International Union of Geological Sciences
International Commission on Stratigraphy

International Subcommission on Stratigraphic Classification

ISSC

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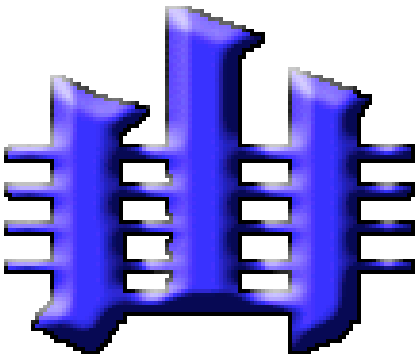

NEWSLETTER N. 11

(Circular n. 112)

June 2007

CONTENTS

1. EDITORIAL

Six months after the distribution of ISSC Newsletter n.10, I have to report on our activities that have been numerous, occasionally very difficult, demanding and requiring to live under permanent stress conditions.

The International Commission on Stratigraphy of IUGS has been accused of scarce democracy, and its entire membership (= chairs of the various Subcommissions) have been requested to vote on various topics. The first article of the March issue of the official IUGS journal EPISODES contains the current, updated version of the ad hoc Review Committee (Paris, November 2005) that you already know in its original version, since it has been reproduced in ISSC Newsletter n.9, almost one year ago. Since the International Stratigraphic Guide was a topic of major concern, I prepared a detailed reponse, here reproduced at pages 2 to 4.
To meet the IUGS requests, ICS had to change their voting procedures and nominating committee. Moreover, a decision that many consider too hasty has been taken by formal voting on the rank, duration and internal subdivision of the Quaternary. IUGS ratified only the vote concerning the rank of the Quaternary (Period/System), as in a letter from the Secretary General of IUGS (Bobrowski) to the Secretary General of ICS (Ogg) of May 29, 2007.

Our ambitious project on NEW DEVELOPMENTS IN STRATIGRAPHIC CLASSIFICATION is making substantial progress, as reported at pages 5 through 29. You are requested to read carefully and comment the preliminary outline on Lithostratigraphy. The outline on Chronostratigraphy distributed last January in a purposedly very tentative form in order to get a large number of responses is also reproduced, and all these responses. Since time is limited and we have no funds whatsoever to cover our expenses, be prepared to receive pdf of texts to comment, separated from Newsletters, that we cannot and will not produce more than twice a year.

MARIA BIANCA CITA
ISSC chair

2. DOCUMENT SUBMITTED TO IUGS

TO: IUGS President and Executive
RE: International Stratigraphic Guide

Among the five explicit recommendations (now, requirements) made by the IUGS ad Hoc Review Committee to the International Commission on Stratigraphy, two (n.1 and n.2) concerned the International Subcommission on Stratigraphic Classification, which I am honored to chair. I am here addressing these two points in detail, with the help of several documents attached.

PREAMBLE
The necessity to implement and update the International Stratigraphic Guide was clear since the years when Prof. Alberto Riccardi was chair of ISSC and I was vice-chair. If Stratigraphy could be considered a single discipline during the twenty year period required to compile, discuss, distribute and print the first edition of the Guide (Hedberg,1976), the developments of the last 20-30 years are so rapid and the advancements in a number of subdisciplines are so great that it is inconceivable that a single person can produce a book representing the official position of IUGS in terms of stratigraphic classification.
Moreover, the present statute and by laws are incompatible with such an approach. Indeed, my predecessor appointed two working group on Sequence Stratigraphy and Cyclostratigraphy, respectively, but neither succeeded in completing their mandates successfully.

So, when I took over in 2002, I face a difficult situation and tried a new approach. This started during the 32nd IGC in Florence, where Riccardi and I were conveners of the first workshop ever in the more than 50 year history of ISSC, entitled "Post-Hedberg developments in stratigraphic classification". There and then we started a new BOTTOM UP instead of TOP DOWN approach (see Enclosure 1).

INTERNATIONAL CONNECTIONS
Notwithstanding the substantial reduction in the number of voting members of ISSC, and the cancellation of the former distinction of individual, organizational and ex officio members requested by the new ICS statute (with the risk of being disbanded as a subcommission if we did not follow the rules), we have been able to keep our identity and strong international connections.
In order to cope with the new statute, we reduced the number of voting members, but we appointed twelve new members after proper nominations, and gave the qualification of LIAISON to members representing national or multinational stratigraphic commissions, committees and alike. Enclosure 2 is a list of such liaisons.

SUBDIVISION OF RESPONSIBILITIES AND STRUCTURE OF ISSC
From the end of 2004 to the end of 2006 we appointed seven Working Group and Task Groups as shown in Enclosure 3. The first two Task Groups to be appointed were on Sequence Stratigraphy and on Cyclostratigraphy, i.e. the same topics already treated under Riccardi, but with a different leader and a different mandate. Enclosure 4 (Strasser et al., now in press) is the final product of the Cyclostratigraphy TG. All three members are voting members of ISSC, and two are voting members of ICS. All are professors of Stratigraphy in their countries and are real authorities in their fields. My task, as scientific coordinator of the various review papers, has not always been so easy, since in several cases our membership did not include scientists of high stature in some new subdisciplines, as chemostratigraphy or paleomagnetic stratigraphy. In these cases, we looked outside the ISSC membership in order to get the best scientists available for our project.

PROCEDURES FOR THE REVISION.

The procedures we follow for the revision by ISSC members are indicated in Enclosure 1 to which reference is made. Two steps are foreseen: first a review of the outline submitted, then a second revision of the full text extended to various stratigraphic commissions. The system worked well for the outlines of Biostratigraphy and Chemostratigraphy, whereas the Sequence Stratigraphy outline did not receive many comments. It worked exceptionally well for the Chronostratigraphy outline, which purposedly was presented in a very tentative style. The thirty critical comments received, mostly highly positive, will contribute toward the success of the final product. Five case studies have been selected to document the variety of situations encountered in the definition of GSSPs, from the Ediacaran to the Hirnantian; from the Pliensbachian to the K/T boundary, and to the Miocene/Pliocene boundary. Chronostratigraphy is the most important part of Stratigraphic Classification, a kind of melting pot to which other subdsciplines are related. The Working Group was appointed during the Louvain ICS Workshop of September 2005 after balancing the various expertises and roles of the members, that include the ICS and ISSC vice-chairs, two experts in Paleozoic stratigraphy, two in Mesozoic stratigraphy, two in Cenozoic stratigraphy, six professors in Stratigraphy, all but one present or past chairs of national or regional stratigraphic commissions, including two past-chairs of the North American Commission on Stratigraphic Nomenclature, as suggested by IUGS. ISSC members took a significant part both in the organization and in the participation to the Penrose Conference on Chronostratigraphy held in Graz in June, 2006.

CHOICE OF THE SCIENTIFIC JOURNAL

The choice of the scientific journal where to submit the series of review articles on the various subdisciplines of Stratigraphy has been the subject of discussions and debates reported in various issues of ISSC Newsletters. Finally we decided for Newsletters on Stratigraphy, now distributed on line and ready to meet our requirement to accept our pre-reviewed articles. The first products are here attached (see Enclosures 1 and 4).

Now IUGS asks to review the drafts of the Guide. This is not yet THE GUIDE, but it already has been reviewed by national and/or regional Commissions/ Committees on Stratigraphy, as explained in Enclosure 1. When distributing the full text for revision, it has been strongly recommended to behave in a politically correct way, in order to preserve the intellectual property.

Near the end of 2006 we received an invitation to use the Geological Society of London special series sponsored by IUGS, but the personal contacts kindly provided by ICS vice-chair showed that this path could not be followed, because they considered only a full book, and a full book cannot be ready in a short time. We are looking for a substantial new approach, bottom-up, starting from the observations to the rules to the test of the rules to the applications, in order to be able to better understand the history of out planet, the basic, fundamental changes undergone, the events, the trends, the cycles controlled by extraterrestrial forcing.

THE PLAN OF WORK AND ITS BUDGET

Having said that, we have a plan and we are working very hard to reach a visible, scientifically significant result to be presented at the 33rd IGC in Oslo, next year. But we have no funding.

We are considering two possible scenarios

A BEST CASE SCENARIO, with all seven chapters of the future guide published in Newsletters on Stratigraphy, and a two days Workshop organized by ISSC, entitled “New Developments on Stratigraphic Classification” to present and discuss the achievements (see Enclosure 5 and special request).

A WORST CASE SCENARIO, with three or four contributions published as above, the remaining ones in press or in preparation, and no Workshop.
The second circular of the Congress was expected in January, 2006. At mid February I called Norway for news, because no information was available on the website. The answer was quite disappointing: no circular until March, no decision on Workshops.

Meanwhile, I was so disappointed by the presentation of the ISSC activities in the ICS Consolidated annual report for 2006, that I submitted a protest. The financial support received last year was only 300 dollars, plus 600 dollars for reimbursment of travel - quite inadequate for our ambitious project. Therefore, we submit to IUGS the REQUEST OF A SPECIAL ALLOCATION of 10,000 dollars for completing our program in the best and more efficient way, including meetings as appropriate, distribution of reprints or PDF.

FINAL REMARKS

I would like very much to know more about the three-step revision by ISSC as proposed by IUGS. Step a) corresponds to the publication of the various review articles (= chapters of the future guide, after adequate open-forum discussion in an international Congress).
Your suggested step b) has already been done before the publication. Step c) should follow after the 33rd IGC in Oslo 2008.
As far as the procedural provisions for future amendments, they should be very simple and short and definitely will not present an obstacle.

CONCLUSION

Stability is essential in Stratigraphic Classification. The times of different schools of thought and of the overwhelming influence exercised by the various treatises and text books written in different languages are over. The IUGS and ICS logos have always been and must be a guarantee for the validity of the agreed upon global Standard.
In the present chaotic situation of media panic for climate change, opinion makers, freelance adventures, aggressive attitude of competing publishing companies, the role of a fixed standard of reference is essential to guarantee stability.
We need clear explanations for the principles and their applications in stratigraphic matters.
We need to distinguish taxonomy, nomenclature, and classification.
We need to clarify what is global and what is regional or local.
We need to clarify the significance of chrono-correlation, with all the methods available, which necessarily differ from the origin of our planet to the present.

Maria Bianca Cita, ISSC chair

LIST OF ENCLOSURES

1. Galley proofs of the article by M.B. Cita “New Developments in Stratigraphic Classification. Presentation of a New Series”.
2. ISSC members that act as liaison with national or regional Stratigraphic Commissions/Committees.
3. Galley proofs of the article by Strasser, Hilgen and Haeckel “Cyclostratrigraphy: Concepts, Definitions, Applications”.
4. Compositions of the various ISSC Task Groups and Working Groups as of March 15, 2007.
5. Announcement of the proposed Work Shop to be organized by ISSC for the 33rd IGC in Oslo 2008.

3. NEW DEVELOPMENTS IN STRATIGRAPHIC CLASSIFICATION: A PROGRESS REPORT

3.1 Presentation of the project (M.B. Cita). In press on Newsletters on Stratigraphy 42-2, 2006. A .pdf file will be distributed to all ISSC members and mailing list as soon as available.

3.2 Cyclostratigraphy. Concepts, definitions, applications (A. Strasser, F. Hilgen, C. Haeckel). In press on Newsletters on Stratigraphy 42-2, 2006. A .pdf file will be mailed by the senior author to all ISSC members and mailing list as soon as available.

