INTERNATIONAL SUBCOMMISSION ON STRATIGRAPHIC CLASSIFICATION (ISSC)

OF

IUGS INTERNATIONAL COMMISSION ON STRATIGRAPHY

CIRCULAR NO. 99

July 26, 2001

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I. SEQUENCE STRATIGRAPHY

ISSC Circular No. 98 (October 27, 2000) included some additional comments to those reproduced in ISSC Circular No. 97 (July 10, 2000), all of them on the document and alternative recommendations presented by the WG on Sequence Stratigraphy (Appendixes B and C to ISSC Circular No. 96 (October 29, 1999). Also included in ISSC Circular No. 98 were the main conclusions of Memo No. 17 of the Working Group on Sequence Stratigraphy.

Since then the Coordinator of the WG on Sequence Stratigraphy, Amos Salvador, has circulated Memo 18 (January 22, 2001), 19 (March 2, 2001), 20 (April 3, 2001) and 21 (May 24, 2001).

As summarized by Amos Salvador (WG Memo 21) the WG agreed to recommend the abandonment of the allostratigraphic units and the synthems, but was not able to agree on a definition of sequence: 1) Six members prefer a single definition of sequence: *"A sequence is a stratigraphic unit composed of a relatively conformable succession of genetically related rocks bounded by discontinuities in the stratigraphic record (unconformities) representing subaerial or submarine erosion and/or nondeposition that are believed to have local or regional stratigraphic significance. A sequence can be extended beyond the basinward limits of its bounding unconformities, when desirable and possible, along their corresponding correlative conformities";* 2) Nine members of the WG favor a bipartite terminology for sequences: a descriptive unit, the *"stratal sequence*", defined as *"a stratigraphic unit that is defined exclusively with reference to bounding unconformities without regard to their character",* and an interpretative unit, the *"depositional sequence"*, defined as *"a relatively conformable succession of strata bounded by unconformities of subaerial erosion/nondeposition or their submarine equivalents and by genetically correlative conformities"*. These proposals are substantiated in two documents that are here reproduced as **Appendix A** and **B** to ISSC Circular No. 99.

These views, and others, will be discussed at a AAPG Hedberg Research Conference that will take place in Dallas next August 26-30 (see below).

Additionally Henk de la R. Winter sent an "Open Letter to ISSC regarding ´Discontinuities Date Deposition in Circular 98". This Open Letter is attached as **Appendix C** to ISSC Circular 99.

Comments and suggestions concerning the attached documents and the general subject of unconformity related units will be appreciated from the members of the Subcommission. It should be noted that the final conclusions reached at Dallas by the WG on Sequence Stratigraphy will eventually be published as a document of ISSC and used in the preparation of a new chapter of the International Stratigraphic Guide.

II. AAPG HEDBERG RESEARCH CONFERENCE

A Hedberg Research Conference, titled "Sequence Stratigraphic and Allostratigraphic Principles and Concepts" will be held in the Ellison Miles Geotechnology Institute at Brookhaven College in Dallas, Texas, August 26 - 30, 2001.

This Conference is sponsored by the American Association of Petroleum Geologists, North American Commission on Stratigraphic Nomenclature (NACSN) and ISSC. It is designed to provide input into the deliberations of the ISSC and NACSN working groups on allostratigraphic and sequence stratigraphic units for possible amendment to the International Stratigraphic Guide and to the North American Stratigraphic Code. Additional information is available from AAPG website at www.aapg.org.

III. CYCLOSTRATIGRAPHY

ISSC Circular No. 97 (July 10, 2000) included as App. B & C a Report and a Questionnaire, dealing with concepts, applications, terminology and operational problems of Cyclostratigraphy, prepared by Frits Hilgen, André Strasser and Walther Schwarzacher.

Responses to the Questionnaire as well as number of comments were included in ISSC Circular No. 98 (October 27, 2000) and were circulated to the ISSC membership and to a number of other interested stratigraphers.

