4) the sand in the western Sa-

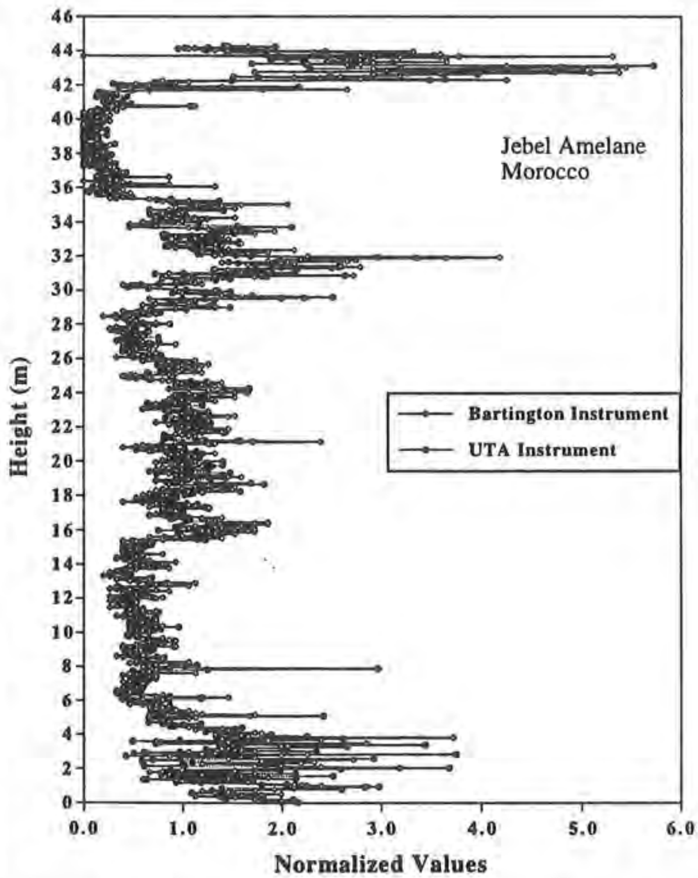

Figure 4 – Comparison of MS values for samples from Jebel Amelane using (1) the Bartington field susceptibility measurement system (open symbols) and (2) samples collected from the same points that field measurements were performed and then measured on the UTA MS bridge. The results are essentially identical with slight variations due to weathering effects and sand contamination of field samples. These effects were removed in those samples that were collected and later measured in the laboratory.

hara contains magnetite and can affect the results if sample sites are not cleaned carefully before the field measurement.

Interpretation of MS data

In general, variations in MS magnitude within a sequence represent changes in the original rate of supply of the iron-bearing lithogenic or detrital fraction to the marine system. Two, somewhat independent controls, constrain the influx of iron-bearing minerals into the marine realm: the degree of climate-induced erosion, and adjustments in base level either through global sea level rise and fall or through tectonically induced changes in attitude of a region relative to sea level. Climate, controlled by orbital forcing cycles, causes variable erosion rates that, in turn, impart a rhythmicity to sedimentary sequences detectable in MSEC data and useful for cyclostratigraphy.

As discussed above, variations in sea level may be controlled by orbital forcing cycles but may also have a random element related to large-scale tectonic controls such as those related to dynamic topography (Gurnis, 1988; Gurnis, 1990; Lithgow-Bertelloni and Gurnis, 1997). In our experience, random adjustments to base level through relative or net changes in sea level are responsible for the MSEC events. Tectonically induced changes on a global scale will produce first-order isochronous MSEC events that can be identified and correlated on global, regional, and local scales, particularly when sequences are constructed from sediment of the same general facies, i.e., pelagic, hemipelagic, neritic. Changes in regional processes will produce second-order MSEC events of moderate frequency and limited in importance to the region of origin. MSEC data will also contain abundant third-order, high-frequency events created by local fluctuations in the type and rate of sediment accumulation. Third-order events are generally not replicated among sections. MSEC data will thus exhibit a complex signature that is representative of the processes and controls on the relative iron content of marine sediments. There is, however, an order to this signature. Global events and processes control the basic character of a signature and fix the general position of major peaks and sustained trends observable in MSEC data sets from different paleogeographies. Regional events and processes generally impart a character to the MSEC data that is distinctive within a region but one that does not obscure the global signature. Modifications to the MSEC signature for individual sequences are useful in comparing variations between geographically related sequences and, if unwanted, may be removed by filtering.

Completed work demonstrates that MSEC events make exceptionally good chronostratigraphic markers. MSEC events are of two types. Those composed of high magnitudes and those composed of low magnitudes. The high magnitude events are typically shorter in duration and more numerous than low magnitude events which are generally fewer in number and of longer duration. Because high magnitude MSEC events represent less time, they are more useful for chronocorrelation and generally increase the resolution of correlation by factors of between 3 and 10. Due to the inherent lack of uniqueness of most MSEC signatures (true also in polarity studies), it is necessary to establish basic biostratigraphic frameworks for temporal constraint. MSEC can then be used to define chronostratigraphic boundaries as is done with polarity magnetostratigraphic markers under Section 2.4 of the revised guidelines for establishing global chronostratigraphic standards (Remane et al., 1997).

Interpretation of MS signatures

We interpret MSEC events in the following ways. Increases in MS magnitude correspond to relative or net drops in sea level. Highest magnitudes represent maximum low stands in sea level. Decreasing magnitudes correspond to relative or net rises in sea level. Lowest magnitudes represent maximum high stands in sea level. Increasing magnitudes correspond to relative or net falls in sea level. Commonly a number of consecutive MS lows or highs will coalesce into broad episodes indicative of sea level stasis. The character of the increase or decrease in MS magnitudes within a sequence represents the rate of the process or processes responsible for the change.

Status of MSEC and Event Stratigraphy

MS data faithfully detect random events of the type related to tectonically induced fluctuations in sea level. In the beginning we concentrated on developing MSEC signatures in sequences known to contain Devonian bioevents (Walliser, 1995). In each case we have been able to identify an abiotic MSEC event whose duration either equals that of the bioevent or is longer. We suspect that the correspondence between MSEC events and biotic events is ultimately linked to tectonic or climatic factors that MS is tracking. MSEC signatures have been studied for only a few of the 17 Devonian biotic events, but in each case we find the same correlation between the stratigraphic position of the biotic event and the MSEC event. There are, however, a large number of MSEC events which do not correspond directly to known biotic or other events and these events are equally valuable to chronocorrelation by MSEC events.

There is the question of how to define the beginning and ending of MSEC events. Although the general character of MSEC events is easy to detect graphically and defined by significant departures from general trends in MS magnitude, there are no objective criteria for marking their beginning and ending. Subjectivity comes into play because an MSEC data set consists of data from two input sources. The first is the continuous or near continuous record of fluctuations in the amount of iron delivered to the pelagic realm as a consequence of the effects of orbital forcing cycles on climate. The second is the record of random but major increases or decreases in the amount of iron delivered to the pelagic realm as a consequence of disturbances in the global tectonic system. Data from the first source create an MS signal that is cyclic. The second source produces a signal of random but major increases or decreases in MS magnitudes. The mixing of the two signals gives the impression that the random events are part of the cyclic MS record. While there are several ways of placing boundaries on such events, we have chosen to place boundaries midway along trends of change in MS magnitudes toward an interval of low or high MS values (the beginning and lower boundary of an MSEC event) and away from an interval of low or high MS values (the ending and upper boundary of an MSEC event). The definition of MSEC event boundaries and the use of events in MSEC chronocorrelation is addressed in the following examples.

The Status of MSEC and Cyclostratigraphy

Cyclostratigraphy relies on the extraction of cycles present in strata. The growing interest in cyclostratigraphy and its application has produced a wide variety of techniques for extracting signals. These range from the spacing and thickness of beds to elemental profiles by neutron activation analysis. Fischer (Fischer, 1995) offers a summary of the common methods. Common concerns about the inadequacies of the sedimentary record to support cyclostratigraphy have been eloquently rebuffed by Fischer. Concerns that orbital forcing cycles (Milankovitch Cycles) are being misused to interpret periodicities in sedimentary phenomena are well documented (Algeo and Wilkinson, 1988; Anders et al., 1987; Fischer, 1995). These concerns may be well founded when studies are based on physical measurements and observations in outcrop and core, and particularly so when studies are based on typical shelf facies. One of the reasons that the SDS and other subcommissions on stratigraphy have avoided shelf facies was to reduce the likelihood of encountering incomplete sequences when selecting GSSPs. While it is likely that pelagic sequences on submarine rises will exhibit some degree of incompleteness, results from the Ocean Drilling Program suggest that stratigraphic gaps in such facies may be less than previously estimated. Although we have and will continue to use exclusively pelagic sequences in constructing CRSs, we are very aware that most if not all sequences may contain cryptic stratigraphic gaps.

