

Reply to Octavian Catuneanu's Comments on the ISSC Report on Sequence Stratigraphy

ISSC Task Group on Sequence Stratigraphy

First of all we would like to thank Dr Catuneanu for taking the time and effort to supply us with numerous comments on the circulating draft of our report. We have great respect for his expertise in sequence stratigraphy, and his numerous criticisms of our scientific efforts will be of value to us when we revise the report. We must note that we were somewhat taken aback at the hostile tone of his comments and by the inclusion of numerous personal slurs and of innuendo suggesting unethical behavior. We have chalked up the darker side of his comments to the price of producing a report on a controversial subject on which Dr Catuneanu holds strong views. Regardless, it is important to remember we are all on the same side, trying to reach the same goal: consensus through scientific debate on an important stratigraphic issue. No matter what the final result is, everyone benefits when science trumps faith and sequence stratigraphic practice and communication are significantly improved.

This said, we emphasize that all us on the Task Group are strong believers in the scientific method – observation, reason, criticism. Some people have a difficult time with criticism of scientific interpretations and models published by themselves and others. However, this is a key part of the process and that is why we welcome Dr Catuneanu's criticisms of our science. Of course, criticism must be confined to the science and not spill over onto the individuals doing the science. In our report we have been critical of a number of past interpretations and nomenclatural schemes in sequence stratigraphy including some authored by Dr Catuneanu and this may have incited Dr Catuneanu's wrath. We tried hard to target only the science but, if we unintentionally crossed the personal line in any of our critical comments, please take us to task. We can assure you that any such unacceptable "transgressions" will be expunged from the next draft and we will offer a sincere apology to the individuals involved.

In this reply to Dr Catuneanu, we do not want to dwell on minor points, especially those related to the historical development of sequence stratigraphy. These will be taken into account in the next draft. Rather, we want to focus on the one main point of contention that separates our approach to sequence stratigraphic methodology and nomenclature from that advocated by Dr Catuneanu in his book and recent papers. This point addresses the critical question of **"Can the two time surfaces (clinofolds/paleoseafloors), which represent the initiation of base level fall and the initiation of base level rise, be delineated and correlated in a scientifically acceptable manner in a variety of geological settings?"** Once agreement is reached by the sequence stratigraphic community on this straight forward question, the path to consensus on methods and nomenclature for sequence stratigraphy will be clear.

In our report, we argued that such time surfaces cannot be recognized by using the acceptable scientific methods that allow the recognition of the five empirical surfaces of sequence stratigraphy (MFS, SU, SR, MRS and RSME) and, for that matter, the stratigraphic surfaces in all the other "concrete" stratigraphic disciplines. Once such a position was arrived at, on the basis of our arguments and references, the various types of sequence stratigraphic units advocated in the report became essentially inescapable.

Alternately, if it can be demonstrated that the two time surfaces in question can be empirically recognized in a manner similar to the other five surfaces of sequence stratigraphy, then the methods and units advocated by Hunt and Tucker (1992), Helland-Hansen and Gjelberg (1994) and Catuneanu (2006) become the obvious way to go.

It is that simple. So the good news is, all we have to do is answer one question in a rigorous, scientific fashion and consensus on sequence stratigraphic methods, surfaces and units is readily at hand. Consensus on nomenclature should be relatively easy to achieve once the different types of surfaces and units are agreed upon.

Dr Catuneanu has objected to our characterization of the “basal surface of forced regression” (BSFR) and the “correlative conformity (sensu Hunt and Tucker)” (CC) as the time surfaces. He prefers to refer to them as “clinoforms”. Nick Christie-Blick (pers. comm., 2007) defines a clinoform as a fossil depositional slope and we think this captures its meaning quite nicely. The stratigraphic record can be seen as consisting on an infinite number of clinoforms stacked on each other as deposition and erosion constantly change the shape of the surface of the earth. To us, a clinoform represents a depositional surface/slope at a given instant in time and thus, for all intents and purposes, the term clinoform is synonymous with the term time surface. We realize that Dr Catuneanu can split hairs and claim that a clinoform is not a true time surface because of the miniscule but finite amount of time it takes for sediment to be deposited on the surface but such a viewpoint is not relevant for the argument at hand. We will be sure to elaborate on the equivalence between a time surface and a clinoform in the final report to remove any confusion on these two ways of saying the same thing.