Since then the following comment has been received:

Alfred G. Fisher

General Comment

My first reaction is that there are many fundamentally different kinds of cycles in Earth history that cyclostratigraphy, if we take it in its general meaning (as I think we should) is a very heterogeneous subject for which it becomes well-nigh impossible to set up a satisfactory set of stratigraphic rules and procedures.

It is one special group of cyclicities that is so particularly interesting because driven by the Earth 's orbital clockwork, such as the day, month, year, precession, obliquity cycle and eccentricity cycles. Unlike all other geological drivers, these are programmed, and we are just learning how to recognize, extract and process them.

I thus suggest that the present need is to design rules for the study of this particular subset of cycles, which one might call Orbital Stratigraphy or Astrostratigraphy or some such, a choice of name which the Committee should deal with.

Adhemar was the first to suggest that cyclicities in the Earth's orbit might be reflected in recurrent geological phenomena (the Pleistocene glaciations), a concept then much farther developed by Croll and by Milankovitch. DeGeer was the first one to build such an orbital stratigraphy, based on the varves of the Swedish Holocene. He is our first real orbital cyclostratigrapher. Hays, Imbrie, Shackleton and others went on to build an ultimately orbitally based isotope chronology for the Pleistocene, which Hilgen then extended through the Pliocene by means of orbitally forced stratal patterns, and which Shackleton and others are pushing into the Miocene. These can all be directly related to Berger's and Laskar et al's astronomic retrojections, extending to about 20 Ma, to which the various geologically observed cyclicities.

Matters are different for the older record. While the general character of the precessional, obliquity and eccentricity variations can be predicted, the uncertainties in their precise timing are such that the phase relations become unpredictable. The orbital variations can be and are being extracted from various facies, but for bits and pieces of the time record, and these cannot now be linked into geochronology except via anchorage in biostratigraphy, magnetostratigraphy or other time signals fitted into a chronological framework via radiometric interpolations. For practical purposes these bits and pieces will remain floating until gradually linked together.

Type sections serve primarily as anchors and templates to correlate to. For the anchored part of the record, essentially Neogene time, that template exists in the form of the astronomical curve. Admittedly, the orbital variations influence sedimentary patterns in many different ways, such as platform emergence, productivity of pelagic skeletons, fluctuations in siliciclastic muds, variations in salinity and aeration of water masses etc. Also some areas or facies will predominantly reflect obliquity cycles and others the precession-eccentricity syndrome (PES). It may become desirable to have specific reference sections for such categories- but let formulations wait until the need arises.

For the older parts of the record with its floating orbital cyclograms we shall soon need type sections to serve as standards for correlation. Take orbital stratigraphies round about the K/T boundary. We have cycle extractions for several sections in Spain and in the South Atlantic, and (in review) for a section on the Black Sea coast, and we may be sure that many others will be developed. They correlate in some ways and show differences in others, and can be interpreted in diverse ways. For practical purposes it will be necessary to choose one of these as a type, to serve as a standard for comparison. Eventually it may be necessary to have multiple standards, as discussed above.

My feelings about stratigraphic term-definitions are that good common words such as cycle or sequence should never be given a special, restricted meaning within the jargon of a given discipline. "Sequence stratigraphy" as such is a sad case in point -sequence means a succession of events, no matter what kind, and is basic to the entire core of stratigraphy, not just those wonderful patterns produced by eustatic/tectonic cycles resulting in pro- and retro-gradation. Cycle is another tricky word often misused. It is a single wave in a wave-train, a single link in a disturbance that we may call a cyclicity or a rhythm or a periodicity. It generally implies that a system begins in one state, passes through one or more other states, and returns to its original state -whether this occurs periodically, quasiperiodically, or with no relation to time. Indeed, the term is deeply ingrained even for the processes in which it is not a system that does this, but in which individual molecules cycle through a number of systems as visualized in diagrams of the water cycle, or any other of the geochemical cycles.