Cyclostratigraphy does have a few safeguards against introducing large errors during analysis. The first lies in the inherent hierarchy of orbital forcing cycles. Small gaps of time in the precessional (19-23 ka, modern not Devonian) and obliquity (41 ka, modern not Devonian) cycles can be compensated for with the much longer 106 ka and 413 ka eccentricity cycles whose periodicities appear to have remained constant over geologic time (Berger et al., 1989). The second safeguard is reproducibility of results. As demonstrated in the following examples, elements of MSEC signatures occur in sequences far removed from the reference section. These signatures have a decided cyclicity that we consider to be the result of orbital forcing cycles. Unlike the concern of Algeo and Wilkinson and others, MSEC data are based on samples taken without regard for the physical characteristics of sequences (other than to avoid structural and other ambiguities) and the data do not show correlation with facies. To effectively correlate between neritic, hemipelagic, and pelagic facies will require the creation of an MSEC CRS in the facies with the dominant biostratigraphic control. However, it is now clear that detrital iron input rather than facies type dominates the MS. This is illustrated in Figure 5 where we present the range of MS values for marine limestone and shale sequences that we have measured for sections in Morocco, France, Belgium, the Czech Republic, the United States (Georgia and Oklahoma) and Vietnam. These results show clearly that there is a broad range of MS values in both limestones and shales and that the MS values observed are controlled mainly by the iron content within these rocks and is generally independent of lithology. It is true that in some sections, shale samples may exhibit the largest MS values, but within the same sections many limestones have higher MS values than do many shale samples

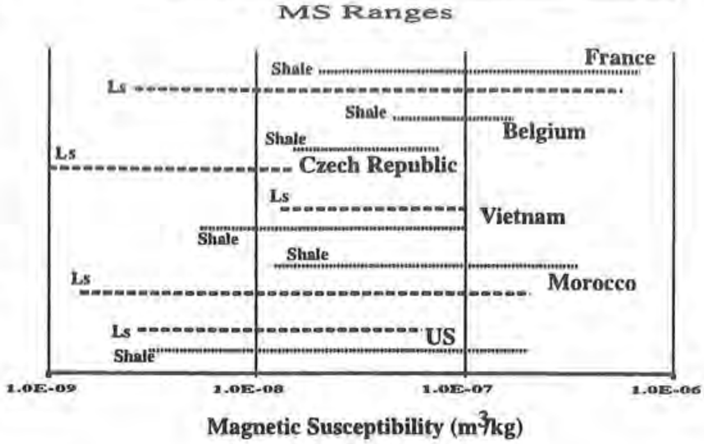

Figure 5 – The range of MS values that we have measured for limestone (Ls) and shale samples from Morocco, France, Belgium, the Czech Republic, the United States (Georgia and Oklahoma) and Vietnam.

An essential part of cyclostratigraphy is the existence of a well-defined geochronology of reasonable resolution. Without the control of a geochronologic framework there is no definitive way of *objectively* determining which orbital forcing cycle controlled which cycle extracted from MSEC or any other data source. The virtual absence of precise and accurate absolute ages of well-defined stratigraphic sections for the post-Silurian Paleozoic presents very real problems for the application of cyclostratigraphy to Paleozoic strata. Presently there are only two published radiometric dates for the Devonian (Gradstein and Ogg, 1996; Tucker and McKerrow, 1995), one at 411.9 Ma from lavas of the Arbuthnot Group (Scottish Midland Valley) which lie one spore zone above the base of the Pragian, and one at 390 Ma from the Tioga k-bentonite that lies within the *Polygnathus costatus costatus* Zone (Early Eifelian) (Tucker and McKerrow, 1995). Clearly, more dates are required. In the mean time we can continue to test the application of cyclostratigraphy with one or more of the existing time scales. The cyclicity present in the strata will remain the same, although specific orbital forcing cycle designations may change depending on revisions to the chronometric scale.

MSEC across the Eifelian/Givetian Boundary and the Kacak/*otomari* Event

Figure 6 illustrates the MSEC signature for the Eifelian/Givetian GSSP sequence of Walliser et al. (Walliser et al., 1995) and taken from (Crick et al., 1997). The published sequence for the GSSP (Walliser et al., 1995) includes Beds 101 through 145. We have extended the sequence through Bed 161. The MSEC signature begins with stepped increases in MS magnitude for Beds 101-107 (Peak 1). The first sample in Bed 108, with a magnitude lower that previous values, begins a trend of decreasing MS. There are no obvious differences between the limestones of Beds 107 and those of Beds 108-110. Low

MS values continue through Bed 121. The sequence of low magnitudes of Beds 108-121 defines the *Late Eifelian MSEC Event.* The important reversal in this trend is Peak 2a that begins to develop in the upper portion of Bed 110 and continues through Bed 111. The appearance of *Po. ensensis* coincides with the small peak in Bed 115. The return to low MS values, similar to those of Beds 101-107, begins with Beds 120/121, but before the disappearance of *Po. ensensis.*

The trend of increasing MS magnitudes that defines the upper boundary of the Late Eifelian MSEC Event culminates in Peak 3 in the upper portion of Bed 122, immediately below the GSSP. Peak 3 is followed by another decrease in magnitude, at the point where *Po. hemiansatus* appears, and one that is sustained through Bed 127. A sustained and well-documented increase in MS magnitude follows this low point and begins an interval of enhanced magnitudes through Beds 128-149. The appearance of *Polygnathus varcus* occurs in this interval, which is divisible into Peaks 4, 5, 6, and 7. Magnitudes in Beds 150-161 document a return to values similar to those of the pre-Late Eifelian MSEC Event. Peaks 8 and 9 occur within this interval.

The overall interpretation of the MSEC signature for the sequence is that of a steady lowering of sea level in the middle *T. k. kockelianus* Zone (Peak 1) abruptly reversed to a sustained high stand through the remainder of the *T. k. kockelianus* Zone and all but the latest *Po. ensensis* Zone (Peak 2). Sea level begins to fall in the latest *Po. ensensis* Zone and, although variable, an interval of low sea level stand continues through the *Po. hemiansatus* Zone and into the Lower *Po. varcus* Zone (Peaks 3-7). A shift toward a rise in sea level occurs in the early portion of the Lower *Po. varcus* Zone and continues to the end of the sequence (Peaks 8-9). This interpretation is supported by comparison with the T-R Cycles of Johnson et al. (1985). Although the T-R Cycles of Johnson et al. (1985) have not been formerly recognized in north Africa, interpretation of the MSEC data in the context of sea level curves shows a rough correspondence with transgressive peaks occurring consistently earlier in southern Morocco than in North America. The latest portion (shallowing) of T-R Cycle Ie is essentially equivalent to the sequence prior to the Late Eifelian MSEC Event (Beds 101-107). The deepening episode marking the Late Eifelian MSEC Event corresponds to the earlier portion of T-R Cycle If. It is likely that the shallowing event following the Eifelian - Givetian boundary corresponds to the completion of the first subcycle of Cycle If.

The data presented here document an abiotic, low-magnitude MSEC event (*Late Eifelian MSEC Event*) that encompasses the Kačák – *otomari* Event. The boundaries of this MSEC event do not correspond to any known faunal turnover. The lower boundary occurs in the upper *Tortodus kockelianus kockelianus* Zone and the upper boundary lies in the upper *Polygnathus ensensis* Zone. The general character of the event is one of an episode of rapid and prolonged rise in sea level. Because of the many differences between the MSEC event and the Kačák – *otomari* Event, we use the term *Late Eifelian MSEC Event* when referring to the longer interval defined by MS data (Figure 6, Peak 2). It is tempting to speculate that the physical controls responsible for the *Late Eifelian MSEC Event* introduced sufficient environment stress to