3.3 Lithostratigraphy - concepts and applications
Outline by B. Pratt (leader), S. Finney, W. Piller, M. Easton.

Introduction
History of naming rocks by local builders, masons, farmers, quarrymen, miners etc. (e.g. chalk, jet rock, Kupferschiefer etc.)
Modern era beginning with William Smith's map showing wide distribution of units characterized by rock type and fossil content; later early examples (e.g. Brongniart's Paris Basin etc.)
Extensive efforts in 19th and 20th century to map large areas required a stable stratigraphic nomenclature, adoption of older rock names, generation of new names using rock types (e.g. Burgess Shale), common fossils (e.g. Lingula Flags, Posidonienschiefer, Muschelkalk), geographic names (e.g. London Clay), facilitate communication
Standard practices and procedures established, formalized codes and guide, history of codes and guide

Standard Practice
Formation as basic subdivision of hierarchy, criterion of mappability; bed, flow, member, formation, group, supergroup, complex (e.g. Valhalla Formation, Xanadu Member, Shangri-la Group, Hades Supergroup); various quasi-formal and informal names in use (e.g. 'unit', 'assemblage'; 'complex', 'lower' Atlantis Formation; old designations, e.g. Weiß Jura; numerical or alphabetical designations, e.g. Dogger ζ); blending traditional with modern (e.g. Burgess Shale Formation), effect of political boundaries; abandoning of superfluous names
Type section; surface and subsurface; description and publication; proper nouns, spelling, historical practice conserved
Scale of thickness, lateral persistence; subjective, dictated by individual situation, rock types
Preference for more or less synchronous rock bodies; avoid including major unconformities (e.g. Nubian Sandstone)
Procedure to institute revisions of existing nomenclature

Complexities of real world: interfingering, facies changes, biostratigraphic uncertainties
The case-studies will include:

- an example from some of the oldest rocks on earth
- a simple "layer-cake" example
- one or more examples from tectonically complicated areas
- one or more examples on metamorphic and igneous situations
- one example on glacial sediments of the Quaternary

Discussion
Lithostratigraphic nomenclature has worked more or less successfully for two centuries.
Conducting biostratigraphy in a lithostratigraphic framework
Placing lithostratigraphy in chronostratigraphic framework
Comparison of lithostratigraphy against sequence stratigraphy

Conclusions
Lithostratigraphy is formalized, functional, mostly independent of biostratigraphy (except preferable to avoid unconformities within unit), original European/North American practices adopted globally, prior nomenclatures (e.g. USSR) being modified; independent of sequence stratigraphy but often duplicates it in part; mechanisms exist to refine existing schemes, often in conjunction with new maps, better sedimentological understanding etc.; now often conducted by government geological surveys as most areas have existing nomenclature; provides framework for more detailed studies aimed at higher resolution

Acknowledgements
References

LITHOSTRATIGRAPHY OUTLINE
ONE MONTH ON-LINE REVIEW PROCESS

ISSC members are urgently requested to send
by **end June 2007 TO MILANO**

COMMENTS…….

SUGGESTED ADDITIONS……..

SIGNATURE……..

DATE……..

3.4 Chemostratigraphy.
Task Group: H. Weissert (leader), M. Joachimski, M. Sarnthein

On March 3, 2007. Helmut Weissert sent to Milano a first preliminary draft that was discussed with the ISSC chair. The full text is almost ready, with three case studies presented. dealing with the Paleozoic (Joachimski), the Mesozoic (Weissert) and the Cenozoic (Sarnthein).
Text and figures will be distributed as soon as available, possibly in a couple of weeks, for the revision by ISSC members.
The task group has been suggested to add a fourth example dealing with the PETM (Paleocene/Eocene Thermal Maximum), a theme widely discussed in the recent literature, but this should not produce any significant delay.

3.5 Chronostratigraphy.

Chronostratigraphy Outline by M. B. CITA - January 9, 2007

A lively and intense brainstorming session was run from mid November to Decemeber 2006, rich in back-and forth communications among the seven members of the Working Group (J. Zalasiewicz, J. Thierry, B. Pratt , A. Embry, F. Hilgen, S. Finney and M.B. Cita).
The WG leader is responsisble for the tentative style of the draft with several question marks aimed at dissipating the "chronostratigraphic imperialism" syndrome, and stimulating comments.
The five case studies have been carefully selected in order to provide concrete examples of the application of the principles to a variety od situations.

Chronostratigraphy. Concepts, Definitions, Applications

Part one: Concepts, Definitions, Procedures

1) Time in Geology: evolution of the concept through the centuries
2) Chronostratigraphy versus Geochronology. Do we need a double nomenclature for time intervals with the same name and the same duration (numerical ages)?
3) Hierarchy of chronostratigraphic units

Eonothem	Eon
Erathem	Era
System	Period
Series	Epoch
Stage	Age

4) Stage, the basic unit (see Hilgen et al, 2006). Duration of stages.
Naming of stages.
5) Smaller units (Substages, Chronozones, Horizons, Marker beds, Datum planes)
6) Significance of Chronozones.

Part two: Case studies

1) EDIACARAN
2) HIRNANTIAN
3) PLIENSBACHIAN
4) K/T boundary
5) Miocene/Pliocene boundary and Zanclean GSSP

Part three: Discussion

1) Stability in stratigraphic nomenclature. Keep old names well rooted in the literature?
   Or create new ones?
   Priority
   Tradition
   Precision

2) Discussion of the case studies illustrated
3) Obvious advantages of an integrated stratigraphy approach
Limitations of the new methods for the older part of the Stratigraphic column.
4) How chronostratigraphy works for the first 5/6 of Earth history.
Percentage of magmatic/metamorphic/sedimentary rocks IN THE CRUST and IN OUTCROP
5) Correlation precedes definition or definition precedes correlation?
6) Global stages versus regional stages

Conclusions

1) The approachs, the methods are not the same, CANNOT BE THE SAME in the pre-fossiliferous times and during the explosive evolution of fossil groups as Graptolites, Ammonites, planktonic foraminifera.

2) Events, especially if rapid and geologically "instantaneous", are of paramount importance for defining major subdivisions, but it is considered inappropriate to create new names.

3) High resolution stratigraphy is more and more popular and successful and may lead to obscure classical stratigraphy.

4) To maintain stability in nomenclature it is imperative NOT TO CHANGE THE STANDARD.

It is suggested not to formalize the chronostratigraphic units beyond??..???

COMMENTS RECEIVED BY:
Heckel - January 10, 2007
Strasser - January 11, 2007
Steininger - January 13, 2007
Waterhouse - January 15, 2007
Reguant - January 15, 2007
Walsh - January 15, 2007
Winter -January 17, 2007
Carter -January 21, 2007 plus attachment Carter-Graz.rtf
Bleeker - January 22, 2007 plus attachment Lethaia-Bleeker.pdf
Takayanagi - January 23, 2007
Salvador - January 24, 2007
Gladenkov - January 25, 2007 and February 6 plus attachment Y.Gladenkov.doc
Holland - January 25, 2007
Ogg - January 31, 2007 and February 2 plus stage_name_evolution.xls
Chang - February 2, 2007
Grigelis - February 5, 2007
Cooper - February 2, 2007
Henderson -February 6, 2007
Riccardi - February 9, 2007
Morton - February 9, 2007
Edwards - February 9, 2007
Csaszar -February 10, 2007
Brakel - February 10, 2007
Piller - February 10, 2007
Odin - February 10, 2007
Berggren - February 11, 2007 plus folder with 7 files Berggren Aubry submitted
Gianolla - February 12, 2007

From: Phil Heckel philip-heckel@uiowa.edu
Date: January 10, 2007
Regarding Part three, item 5, concerning timing of correlation and definition, I believe that Remane et al. (1996) on the revised guidelines for boundary selection, stated that correlation must precede boundary definition, and I can think of no reason to reverse that procedure.

From: **André Strasser** andreas.strasser@unifr.ch
Date: January 11, 2007

I have looked through the outline of the Chronostratigraphy chapter and find it generally good. Just two remarks:
Part 1, 4): There should be a definition of the GSSPs and what the requirements are. Even if this is given in other publications, it would be important to have it here as a reminder.
Conclusions 3): High-resolution stratigraphy definitely needs "classical stratigraphy". Only within a well-defined frame (bio, chrono) can the high-resolution work be done. If there are no guidelines (even rough ones), the high time resolution cannot be constrained and stays speculative. Example: floating astronomical time scales, which need at least two chrono tie points to confirm that hierarchical stacking is indeed orbitally controlled.

From: **Fritz Steininger** Fritz.Steininger@senckenberg.de
Date: January 13, 2007
Comments are in bold

Part one: Concepts, Definitions, Procedures

1) Time in Geology: evolution of the concept through the centuries
2) Chronostratigraphy versus Geochronology. Do we need a double nomenclature for time intervals with the same name and the same duration (numerical ages)? **YES, definitly**
3) Hierarchy of chronostratigraphic units

Eonothem	Eon
Erathem	Era
System	Period
Series	Epoch
Stage	Age

4) Stage, the basic unit (see Hilgen et al, 2006). **FOR REGIONAL CHRONOSTRATIGRAPHIC UNITES**
Duration of stages **2 to 4 MILL.Y.**
Naming of stages **AFTER REGIONAL FEATURES**
5) Smaller units (Substages, Horizons, Marker beds, Datum planes) **SHOULD BE DEFINED PROPERLY; ESPECIALLY HORIZONS AND DATUM PLANES – QUESTION IS DO THEY ALL BELONG PROPERLY INTO CHRONOSTRATIGRAPHY**
6) Significance of Chronozones **BELONG TO BIOSTRATIGRAPHY.**

Part two: Case studies

1) EDIACARAN
2) HIRNANTIAN
3) PLIENSBACHIAN
4) K/T boundary
5) Miocene/Pliocene boundary and Zanclean GSSP

Part three: Discussion

1) Stability in stratigraphic nomenclature. Keep old names well rooted in the literature?
Or create new ones?
Priority
Tradition
TRADITION AND PRIORITY ARE IMPORTANT FOR THE STABILITY
Precision
2) Discussion of the case studies illustrated
3) Obvious advantages of an integrated stratigraphy approach **HAS NOTHING TO DO WITH CHRONOSTRATIGRAPHY OR GEOCHRONOLOGY** - integrated stratigraphy is an integration of correlation methods
Limitations of the new methods for the older part of the Stratigraphic column – **WHAT LIMITATIONS DO YOU MEAN – CHRONOSTRATIGRAPHIC UNITS ARE DEFINED AT A CERTAIN POINT IN THE ROCK COLUMN – LIMITATIONS OF NEW METHODS CONCERN THE APPLICATION OF DIFFERENT CORRELATION METHODS.**
4) How chronostratigraphy works for the first 5/6 of Earth **history – IF THE UNITS ARE PROPERLY DEFINED – AS STATED ABOVE: AS A POINT IN A ROCK COLUMN – CHRONOSTRATIGRAPHY WORKS PERFECT – THERE MIGHT BE PROBLEMS WITH CORRELATION, HOWEVER THIS HAS NOTHING TO DO WITH CHRONOSTRATIGRAPHY PER SE.**
Percentage of magmatic/metamorphic/sedimentary rocks IN THE CRUST and IN OUTCROP
5) Correlation precedes definition or definition precedes correlation –

no question if defining a chronostratigraphic unit it is most important to fix that point in the rock column in a way that this point can be "exported" by various methods of correlation – can be correlated, however if a point for a chronostratigraphic unit is fixed and e.g. the bug, which is thought to be a good tool for correlation turns up on the other side of the point, so what, the point stays fixed and that is the reason why we can hope for stability in chronostratigraphy and why chronostratigraphy has nothing in common with Geochronology but the names of the units!

6) Global stages versus regional stages

IN MY OPINION – SEE ALSO ABOVE – STAGES EXPRESS THE REGIONAL DYNAMICS OF A SPECIFIC PART OF THE PLANET.

THEREFORE IT IS IMPOSSIBLE TO DEFINE GLOBAL STAGES – E.G. AQUITANIAN, BURDIGALIAN, MESSINIAN ETC. – WHAT MEANING DO THEY HAVE E.G. IN NEW ZEALAND, IN CALIFORNIA.

THEREFORE I WOULD PROPOSE: HAVE REGIONAL STAGES AND FOR GLOBAL CHRONOSTRATIGRAPHIC UNITS DEFINE PROPER **SERIES**

Conclusions

1) The approachs, the methods are not the same, CANNOT BE THE SAME in the pre-fossiliferous times and during the explosive evolution of fossil groups as Graptolites, Ammonites, planktonic foraminifera.