Thus my recommendations are

(1), do not redefine and narrow the use of common English words for the jargon of any branch of Geology.

(2), Deal specifically with cyclicity related to orbital forcing -it is this field that has such potential bearing on geochronology, and its demands are very specific.

(3) design some simple system of letters and numbers by which any set of cycles can be expressed as part of the hierarchy in which boxes lie within boxes within boxes, and which relate to some specific event. For the Neogene, that event is the Present. Floating orbital stratigraphies will have to be anchored to biotic or magnetic zonal boundaries or to fated ash beds.

In this scheme, the Precession-eccentricity syndrome, reaching up to the 2 Ma level, should hold priority, inasmuch as its long cycles are likely to be the most important for correlation, and the first to link together into a coherent cyclochronology. Particularly important here will be the ca. 2-million year cycle of eccentricity, only recently discovered, because it overlaps onto the biostratigraphic and magnetostratigraphic dimensions and will be the ultimate means of linking the floating pre-Neogene cyclostratigraphies into the whole.

Obliquity cycles might have to be identified in either of two ways. Some long sequences such as the early Cretaceous ones of the Vocontian trough were long dominated by obliquity forcing, and these should be numbered in relation to whatever the best chronologic markers are. The alternative, and the only practicable solution for sequences in which the obliquity surfaces episodically, is to refer them to specific eccentricity cycles.

A format terminology should be developed specifically for orbital cycles, i.e. for the Milankovitch theory, extended to include the ca. 2 Ma eccentricity cycle, and for the "calendar frequency band" of annual, lunar, and diurnal cycles. I am aware of the existence of cyclicities in the gap between these two frequency bands, but suggest that we do not as yet understand these periodicities well enough to force them into any kind of mold at this time.

Response to Questionnaire (ISSC Circular No. 97)

Question 1. <u>Should the term "sedimentary cycle" be restricted to those repetitive changes in sedimentary successions that have a time significance and are periodical or near periodical?</u>

No, surely not - the term has been used for many non-periodic phenomena, many of which are recorded in strata (e.g. Beerbower's autocycles). In may cases we still do not know whether cycles long observed and described are periodic (e.g. the classical Carboniferous cyclothems -most of us think of

them as examples of eustatic cycles driven by orbitally forced ice sheets, but note Grossman's failure to find isotopic support for this.

Question 2. Should the term "sedimentary sequence" be used for a succession of lithofacies in the sedimentary record that repeats itself but has no a-priori time significance?

No. Any stack of beds is a sedimentary sequence, I find it hard to write about stratigraphy without using sequence in its normal grammatical meaning.

Question 3. Is there a conflict with sequence stratigraphy by the use of "cycle" and "sequence" in the terms mentioned above?

I object to the use of *sequence* for both, and think "sequence" in the Vail sense should always be modified in some sensible way (depositional sequence unfortunately also isn't clear, as any stratigraphic sequence is depositional), or should simply be called a Vail sequence.

Question 4. Should the term "proxy cycle" be applied for describing cyclic variations in proxy records (e.g. stable isotopes, geochemical proxies)?

Proxy is another one of those general terms that should not be infringed upon. Any character in the sedimentary record can be used as a proxy for something else -such as oxygen for ice volume, fossils for time, etc.

Question 5. Do we need to introduce a cycle hierarchy or orders to differentiate sedimentary cyclicities in different frequency bands (Milankovitch, sub-Milankovitch, annual, sub-annual)?

Yes, so long as the cycle terminology is designed specifically for the hierarchical orbitally driven ones.

Question 6. Should the term "sedimentary cycle" also be applied to the sedimentary record of annual and sub-annual periodic processes (e.g. varves, tidal laminae)?

As mentioned above, I oppose formalizing that term. But in a general sense I would say that these indeed are sedimentary cycles, and that deGeer's varve chronology of the Holocene was the first and remains a prime example.

Question 7) Should cyclostratigraphic units that are calibrated to the astronomical record and underlie the standard geological time scale be formally stratotypified in a section or core?