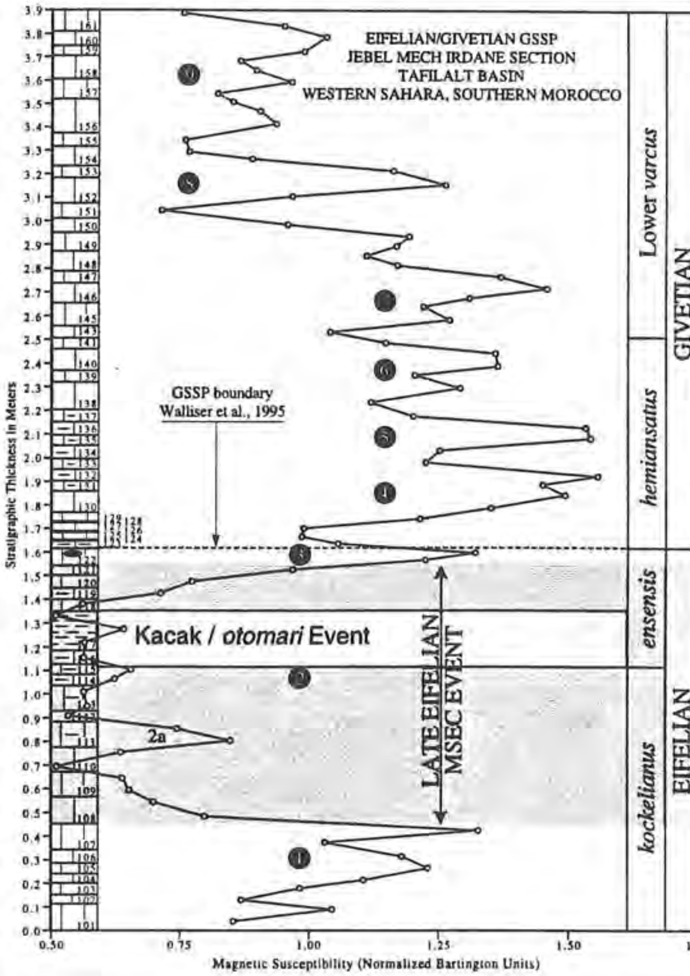

Figure 6 – MSEC signature for Eifelian/Givetian GSSP. Details discussed in the text and in Crick, et al. (1997).

cause the faunal changes we use to recognize the beginning of the Givetian.

The *Late Eifelian MSEC Event* is only one of 9 MSEC events identified in the GSSP boundary sequence but it is the only one related to an increase in sea level, although other broad trends exist, e.g., the trend defined by MSEC Events 8 & 9. The MSEC events are described in detail elsewhere (Crick et al., 1997) and are shown in Figure 7 to have correlatable value among sections of the same basin (Fig. 7, A,B,C) as well as between regions (eastern Morocco and southern France). At least one study (Galle et al., 1995) places the Montagne Noire region between 600 and 1000 km from eastern Morocco during the Devonian. The upper and lower limits of these additional sequences for JA, BT, and PBMN were chosen from much longer MSEC signatures on the basis of their agreement with the combined biostratigraphy and MSEC signature of the GSSP. Thus the thickness of the boundary sequence of JA, BT, and PBMN corresponds to GSSP MSEC Events 1 through 9. Differences in rate of sediment accumulation among sections is shown as differences in section thickness. Differences between the MSEC signature for the Montagne Noire and those of the Tafilalt of southeastern Morocco are no greater than among the Tafilalt sections. Boundaries of the *Late Eifelian MSEC Event* boundaries in JA, BT and PBMN were positioned relative to trends in transition between MSEC

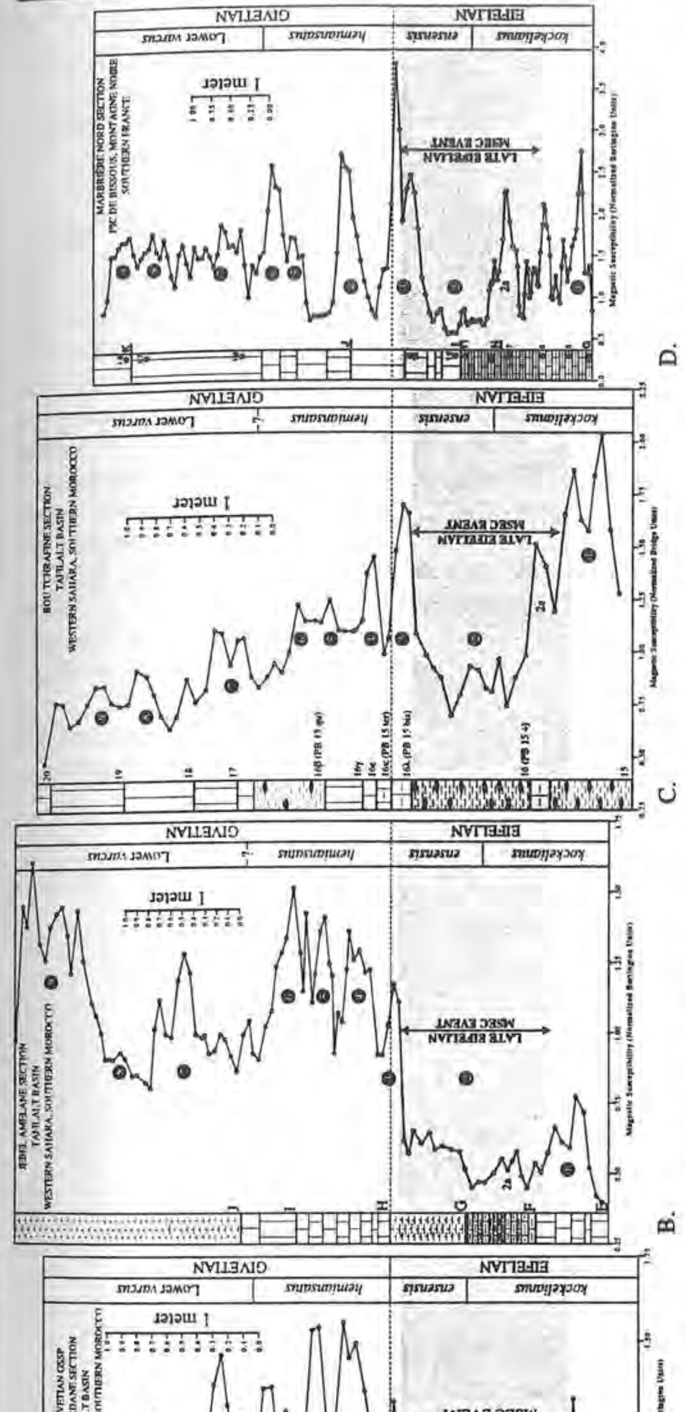

Figure 7 – Comparison of MSEC signatures for Eifelian/Givetian boundary sections of Anti-Atlas, Morocco (A,B,C) and Montagne Noire, France. Numbered portions of MSEC signatures are MSEC events. Scales vary among sections. Details in the text and Crick, et al. (1997).

	MSEC EVENT	*ensensis*	*hemiansatus*
GSSP	69%	31%	39%
JA	70%	42%	38%
BT	69%	45%	37%
PBMN	70%	42%	45%

Table 1 – Stratigraphic thickness of Late Eifelian MSEC Event and zones of *Polygnathus ensensis* and *Po. hemiansatus* as a percent of the stratigraphic thickness of the Eifelian or Givetian portion of the sequences of Fig. 6. See text for details. Labels are those of Fig. 7.

Events 1 and 2 for the lower and between MSEC Events 2 and 3 for the upper.

Table 1 gives the stratigraphic thickness of the Late Eifelian MSEC Event and the zones of *Polygnathus ensensis* and *Po. hemiansatus* in percentages of either the Eifelian or Givetian portion of each boundary sequence in Fig. 7 depending on the stratigraphic position of the event and zones: Eifelian for the Late Eifelian MSEC Event and *Po. ensensis* and the Givetian for *Po. hemiansatus*. The thickness of the *Late Eifelian MSEC Event* is essentially a constant percentage of the Eifelian portion of the boundary sequence while those of the two biozones are more variable. The lack of variability in the percent duration of the *Late Eifelian MSEC Event* is attributable to a number of factors such as the density of sampling, the continuous nature of MSEC data, no difficulties with preservation, but most important is that the geometry of the MSEC signature is preserved regardless of differences in rates of sediment supply and accumulation. It is this last factor that allows reproducible results when applying criteria to select MSEC event boundaries. Variability in the percent duration of the two biozones among the four sequences is almost certainly due to the lower sample density common to and practical for biostratigraphic studies as well as vagaries in the presence and preservation of biozone taxa. These four sections are the exception in that they are extremely well known for their biostratigraphy. The conodont sample density for the GSSP was 30 samples in 2.35 m for an average of sample spacing of 8 cm, although the greatest concentration of samples occurs within a 35 cm interval suspected of containing the boundary. By comparison, the MSEC signature is based on 50 samples for the same 2.35 m interval and 80 samples for the 3.9 m of the GSSP boundary sequence shown here. The sample spacing for the MSEC signature was approximately 5 cm.

Frasnian/Famennian Boundary and Upper Kellwasser Event

Figure 8 illustrates a similar but much more complex MSEC analysis of the Frasnian/Famennian GSSP and associated boundary sequences in the Montagne Noire region of southern France. The sequences are short with thickness ranging from 0.7 m to 2.35 m. For this reason, each sequence was analyzed centimeter by centimeter for portions available for sampling. TM Raimund Feist (Univ. Montpellier/CNRS) provided the initial samples and details of conodont zonation.