QUESTION: WHY – IF YOU DEFINE A POINT IN A ROCK SEQUENCE AS THE GSSP OF A CHRONOSTRATIGRAPHIC UNIT YOU ONLY HAVE TO CONSIDER HOW YOU GO AHEAD AND EXPORT – CORRELATE THIS POINT BY ONE OR THE OTHER CORRELATION METHOD – THERE IS NO CONNECTION WHAT SO EVER IF YOU ARE IN THE PRE-FOSSILIFEROUS TIMES OR AFTERWARDS – THERE ARE, AS WE ALL KNOW, CORRELATION METHODS WHICH ARE NOT DEPENDENT ON FOSSILS AND WHICH CAN BE USED THROUGOUT THE ENTIRE ROCK RECORD OF OUR PLANET

2) Events, especially if rapid and geologically "instantaneous", are of paramount importance for defining major subdivisions, but it is considered inappropriate to create new names. **AGREE**

3) High resolution stratigraphy is more and more popular and successful and may lead to obscure Classical stratigraphy. **NO – ALSO FOR THE SOCALLED HIGH RESOLUTION STRATIGRAPHY YOU NEED A REFERENCE SCALE – THE CHRONOSTRATIGRAPHIC TIME SCALE!!!!**

4) To maintain stability in nomenclature it is imperative NOT TO CHANGE THE STANDARD. **AGREE**

It is suggested not to formalize the chronostratigraphic units beyond??..???

WOULD SAY NOT BEYOND THE STAGE LEVEL

HOWEVER IT WOULD BE INTERESTING FOR EVERYBODY TO HAVE A GUARDLINE FOR DEFINING AND THE USAGE OF SUBSTAGES, HORIZONS ETC.

From: **Bruce Waterhouse** perma@xnet.co.nz

Date: January 15, 2007

Thank you for the Chronostratigraphy outline. I make some suggestions.

Part 1. 2. I have no strong feelings as to whether we need a double hierachy. Some of the names - Eonothem, Erathem are not in common usage now: period and system seem to be used interchangeably - carelessly prehaps, and epoch and age seem less used than series and stage. Purists may not like what is done, but whther they need support or dismissal is the question.

Part 2. I would like to see a Late Paleozoic stage, or the P/T boundary brought in as a way of engaging the Asian fraternity. The others look fine.

Part 3. 1. Excellent to have this properly discussed. Hedberg of course insisted on change of name for change of usage, and unfortunately this dictum has often been ignored - perhaps irreparably. Then you get into the questions of availability of substitute names - a severe problem though you dont seem to believe it, and the question of acceptability.

Part 3.5. I suppose definition preceeds, because otherwise you cant communicate what is being correlated. But in fact the two often go hand in hand.

Conclusions.

Approaches

2. Some events define boundaries and so naturally get a name, that need not be new.

3. Tend instead of lead. Maybe true, but classical stratigraphy has changed so much in the last few years, even though it retains the name. I as a stratigrapher and correlator am a little uneasy at any claim that new techniques are in conflict with "classical stratigraphy", because as a rule the new can easily be absorbed and used, and "old" is open to modification, and even overturning.

4. For that reason, dont we need to avoid absolute absolutes? NOT to Change - Yes, UNLESS>>>>>>

(5) formalize units world wide beyond substages and perhaps events or some of them.

locally, marker beds, datum planes, horizons, other events seem feasible.

From: Salvador Reguant sreguant@ub.edu
Date: January 15, 2007
In general, the text of the "Chronostratigraphic outline. january 9, 2007) is acceptable in my opinion.
1. I think that is essential to maintain clearly the distinction between Chronostratigraphy and Geochronology.
2. The hierarchy accepted is good and useful for me.
3. On the first 5/6 of Earth History is necessary to progress in its knowledge. I have presented as inaugural dissertation in "Real Academia de Ciencias y Artes de Barcelona" a detailed text on this subject (I am sorry, but is in catalan).
4. I prefer the use of global stages, preceded by the knowledge and identification the relationship of regional stages with them .
5. It is useful to try to maintain stability in stratigraphy.
I remember the long time ago I have encountered you some days in a Geological Congress.

From: Steve Walsh slwalsh@sdnhm.org
Date: January 15, 2007
Thanks for sending me the chronostratigraphy outline. At this point there's not much specific to comment on, but here are a few suggestions. 1. Somewhere in the Concepts, Definitions, and Applications section, the definition of "chronostratigraphic unit" should say that such units are spatiotemporally restricted classes, and are defined in terms of a span of time (geochronologic unit). 2. Yes, we still need the dual nomenclature. 3. In the previous Guides, the ranks of period/system, epoch/series, formation/member, etc. were referred to as "unit terms" (Salvador, 1994, pp. 10; 21). However, the word "unit" is used for many other concepts in the Guide. So, why not refer to period/system, epoch/series, group/formation/member, etc., as "rank terms"? That is what they are. "Rank term" is much more self-defining than "unit term." 4. A decision on whether or not chronostratigraphic units include unstratified crystalline rocks (e.g., granite) should be made. For example, the Woodson Mountain Granodiorite crystallized during the Cretaceous Period, but does the Woodson Mountain Granodiorite belong to the Cretaceous System? I would say no, and would restrict chronostratigraphic units only to stratified rocks. 5. I disagree that the stage is the basic unit in any foundational sense. This is certainly untrue for the Precambrian and is often untrue for the Phanerozoic. However, it could be said that for the Phanerozoic, the age/stage is the smallest ranked geochronologic/chronostratigraphic unit for which Simpson's Rule must be obeyed. This means that every moment of Phanerozoic time must be assigned to one named Age. The statement in Salvador (1994:78) that "Furthermore, it is the smallest unit in the standard chronostratigraphic hierarchy that can be recognized at a global scale" should be modified by putting the word "usually" or "generally" between "is" and "the". 6. Correlation must precede definition in the vast majority of cases. The only exception would be in those cases where, for a given GSSP, there is a consensus among the members of a given boundary working group to place a golden spike at a historically-recognized boundary, in which case preservation of that historical boundary would outweigh the selection of a new, somewhat different boundary level that might be more correlatable. The Paleocene/Eocene and Miocene/Pliocene boundaries are examples of this situation, where two different solutions were adopted. Most historical boundaries are unconformities, however, so in my view it is generally inappropriate to maintain them as formal geochronologic/chronostratigraphic boundaries. 7. I see no need to establish "LSSPs" for regional stages, which are defined on a variety of criteria, are expected to evolve in meaning over time as new evidence accumulates, and so do not require permanent or even quasi-permanent definitions using golden spikes. Please keep me posted on further developments.

From: Henk Winter winterh@xconnect.co.za
Date: January 17, 2007
I attach (see below) my response to the Chronostratigraphic outline today, Tuesday 16th January, 2007, hoping that my comments be given due attention before the final report is tendered.
I object to the statement that no reply equals agreement. It should mean disagreement, to be conservative, or be viewed as geopolitical by geologists not concerned with this review. I noted that several names on the 'send to' list do not respond and may be thought to agree, but ought to be struck off the list. They could be located by hitting "Reply all". In particular L. Robb, Chair of ISPS resigned at the Rio de Janeiro ISC, thus leaving a gap recently filled by Wouter Bleeker on the list, WBBleeker@NRCCan.gc.ca representing the non-biostratigraphic early majority of stratigraphic opportunity mentioned in my comments as an essential addition. This gap threatened to ruin my career, and perhaps that of numerous other practising geologists dependant on resource evaluation for their lifestyle.
Not being in the position to sign my name at present, I am sure that my credentials are still valid.
My regards to the the other members of the working Group,

COMMENTS ON CHRONOSTRATIGRAPHY OUTLINE
By Henk Winter, Independent ISSC Member, South Africa

PREAMBLE
My comments are based on numerous contributions to ISSC since becoming an Independent Member in 1994 because of divergence from the official Code of the South African Committee of Stratigraphy (SACS, 1994). I published several articles in the South African Journal of Geology in defence of the concept that unconformity-bounded orders of sequence stratigraphy equated to the chronostratigraphic hierarchy, with the rank of System the equivalent of Archean and Proterozoic depositional basins. Coastal and offshore Jurassic to Cenozoic basins of South Africa are also controlled by local dominant subsidence, with uplifted continental provenances, and with identical natural orders of nested sequence chronostratigraphy.

CONCEPTS, DEFINITIONS, PROCEDURES

Time In Geology
Concept of Chronostratigraphy well established from turn of 20th century, modelled by Wheeler (1964), equates to Unconformity-Bounded Sequences, and later called Sequence Stratigraphy by consensus. Remane et al. (1996) erred by renaming the Standard Global Time Scale, defined by the GSSP procedure, globally as chronostratigraphic. Hedberg (1976) correctly indicated that time is not a stratigraphic unit (Ann A, ISSC Circ 98), also that Precambrian basins may be analysed not only by superposition (= sequence), but also by isotopic age dating. The concept of several chelogenic or plate tectonic cycles developed rapidly thanks to Wheeler modelling and Sloss applications until the 2nd Guide (p. 13), when inadequate and some faulty new definitions were added.

Geochronology
Since time is not stratigraphic, the time equivalent of chronostratigraphy, which is the equivalent duration term (not name, please) called geochronology, remains valid. To add injury, geoscientists involved with isotopic age dating grandly began to call themselves Geochronologists and their results Geochronology (the ultimate objective attained) instead of the correct term defining the results of their technological procedures: Geochronometry.

Stage
Stage may be the basic unit for the GSSP procedure to create enough data points for statistical analysis to determine when the establishment of a new time scale is no longer worth the effort. Naming of stages in other parts of the world on other plates may find a close to true beginning age for the basin on that plate, but does that guarantee that the original European basin, from which the age of initiation is unavailable, would be exactly the same? I doubt it. The GSSP there would require correlation before defining the stratotype, and only then. Eventually, geostatisticians will call a halt to waste of effort.

Smaller Units
Important for local basin analysis, purpose to establish needed resources, but why bother ISC/ISSC with this?

CASE STUDIES Apparently this is a good sampling. Let us first see them performing.

DISCUSSIONS AND CONCLUSIONS
For stability in stratigraphic nomenclature, keep old names well rooted in literature. Take special care in defining new terms and test until consensus reached. Weak definitions retard progress in stratigraphic science, may be fatal to aspirations. The older part of the Stratigraphic column has equal right for inclusion, and its neglect is unforgiveable. Each term in the Global Geochronological Time Scale hierarchy may have to depend on specialised procedures before successful application. Stratigraphy of any part of the older Stratigraphic column can be successful if a sufficient amount of the geohistory was preserved and available in terms of altered strata, whether in subsurface filling of magma chambers, thermal, metamorphic or tectonic terranes. However, if the stratigraphic data gleaned is too limited, by all means initially map the affected region lithostratigraphically as magmatic, metamorphic or tectonic complexes. Both global GSSP-derived stages and regional stages can and have been mapped thus and then converted chronostratigraphically to geographically limited depositional volcano-sedimentary basins.

In conclusion, the biostratigraphers by far outnumber other stratigraphers on the ICS/ISSC list, so that voting by the Members listed herewith will not lead to progress in geological sciences. I see no change in the proposed actions since Chair Cita's campaign prior to election. I cannot support the sketched outline, until such terms as 'integrated stratigraphy approach', 'the new methods' and 'classical stratigraphy' are properly defined for all readers to respond adequately. I cannot appreciate why rapid (global?) events be considered essential for local Chronostratigraphic nomenclature, the Standard Time Scale being Geochronologic of nature, to tie to a classification limited and bounded by specific dates, a sequence of durations. The basis of the Chronostratigraphic unit hierarchy is the natural nested

layering framework scientifically recorded (not merely described) within local basins, and is not to be subjected to such human interference constraints as formalisation (ISSC Circ 100, App.B).

From: **Bob Carter** bob.carter@jcu.edu.au
Date: January 21, 2007

I only comment on those points where I have some substantive comment to make. I am in broad agreement with all the other points.

A. Chronostratigraphy versus Geochronology. Do we need a double nomenclature for time intervals with the same name and the same duration (numerical ages)?

No. The double hierarchy is redundant, very confusing, and widely misused by even experienced professional stratigraphers.

I would prefer to see the Chronologic hierarchy maintained, but would consider compromises such as substituting Stage for Age in that hierarchy (in recognitiono of the widespread recognition of the term, and its use almost invariably in an "age" sense).

B. Stability in stratigraphic nomenclature. Keep old names well rooted in the literature? Or create new ones?

I am in favour of a strong priority principle.

And also a laissez-faire attitude towards older units that remain in widespread use (such as Tertiary and Quaternary). Such terms should NOT be legislated out of existence, but left intact (alongside any new terms that may have been judged necessary and which partly or wholly cover the same period of time) for use as individuals prefer.

C. Correlation precedes definition or definition precedes correlation?

It is fundamental that definition precedes correlation.

D. Global stages versus regional stages

Regional stages should be renamed as Oppelzones, which is what they are. This will necessitate the reintroduction of the term Oppelzone into the Guide.