A type section is a standard of comparison. For the last 20 Ma the astronomical curve of Laskar (and its successors) will be the standard to which the cyclostratigraphic record will be compared, and thus a type section will be unnecessary. But the floating cyclochronologies of the older record will need to be anchored to some event(s) in time, and will therefore require some stratigraphic type section, but I would hope for flexibility, allowing one such section to replace another as better, more broadly or precisely linked sections are found.

IV. ICS NEWS

The ICS Executive Committee held a meeting on March 9 - 11, 2001 at Clifty Falls State Park Lodge, Madison, Indiana. Following are some of the decisions or action items:

ICS EXECUTIVE COMMITTEE

Professor Domenico Rio (Univ. Padova) was nominated by the Italian National IUGS representative, in consultation with the next International Congress Preparatory Committee, to serve as Vice Chairperson at Large of ICS. The nomination was voted within ICS and unanimously accepted.

SUBCOMMISSION RESTRUCTURING

The ICS outgoing Executive Committee and incoming Chair compiled a possible restructuring of ICS, which was included in the 4-year Report to IUGS submitted in April 2000. Now the ICS Executive Committee informed that several of the suggested changes were not favorably received at its initial presentation at an information meeting at the International Geological Congress in Rio de Janeiro (August, 2000), and that the IUGS Council did not allow the Full Commission to decide its own restructuring. Nevertheless, some changes were introduced and the ICS Executive Committee agreed to dissolve the Committee on Quantitative Stratigraphy and the Subcommission on Gondwana Stratigraphy, to merge the Subcommission on Quaternary Stratigraphy and the Subcommission on Neogene Stratigraphy to establish a Subcommission on the Late Cenozoic, and to establish a working group on Stratigraphic Information Services, to be organized by Prof. J. Mutterlose, to distribute and publicize stratigraphic information.

STATUS OF ISSC

The ICS Executive Committee informed: *"The ISSC was formed 50 years ago, and pre-dates the ICS. It successfully compiled the International Stratigraphic Guide, and recently issued a full and abridged version of the Second Edition of the guide. In the recent years, the activities have centered on terminology in sequence stratigraphy and cycle stratigraphy - topics that have generated considerable discussion in the valuable newsletter of the ISSC. The sequence stratigraphy concepts and associated standardization of terminology will be the topic of a 3 1/2 day AAPG-sponsored conference in Houston in August 2001.*

At times during the past couple of years, the previous Executive Committee had considered converting the Subcommission to a committee. Such tentative proposals generated considerable feedback from ISSC members, who vehemently indicated that the continued discussions of stratigraphic classification required a full Subcommission status."

ABRIDGED VERSION OF THE INTERNATIONAL STRATIGRAPHIC GUIDE

The ICS Executive Committee suggested posting an on-line version of the Guide using color graphics and other enhancements.

USER-FRIENDLY VERSION OF THE INTERNATIONAL STRATIGRAPHIC GUIDE

The ICS Executive Committee informed about a UK initiative to prepare a *"user-friendly"* version of their stratigraphic guide and considered that this venture could provide a model for posting a user-friendly version of the ISG, which may *"tackle"* the Geol. Soc. Stratigraphic Commission initiative to simplify stratigraphic classification.

GSSP

The ICS Executive Committee decided to amend the submission process in the GSSP Guidelines (Remane et al., 1996, Episodes, issue 3, sect. 5.2) *"to include a comment and review of potential GSSPs from the three-person GSSP Review and Advisory Board before the voting of the Subcommission (hence before submission to ICS). The GSSP Review and Advisory Board will provide an unbiased summary of advantages and known drawbacks of the GSSP, etc. And how these concerns were addressed during the selection processes. These discussions should be included in the documentation submitted to the Subcommission during voting and to the Full Commission. The draft manuscript for the Episodes publication of the GSSP must be included either as part of the GSSP submission to the Full Commission for consideration and vote, or as part of the final submission to IUGS for ratification"*.

