These minutes below represent a record of the deliberations of the ISSC meeting and are not intended as a "Lutheran" set of edicts. Rather they show progress in understanding among the various proponents. Readers of these minutes should know that not all the listed participants were in the room during the entire workshop. The "votes on consensus" were made by the people present at the meeting at that time. Similarly the listing attendance is only of those who signed and others were present at the meeting were not listed.
The issues and conclusions of the meeting participants still remain controversial and may even be incorrect. They represent a working agenda that could form part of the focus of the discussion among the SEPM friends of sequence stratigraphy at the coming AAPG Denver that may be organized for next year.

"Minutes of the ISSC Workshop on "New developments in stratigraphic classification"

WSS-11 at the 33rd International Congress, Oslo, Norway, August 10, 2008, 2 - 5.30 pm

Workshop moderator:	Kendall, Christopher
Secretary:	Strasser, André
Participants:	Abreu, Victor
	Beyer, Claus
	Catuneanu, Octavian
	Christie-Blick, Nick
	Cita, Maria Bianca
	Csaszar, Geza
	Embry, Ashton
	Finney, Stan
	Freeman-Lynde, Raymond
	Johannessen, Erik
	Kurina, Ekatarina
	Laursen, Gitte
	Lerch, Chris
	Menning, Manfred
	Pratt, Brian
	Räsänen, Matti
	Reijmer, John
	Weissert, Helmut

Background

Following the symposium HPS-12 on "New developments in stratigraphic classification", this workshop concentrated on sequence stratigraphy. The goal was to reach a consensus concerning sequence-stratigraphic nomenclature and definition of sequence-stratigraphic elements. The ultimate outcome should be a publication in the *Newsletters on Stratigraphy*, as for the other stratigraphic disciplines. This is part of an effort towards an update of the International Stratigraphic Guide as initiated by Maria Bianca Cita, outgoing chair of the International Subcommission on Stratigraphic Nomenclature (ISSC) of the International Commission on Stratigraphy (ICS).

The symposium on August 8 comprised the following presentations, which showed the state of the art in the different disciplines of stratigraphy:

Pratt, B.: Lithostratigraphy stays with the times.

Schokker, J., Weerts, H. & Westerhoff, W.: Integrating the concepts of lithostratigraphy and lithofacies in applied geological mapping.

Thierry, J.: Biostratigraphy: past evolution and future challenges.

Langreis, C., Krijgsman, W., Muttoni, G. & Menning, M.: Magnetostratigraphy - its future: possibilities, pitfalls and applications.

Weissert, H.: Carbon isotope stratigraphy - potential, problems and questions.

Strasser, A., Hilgen, F. & Heckel, P.H.: Cyclostratigraphy - from orbital cycles to geologic time scale.

Zalasiewicz, J.: The newest geological time period: the Ediacaran.

Finney, S.: The Hirnantian Stage and its GSSP: a record of rapid global climate change.

Melchin, M., Rong, J., Williams, S.H., Koren, T. & Verniers, J.: Report of the first restudy of a Global Stratotype Section and Point: the base of the Silurian System.

Thierry, J.: The Pliensbachian GSSP definition (Mesozoic, Lower Jurassic): a case study.

Cita, M.B.: K/T boundary and Danian GSSP.

Hilgen, F.: Progress in chronostratigraphy: the case history of the Miocene-Pliocene boundary and Zanclean GSSP.

Lerch, C., Thompson, T., Apps, G. et al.: Creation and application of a 3D synthetic stratigraphic and seismic model using systematic stratigraphic principles and realistic rock properties.

Singh, P., Slatt, R. & Coffey, W.: Sequence stratigraphy of mudrocks: example of the Barnett Shale, North Texas, USA.

Miller, K., Browning, J., Katz, M., Wright, J., Aubry, M.-P., Wade, B., Cramer, B., Kulpecz, A. & Rosenthal, Y.: St. Stephens Quarry, Alabama (SSQ) corehole: an integrated magento-, bio-, isotopic, and sequence stratigraphic reference section for the Icehouse-Greenhouse transition.