Those comments that may seem outlandish are discussed in more detail in the attached ms, which is being considered by referees for publication in the Schloss Seggau special issue of "Stratigraphy".

From: **Wouter Bleeker** WBleeker@NRCan.gc.ca
Date: January 22, 2007

As it currently stands (see chapters in GTS2004 book), and read my paper (attached).

The Proterozoic Eon (542-2500 Ma) is divided in three eras: Paleo-,Meso-, and Neoproterozoic with boundaries pegged at somewhat arbitrary round ages. These names are formal and accepted.The Archean (2500 Ma and older...no lower limit defined) is proposed to be subdivided into four eras: Eo-, Paleo-, Meso-, and Neoarchean. Again with boundaries pegged at selected rounded ages ("GSA's" ...Global Stratigraphic Age). This is only a proposal and has not been formalized. Usage in the community is very mixed. See my paper that explains some of the background.

I, and a fair number of like-minded scientist working on Precambrian rocks, would like to change this, get rid of the GSA concept and go to a modified GSSP concept, using the most significant stratigraphic "event" or change in best-preserved type sections around the world to peg boundaries to real rocks, i.e. selected marker layers which can be dated precisely. Then use these determined ages (and or the attributes of the selected event) for global correlation.

As there are few "ideal" instantaneous event markers that are global, in practise it will mean that we would correlate mostly on ages, as we do now, but that the boundaries would be more meaningfull in terms of Earth evolution and historical geology. Now they are not, which in my view is a heresy.

However, there are many out there that prefer just simple "pidgeon holes" with round numbers that are easy to remember, never mind that they don't mean much. They apparently don't care that this is kind of dissappointing ...e.g. for students. We really do have a remarkable record in the Precambrian with all kinds of "events" that DO jump out and grossly define era-scale intervals in the irreversible evolution of planet Earth: meteorites, then few rocks at all (the Hadean), the first supracrustal (my start of the Archean proper), the first true continental regional quartzite units (extensive exposed continents!), giant BIFs in extensive platformal successions (my onset of the Proterozoic), the first true red beds, etc.

It will be tricky to find ideal marker beds. The main requirement is that they occur in the best global section of that age and can be dated.

The only downside is really that instead of round numbers we have non-round numbers for boundaries, BUT now correlated with some of the main features in the Precambrian record.

It's a no-brainer to me, but there are many people stuck on the old concept, EVEN if that is not used systematically. (In my view, it's a mess out there, but to change this around will take time!)

On your point 6) Well...yes an no. We know enough about the global record to pick these main events that we want to highlight...to some extent this is crude global correlation, but not in detail. So, once we pick the best preserved section, let's say the Hamersley Basin in northwestern Australia for the new Archean-Proterozoic boundary, we'll
select a stratum at the base of giant BIFs in this section (considered a Proterozoic feature) and date this horizon. In most cases, it will be the date that is correlated around the world. So, in that sense, it is
definition that preceeds (detailed) correlation.
We should always be open to finding "better events" that do have the potential for global correlation but in their absence we'll peg boundaries to the most meaningfull parts of the stratigraphy in the
preserved (!) record.
So, it is similar to the GSSP concept, but will have to be relaxed more and more once we get into the older record. (Again see my paper and GTS2004). Note that my chapter in GTS2004 was a "proposal"....The formal state of affairs is what I have explained at the beginning of this email.

From: Yokichi Takayanagi ytaka@cat-v.ne.jp
Date: January 23, 2007
COMMENTS
It is highly agreeable not to change the standard for maintenance of stability of nomenclature, including chronostratigraphy and geochronology.

From: **Amos Salvador** amos.salvador@mail.utexas.edu
Date: January 24, 2007
Until a more detailed outline is produced, I will limit myself to answer the four questions raised in the outline of the proposed paper on chronostratigraphy.

1.Do we need a separate (double) nomenclature for chronostratigraphic and geochronologic units ? Absolutely !!! To have the same nomenclature (terminology) for units based on time and those based on the physical characters of rocks would be absurd.

2.Should old names well-rooted in the literature be kept ? Yes. The Guide under the section on "Preservation of traditional and well-established names" (Chapter 3, B3g, p.22-23) states that such names should be retained but only after being carefully defined in detail.Tolerance and flexibility are advised.

3.Should correlation precede definition or definition should precede correlation ? It depends. In the selection of the GSSPs of chronostratigraphic units that are hopefully to be of worldwide recognition,correlation should precede definition. Correlation should also precede definition in the case of all units of lesser geographic extent. But it is possible that during the early study of a new area, useful mappable units (lithostratigraphic units) may be defined before their geographic extent has been established. Each case should be considered under the circumstances. Again, flexibility is advised.

4. I do not understand the last question : " It is suggested not to formalize the chronostratigraphic units beyond ...?

From: **Yuri B. Gladenkov** gladenkov@ginras.ru
Date: January 25, 2007
Thank you for your letter from January 9, 2007 (Chronostratigraphy).
I agree with ideas of your project. As my contribution I am sending (attachement) you a draft of my article prepared to submit for publication - possibly in the Seggau Volume on Stratigraphy, the special issue in the Micropress. It considers, in particular, some problems of chronostratigraphy. You may use either the whole article or some fragments as you think necessary.

If you need my formal opinion, I may send it as well.

From: **Holland** (comments revceived by post)
Date: January 25, 2007
Part 1, point 3. Dinosaurs lived in the Jurassic Period, not in the Jurassic System. Rocks belong to the Jurassic System
Point 6. Stages
Part 2. No comments
Part 3, point 1. Yes (stability)
Point 6. Regional stages may be changed
Conclusion
Point 1. Agree
Point 2. No
Point 3. No
Point 4. Agree

From: **Jim Ogg** jogg@purdue.edu
Subject: Stage names
Date: January 31, 2007

Quoting Maria Bianca Cita <maria.cita@unimi.it>:

Jim,

Other questions I ask you to answer:

1- how many new names for stages have been accepted in the last ten years? Or since you are the secretary general?

Dear Maria,

Technically, the only international stages are those that have been defined by GSSPs at their base and ratified by the IUGS.

Therefore, it is difficult to say which names are "new". Many of the ratified stages were named according to traditional European, North American, Australian or Chinese stages that had approximate time-spans. I think that the only truly "new" names that underwent a separate round of voting were three of the Ordovician international stages (Floian, Sandbian, and Katian). I think that the Drumian of the Cambrian is a "new" name that did not formally exist in the North American scheme -- this will be submitted to ICS shortly.

Most of the other names, such as Hirnantian and Paibian, seems to have been used (but not always as stage-level units) in at least one widely-used regional scale.

For your amusement, I attach a comparison of the "standard chronostratigraphy" of 1894 from the "first" equivalent of ICS, and the current standard (assuming that the subcommissions will continue to use the stage names as in their recent Annual reports). I tried to show a rough equivalence in apparent ages.

We hope that some stability will finally be achieved from GSSP-defined units that have demonstrated global correlation potential.

2- (if possible) Is the subdivision of the Precambrian in system/ period Ediacarian, Cryogenian, Tonian, Stenian, Ectasian, Calymmian, Statherian, Orosirian, Rhyacian and Siderian followed worldwide or not?

It is followed in North America?

in a) scientific publications?

b) geological maps?

c) textbooks?

Only the Ediacaran and Cryogenian have widespread usage in publications.

The GSA and other scales show the other Precambrian units, as do many textbooks (at least the ones that I have used in my stratigraphy classes). The names are poetic to refer to major changes in Earth's history, but the rigorous requirement that the absolute age fit into the slot has probably discouraged many potential users. This was one reason that ICS re-established a Precambrian subcommission -- to make a suite that will be utilized by the Precambrian workers, and can utilize chrono-stratigraphic definitions, rather than numerical age pigeon-holes.

From: **Jim Ogg** jogg@purdue.edu
Subject: Re: Chronostratigraphy outline-URGENT
Date: February 2, 2007

Dear Maria,

That is a very ambitious outline, and it will be fascinating to see how the project progresses.

I only have a few suggestions:

(1) The GSSP concept (and IUGS ratification) for defining international units of geologic time should be summarized as Item #2, before the discussion on double-nomenclature.

(2) Geochronology, as has been frequently stressed by Geochronologists, concerns the science of acquiring numerical ages (radiometric, cycles, etc.); and it is very confusing to talk about a "geochronologic unit". This perceived flaw in nomenclature in the stratigraphic guide should be included in that discussion.

(3) Similarly, the geochronologists and many other workers (e.g., Harland et al.) have objected to the confusing term "Age" as a counterpart for Stage. It is rare for authors to use "Age" in that context.

(4) I thought that "Chronozones" (as listed after Substages) in a chronostratigraphic-sense were removed from the later edition of the stratigraphic guide. Or, do you mean Chronozones as are commonly used by Paleomag workers? This term is also confusing, because different groups use it in different ways.

(5) The review must avoid being "Euro-Centric" in its discussion of "stability in stratigraphic nomenclature". As I relayed to you in the table earlier this week, "stability" is certainly not present if we compare to the first compilation of geologic units for the Geologic Congresses in 1894. It seems that only about 30% of those stage names are in the current scale; and nearly all of these have a revised definition! Perhaps Stan Finney should be involved in writing of this section to emphasize that most "historic stages" have proved to be not useful in a global context.

(6) The "stage" is not the "basic unit" for 85% of geologic time. There are no defined stages for pre-Cambrian; and

even the lower Cambrian has no agreement on international stage divisions at present. For those intervals, the "Era" and sometimes "Period" seems to be the basic unit. And, for Holocene-Pleistocene, the term "stage" has many precise meanings for different groups, so is not easy to utilize in the same fashion. I do not think that the Holocene will ever have international stages.
(7) The "Conclusion" that "it is considered inappropriate to create new names" is your own, not that of the Cambrian, Ordovician, etc. subcommissions and their workers. We should let the active workers in each interval decide on the best global units that fit their needs. Even the Silurian scale seemed to have involved the creation of a full set of new names (none were in the 1894 version of Silurian, and were named after the location of the new GSSPs). However, once a unit has undergone formal definition by a GSSP and has been ratified by the IUGS, then it's given name should be retained for stability. Although, there is now the problem with the Precambrian -- that set of age-defined periods was ratified, so is it proper to replace this set of periods because they did not become useful?
(8) What do you mean by "High resolution stratigraphy .. may lead to obscure classical stratigraphy"? What is meant by "classical"?
This will be a fascinating article to spark debate among all types of stratigraphers. Please write it so that a general geoscience audience can appreciate it.
Sincerely,
Jim Ogg (as a Mesozoic worker, not as ICS secretary)

From: K.H. Chang khchang@knu.ac.kr
Date: February 2, 2007
COMMENTS:
Part one, 2) A double nomenclature is needed as is logical and already a tradition. Time is abstract while chronostrastigraphic unit is material. So, they differ entirely though mutually refered parallelly. 6) A chronozone is a time-significant stratigraphic zone.
Part three 1) Stability(tradition) and rationality(scientific precision) should be well balanced depending on cases. 4) To do the best with an integrated chronostratigraphic approach for the older part of the earth history. There seems to be no other choice. 5) Your question is rather obscure. I guess both ways work depending upon cases. 6) Both are useful. Conclusions 3) What do you mean by 'may lead to obscure classical stratigraphy'? 4) Plausible! But, your last sentence is enigmatic. From now on, please make your questions more clear. But, I would praise you efforts for the science.