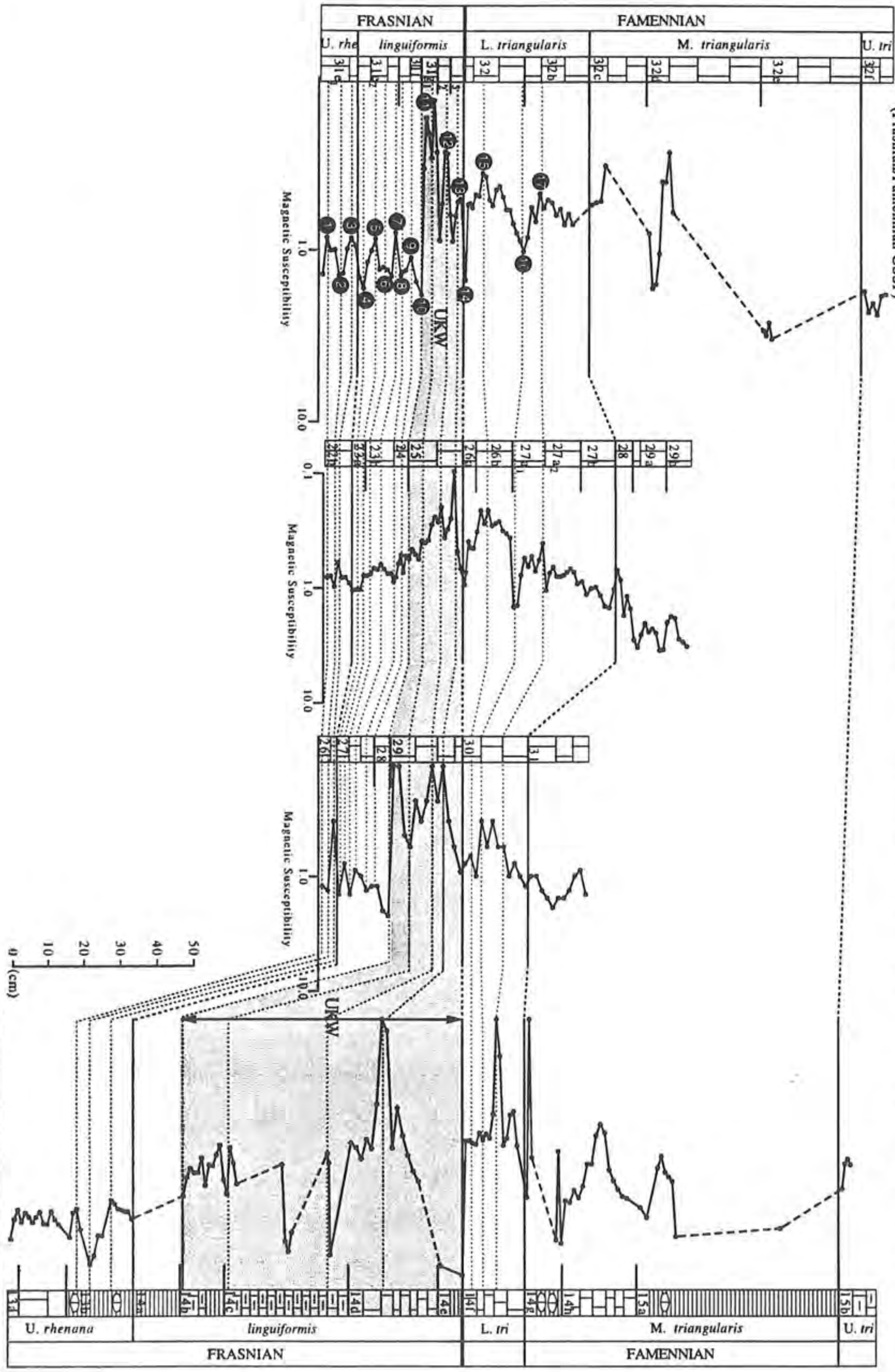

Figure 8 – Comparison of MSEC signatures for Frasnian/Famennian boundary sections in Montagne Noire of southern France. Each dot on an MSEC curve is a sample. Dashed portions within curves represent missed section. Heavy dashed lines among sections represent lines of correlation based on conodont biozones. Light dashed lines among sections represent correlations on the basis of MSEC peaks or events. Details in the text.

This and the frequency of events provide a very detailed event stratigraphy for the GSSP in the Upper Quarry section at Coumiac beginning in the uppermost *Pa. rhenana* Zone and extending almost to the Middle *Pa. triangularis* Zone where resolution was lost due to missing section. The GSSP, Lower Quarry (LQ) and Caussess-et-Veyran: South (CVS) sections are separated by less than 1 km. The LSC section lies approximately 40 km northeast of the GSSP. GSSP, LQ, and CVS sections are described as having been deposited on submarine rises while LSC was deposited in a deeper basinal setting (Feist, 1985; 1990). Although the magnitudes of the MSEC events vary, the control is quite good and greatly enhances the already excellent biostratigraphy. Particularly interesting is the agreement between the MSEC data and the boundaries of the Upper Kellwasser (UKW) Event. The rapid decrease in MS magnitudes in beds of GSSP, LQ, and CVS, picked as the starting point for the UKW by others using different criteria (see summary in Girard and Feist, 1996) is suggestive of a deepening event, the effects of which are more pronounced in the shallower water submarine rise sequences than in the basinal sequence of LSC. Three MSEC events (11, 12, 13) occur within the UKW interval of the GSSP within already identified subhorizons of bed 31g (Fig. 8). These can be traced with considerable fidelity to event peaks in LQ and CVS where

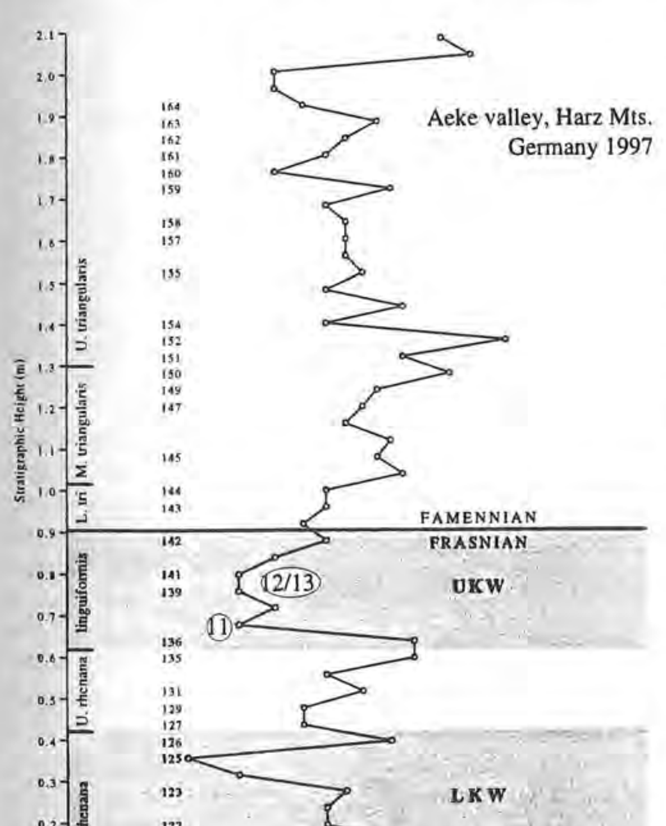

Figure 9 – MSEC signature for Kellwasser type section. Biostratigraphy and bed numbers from Schindler (1990). LKW (Lower Kellwasser), UKW (Upper Kellwasser). Circled numbers are MSEC events of Figure 8 (Frasnian/Famennian GSSP). Details in the text.

they were not known and into LSC with some loss of accuracy related to missing section. The Frasnian/Famennian boundary intervals of the submarine rise sections in the Montagne Noire have a peculiarity that affects the magnetic susceptibility signature. This is the often reported iron crust that occurs in the final 1 cm of *Pa. linguiformis* Zone immediately below the boundary. This crust returns a very high MS magnitude which can only be associated with a high concentration of magnetite. Such concentrations are rare and normally associated with winnowed and condensed zones. We have chose not to use this very high MS value. Even without this value there is an increase in MS magnitudes toward the end of the *Pa. linguiformis* Zone. The increase also occurs in the latest *Pa. linguiformis* Zone at basinal section (LSC) where no iron crust developed.