Suc, J.-P., Clauzon, G., Bache, F. et al.: The latest Miocene – earliest Pliocene Mediterranean mega-cycle in sea-level.

Cita, M.B.: Depositional processes, erosional episodes and stratal geometries recorded in the deep and steep slopes of the Atlantic Ocean: a marine geologist's perspective.

Freeman-Lynde, R.: Depositional processes and erosional episodes on the Bahama Escarpment.

Trincardi, F., Cattaneo, A., Ridente, D. & Verdicchio, G.: Quaternary sequence stratigraphy of the Adriatic sea: the role of sediment advection and short-term sediment flux fluctuations.

Reijmer, J.J.G.: Carbonate turbidites and debris flows: sea-level variations versus tectonic processes.

On August 10, five more lectures were given to prepare for the workshop that concentrated on sequence stratigraphy:

Kendall, C.: Sequence stratigraphy provides a basic framework to conceptual models used to interpret depositional systems: the key to simplification of the complex terminology of sequence stratigraphy is to use simple depositional models.

Christie-Blick, N., Madof, A.S. & Pekar, S.F.: Sequence stratigraphy: interpretation versus classification.

Catuneanu, O. & Posamentier, H.: Stratal stacking patterns and key bounding surfaces: the basis for a standard system for sequence stratigraphic analysis.

Embry, A., Johannessen, E., Owen, D. & Beauchamp, B.: Two approaches to sequence stratigraphic classification.

Neal, J. & Abreu, V.: A simplified scheme to classify the surfaces and geometries of sequence stratigraphy: the accommodation succession method.

The following minutes concern the ensuing discussion:

1. General procedure

We hope to determine common terms, standard hierarchy, and uniform methodology in sequence stratigraphy so users and teachers have a uniform understanding of this tool. At the same time we recognize that some interpretation is involved when naming a surface or a sedimentary package.

The classification proposed encompasses facies evolution, stratal geometries, and stacking patterns. Lateral *and* vertical relationships are to be considered. We recognized the importance of the lateral continuity of a surface if it is to be of sequence-stratigraphic significance (as for example the unconformities displayed on seismic sections or wide-spread stratigraphic markers in outcrop). We recognized that in many cases the maximum-flooding surfaces are the most useful of correlation horizons.

All features used for interpretation have to be **observation-based**, whether using outcrop, core, well logs, and/or seismic sections. Systematic changes in the patterns that are correlatable and define an evolution of the sedimentary system are of prime significance.

Consensus 1: Start with observable features in outcrop, core, well-log, and/or seismic sections.

A **stacking pattern** is represented by vertical stacking of facies. All observational data that characterize facies evolution, including surfaces, have to be considered in the analysis. Geometries can be seen because of contrasts in fabric and facies (grain-size trend, lithological contrast, seismic discontinuity, well-log characteristics). This is valid for all scales.

The **lateral correlation** is based on the observation of the continuity of surfaces and/or facies pattern. Random surfaces and facies patterns are generally related to local processes, whereas consistent patterns probably have a sequence-stratigraphic significance. Lateral correlation is an iterative process that optimizes the observations ("objective description"). It is recommended that one should start with the large-scale features, then work down into the detailed ones.

Consensus 2: First describe the large-scale features of stacking and geometry to establish a framework, within which the details can be later worked on and added.

The procedure for defining stacking pattern and lateral geometries is strongly dependent on the type of data. As the identification of stacking patterns is an interpretive process and the procedure cannot be generalized, examples should be provided (in the form of figures) that demonstrate how the stacking patterns were identified. This is valid for all types of data and for all scales. Additional data (e.g., biostratigraphy, chemostratigraphy, magnetostratigraphy, radiometric ages) can be added at this or at a later stage.