From: Algimantas Grigelis grigelis@geo.lt
Date: February 5, 2007
COMMENTS ARE IN BOLD
CHRONOSTRATIGRAPHY OUTLINE
January 9, 2007
Chronostratigraphy. Concepts, Definitions, Applications
Part one: Concepts, Definitions, Procedures
1) Time in Geology: evolution of the concept through the centuries
NECESSARY, BUT BETTER SAY 'DEVELOPMENT' INSTEAD 'EVOLUTION'
2) Chronostratigraphy versus Geochronology. Do we need a double nomenclature for time intervals with the same name and the same duration (numerical ages)?
YES, WE DO NEED
3) Hierarchy of chronostratigraphic units

Eonothem	Eon
Erathem	Era
System	Period
Series	Epoch
Stage	Age

OK, AGREE
4) Stage, the basic unit (see Hilgen et al, 2006). Duration of stages. Naming of stages.
5) Smaller units (Substages, Chronozones, Horizons, Marker beds, Datum planes)
INCLUDE 'REGIONAL STAGE', 'REGIONAL SUBSTAGE'
WHAT MEANS HORIZON? IN SENSE OF RUSSIAN CODE?
6) Significance of Chronozones.
OF HIGH IMPORTANCE
Part two: Case studies
1) EDIACARAN
2) HIRNANTIAN
3) PLIENSBACHIAN

4) K/T boundary
5) Miocene/Pliocene boundary and Zanclean GSSP

Part three: Discussion

1) Stability in stratigraphic nomenclature. Keep old names well rooted in the literature?
Or create new ones?
Priority
Tradition
Precision

WHAT MEANS OLD NAMES? NEW ONES? DETALIZATION IS ALWAYS GOING ON BUT NAMES USED ON THE MODERN GEOLOGICAL MAPS SHOULD BE STORED AND SAVED

2) Discussion of the case studies illustrated
3) Obvious advantages of an integrated stratigraphy approach
Limitations of the new methods for the older part of the Stratigraphic column.

???

4) How chronostratigraphy works for the first 5/6 of Earth history.

GEOCHRONOLOGY [ROCK AGE DETERMINATION] WORKS BUT CHRONOSTRATIGRAPHY IS SECONDARY MATTER

Percentage of magmatic/metamorphic/sedimentary rocks IN THE CRUST and IN OUTCROP

5) Correlation precedes definition or definition precedes correlation?

DEFINITION IS PRIMARY SOURCE

6) Global stages versus regional stages

ALL GLOBAL STAGES ARE BASED ON REGIONAL STAGES AND ARE RESULT OF MUTUAL AGREEMENT

7) ADDITION: STRATOTYPES. PURPOSE, LIMITATIONS

Conclusions

1) The approaches, the methods are not the same, CANNOT BE THE SAME in the pre-fossiliferous times and during the explosive evolution of fossil groups as Graptolites, Ammonites, planktonic foraminifera. **YES**

2) Events, especially if rapid and geologically "instantaneous", are of paramount importance for defining major subdivisions, but it is considered inappropriate to create new names. **YES**

3) High resolution stratigraphy is more and more popular and successful and may lead to obscure Classical stratigraphy. **NO**

4) To maintain stability in nomenclature it is imperative NOT TO CHANGE THE STANDARD. It is suggested not to formalize the chronostratigraphic units beyond??**..???**

SUGGESTED ADDITIONS 7) STRATOTYPES. PURPOSE, LIMITATIONS

From: **Roger Cooper** R.Cooper@gns.cri.nz
Date: February 2, 2007

I am happy with the outline. One suggestion is that we include a section on methodology and practice of chrono-correlation. Maybe the authors envisage this already under one of the existing subheadings. It is such a fundamental part of the practice of chronostratigraphy that it would be a useful addition.

From: Yuri B. Gladenkov gladenkov@ginras.ru
Date: February 6, 2007

Dear Maria,
I have sent you my article about new Russian Stratigraphic Code (2006), where I discuss some problems of chronostratigraphy. Have you used it when preparing "Chronostratigraphy outline"?
For any case, I am sending you some comments on the problem.
1. There exist different interpretations of chronostratigraphy. Some stratigraphers suppose that a chronostratigraphic unit corresponds a rock strata forming in certain time interval. Question: what interval? Russian specialists emphasize historical-geological nature of chronostratigraphic units. They believe that every stratigraphic units (both global and regional) reflects a natural stage of geological history of the biosphere and stratisphere. This enables reconstructing succession and directions of geological processes and phenomena.
2. Chronostratigraphic units may have different extent: (a) global (stages), (b) regional (regional stages, provincial zones) and (c) local (suites). All of them must have stratotypes.

3. Local "lithostratigraphic" units (formations), whose boundaries may be diachronous, are not chronostratigraphic ones in strict sense (they are actually lithological bodies). In this case "lithostratigraphy" represents "prostratigraphy" and is employed in initial studies of sequences. Therefore suite is a major local unit and differs from a formation, although somewhat similar. It does not mean that we do not need lithostratigraphy. Employment of marker horizons, members, and other units
is very fruitful. On maps of 1:10 000 to 1:25 000 scale boundaries of "lithostratigraphic" units are usually virtually isochronous, and for these scales lithostratigraphy can be used in the chronostratigraphic context.
4. Russian geologists interprete a chronozone (established with due account of standard assemblage zone) as a part of stage.
Like stage, chronozone has complex (bio-, magneto- and other) characteristics reflecting certain phase of Earth evolution.

From: **Charles Henderson** charles.henderson@ucalgary.ca
Date: February 6, 2007
Some comments on your Chronostratigraphy outline:
Part One; 2) Chronostratigraphy versus Geochronology: Do we need a double system? No. Is the double nomenclature a useful distinction and worthy of retention? YES, if use correctly/consistently. However, I see no reason for the retention of both Geochronology and Geochronometry. In my view a geochronologic age should be used as a means of correlation away from the GSSP (perhaps it could define some PreCambrian subdivisions although I prefer some material reference) as are other techniques including geochemistry, magnetostratigraphy and biochronology.
Our current definition of chronostratigraphic units is "a body of rocks that includes all rocks formed during a specific interval of geologic time" is distinct from divisions of time (geochronology). One problem may be the fact that we do not define bodies of rock, but rather boundaries at GSSPs (a very useful concept that is employed well by ICS). Perhaps we should be talking about "a conceptual body of rocks that includes all rocks formed…".
3) This list includes both chronostratigraphic and geochronologic units. I am not an advocate of the system proposed by Zalasiewicz et al 2004 in which they use chronostratigraphy, but geochronologic subdivision except for age for which they substitute stage.
4) I don't think there has to be a certain duration to a stage, and there is definitely quite a variation in the current Time Scale. Some might suggest that these are closely aligned to what might be regarded as 3rd order sequences (roughly 3-10 myrs); which does constitute the majority currently defined.
5) I think chronozone is the smallest unit, but there may be horizons and marker beds that might subdivide these locally. Neither a horizon, nor a datum plane constitutes a chronostratigraphic unit because they are not a body of rock, but rather a surface.
Part two: I think the idea of case studies is a good one. Does the list represent the variety of approaches currently employed by ICS?
Part three: Stability: I like the idea of retaining old names, but in most/all cases they will need (have been) redefined away from unconformities (laterally in the sense of correlative conformity or vertically). However, don't think that this should be mandatory. The practice of the Ordovician Subcommission to provide new names seems to me to be equally valid.
5) I do not know how it is possible to correlate a chronostratigraphic unit until it is defined, but the potential for correlation must be accessed prior to formal definition.
6) The primary goal of ICS regarding the Geologic Time Scale should be a global scale with global stages. This does not preclude the use of regional stages by various groups (in Russia for example), but ultimately we would like to see these regional stages correlated with the global stages. It should in the future be considered a poor practice to include only the regional stages in a paper; there should always be an attempt to correlate with the Global Stages.
Conclusions:
1. Probably true, but there may be events that can be correlated as discussed by PreCambrian Subcommission. They will undoubtedly be larger divisions.
2. Rapid events yes, but I don't see a problem with new names, although I would prefer that they be used unless there has been no significant agreement in the past.
3. What is classical stratigraphy? Is it correlation of unconformities? If so, they it should evolve. We should be aiming for high resolution.
4. Stability is important if it is being consistently used.

In addition, I offer some comments in **bold** to Yuri Gladenkov's remarks today.
(Gladenkov) 1. There exist different interpretations of chronostratigraphy. Some stratigraphers suppose that a chronostratigraphic unit corresponds a rock strata forming in certain time interval. Question: what interval? Russian specialists emphasize
historical-geological nature of chronostratigraphic units. They believe that every stratigraphic units (both global and

regional) reflects a natural stage of geological history of the biosphere and stratisphere. This enables reconstructing succession and directions of geological processes and phenomena.
"the time interval needs to be defined and does not have to have same definition as historical usage" At one time the Chinese and North Americans had two very different definitions for the Carboniferous-Permian boundary. Both were at so-called "natural events or stages". A single definition, which we now have, was needed before any correlation could be truly achieved. Are there any unnatural stages out there?
(Gladenkov) 2. Chronostratigraphic units may have different extent: (a) global (stages), (b) regional (regional stages, provincial
zones) and (c) local (suites). All of them must have stratotypes.
I disagree. ICS should only be formalizing international stages. Regional stages may be correlated to these, but do not require international GSSPs. Local organizations could have their own process for this, but hopefully they would correlate to the international standard. I think a suite has different usages according to guide. Zones are not chronostratigraphic, but biostratigraphic.
(Gladenkov) 3. Local "lithostratigraphic" units (formations), whose boundaries may be diachronous, are not chronostratigraphic ones
in strict sense (they are actually lithological bodies). In this case "lithostratigraphy" represents "prostratigraphy" and is
employed in initial studies of sequences. Therefore suite is a major local unit and differs from a formation, although somewhat similar. It does not mean that we do not need lithostratigraphy. Employment of marker horizons, members, and other units
is very fruitful. On maps of 1:10 000 to 1:25 000 scale boundaries of "lithostratigraphic" units are usually virtually isochronous,
and for these scales lithostratigraphy can be used in the chronostratigraphic context.
Lithostratigraphic and chronostratigraphic correlation is different.
(Gladenkov) 4. Russian geologists interprete a chronozone (established with due account of standard assemblage zone) as a part of stage.
Like stage, chronozone has complex (bio-, magneto- and other) characteristics reflecting certain phase of Earth evolution.
I agree.

From: Alberto Riccardi riccardi@fcnym.unlp.edu.ar
Date: February 9, 2007
Dear Maria:
I found some parts of this Outline too sketchy and imprecise. A few comments are **in bold**.

Part one: Concepts, Definitions, Procedures
1) Time in Geology: evolution of the concept through the centuries **IS THIS NECESSARY??? WHY NOT THE EVOLUTION OF STRATIGRAPHY BASED ON RELATIONSHIP???**
4) Stage, the basic unit (see Hilgen et al, 2006). **????** Duration of stages.
Naming of stages.
Part three: Discussion
3) Obvious advantages of an integrated stratigraphy approach
Limitations of the new methods for the older part of the Stratigraphic column. **WHICH ONES??? I DO NOT AGREE WITH THE WHOLE APPROACH IMPLICIT IN THIS SHORT STATEMENT.**
5) Correlation precedes definition or definition precedes correlation? **OR BOTH GO TOGETHER???**

From: Nicol Morton nicol.morton@wanadoo.fr
Date: February 9, 2007
Comments: in square brackets [ ]
Part 1. Concepts, Definitions, Procedures
1) Time in Geology:
[Is this more than a history of stratigraphy?]
2) Chronostratigraphy versus Chronology:
[The questioning of a need for dual nomenclature betrays a complete lack of understanding of basic stratigraphical principles and the fundamental basis for the geological time-scale. Time can be measured EITHER by counting the repetitions of a regularly-repetitive event such as the rotation of the Earth and its orbit round the sun etc. OR by observing the progress of a non-reversible process such as the burning of a candle. The former is extremely rarely available in geology and must be based on interpretation of the cause observed phenomena and on presumed continuity of representation of the passage of time. The latter is what we have from organic evolution, radioactive isotope decay

and so on. We can only observe these in rock successions, so that the fundamental unit of what we now call chronostratigraphy are the chronostratigraphic units (so-called time-rock units). These have geological properties (such as thickness, facies, stratigraphical completeness etc.) which have nothing to do with time. The units of the Geological Time-scale are founded on these chronostratigraphic units, but are different in their character; all or part of a unit may not be represented by identifiable phenomena in a particular area; but ancient environments existed in time – so palaeogeography, palaeoclimatology etc relate to time units NOT chronostratigraphic (rock-) units.

In the English language this can be emphasised by the distinction between Lower/Middle/Upper from Early/Middle/Late, though this linguistic distinction does not apply to all languages.]

3) Hierarchy of chronostratigraphic/chronological units

4) Basic unit

5) Smaller units

6) Significance of Chronozones

[Please note that in Jurassic stratigraphy (which is, after all, where almost basic stratigraphical principles were first established) the basic unit has always been regarded as what we now call the Standard Zone (and Subzone), based largely on ammonite assemblages, NOT the range of the species name which happens to be used as a label for the Zone. A Stage is a group of such Zones. Unfortunately the term was misapplied elsewhere!]