Kellwasser type section, Aeke Valley, Harz Mts., Germany

Access to the section and details of biostratigraphy were made possible by CM Shindler. Figure 9 illustrates the MSEC signature of the Kellwasser type section. Like the GSSP, it too is only a few meters thick (as sampled) but samples were taken at intervals of 4 to 5 cm as opposed to 1 cm at the GSSP. The sequence represents a greater portion of time beginning in the Lower *Pa. rhenana* Zone and ending in the Upper *Pa. triangularis* Zone and includes the Lower Kellwasser in the uppermost Lower *Pa. rhenana* Zone. Both Kellwasser horizons contain MSEC signatures indicative of sea-level rise. The MSEC signature for the Aeke Valley UKW is very similar to those of Montagne Noire sections and nearly identical to that of CVS with MSEC event 11 being well defined and an event peak occurring where events 12/13 should be located. Either the data are too coarse to resolve the peaks or one of the peaks is unique to the Montagne Noire region. The sample spacing above the Frasnian/Famennian boundary is too coarse to extend the event stratigraphy into the Lower *Pa. triangularis* Zone. We plan to resample the sequence at the same interval as used for the GSSP.

Lower Devonian, Jbel Issemour, Taalalt, Morocco

The MSEC signature for Jbel Issemour located on the northern margin of the Ma'der Basin is shown in Figures 10, 11, and 12. The work was possible through continued collaboration with our long time field partner CM Ahmed El Hassani (Rabat) and new collaboration with members of the Department for Paleontology and Historical Geology at the Senckenberg Research Institute (Ulrich Jansen, Gerhard Plodowski, CM Eberhard Schindler, Gunnar Schraudt, TM Karsten Weddige, TM Willi Ziegler). The Senckenberg group is developing the biostratigraphy necessary to show the temporal position of MSEC events. We have a general idea of the position of stage boundaries from published and unpublished works of Henri Hollard and it is on this basis that we have placed stage boundaries in Figures 10, 11, and 12. It should be appreciated that samples are still being analyzed and that the total thickness sampled at approximately 10 cm intervals is close to 260 m. Figure 10 shows the complete sample density of 1919 samples and the position of beds identified as tempestite layers with elevated MS magnitudes.

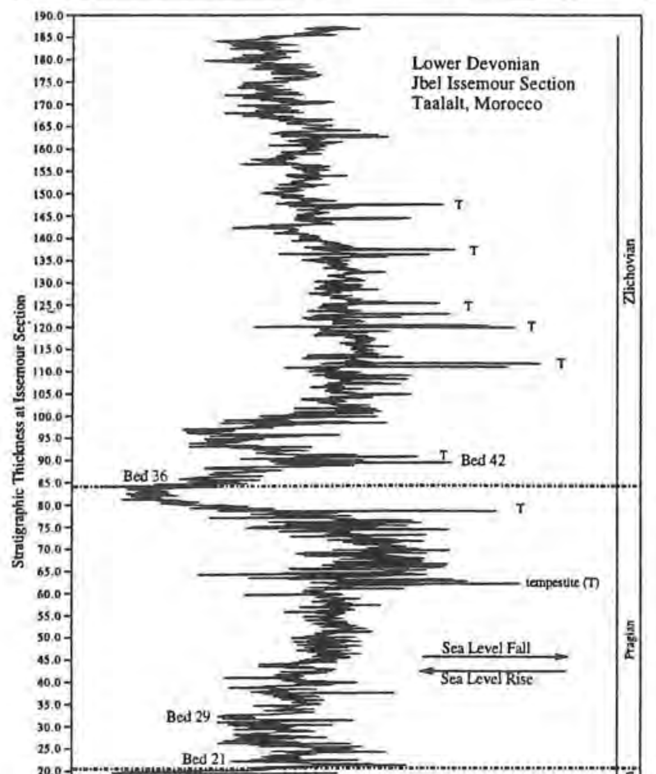

Figure 10 – MSEC signature through the Lower Devonian portion of the sequence at Jbel Issemour (Ma'der Basin, Taalalt, Maroc). The signature is unaltered and represents 1919 samples with an approximate spacing of 10 cm. Much of the noise in the signature is due to very high frequency fluctuations in MS magnitude. Bed numbers are shown for a few of the more important beds (see text). High frequency and very high MS magnitude peaks are tempestite layers. Only those of the highest magnitude are shown. There is some disagreement over the position of all but the S/D boundary. Resolution awaits biostratigraphic work currently underway at the Senckenberg Research Institute (Frankfurt).

Figure 11 shows the MSEC signature with high frequencies removed by the splining. The temporal position of "events" is not well controlled biostratigraphically and we really are not looking to match the known events with the position or duration of MSEC events. They may coincide and they may not. We know where the S/D boundary located and we see a decrease in MSEC values at the boundary as we have in other sections on other continents. The Lochkovian/Pragian boundary lies somewhere between Bed 21 and Bed 29. We will have to wait on conodont and trilobite biostratigraphic results from the Senckenberg to make a final decision. Based on Hollard's descriptions, we are more certain of the Pragian/Zlichovian boundary at or very near our Bed 36. There is also the possibility of this boundary falling within Bed 42. The preliminary definition of the boundary here corresponds to the classic boundary in Bohemia. The boundary falls within a major MSEC event of low magnitude and rather long duration, and describes a rapid and prolonged drop in sea level. Because this is the first MSEC event in the Zlichovian we have given it the name Zlichov MSEC Event I. There is a second MSEC of low magnitude and decent duration above Bed 42 to which we have assigned the name Zlichov MSEC Event II. Based on our experience in the Tafilalt and MSEC work across the Zlichovian/Dalejan boundary near Rabat we have positioned the Daleje Event (Walliser, 1995) just prior to the rapid rise in MS magnitudes (= sea level fall).

The MSEC signature is less subjective when using it to characterize the history of sea level changes or transgressive-regressive cycles for the region of at least the Ma'der. The transgressive (T) -regressive (R) cycles suggested in Figure 12 may represent the effects of sea level changes on the Ma'der, the northern margin of Gondwana, or Earth. We will not know the extent until further comparison are made. It is clear from Figure 12 that there are many episodes of sea level rise and fall within each of the larger T-R cycles. The thick bar labeled with "(Pre Ia)", etc. reproduces the T-R cycles of Johnson et al. (Johnson et al., 1985) for Euramerica. The adjacent bar presents the T-R cycles defined on the same general criteria of Johnson et al. (1985), that is, a T-R cycle begins with a deepening event and ends with a shallowing event. The greatest similarity between our T-R cycles and those of Johnson et al. is in the Pragian portion of the MSEC signature. We feel the remaining differences are due either to the greater resolution of MSEC data or regional differences. We feel that the MSEC

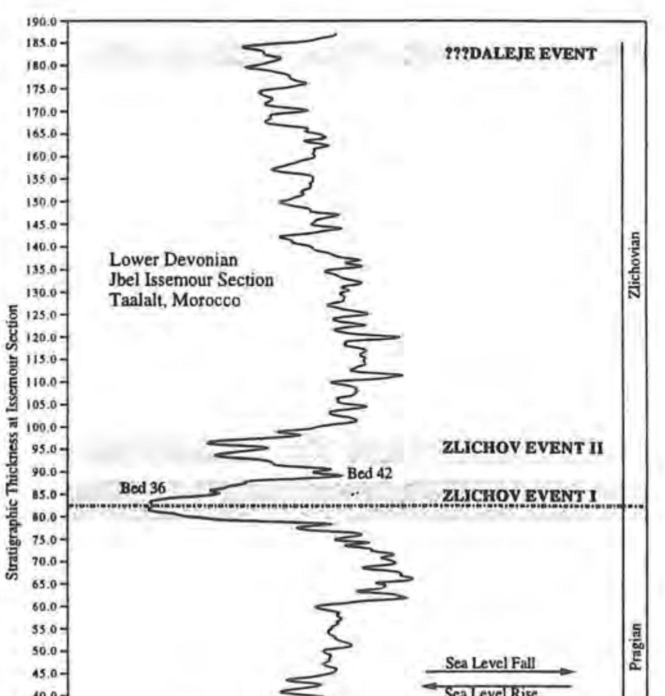

Figure 11 – Splined version of the MSEC signature of Fig. 10 showing suggested position of various standard Devonian events and new Zlichov Events I & II.