There are potentially millions of conceptual clinoforms/paleoseafloors (time surfaces) which might be delineated in a stratigraphic succession with each one representing the depositional surface/slope at the time of a defined, site-specific event (e.g. the first appearance of fossil X at locality Y or a change in chemical signature W at locality Z). As noted previously, the conceptual clinoforms proposed for use in sequence stratigraphy by Dr Catuneanu and others workers are those that formed at the start of base level fall at the shoreline (BSFR) and the start of base level rise at the shoreline (CC). In order for these, and any other conceptual clinoforms, to be considered “real”, physical criteria which allow them to be delineated and correlated in a stratigraphic succession must be demonstrated to exist. In short, we need adequate empirical data to allow such deductive entities to be accepted as bona fide surfaces of sequence stratigraphy. Unfortunately neither the BSFR and CC have any physical expression (“traces” in philosophy of science terms) to allow them to be recognized by scientific means in most geological settings. The simple reason for this is that nothing sedimentologically happens over most, if not all, the marine area at the instants when base level starts to fall or starts to rise.

We have argued in our report that no acceptable physical criteria have been demonstrated to exist or would even be expected to exist so as to allow the recognition of the proposed clinoforms/time surfaces in a scientific manner. We would again emphasize that there are no published examples of such conceptual entities being delineated and correlated on stratigraphic cross sections. There are only a few, “real world”, stratigraphic cross sections in Dr Catuneanu’s book and notably such surfaces are not present on any of them. These surfaces are also absent from any “real world” stratigraphic cross sections published by Dr Catuneanu in his numerous papers on sequence stratigraphy. Dr Posamentier’s book and papers also do not contain such surfaces on cross sections.

Furthermore, there are no pictures of such clinofolds in any publication. This stands in stark contrast to the delineation of the five empirical sequence stratigraphic surfaces on innumerable published cross sections (including the few sections in Dr Catuneanu's book) and to their illustration in many published photographs (including nice examples in Dr Catuneanu's book).

In his book and his comments on our report, Dr Catuneanu appeals to the existence of such clinofolds on seismic sections and in his book he provides a few seismic lines (e.g. Figures 4-17, 4-19) with such clinofolds interpreted on them. To him, this provides the necessary data to document the "realness" of the BSFR and CC. We would argue that such seismic-based interpretations are very speculative because of the low vertical resolution of seismic data and the complete lack of any core data to support the interpretations. On Figure 4-19 in Dr Catuneanu's book, the reflector interpreted as the BSFR can be simply interpreted as an MFS because of the downlapping geometry associated with the reflector. The interpreted CC (Figure 4-17) can be readily interpreted as an MRS and geometrical relationships on published, adjacent seismic lines, not discussed by Dr Catuneanu, strongly support the MRS interpretation. These alternative interpretations will be the subject of a forthcoming paper and are mentioned to emphasize the point that seismic data, with its low vertical resolution, will always be equivocal in regards to the identification of a specific stratigraphic surface. The bottom line is seismic data will never be adequate for demonstrating the existence and determining the physical characteristics of the conceptual clinofolds/paleoseafloors proposed for use in sequence stratigraphy. There can be no doubt that data from exposed strata are required to accomplish this and such data have yet to be collected and published by anyone. At best, such seismically-defined clinofolds can be considered part of seismic stratigraphy in which reflectors are mapped but not interpreted in terms of surfaces from other stratigraphic disciplines (sequence stratigraphy, lithostratigraphy).

We challenge those who would want to employ the two conceptual clinofolds/paleoseafloors in sequence stratigraphy, to provide adequate physical criteria which allow them to be recognized and correlated in well exposed strata in a wide variety of geological settings by competent stratigraphers. It is essential that such surfaces be recognizable in both ramp and shelf/slope settings and in both clastic and carbonate sedimentary regimes. Their delineation and correlation on stratigraphic cross sections would go along way to convince us of their reality as would photographs of the clinofolds from various localities and settings. If we are going to recognize them and use them to bound our sequence stratigraphic units, we have to know what they look like. Such data are abundantly available for the five empirical surfaces we accept as bona fide sequence stratigraphic surfaces in our report and there is no reason not to hold any other surfaces proposed for use in sequence stratigraphy to the same standard. If such scientific data become available for the proposed clinofolds, we will accept them as being "real" and incorporate them into our recommendations to ISSC for sequence stratigraphic methods, units and terminology. Their addition would increase the value of sequence stratigraphy and we would welcome them. However, until such data are available, we feel it would be irresponsible and a disservice to the sequence stratigraphic community to offer any recommendations which imply the existence of these conceptual clinofolds. Such a premature recommendation would burden stratigraphers with the task of trying to recognize surfaces and associated units which may well turn out to be unrecognizable with scientific methods.

Finally, it is perhaps worth repeating the words in the NACSN Code “Emphasis is placed on the relative objectivity and reproducibility of data in defining units in each category”. We await the assembly and presentation of objective and reproducible data by those who advocate the “realness” and use of these conceptual clinofoms.