Part 2: Case Studies

[It may be useful to document a greater number than the five proposed; if space does not allow inclusion of more case studies, then a selection can be made which would illustrate the diversity of approaches necessary in different parts of the geological column.]

Part 3: Discussion

1) Stability

[Some argue that rules of nomenclature similar to those for biological nomenclature should be developed and applied, including the principle of seniority. I have some sympathy with this but not at all costs. In the Jurassic d'Orbigny, the "founder" of the Stage concept, proposed more or less the same number of Stages we now recognise. However, over 120 Stage names were in use, many overlapping others or exactly synonymous. Fortunately we had W.J. Arkell to sort this out – the Introductory chapters of his 1933 book on the Jurassic of Britain and of his 1956 book on the Jurassic of the World should be studied by all of you. The end result has been stability of chronostratigraphic nomenclature for about 50 years.

However, stratigraphy is essentially a pragmatic science, so usefulness and wide applicability of terms and definitions should be the main priority. I understand WHY the Cambrian and Ordovician Subcommissions have decided to "start again" with their chronostratigraphic classifications; my concern has always been whether they have the total support of ALL OF THE COMMUNITY of Cambrian and Ordovician stratigraphers. I very rarely see the newly defined Ordovician Stages used in recent publications. It is EXTREMELY IMPORTANT that ICS and its Subcommissions are accepted as being relevant to the great majority who are not involved in these organisations.]

2) Discussion

3) Advantages

[These must be illustrated by good examples to be meaningful.]

4) How … works…

[Stratigraphical principles can be applied to ALL types of rocks and rock structures. The same distinctions between lithostratigraphy and chronostratigraphy apply, though the techniques may differ.]

5) Corrrelation/ definition

[I would have thought it obvious that the ability to make correlations, using whatever technique, MUST be available BEFORE any meaningful definitions can be made. Of course, the ability to correlate cannot be expected to be universally available – we cannot expect the ideal! Any point in any section can be used to DEFINE a chronostratigraphic boundary, but unless it can be CORRELATED it is of no value.]

6) Global/regional units

[There is almost no such thing as a "global" unit, though we can strive to make them as widely recognisable and usable as possible, but we MUST accept that in some circumstances "regional" units can be extremely useful. I suggest you consult J.H. Callomon on Primary and Secondary Standards.]

Conclusions

1) Approaches

[It is very important to stress the diversity of approached indifferent parts of the geological "column", even within the Phanerozoic.]

2) Events

[Event stratigraphy is a useful tool, but it can be misused if assumptions of synchroneity are not supported by sound correlation using other tools. The worst example was the Vail et al sequences bounded by “unconformities” which were given numbers which were no more than guestimates of stratigraphical ages, and gave a spurious “accuracy” which was NOT understood by many.]
3) High resolution stratigraphy
4) Stability of nomenclature
[These are quite simple to accommodate. Once a boundary is defined by a GSSP, the principle must be that EVERYTHING which can be shown to be older than the GSSP-defined boundary falls into the underlying chronostratigraphic unit.]
[The usefulness of formalising chronostratigraphic units below a certain level varies from one System to another; it would be preferable to give GUIDANCE rather than RULES.[

From: Lucy E. Edwards leedward@usgs.gov
Date: February 9, 2007
Dear Maria-Bianca,
Like Alberto Riccardi, I found it brief. Thus, I did not always know from the outline where the final product is heading. Specific comments follow:

2) Chronostratigraphy versus Geochronology. Do we need a double nomenclature for time intervals with the same name and the same duration (numerical ages)?
LE-Interesting to have in the outline. Will the final product be pro, con, or neutral?
5) Correlation precedes definition or definition precedes correlation?
LE-Will the final product be correlation first or definition first?
Conclusions
1) The approaches, the methods are not the same, CANNOT BE THE SAME in the pre-fossiliferous times and during the explosive evolution of fossil groups as Graptolites, Ammonites, planktonic foraminifera.
LE-Disagree, some approaches, and some methods, are the same.
2) Events, especially if rapid and geologically "instantaneous", are of paramount importance for defining major subdivisions, but it is considered inappropriate to create new names.
LE-I'm not sure what this means. Sometimes new names are better than severely changing old ones.
3) High resolution stratigraphy is more and more popular and successful and may lead to obscure classical stratigraphy.
LE-I'm not sure what this means.
4) To maintain stability in nomenclature it is imperative NOT TO CHANGE THE STANDARD.
LE-Never say “never,” but make it very, very, very rare.

It is suggested not to formalize the chronostratigraphic units beyond??..???
LE-Utility is paramount. If someone wants to formalize down to the zonule, fine with me.
Overall, please emphasize that geologic time is not an end product, but rather a tool to help unravel and to communicate Earth history. Do not omit that products, especially geologic maps, use chronostratigraphic units (not as map units -in the US- but in the legends and colors). Chronostratigraphers need to make it easy, not hard to make maps.

From: **Geza Csaszar** csaszarg@mail.datanet.hu
Date: February 10, 2007
I am sending this letter from home where I do not have the original letter of you just a printed copy and I am sending my comments without inserting them into the proper place. I hope a simple reference to the proper number of the chapter Chronostratigraphy is still acceptable.

Ad Part one
2)
I fully support the idea separating the stratigraphy (chronostratigraphy) from the geochronology. This makes chance to distinguish events from its products (rocks) clearly and to describe palaeogeographic situations, showing where erosional or accumulation areas etc. have been situated, while using appropriate (geochronologic) terms instead of chronostratigraphic ones.
5)
For the time being horizons, marker beds, datum planes are informal units and I suggest to leave it as it is, except they became organic part of the chronostratigraphy in certain rank of hierarchy.

Ad Part two
4)
It was proposed and it remaind in my memory as an accepted idea that Tertiary is a gratuitous term, therefore I suggest to replace this deeply infiltrated, wrong abbreviation with a more proper one. It should express units of the same rank either system (K/E) or erathem (MZ/CZ). It should be added that abbreviation T means Triassic!

Ad Part three
6)
The aim of the geochronology is to subdivide geological history into reasonable time interval that reflects its recognizable steps in both global and regional scale. As they manifested in rocks the sentence above is valid for the chronostratigraphy as well. If it works well then the correlation of successions (rocks) can be solved globally. In principle regional stages are needed until this correlation is not achived. As the accuracy thanks to the technical and technological development in radiometric dating and also in other fields including integrated stratigraphy is increasing, regional stages can be omitted in the future but until this stage (status) is not achieved, regional stages are useful part of the chronostratigraphy (see Para-Tethys stratigraphy).

Conclusions
3) I do not see reason to worry because of obscureness of classical stratigraphy by the high resolution stratigraphy.
4) Why not? Let me refer to some extremity: Precambrian stratigraphy because of various reasons, can not be as precise as Quaternary (Holocene) one, therefore should be given chance for more precise subdivisions of the youngest sequences in the future (may be for tomorrow?).

P.S.
I hope you can accept my comments even if I am unable to sign the formular. To be honest I have to add that I will not be surprise if this comment would be remain without reverberations just like all of the former notes. This is one of the reasons why this comment concerns the most important subjects only and as briefly as it is.

From: **Albert Brakel** abrakel@netspeed.com.au
Date: February 10, 2007
Part one (2) of the outline asks the question: Do we need a double nomenclature for time intervals with the same name and the same duration? Apparently the answer is inferred to be yes, because if the answer is no, then the outline would not need the references to chonostratigraphic units (eonothem to stage) mentioned in (3), (4), (5) and subsequently.

I believe it is time we got rid of this unnecessary complication of dual nomenclature, and used only the geochronologic units (eon to age). When the proposal to this effect was argued by Zalasiewicz et al (2004), in the discussions here most people agreed that it should be done. I therefore propose that references to chronostratigraphic units after Part one (2) be replaced by geochronologic ones.

From: **Werner Piller** werner.piller@uni-graz.at
Date: February 10, 2007
In Bold by Werner E. Piller
Part one: Concepts, Definitions, Procedures
1) Time in Geology: evolution of the concept through the centuries
2) Chronostratigraphy versus Geochronology. Do we need a double nomenclature for time intervals with the same name and the same duration (numerical ages)?
Yes, we should still apply the dual system! Reduction to a single system will cause loss in information.
3) Hierarchy of chronostratigraphic – **geochronologic** units

Eonothem	Eon
Erathem	Era
System	Period
Series	Epoch
Stage	Age

4) Stage, the basic unit (see Hilgen et al, 2006) **for regional chronstratigraphical and geochronological units. Duration of stages – cannot and should not be fixed and depends on the events used for definition (range: 2-5 Ma).**
Naming of stages - **geographic names.**
5) Smaller units (Substages, Chronozones, Horizons, Marker beds, Datum planes) **- have to be properly defined!**

Datum planes are, however, no chronostratigraphic units!

6) Significance of Chronozones – the**se are part of biostratigraphic classification!**

Part two: Case studies **- this is a good idea and may help understanding the problems for a broader readship**

1) EDIACARAN
2) HIRNANTIAN
3) PLIENSBACHIAN
4) K/T boundary
5) Miocene/Pliocene boundary and Zanclean GSSP

Part three: Discussion

1) Stability in stratigraphic nomenclature. Keep old names well rooted in the literature?
   Or create new ones?
   Priority
   Tradition
   Precision
   Tradition is important but we have to be careful not blocking ourselves by totally sticking to it. Keeping old names may sometime produce more confusion than providing solutions!
2) Discussion of the case studies illustrated **- yes**
3) Obvious advantages of an integrated stratigraphy approach
   Limitations of the new methods for the older part of the Stratigraphic column.
   this is not part of chronostratigraphy! This has to be treated in an overview chapter!
4) How chronostratigraphy works for the first 5/6 of Earth history.

To define a GSSP should work in all types of rocks! Correlation may be tricky, but this requires extra care in choosing location where good correlation methods can be applied.

   Percentage of magmatic/metamorphic/sedimentary rocks IN THE CRUST and IN OUTCROP

5) Correlation precedes definition or definition precedes correlation?

These should go together and is highly depending on topic 4 (above)

6) Global stages versus regional stages

The stage level does frequently not reflect global processes and has mostly a regional character. The global scale should be well visible on the series/epoch level!

Conclusions

1) The approachs, the methods are not the same, CANNOT BE THE SAME in the pre-fossiliferous times and during the explosive evolution of fossil groups as Graptolites, Ammonites, planktonic foraminifera.

The methods cannot be the same because of lack of useful biota. However, correlation methods exist which are independent of fossils and these can be applied. This clearly implies that also for the Precambrian the GSSP concept can and has to applied.

2) Events, especially if rapid and geologically "instantaneous", are of paramount importance for defining major subdivisions, but it is considered inappropriate to create new names. **– in general, yes, however, as already mentioned above, new names may sometimes be more appropriate.**

3) High resolution stratigraphy is more and more popular and successful and may lead to obscure Classical stratigraphy.

I don't understand why HRS should obscure classical stratigraphy? Also HRS is carried out on concrete rock entities and offer therefore a reference, which can be put into the geological time scale.

4) To maintain stability in nomenclature it is imperative NOT TO CHANGE THE STANDARD. **- yes**

It is suggested not to formalize the chronostratigraphic units beyond??..???

Why is this suggested? The stage has to be formalized – this is what we have learned from history! Why should a substage not be formalized? Since it has to be defined why not formalizing it?

From: Gilles Serge ODIN gilodin@ccr.jussieu.fr
Date: February 10, 2007

Part one: Concepts, Definitions, Procedures

Q 2: Chronostratigraphy versus Geochronology. Do we need a double nomenclature ?

we do not need double nomenclature. Especially, it would be appropriate to return the word Geochronology to its basic sense : the science of numerical dating. As used by some terminologists the word has a restricted meaning and is confusing.

Q 3): Hierarchy of chronostratigraphic units ?
We* have proposed a single and simplified hierarchy with terms simple and selected with the aim at being different from those of the common language: Eon, Era, System, Subsystem, Stage.
This is not a mixture this are the word most clear in geology whatever they are used for time or bodies of rock units.
* Odin et al. (2004).- Stage boundaries, global stratigraphy, and the time scale: towards a simplification. Notebooks on Geology, Brest, Article
2004/02; 12 p. available at
http://paleopolis.rediris.es/cg/CG2004_A02/index.html

Q 4 : Stage, the basic unit (see Hilgen et al, 2006). Duration of stages.
The duration of GLOBAL stages for most of the Phanerozoic is quite homogeneous (with a mean at about 5-7 Ma). The duration might be used as a guide for their validity-usefulness. Stages shorter than let us say 2-3 Ma will not be easily recognised all over the world and should be rejected.
Substages are useful for regional purpose and are not relevant for international classification.