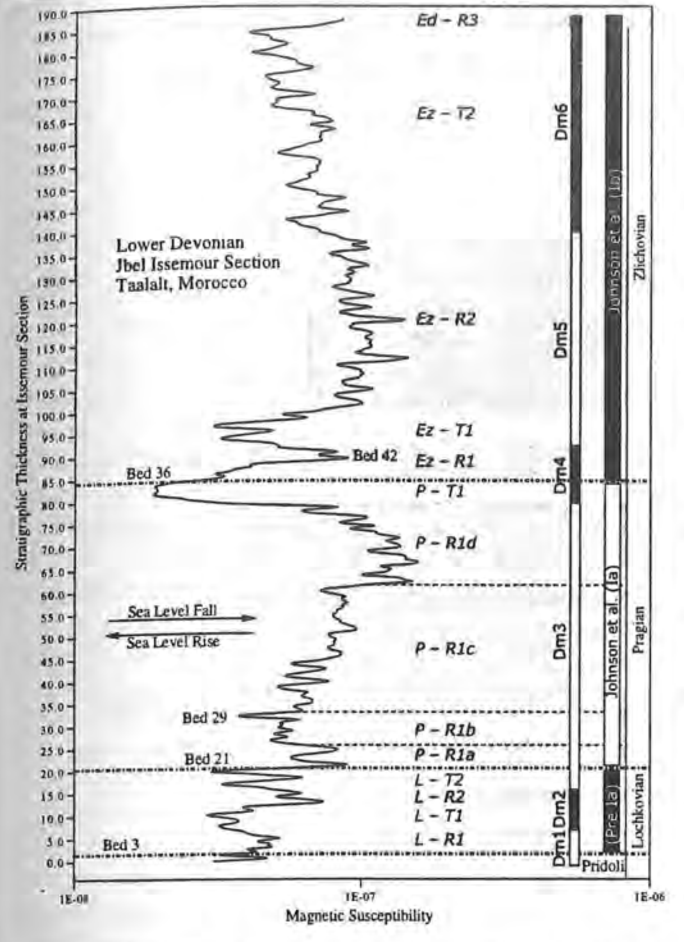

Figure 12 – Same curve as Fig. 11 showing various subdivisions of the MSEC curve in support of transgressive cycles and regressive cycles and T-R cycles (after Johnson et al., 1985). Dm1 (Devonian Ma'der 1) through Dm6 represent T-R cycles defined on the same general criteria of Johnson et al. (1985). L, Lochkovian; P, Pragian; Ez, Emsian (Zlichovian); Ed, Emsian (Dalejan); R, regression;T, transgression. The T-R cycles of Johnson et al. (1985) are shown for comparison.

data can offer much greater detail about each T cycle and each R cycle. The shaded and intervening unshaded regions of Figure 12 labeled *L–R1* through *Ed–R3* illustrate the breakdown of the MSEC curve into transgressive and regressive components. It is likely that this subdivision contains a component of regional events and that the high frequency pulses within each T or R event represent the local record of sea level change. We hope to soon overlay these data with the record of biostratigraphy for a comparison of faunal changes and sea level changes.

The Lochkovian, Pragian, and Zlichovian sea level history for the Ma'der reads as follows. The Lochkovian began with a slight regression, experienced a transgression followed by a regression perhaps more severe than the initial regression and ended with a transgression. The Pragian began with a regression that continued through most of the stage which ended with transgression. MSEC data suggest that there were at least 4 different regressive episodes (P–R1a to P–R1d) separated with short-lived deepening or stasis events. The Zlichovian began with a brief regression followed by an equally brief transgression and then experienced a long-lived regression and an equally long-lived transgression. It appears that the Dalejan began with a regression of unknown duration (we'll know more as samples are analyzed).

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CM Ahmed EL HASSANI (Rabat, Morocco)

During this year I concentrated my work essentially on the eastern Anti Atlas and also by the achievement of the geological map of Khemisset to 1/100 000 which will be printed in the Notes & Memoirs of geological service of Morocco soon. This map includes a Paleozoic substratum (Cambrian to Permian) and a Mesozoic-Cenozoic cover. The Devonian is well exposed on this map, notably in the zone of Tiflet and also in the zone of Tiliouine-Tsili to the South part of the map.

The investigations into the eastern Anti Atlas were elaborated in two periods:

May 18-28: in collaboration with Prof. Rex E. CRICK& Prof. Brooks ELLWOOD (University of Texas at Arlington): our works were concentrated on the MagnetoSusceptibility and Cyclostratigraphy of the Devonian in Bou Tchrafine, Hamar Lakhdad, jbel Amelane and Mech Irdane.

October 27 to November 7: in company of Prof. Brooks ELLWOOD. We were interested by Lower Devonian sections in the Maider basin. A collaboration on the biostratigraphy of this outcrop was efficient with colleagues from the Senkenberg Museum of Frankfurt (notably E. Schindler). The chosen outcrop in the jbel Issemour (NW of Maider) includes the Silurian-Devonian boundary and allows to follow the set of Lower Devonian on more than 300m of continuous section. This outcrop is very well exposed and is very rich in fossils (especially Trilobites, Goniatites, Tentaculites, Brachiopodes,...).

In the Moroccan Meseta, beside my work on the Khemisset map, I follow with big interest the work of Dr. EL KAMEL (from Casablanca University, PhD in progress) on the Rehamna massive. In the carbonate platform of Northern Rehamna, Late Emsian - Late Givetian reefs are preceded and well accompanied by tilted block tectonics which develop reefal bioconstruction in their crests. This tectonic tilting is materialized, in the reefal growing zone and in the external platform, by a series of unstable tectonic figures, notably tension faults associated with progressive unconformities and landslides.

CM P.E. ISAACSON

Since Upper Devonian rocks throughout South America have source rock potential, recent work has addressed better biostratigraphic controls and depositional settings of rocks of the Devonian System as a whole. Southern South America has the classical Malvinokaffric benthic faunas, whose correlation to other areas has always been speculative.

Devonian paleobiogeography of the central Andes is influenced by three major factors: paleogeographic setting, high latitudinal position (and cold temperatures) of the region during Early Devonian time, and an apparent influx of slightly warmer water during Middle and Late Devonian time. The highly endemic Malvinokaffric shelly faunas of southern South America, Antarctica, and South Africa have long been assumed to have lived in cold water, with evolutionary ties to Eastern Americas Realm organisms of the northern Appalachian Basin, U.S.A., and possibly the Bohemian region of central Europe. Unfortunately, the Malvinokaffric faunas provide a basis for correlations within part of South America, though biostratigraphic precision for sequence stratigraphic analysis and correlation to extra-Gondwanan Devonian units continues to be a problem. It has been suggested that Early Devonian Eastern Americas Realm brachiopods entered the region by means of an influx of warmer water, and the migration routes may have been restricted by intra-arc basins. Higher in the Andean sequence, however, the much lower diversity "post-Malvinokaffric" fauna has been identified. It consists of the "circum-Atlantic" brachiopod genus, *Tropidoleptus* and other taxa. It appears that *Rhipidothyris*, above *Tropidoleptus* in the Devonian sequence, moved from Libya, where both taxa are present in the Idr Formation, of Givetian age. This Middle Devonian fauna, however, does not achieve the diversity of "Hamilton" and other Givetian fauna in New York and North Africa. Megafaunas are absent from Upper Devonian rocks in the Andes. Therefore, these rocks have been correlated by palynomorphs, utilizing the standard European zones.

Late Devonian rocks have few benthic faunas and no conodonts, although recent work, by Streel and Loboziak (Brazilian basins), Wood (Peru), Vavrdova (Bolivia), has recovered palynomorphs with excellent potential for correlation to sections on other continents. Biogeographic comparisons of Late Devonian palynomorphs and marine microplankton point to the close relation between western Gondwana, some parts of North America (Ohio, Michigan, Ontario, Tennessee), as well as North Africa (Libyan and Algerian subsurface). This is unexpected considering the presumed difference in paleoarctic and paleosubtropical position of the Gondwanan and Laurussian terranes. There was free dispersal of both land-derived and planktonic species such as Umbellasphaeridium saharicum between western Gondwana and Appalachians, areas of supposed palaeotropical to paleo-polar regions. There is a possibility of newly opened migrational routes between western Gondwana and Appalachian region during Late Devonian.

Significant in Upper Devonian rocks are glacial diamictites of Famennian age, which occur from Lake Titicaca through most of Brazil. It appears that this Late Devonian glaciation may have influenced non-South American sequences. It may be a suspect in the Frasnian/Famennian extinction event.

In July, 1996, a meeting on South American Silurian and Devonian stratigraphy and paleontology was held in Ponta Grossa (Paran), Brazil. Because of this meeting, held in honor of Frederico Lange, principals in such research could be identified.