The ICS also indicated that *"the working group on cycle stratigrapby (especially ISSC, but also Neogene and Paleogene subcommissions) should consider requesting permanent curation of key cores and outcrops that serve as standard references for the orbital cycle calibration and associated numbered nomenclature"*.

NEW GSSP

Since distribution of ISSC Circular # 98 the following GSSP were ratified by the IUGS Executive:

- the Maastrichtian Stage in Tercis-les-Bains, Landes, France.

- the Triassic in Meishan, Changxing County, Zheijiang Province, China.

- the Middle Permian Guadalupian Series and coincident Roadian Stage in Stratotype Canyon, west face of southern Guadalupe Mountains, USA.

- the Middle Guadalupian Wordian Stage in Guadalupe Pass, Southeastern Guadalupe Mountains, USA.

- the Upper Guadalupian Capitanian Stage in Nipple Hill, southeastern Guadalupe Mountains, USA.

- the Sinemurian Stage in the East Quantoxhead section, UK.

PHILOSOPHY OF GSSP-DEFINED CHRONOSTRATIGRAPHIC AND GEOCHRONOLOGIC UNITS

The ICS Executive Committee informed that *"Jürgen Remane has prepared an excellent review of the GSSP concept and its role in the modern chronostratigraphic time scale. He requested the Executive Committee to consider the concepts of his article and aspects in papers by Stephen Walsh.*

Some groups have noted that GSSPs unite the concepts of formalized geochronologic and chronostratigraphic units. Therefore, especially a team of stratigraphers in Britain, have recommended that is unnecessary to maintain dual sets of terminology for essentially identical-defined units. For example, the Devonian period is defined as the interval of time between two GSSP-marked horizons, and the Devonian system is defined as the sedimentary record that formed within the interval between the same two GSSP-marked horizons.

The Executive Committee considered this debate on stratigraphic terminology , but decided to leave this topic for the ISSC to consider and make recommendations to the Full Commission."

REVISIONS OF THE STRATIGRAPHIC GUIDE

According to the ICS Executive Committee *"a concern was raised about whether proposed revisions of the stratigraphic guide are also circulated among the Full Commission. Within the next years, the ISSC will be finalizing proposed nomenclature and principles for sequence stratigraphy and orbital-cycle stratigraphy. These topics are of broad interest and importance to all subcommissions"*. Therefore, *"the ICS Executive Committee requests that the International Subcommission on Stratigraphic Classification to notify the Full Commission of any decisions on revisions to the Stratigraphic Guide. These decisions should be distributed among the members, and, if necessary, a vote may be requested"*.

It is clear from this quotation that the concern mentioned by the ICS Executive Committee was raised by someone ignoring that ISSC Circulars are distributed to all members of the ICS Executive Committee and all Chairmen of Subcommissions, which are considered ex-officio members of ISSC, and as such are entitled to participate in all the discussions going on within the subcommission.

ICS WEBSITE

A home web page for ICS with links to Subcommissions will be hosted as *"www.stratigraphy.org"* on the computer system at the American Museum of Natural History in New York. The goal is to make this site a "first stop" to get information on the array of GSSP´s, Stratigraphic Code guidelines, biostratigraphic zonal schemes, Period oriented web-sites, education programs, on-line stratigraphic data base, and other stratigraphic information.

2004 INTERNATIONAL GEOLOGICAL CONGRESS (FLORENCE, ITALY)

ICS is encouraging a major set of symposia, meetings, relevant field trips, and other stratigraphic events at the next Congress. During the next year, the planning committee for the Florence meeting will begin assembling ideas for the program. It has been suggested that each Subcommission consider having a relevant topical symposium.

ICS STATUTES

The ICS will rewrite its Statutes to bring them into line with IUGS statutes on commission and subcommission procedures.