Q 6 : Significance of Chronozones answer a , the problem of definition of stage: The basic unit in chronostratigraphy is the Stage (time or body of rocks); therefore, there cannot exist smaller units of conventional global nature.
answer b, the problem of nature of the units :Units based on a single stratigraphic tool -as are supposed (bio- or magneto- or climato-Š)chronozones are of basically different nature : they result from a particular (and -may be- personal) KNOWLEDGE not from a CONVENTION itself based on an integrated approach.
answer c. the problem of coinciding limits : Because stages result from an integrated approach their limit is conventionally located in a given body of rocks at a given place (this implies that the only place in the world where the stage is perfectly defined -in many cases- is the stratotype). At the boundary, the limits of chronozones will nearly always differ from that of the Stage -except, potentially, for the chronozone using the same tool as the guide event-. Therefore, a stage cannot be subdivided in chronozones.

Part three: Discussion
Q : Keep old names well rooted in the literature? Or create new ones?
No rigid answer here; the question is not about Priority or Tradition but of significance and usefulness. A rule should be, however, not to change significantly the significance of a widely used name.

Q : Global stages versus regional stages
Regional stages(and substages or suprastages) are regionally useful units and should not be banished.

Conclusions
Q : pre Phanerozoic The approachs, the methods for pre-Phanerozoic may be more ot less similar or different, the question is not there; the question is how to define GLOBAL units. It is also supported by a number of colleagues that the definition has to be adpated (no GSSP) * see ref above (http://paleopolis.rediris.es/cg/CG2004_A02/index.html)
addition: a number of colleagues also beleive that the Quaternary is another matter for which units, conventions and hierarchy must be adapted.
see enclosed paper pdf format : "odin & al. Q5.pdf"
Q : It is suggested not to formalize the chronostratigraphic units beyond??..???
Beyond stages obviously. It would be already a considerable progress in the Phanerozoic interval between 540 and 2,6 Ma.

From: Bill Berggren wberggren@whoi.edu
Date: February 11, 2007
Maria
Sorry for the delay in responding to your inquiry regarding a document on Chronostratigraphy. Marie and I have just returned from a month in Egypt working on the GEOARCHEOLOGY OF TOMBS IN THE VALLEY OF THE KINGS with Egyptian and European colleagues.. While I am not sure where this document is leading (a white paper on the topic?) I am happy to send along my comments on the subject.
1. There are several areas that need/require clarification as pointed out by Werner Piller and Lucy Edwards.
2. I think an in-depth discussion of the historical basis for chronostratigraphic principles laid out so clearly by Hedberg in the 1940s-1970s vs the (as I perceive it) inconsistent and partly illogical "reformation" by the ICS in the 1980s and 1990s. We need to clear the air on this issue before proceeding further with the (endlessly futile and at times unnecessarily acerrbic) debate in the literature on this topic.
3. I take the liberty of sending you (and colleagues) two preprints by Marie and one by myself on topics presented at

last year's Penrose Conference. They will soon appear in the Proceedings volume in Stratigraphy published by Micropress in NYC and edited by Brian McGowran..
With best regards,
Bill Berggren
Marie-Pierre A

From: **Piero Gianolla** glr@unife.it
Date: February 12, 2007

Part one: Concepts, definitions, applications

Time in Geology: evolution of the concept through the centuries

It's important to stress the role of different approaches in defining time slices.

Period	Arduino 1750	Lyell 1872	1950-Today	Tomorrow
Key feature	Lithology	Biology	Biostratigraphy	GSSPs
Alternatives	Toponomastic		Orogeny	Chronozones?

Table 1 - modified after G.B.Vai, 2006

What we have to learn from the past is that as new methods came out, and they are more precise, they should (must) be the framework for future stratigraphy.

Definition of what have to mean for Geological Time is the key to solve many points of the discussion. Is the G.T. a representation of a structure of the Universe (a dimension like Sir Isaac Newton's point of view) or is it a way to quantify durations or to compare subsequent events, thus being part of the structure of our mind (as Gottfried Leibnitz or Immanuel Kant stated)? The first position requires the ability to seriate-and-scale each event in Earth history into a continuous timescale, thus the ability to define instantaneous events as points on the Time line (like GSSPs). The second position is ultimately related to the physical manifestation of Time into the stratigraphic record (remarkably discontinuous) and is more similar to the definition of the stratotype of the unit. Zalasiewics point of view appear to be closer to the Newton's one ("What's important is what happened where and when in the space/time framework", J. Zalasiewicz, Penrose conference presentation), Bergreen's one is the Kant's one ("Time is only an inference", M.-P. Aubry, Penrose conference presentation).

Chronostratigraphy versus Geochronology. Do we need a double nomenclature for time intervals with the same name and the same duration (numerical ages)?

Yes, but today only stratigraphers need double nomenclature, other geologist maybe not.

Have the Geological Time Scale to be defined to help geologist to communicate or just to represent something that exist? I think we should separate the timescale work in 4 steps: seriating, scaling, correlating and the naming. The naming target is to create a common, unambiguous vocabulary between Earth Sciences' workers (and it implies a position concerning the nature of Time). Only correlating and seriating targets require a specialized geologist, trained in recognize certain types of events (like fossils FO/LO) from real rocks. Those geologists may find useful certain types of hierarchical chronological subdivision (and a separate language, making the dual nomenclature necessary). The "Scaling" step flattens down to a single dimension all the knowledge about the past history of the Earth thus representing the ultimate synthesis.

Hierarchy of Chronostratigraphic units

Eonothem	Eon
Erathem	Era
System	Period
Series	Epoch
Stage	Age

It's ok, in my opinion. May be eventually discussed the usage of "Stage" as basic unit.

It's a normal convention for Geologists to name time intervals after biological events. The first purpose of structuring a hierarchical time scale was to represent the irreversibility of evolution (of Earth through lithosphere or biosphere's evolution) and differences in major breaks during Earth's life history. Life on Earth evolved; each species existed only for a defined, bounded time interval.

Geological Time reflects this aspect by naming time slices showing similar biosphere characteristics. Extinction rate is inhomogeneous along time allowing the definition of major and minor "breaks" in the biosphere history (e.g. Sepkosky 1998; Benton, 2003).

Stage, the basic unit (see Hilgen et al., 2006). Duration of stages.

Stage is the basic unit? Yes, as far it's the finest worldwide-correlatable unit.

Duration of stages is highly variable and still not consolidated (e.g. Late Triassic). Duration of stages is variable because it reflects the non-rhythmic nature of extinction rates. This should not represent a problem at all, except if we want to subdivide equally the Time scale (refusing the hierarchical nature of Geological Time). Naming of stages: priority should be the rule.

> *There is a minimum/maximum requirement for the duration of a stage? Are stage really "event bounded" or are they "event containing"? If the stage is an event container then we should debate if there are too much events or not, but the duration expressed in Myr is just a measure of the distance between two major events, and we cannot do anything to change that. This is the Stage type-section against the stratotype of the boundary war. Has been already decided that GSSP are the answer, please don't debate anymore. The only allowable shape change in the GTS is when we recognize a sub-stage as global correlatable, thus rising it at the Stage level.*

Smaller units (Substages, Chronozones, Horizons, Marker beds, Datum planes)

Smaller units, see point #4. What is the lowermost worldwide-correlatable unit? Stage or finer subdivisions?

Significance of Chronozones

In my opinion they should became the basic GTS units, but only theoretically: many chronozones may be completely missing in the stratigraphic/rock record.

Part two: Case studies

P/Tr boundary may be added because is one of the case where there was a ferocious discussion about the use of a bio-event versus the possibility to use a worldwide physical signature ……

Part three: Discussion

Stability in stratigraphic nomenclature. Keep old names well rooted in the literature? (Priority, Tradition, Precision)

Keep old names only if their meaning is unchanged? This may apply only to not-yet-established GSSPs or it will invalidate the previously established ones. But if we are looking for the best correlation often this is in contrast with the old literature or the tradition (the recent Anisian/Ladinian boundary is a good test). I think that stability is important for the geologist and also for a common reader. But anyway we must take a decision and often this decision is in contrast with the tradition (and this could be more and more evident when we will use the best available signal for global correlations).

Discussion of the case studies illustrated

Maybe it's worth talking about the Anisian/Ladinian boundary as well?

Obvious advantages of an integrated stratigraphy approach. Limitations of the new methods for the older part of the stratigraphic column.

No limitations into the integrated approach! The older part has different approaches but not less (today or in the future). Every definition of "integrated approach" should account for that point; it should be open to future developments and at the same time rigorous, precise in its meaning. I don't think is worth discussing this point: it's obvious and discussing doesn't lead to anything.

How chronostratigraphy works for the first 5/6 of Earth history. Percentage of magmatic/metamorphic/sedimentary rocks IN THE CRUST and IN THE OUTCROP

This is a very important point! So, what the age of a rock means? Does the term "age" have to be different for different types of rock? Is it scale-dependant (Below a certain scale cannot be assessed e.g. because of bioturbation, over a certain scale cannot be assessed because magmatic/metamorphic rocks should be included as well)? I think we should build a timescale for all kind of rocks… but ok, I understand this is an international STRATIGRAPHIC code.

Correlation precedes definition or definition precedes correlation?

Correlation should precede definition because we need agreement on what the boundary should divide (see also Walsh, 2003). Note that the question has no sense for physical events! Physical events exist, no matter if humans define them! Boundaries are human-made and lead to (infinite) discussions. This point should be discussed only if we decide that biostratigraphy is the framework for the global chronostratigraphic scale.

Global stages versus regional stages.

I say Global. Regional stages are an endless effort to fix something that's completely overlapping with the Global Timescale.

Conclusions

The approaches, the methods are not the same, CANNOT BE THE SAME in the pre-fossiliferous times and during the explosive evolution of fossil groups as Graptolites, Ammonites, planktonic foraminifera.

I agree. But ISC have to show a link between pre-fossiliferous and fossiliferous times (and among different groups).

Events, especially if rapid and geologically "instantaneous", are of paramount importance for defining major subdivisions, but it is considered inappropriate to create new names.

Events are intimately similar to GSSPs and should be accepted in the same way. They define chronozones, but they don't name anything. Chronozones, indeed, should be named without numbering when possible, because we'll never know if another event has been hidden by hiatuses/bad sampling. They may eventually rely on GSSPs names (then to stages names) for naming conventions - but it is dangerous (e.g. FAD Hindeous *parvus*: Chanxingian or Induan). An "*Event Catalog*" may solve any problem (like stars catalogues).

High resolution stratigraphy is more and more popular and successful and may lead to obscure Classical stratigraphy.

And so? "Classical" stratigraphy doesn't exist. It's only the stratigraphy that the member of the commission used to do, but stratigraphy evolves! So ISC should account for that and eventually include it (if not this time it will be the next one so why we have to wait?)

To maintain stability in nomenclature it is imperative NOT TO CHANGE THE STANDARD.

I agree completely. GSSPs must be immutable as the holotype for a fossil. But GSSPs may be plotted also in an event-driven timescale, not only in a relative biologically-driven one.

It is suggested not to formalize the chronostratigraphic units beyond??..???

The limit to the formalization process is given by correlability of events. We should stop when, at a given smaller scale, we cannot recognize any general trend worldwide.

Notes

Following Hilgen et al. (2006) astronomically tuned sections allow the reintroduction of unit Stratotype where completeness of the section is confirmed. I think that cyclostratigraphy is just one of many ways on which we should subdivide geologic time. Unit Stratotype is in my opinion obsolete and may be substituted by a global record of events, a composite standard. The composite standard may have as many sections (read Stages, Epochs ...) as required and may include local events not clearly observable in any other place.