Bolivia:

Oscar Arispe (sedimentology), Alejendra Dalenz (bivalves), Enrique D!az (sedimentology), Magaly Gonzalez (stratigraphy), Bruce Liebermann (trilobites), LeGrand Smith (trilobites), and Ramiro Suarez-Soruco (regional synthesis)

Brazil:

Mario Assine (sedimentology), Ines Azevedo (ostracodes), Leonardo Borghi (facies analysis), Elvio Bosetti (inarticulate brachiopods), Norma Maria da Costa (palynology), Roberto Daemon (palynology), Vera Foncesca (brachiopods), Alm,rio Franca (stratigraphy), Jos, Henrique Godoy (ichnofossils), Yngve Grahn (chitinozoans), Roberto Ianuzzi (paleobotany), Jos, Henrique Melo (regional synthesis), Setembrino Petr! (regional synthesis), and Raquel Quadros (brachiopods)

Uruguay:

Rodolfo Barnech, Claudio Gaucher, Pedro Sprechmann (their paper was withdrawn, so specialties are not given)

Other Regions:

I apologize for incomplete reporting for other countries, but they were unrepresented at the Ponta Grossa meeting. In Argentina, a basin analysis of Devonian units in the Tarija-Salta basin has been published (daniel Starck). Other principals involved in Devonian research include Bruno Baldis, Juan Benedetto, Gustavo Gonzalez-Bonorino, Teresa Sanchez, among many others. Eduardo Ottone has published on Devonian palynology.

Similarly, I have little information from Colombia, Venezuela, and Ecuador, where new information from the Oriente suggests presence of a fossiliferous Devonian sequence there.

Little Devonian work has been completed recently in Peru. Chilean Devonian outcrops are limited; they and their faunas have been described by Heinrich Bahlburg, Christoph Breitkreuz, Hans Niemeyer, and Felipe Urzua.

Ruth MAWSON and John TALENT (Sydney)

News from Macquarie University Centre for Ecostratigraphy and Palaeobiology (MUCEP)

A long paper on the Late Devonian-Early Carboniferous conodonts from the Burdekin Basin, their chronological implications, and the Devonian-Early Carboniferous T-R pattern in north-eastern Queensland has appeared in the Jess Johnson commemorative volume, Geol. Soc. America Special Paper 321. Another paper on Late Devonian-Early Carboniferous conodonts from the south-eastern Khyber region of Pakistan and their chronologic implications appeared in Rivista Italiana in July. Other papers are in gestation on the diverse Early Carboniferous conodonts from the Ruxton Formation of the Clarke R. Basin of northern Queensland, the Murrindal Limestone (Emsian) of eastern Victoria, and on the overwhelmingly allochthonous carbonates of the Tolga "Calcarenite", Nubrigyn Fmn, Jesse Limestone and Cunningham Formation of the Dripstone-Euchareena area of central New South Wales. A manuscript is in preparation (in collaboration with Covadonga Brime, University of Oviedo) on patterns of illite crystallinity and conodont colour-alteration indices in relation to Ordovician-Early Carboniferous tectonic events in the Townsville hinterland (Broken River, Burdekin and Clarke River Basins) of north-eastern Queensland.

Radiometric dating for improving the mid-Palaeozoic time scale is progressing, partly by SHRIMP dating (Curtin University) but mainly by TIMS dating of zircons. The latter is being carried out in association with Greg Dunning (Memorial University, Newfoundland); Greg spent 2 months with Ruth and John earlier this year sampling chronologically constrained ashfalls in eastern Australia.

Other activities have been connected with IGCP 421 "North Gondwana mid-Palaeozoic bioevent\biogeography patterns in relation to crustal dynamics" (co-ordinators Raimund Feist and John Talent). These IGCP activities included two highly successful conferences: in Vienna (17-21 September) and Wollongong (8-11 December), the last in association with a well-attended conference on Palaeobiogeography of Australasian Faunas and Floras.

Glenn Brock has taken over the palaeontology slot vacated by retirement of G.C.O. Bischoff. He is polishing a monograph on silicified late Lochkovian-early Pragian brachiopods from Eurimbla in east-central New South Wales.

Chen Xiu-qin (Nanjing Institute of Geology and Palaeontology) is at Macquarie for a few months probing the biogeographic linkages of Australian Devonian brachiopod faunas.

John Farrell has resumed work on his dissertation on Lochkovian conodonts from The Gap in east-central New South Wales.

Theresa Winchester-Seeto has been attacking Lochkovian chitinozoan assemblages from bores in western New South Wales. She is extending her chitinozoan investigations down into pre-Devonian horizons.

Zerina Johanson has submitted an elegant PhD dissertation (much of it, commendably, already published) on fish from various Late Devonian sequences in New South Wales.

Eberhard SCHINDLER (Frankfurt)

Research continued on Upper Devonian strata in several areas of the Rheinisches Schiefergebirge (Germany). The Eifel area (trench near Büdesheim, Steinbruch Reichle near Loch, and the 'Büdesheimer Bach' drill hole) is investigated in cooperation with German and Belgian colleagues.

Work on the Sessacker Trench in the Dill Syncline is also in progress together with German researchers and with R. Feist (Montpellier). A publication about very detailed analyses (conodont biostratigraphy and sedimentology) across the Frasnian/Famennian (F/F) boundary is in press (see list below). For the first time in hemipelagic cephalopod limestone facies, the F/F boundary has been found not directly on top of the Upper Kellwasser (KW) Horizon. Very small-scaled sampling yielded a bed above the Upper KW Horizon, containing a Frasnian conodont fauna, without KW type dark rocks.

Concerning F/F problematics, there has been sampled a newly excavated section in the Kahlleite E section (Thüringisches Schiefergebirge) together with colleagues from Magdeburg, Halle, and Saalfeld.

During the SDS meeting in Rochester and the field-trips to the Devonian of New York State, there have been started new cooperations with Devonian workers from the U.S. on biostratigraphy, sedimentology, and tentaculites. Jeff Over (from SUNY, Geneseo) and Richard Lindemann (from Skidmore College, Saratoga Springs) shall be mentioned among others. Close cooperations have also been established with the magnetic susceptibility group from Arlington, Texas (Brooks Ellwood and Rex Crick) during the Rochester meeting. Joint work with them has since progressed in German and Moroccan sections.

Other activities can be incorporated in the new IGCP project 421 'North Gondwanan mid-Palaeozoic biodynamics' (leaders: John Talent and Raimund Feist):

The studies on the NE Albanian Palaeozoic have been continued (Selam Meço from the Polytechnic University of Tirana has been in Frankfurt for two months) and demonstrated at the initial meeting of the IGCP project in Wien.

New activities are part of the cooperation project between the Forschungsinstitut Senckenberg, Frankfurt and the University of Marrakech, Morocco which are also contributing to the IGCP project. Research here is concentrated on Lower Devonian sections in the western Anti-Atlas.

Contributions to the two working groups of the German SDS (subdivisions of the Emsian and Famennian stages) will continue.

Recent publications:

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Königshof, P.; Schindler, E. & Vogel, O. (1997): Albanien problem – Eine geologische Forschungsreise in den Nordosten Albaniens.– Natur und Museum, 127 (5): 157-161, 5 figs.; Frankfurt/M.

Schindler, E. & Königshof, P. (1997): Sedimentology and microfacies of Late Devonian Kellwasser Limestones in relation to palaeobathymetry (Upper Kellwasser Horizon, late Frasnian).– Zentralblatt Geol. Paläont. Teil I, 1996 (H.5/6): 597-607, 4 figs.; Stuttgart.

Jansen, U. & Schindler, E. (1997): Subdivision of the Emsian stage – state of discussion in the German Subcommission on Devonian Stratigraphy.– Subm. to the Subcomm. on Devonian Stratigr. (SDS), Rochester, July 1997: 2 pp.; Rochester.

Schindler, E., Königshof, P. & Meço, S. (1997): Cooperation programme in Mid-Palaeozoic to Early Mesozoic rocks of the NE Albanian Korabi Zone.– 1st Internat. Conf. on North Gondwanan Mid-Palaeozoic Biodynamics (IGCP Project 421), Vienna 17-21 Sept. 1997, Abstr.: 49; Vienna.

Schindler, E., Schülke, I. & Ziegler, W. (in press): Preliminary remarks on the Frasnian/Famennian boundary at the Sessacker Trench section near Oberscheld (Dill Syncline, Rheinisches Schiefergebirge, Germany).– Senckenbergiana lethaea, 77: xxx-xxx, 3 figs., 1 tab., 5 pls.; Frankfurt/M.