ICS MEETING TO DEFINE FUTURE GOALS

According to the ICS Executive Committee *"the main task of ICS during the past two decades has been standardization of the global geological time scale through GSSPs. An international stratigraphic guide and set of geochronologic standards have also been maintained. All these efforts will have been successfully completed by 2008. What next? The previous and current Executive Committees have proposed some possibilities (e.g., initiatives on databases, education, stratigraphic information services), but it is essential that a new suite of goals involve all members of ICS. Therefore, Felix Gradstein proposed a general workshop of all chairs of ICS subcommissions and select stratigraphers (e.g., coordinator of the working group on Stratigraphic Information Services) to be held in the early summer of 2002.* The meeting will take place at Urbino, Italy, on June 15-16, 2001.

V. PUBLICATIONS ON STRATIGRAPHIC CLASSIFICATION, ETC.

Following is a list of publications on stratigraphic matters kindly sent or brought to my attention by some ISSC members:

Chlupác, I., 2000. Mezinárodní stratigrafické zásady a soucasny deleni geologické minulosti. Vestnik Ceského geologického ústavu 75(4): 361-369 [Review of the abridged version of the ISG and discussion of some points topical for stratigraphic work in the Czech Republic].

Holland, C.H., 1999. The Idea of Time. John Wiley, 150 p.

Zhamoida, A.I., Ed., 2000. Supplements to the Stratigraphic Code of Russia. VSEGEI Press, St. Petersburg, 107 p. [Supplements devoted to the Phanerozoic Magnetostratigraphic scale, olistostromes, stratigraphic hiatuses and terminology used in Russian and English literature. Also on sequence stratigraphy, event stratigraphy, geochronometry, Phanerozoic Time Scale and lower boundaries of Upper Proterozoic and Cambrian units]

VI. MISCELLANEOUS

• Prof. Ivo Chlupác, Czech representative to ISSC has sent copy of his letter to the Bureau of the Interdepartmental Stratigraphic Committee of Russia concerning the "International Stratigraphic Scale 2000". It is here reproduced as **Appendix E** to this Circular.

• Prof. Maria Bianca Cita, Italian representative and Vice Chair to ISSC, has sent a copy of the new draft of the Italian Stratigraphic Guide (Guida italiana alla terminologia e alla classificazione stratigrafica), prepared under her supervision by L. Angiolini & D. Germani, now being circulated for discussion.

• Prof. Kazuo Amano, Japanese representative to ISSC, has sent a copy of the "Stratigraphic Guide of the Geological Society of Japan", published October 2000 (GSJ News 3, 10: 14-15).

In addition, Prof. Amano reported that the Japanese translation of the International Stratigraphic Guide will be available this year.

• Prof. Algimantas Grigelis, Lithuanian representative to ISSC, has sent a paper titled "The Lithuanian Stratigraphic Guide: A newly introduced terms", which will be included in the next ISSC Circular.

• Prof. A.I. Zhamoida, Head of the Interdepartmental Stratigraphic Committee of Russia and Russian representative to ISSC, has requested publication of a "Resolution of the enlarge meeting of the Bureau of the Interdepartmental Stratigraphic Committee of Russia (ISC) concerning the International Stratigraphic Scale 2000". It is here reproduced as **Appendix D** to ISSC Circular No. 99.

In addition, Prof. Zhamoida has sent a copy of "Supplements to the Stratigraphic Code of Russia"(VSEGEI, St. Petersburg, 2000, pp. 107).

• Prof. Salvador Reguant, Spanish representative to ISSC, has sent a copy of the Catalan version of the Abridged Version of the International Stratigraphic Guide, published by the Institut d´Éstudis Catalans, Secció de Ciències i Tecnologia. Barcelona, 2001, pp. 81. Its distribution is free to all Catalan High Schools.

In addition, Prof. Reguant informed that a translation into Spanish, by Prof. Jorge Civis, Salamanca University, will be available soon.

• Professor Yu. B. Gladenkov has requested circulation of his document “Concerning one Concept of Stratigraphy”. It is here attached as **Appendix F** to ISSC Circular No. 99

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