Obviously, cyclostratigraphy is nowadays the most precise dating technique for recent Stages but at a smaller scale, the precision achieved fades in the assumption of continuous sedimentation, an assumption easily falsifiable. We have no idea of what the maximum precision will be in the next thirty years. I suggest that GSSP, orbitally tuned surfaces, magnetozones and biological events may be integrated in a unique, ordinate and scaled catalogue of events (the composite standard). Each recognized geological feature should be identified along the time direction by the surrounding events, in a graphic correlated way (Shaw, 1964; in his modern review as CONOP; Sadler, 1980). ATS will fix time for small scale, and radiometric dating will offer correlation where no cyclic sedimentation is provided. Radiometric dating is also incorporated in the tuning parameters of present and future astronomic models. The greater majority of magnetic, chemical and biological events will lie in between two chronozones defined by cyclostratigraphy, adding further precision to the composite standard. Definition of Stages and larger subdivision must rely on GSSPs, defined mostly by biostratigraphy (but not necessarily! It's just a matter of stability of nomenclature). Each GSSP should be referred to the events surrounding it, thus correlation of the GSSP to other sections will always be possible. It is clear then that we need GSSPs only because we need to name stages, eras, epochs and so on, where we need only an ordered list of events to define the relative position in time and an ordered and scaled list of events to define the absolute position in time. The distinct usage of Myr and Ma will became unnecessary and, remarkably, it's an anomaly in both natural physical sciences. The age of an event should then be defined to the "Standard Present" (B.P.).

What is the future? It will be a worldwide collaboration to synthesize of the paramount of data collected locally (and everyday growing) into the composite (global) standard. ICS should guide that revolution. Event stratigraphy needs that database as well as traditional stratigraphy. This is in my advice the synthesis of the Hedbergian thinking and the GSSPs and event-driven stratigraphy. Hedbergian stages will be defined by the composite standard events between two GSSPs, making the Stage to be defined not only by its boundaries but also by its content, in a virtual stratotype of the unit.

3.6 Paleomagnetic stratigraphy.

A preliminary outline was prepared in June 2006, but it required a revision. A planned meeting of the WG members has been postponed. The last news I have are as follows:

From: langer@geo.uu.nl
Subject: **Re: Progress report for ISSC Newsletter n.11 & Oslo 2008 Workshop**
Date: May 7, 2007 10:52:07 PM GMT+02:00
To: maria.cita@unimi.it

Dear Cor,
Maria Rose and I are collecting materials for ISSC Newsletter 101, that we plan to distribute by end May. I tried several times to call at the phone Helmi Weissert and Cor Langereis, but had no success.
I expected for a long time an outline for the Paleomag, because I do not intend to skip the first step of the planned review process. What is wrong
in the system? Why the project seems to be stuck? Please, Cor, say a word.

Dear Maria Bianca,
I admit I have been slow, but I have been doing something. The first draft is ready, but still missing the Permo-Triassic case study.
I am now in Turkey, will be in Spain the last part of May, and I have 3 weeks in June with - at present - not too many obligations.
Hence, as soon as I come back, I will finish the first draft, and push Giovanni and Manfred Menning to add to this draft. Once they have a draft, things will be easier for them, I hope.
Please keep pushing me: my students all know that this helps ...
Best wishes from Turkey,
Cor

3.7 Biostratigraphy.

The WG leader Jacques Thierry, emeritus at the University of DiJon, is very close to our project, as shown by what he wrote at pages 34-38 of ISSC Newsletter n. 10, but this spring he had serious, and sad family problems. We cannot urge him.

3.8 Sequence stratigraphy.

After the frenetic communications of March-April- beginning May we need a pause to develop a better strategy.

4. GSSP APPROVED

INTERNATIONAL UNION OF GEOLOGICAL SCIENCES

INTERNATIONAL COMMISSION ON STRATIGRAPHY

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11 Apr 2007

IUGS Secretariat
Geological Survey of Norway
N-7491 TRONDHEIM
NORWAY

Request for IUGS Ratification of the GSSP defining the **base of the Middle Series (and third stage) of the Ordovician System**

The International Commission of Stratigraphy has approved the following Global boundary Stratotype Section and Point (GSSP) defining the base of the Middle Series of the Ordovician System.

The associated name for this stage is yet to be decided, but will probably be submitted within the next couple of months.

This completes the establishment of all GSSPs that define the international Ordovician stages!

The Global boundary Stratotype Section and Point (GSSP) for the base of the Middle Ordovician Series and the *yet-to-be-named* "THIRD stage" of the Ordovician System is defined at a point 10.57 m above the base of the Dawan Formation at the base of Bed SHod-16 in the Huanghuachang roadside exposure (30° 51' 37. 8''N; 110° 22' 26. 5''E) at 22km NE of the Yichang city, Hubei Province, South China. This level coincides with the lowest occurrence of the conodont *Baltoniodus triangularis*. Secondary conodont markers are the lowest occurrence of *Periodon* sp. A, and followed closely by the lowest occurrence of *Microzarkodina flabellum*; and the level approximates the boundary between the lower and upper intervals of the *Azygograptus suecicus* graptolite Biozone. and nearly coincides with the base of the *Belonechitina* cf. *henryi* chitinozoan Biozone.

The details of this GSSP are explained in the on-line proposal:

The full proposal is a large PDF (12.2 Mb) that can be downloaded from:

http://www.silurian.cn/down/huanghuachangGSSP.pdf

The PDF will take several minutes to download.

If you have any problems accessing this PDF, please notify Chen Xu (Nanjing Institute of Geology & Palaeontology) at: Chen Xu <xu1936@yahoo.com>

This proposal had been revised following an initial ICS Executive review, then transmitted to ICS for final voting during March-April 2007.

The votes received from the Full Commission were **16 "Yes"(89%) and 2 Abstain** (*details, and summary of remarks are on the next pages*). All members responded.

The final set of voting by the Ordovician Subcommission on this GSSP was 84% "Yes" (19 voting; 16 Yes, *1 No, 2 Abstain or blank ballots).* Details of the Subcommission voting rounds are attached as a separate PDF to this e-mailed letter.

The ICS hereby submits this GSSP for the base of the **Middle Series** of the **Ordovician** to the IUGS for ratification at their next meeting. We also attach the set of comments on the proposal by ICS voting members. If ratified, then a modified form of this proposal will be published in *Episodes*.

Sincerely,

James G. Ogg ***(Secretary-General of the ICS)***

5. ICS STRATIGRAPHY PRIZES

From: scfinney@csulb.edu

Subject: ICS Stratigraphy Prizes - Announcement and Call for Nominations

Date: December 19, 2006

To Offices of ICS and ICS Subcommissions:

With this message, I call for nominations for the ICS Stratigraphy Prizes that will be awarded at the 33rd IGC in Oslo in 2008. Please see the attached Formal Announcement for detailed information. Awarding the ICS Prizes was a highlight of the opening ceremony at the Florence IGC in 2004. Outstanding stratigraphers (Jan Hardenbol and Steven Hessbro) were recognized, and the presentation gave prominent visibility to ICS. The success of the program is dependent on a significant number of outstanding candidates being nominated. I urge all of you to consider making nominations. I also ask that you disseminate the announcement as widely as possible, sending it to all voting and corresponding members of your subcommission and including it in your newsletters.

Best wishes for the Holidays and for the New Year,

Stan

International Commission on Stratigraphy

ICS Stratigraphy Prizes

The International Commission on Stratigraphy (ICS) is a leading entity of the International Union of Geological Sciences (IUGS) with responsibility for establishing international standards in stratigraphy, such as the Geological Time Scale and the International Chronostratigraphical Scale, defined by boundary stratotypes (GSSPs).

Stratigraphy is the core discipline of the geological sciences, concerned with the relationships in time and space of rocks (not just sedimentary, but also igneous and metamorphic rocks) and the varied processes that have formed and affected them. Results and interpretations deriving from other disciplines can only be integrated into a coherent all-embracing geological history if they are based on sound stratigraphy.

To emphasise this key role of stratigraphy, the International Commission on Stratigraphy awards two ICS Prizes to outstanding geoscientists every four years during an International Geological Congress. The first awards were made at the 32nd IGC in Florence, 2004; the second will be made at the 33rd IGC in Oslo, 2008.

The awards are made at two levels:

6 The **Digby McLaren Medal** is awarded to honour a significant body of internationally important contributions to stratigraphy sustained over a number of years. The contributions can be in research (through publication of papers, monographs or books) or in education (through development of influential educational material or resources). It is expected that a major proportion of this work will have been published in an international language. The medal is named in honour of the Canadian geologist Digby McLaren who was so influential in developing the key "golden spike" concept of a Global Stratotype Section and Point (GSSP) with reference to the Silurian - Devonian boundary, and a major force behind the International Geological Correlation Programme (IGCP) of UNESCO.

7 The **ICS Medal** is awarded to honour high-quality research in stratigraphy by recognizing a single major achievement in advancing stratigraphical knowledge. The research can be either in the development of new methods of analysis or in the presentation of new data and/or interpretation of the geological history of a particular area or time interval. There are no limitations to the size or scale of the subject matter. The geographical scope of the work need not be international, but the work should be of an international scientific caliber. The language of publication of the work is not a criterion, and it may comprise a single paper of distinction or a series of papers over a short period of time that have similar impact.

Nominations and Selection

Nominations for either of the Awards are solicited from any source, not just members of the Commission or other entities within IUGS. Nominations should include a brief biographical background of the Nominee, a reasoned case based on the Nominee's contributions, and, if necessary, translation into English of at least abstracts of this material so that independent judgement can be made.

The ICS has established a committee to elicit and evaluate nominations for the two Prizes, and afterwards to make recommendations to all members of ICS, who must then approve the nominations by a clear majority vote. The committee includes Stan Finney (Vice-Chair of ICS, California State University at Long Beach), Brian Pratt (University of Saskatchewan, Canada), André Strasser (University of Fribourg, Switzerland), and Finn Surlyk (University of Copenhagen, Denmark).

Nomination documents should be submitted to:
Prof. Stan Finney
Chair of ICS Stratigraphy Prizes Committee
Dept. of Geological Sciences
California State University at Long Beach
Long Beach, CA 90840

USA
Tel. ** 1 562 985 8637
email scfinney@csulb.edu
by October 1, 2007
For further information please contact Stan Finney or other members of the committee.

6. DOCUMENTS RECEIVED

All very useful for the Chronostratigraphy chapter.

BLEEKER- Towards a 'natural' time scale for the Precambrian– A proposal. Lethaia, vol. 37, p. 219-222.

OGG - Table with the comparison of the "standard chronostratigraphy" of 1894 from the "first" equivalent of ICS, and the current standard (assuming that the subcommissions will continue to use the stage names as in their recent Annual reports).

MANUSCRIPTS prepared for STRATIGRAPHY - Proceedings of the Penrose Conference Chronostratigraphy: Beyond the GSSP (Leibniz, Austria, June 3-9, 2006):

- CARTER - Stratigraphy into the 21st century by Robert M. Carter.
- GLADENKOV – The new Russian stratigraphic code and some problems of stratigraphic classification by Yuri B. Gladenkov.
- ZALASIEWICZ - The scale-dependence of strata-time relations: implications for stratigraphic classification Jan Zalasiewicz, Alan Smith, Mark Hounslow, Mark Williams, Andrew Gale, John Powell, Colin Waters, Tiffany L. Barry, Paul R. Bown, Patrick Brenchley, David Cantrill, Philip Gibbard, F. John Gregory, Robert Knox, John Marshall, Michael Oates, Philip Stone, Peter Rawson and Nigel Trewin
- AUBRY - Chronostratigraphic Terminology: Building on Principles by Marie-Pierre Aubry
- AUBRY - Chronostratigraphy beyond the GSSP by Marie-Pierre Aubry

Complete list of IGCP project (1974-2006) provided by William Cavazza.

31 reprints of recently published papers by Eustoquio Molina and associates dealing with the K/T boundary, Paleogene successions from Spain, north Africa and the Caribbean, impactites, very useful for the case-study on K/T boundary.

Sprovieri, R., Di Stefano, E., Incarbona, A. & Oppo, D.W. (2006). Suborbital climate variability during Marine Isotopic Stage 5 in the central Mediterranean basin: evidence from calcareous plankton record. Quaternary Science Reviews, 25 (17-18): 2332-2342.

From William Cavazza – Documents on INQUA history, from its foundation (1928) to the present day.

7. ANNOUNCEMENT

The Geological Society of America

PENROSE CONFERENCE

Hothouse, Icehouse, and Impacts: The Late Eocene Earth

Cònero Riviera, Ancona, Italy
October 3-6, 2007

Conveners:

Alessandro Montanari
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