Susan TURNER (Brisbane)

Phoebodontiform and xenacanthiform shark teeth in USA and their significance for the Devonian Correlation Table (DK)

Discovery of Devonian-Carboniferous phoebodont and xenacanthiform teeth in Australia (e.g., Turner 1982, e.g., Turner et al. submitted) and consideration of the biostratigraphical potential of these sharks by Ginter and Ivanov (e.g., 1992, 1995a,b) has prompted re-appraisal of type material from the U.S.A

The type phoebodont, *Phoebodus sophiae*, which was described from the Cedar Valley Group of Iowa in the last century (St John and Worthen 1875) is now thought to be indicative of the mid *varcus* CZ. *Phoebodus sophiae* also occurs in the material from the North Evans Conodont Bed at the base of the Genesee Formation (considered to be a remanié deposit condensing Givetian-lower Frasnian *varcus/hermanni-cristatus* to lower *asymmetricus* Conodont zones) from New York State (Turner 1997 in press). While most phoebodont teeth are microscopic, larger teeth of this shark are found including a new record in the Milwaulkee Formation of Milwaulkee (Paul Mayer coll., Milwaulkee Public Museum). *P. sophiae* seems to appear worldwide in relation to the Taghanic onlap (IIa T-R cycle). It also occurs in Russia, the Holy Cross Mountains and several other places in Europe, and in Australia, all appearing in the same time interval. Ginter (1995) has produced a zonation based on the type and other phoebodont taxa which occur principally in shelf marine rocks. There is little sign of strong provincalism in this mid Devonian to Carboniferous group of sharks.

Another group of xenacanthiform sharks appear in significant numbers in Givetian times. Examination of USA Devonian "*Dittodus*" species described by Eastman in 1899 from a fissure filling in a quarry near Chicago, Illinois, indicates that "*Dittodus*" *priscus* and "*D.*" *striatus* teeth probably belong in the same dentition; these xenacanthiform teeth have been referred to a new genus, *Wellerodus* by Turner (Modern Geology 1997 in press). Weller (1899) had thought that this infill was Famennian in age as the shark teeth were associated with numerous ptyctodont toothplates (e.g. Kluessendorf et al. 1988) but they could probably more likely be of Givetian age)

Klussendorf et al (1988) give other examples of these "sink hole" faunas in the mid west. Further teeth called "*Dittodus priscus*" and "*D. striatus*" and spines referred to *Ctenacanthus wrighti* by Hussakof and Bryant (1918) came from the North Evans Limestone, from the older Upper Tully Formation (*varcus* zone), and the younger Rhinestreet Shale (*rhenana* zone). Turner (1997 in press) has transferred these to a new species, *Wellerodus wellsi*.

These teeth and spines are most similar to those of *Antarctilamna prisca* Young 1982, from the Aztec Siltstone of Antarctica and Bunga Beds of eastern Australia, presumed Givetian to early Frasnian in age, which Young presumed were preserved in non-marine deposits. However, as these xenacanthiform sharks were probably not restricted to fresh or even shallow water and it is possible that these taxa are synonymous; further material from New York State will need to be examined to enable further assessment.

Most of the other xenacanthiform teeth from the North Evans Conodont Bed were called "*Dittodus*" *grabaui* by Hussakof and Bryant (1918). Turner (1997 in press) has placed these within the genus *Omalodus* Ginter and Ivanov (1992) while some are comparable with *Phoebodus fastigatus* Ginter & Ivanov 1992. *Omalodus bryanti* (Wells 1944) was described from the (Givetian) Kiddville and East Liberty Bonebeds of Kentucky and Ohio. Teeth referred to *P.? bryanti* and i by Gross (1973, tab. 34, fig. 23 and tab 35, fig. 8 respectively) from the Cedar Valley Limestone of Iowa are also now placed in *Omalodus grabaui*. Wells (1944b, p. 140) perceptively thought that the teeth of his new taxon, *P.? bryanti*, were similar to very small teeth of "*D. grabaui*". Ginter and Ivanov (1992) transferred Wells' and Gross' *P.? bryanti* to their genus *Omalodus*. These other omalodontid teeth in the U.S.A. seem to differ from Hussakof and Bryant's material in only small details. New omalodont records include the Thiensville Formation of Milwaukee (J. Kuglitsch coll., Turner pers. obs. 1997), supporting a Givetian age for that unit, and the Prout Limestone of EC Ohio (Sparling & Turner in prep.).

Although omalodonts may occur earlier in the Devonian, the phoebodontiform and xenacanthiform sharks first appear in the USA across the midwestern basin in early Givetian times with maximum spread occurring with the transgression noted in the late Frasnian in New York State and Utah (Turner & Youngquist 1995). Ginter (1995) has documented the Frasnian-Famennian boundary collapse of these sharks with no known Famennian omalodonts and Lazarus phoebodont taxa in the early mid Famennian (also Ginter & Turner MS, 1997 submitted).

Turner (1997 in press) recommended that the name 'Dittodus' should be finally suppressed. Ginter (pers. comm.) is preparing a column reflecting the new data for the Devonian Correlation Table (DK).

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E.A. Yolkin (Novosibirsk)

During last year my team and myself continued to work on projects that are mentioned in the Newsletter #13, particularly:

1. The Silurian and Devonian event-stratigraphy and paleogeography of the West Siberia;
2. The subsurface Paleozoic stratigraphy of the Western Siberian Plane; 3. The Information-Research Complex "BIOCHRON".

I would also like to ask all colleagues to pay attention to the Kitab Research sections in discussions on substage subdivisions, possibly to the West Siberian ones. Here you could find new interesting data. During ten years work there are accumulated numerous collections. It is possible that they will soon be lost. Let's work together on belateral or multilateral basis. A financial support could be from different sources, particularly INTAS, INTAS-RFBR (Russian Foundation of Basic Researches) and so on.

Finally, sad news. Dr. Zheltonoghova Vera Artem'evna (rugose corals, Novokuznetsk) passed away at 30th December 1997.

NON-MEMBER REPORT

RECALIBRATING DEVONIAN TIME WITH NEW U-Pb ZIRCON AGES FROM EASTERN NORTH AMERICA

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Six new U-Pb zircon ages from the Appalachian Basin and adjacent areas of eastern North America have enabled a recalibration of the Devonian time scale. The age for the lowest of these samples (a K-bentonite in the Kalkberg Formation, Helderberg Group) was presented at the SDS meeting in Rochester by Ebert and Tucker (1997). This and the other new ages were presented at the annual meeting of the Geological Society of America in Salt Lake City (Tucker, et. al. 1997) and are summarized below (Table 1). Some dates differ slightly from those that appear in the Tucker, et. al. abstract as a result of later analyses.

TABLE 1: U-Pb Zircon Data From Eastern North America

Sample	Location	U-Pb Age	Lithostratigraphy	Stage and Biostratigraphy
Kalkberg K-bentonite	Cherry Valley, NY	417.6 +/- 1 Ma	Kalkberg Formation, Helderberg Group	Lochkovian *Icriodus woschmidti*
Sprout Brook K-bentonites	Cherry Valley, NY	408.3 +/-1.9 Ma	Esopus Formation, Tristates Group	Probable Emsian *Etymothyris (Polygnathus dehiscens or gronbergi to inversus)*
Tioga Bentonite	Wardville, PA and Wyethville, VA	391.4 +/- 1.8 Ma (See also Roden, et. al. 1990)	Onondaga Formation	Eifelian *Polygnathus costatus costatus*
Center Hill K-bentonite	Little War Gap, TN	380.8 +/- 1 Ma	Chattanooga Shale	Frasnian *Palmatolepis punctata to hassi*
Carrow Formation Tuff	New Brunswick	363.8 +/- 2.2 Ma	Pumiceous Tuff Member of Carrow Formation, Piskahegan Group	Famennian *pusillites-lepidophyta* spore zone or possibly *flexuosa-cornuta* spore zone (Fa2d to Fa2c) equivalent to *expansa* zone
Bailey Rock Rhyolite	New Brunswick	363.4 +/- 1.8 Ma	Bailey Rock Rhyolite, Piskahegan Group	Famennian *pusillites-lepidophyta* spore zone or possibly *flexuosa-cornuta* spore zone (Fa2d to Fa2c) equivalent to *expansa* zone

These new ages, in conjunction with published isotopic ages from the early and late Ludlovian, Eifelian and early Tournaisian, have been used by Tucker, et. al. (in review) to recalibrate the Devonian time scale. The revised Devonian Time Scale is summarized in Table 2.

TABLE 2: REVISED DEVONIAN TIME SCALE (after Tucker, et. al., in review)

STAGE	AGE OF LOWER BOUNDARY
Tournaisian (Devonian - Carboniferous boundary)	362 Ma
Famennian	376.5 Ma
Frasnian	382.5 Ma
Givetian	387.5 Ma
Eifelian	394 Ma
Emsian	409.5 Ma
Pragian	413.5 Ma
Lochkovian (Silurian - Devonian boundary)	418 Ma

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INFORMATION FOR CONTRIBUTORS

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