2. Defining surfaces

Subaerial unconformities are identified by a break in sedimentation. They may truncate underlying strata, form incised valleys, display karst and palaeosol features, and/or show evidence of continental facies. Local subaerial exposure may be related to random processes, but a wide-spread extension is significant for sequence-stratigraphic interpretation.

Consensus 3: In order to have sequence-stratigraphic significance, a subaerial discontinuity must have an obvious lateral continuity.

Maximum-flooding surfaces are characterized by a granulometric change from fining-up to coarsening-up, a facies change from deepening-up to shallowing-up, enrichment in organic matter, high gamma-ray, hardgrounds, enrichment in certain minerals (P, Fe, Mn, glauconite), intense bioturbation, and/or downlap seen on seismic profiles. On a basin-scale, they define the turn-around from retrogradation to progradation. They generally indicate maximum condensation through sediment starvation. Maximum flooding may be expressed by a discrete surface, and/or by an interval of maximum condensation (possibly containing a series of surfaces).

Two opinions are expressed regarding the terminology:

a. "Maximum-flooding surface" (MFS) is popular and should not be changed, although it already implies an interpretation related to relative sea-level change.

b. "Maximum condensation surface or interval" is purely descriptive. Once the sequence-stratigraphic interpretation is established, it can become a MFS. However, condensed intervals also occur in other settings (e.g., top lowstand in the basin). On shallow platforms, maximum-flooding conditions are commonly not expressed by condensation but by maximum accommodation gain. The turn-around from retro- to progradation, however, is visible in grain-size and facies evolution.

No consensus is reached on this issue.

Ravinement surfaces occur in coastal environments and are expressed by an erosional break between underlying shallow-marine, intertidal, or supratidal facies and overlying marine facies. The overlying sediment package may have a coarse-grained base and fines (deepens) upward. These surfaces may, however, be difficult to identify in seismic sections since they have limited lateral extent.

Consensus 4: this definition of ravinement surface is accepted.

Maximum-regressive surfaces (= transgressive surfaces) form at the change of facies from coarsening-up to fining-up, respectively from shallowing-up to deepening-up. The same turn-around is expressed in the stacking pattern. These surfaces can be conformable but may also contain a hiatus. In some cases there is not a well-defined physical surface developed but the rapid turn-around indicates the position.

Consensus 5: this definition of maximum-regressive surface (= transgressive surface) is accepted.

Correlative conformities are prolongations into the basin of surfaces developed on platform, ramp, and slope. On seismic profiles, the reflectors can be followed and are important for basin analysis (although they may not be exact time lines). However, correlative conformities are not identifiable in outcrop or well log.

Consensus 6: this definition of correlative conformity is accepted.

A **basal surface of forced regression** cannot be identified in outcrop, nor in seismic sections and well logs. The term should be abandoned.

Consensus 7: "basal surface of forced regression" is not a good term and should not be used.

A **slope onlap surface** (*sensu* Embry) is difficult to define because surfaces on the slope may be created by slope failure, contour-current erosion, and other processes. The definition is not clear; at the most it could correspond to a sequence boundary (*sensu* Vail).

No consensus is reached on this issue.

3. Defining sequences

To define sequences, surfaces have to be correlated and boundaries have to be established. A sequence is a template, depending on and varying with the type of depositional setting and the type of sediment. The goal is to provide a generic definition that is applicable to the different types of sequences.

Consensus 8: a 1-day workshop is needed to work out the definition of sequences.

This workshop could be held in conjunction with the AAPG Meeting in Denver in June 2009.

The PP-presentations of Symposium HPS-12 concerning sequence stratigraphy may be sent to Chris Kendall to be put on his web site (http://strata.geol.sc.edu/kendall.html).

Andreas Strasser / Fribourg, Christopher Kendall/ Columbia, Maria Cita/ Milan, Brain Pratt/ Saskatoon, 9 Septembert 2008