Ordovician sea-level changes in Baltoscandia

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Baltoscandia was positioned at about 60ºS latitude in the Early Ordovician, but gradually moved northwards and entered the subtropical realm in the Late Ordovician. This caused changes in the depositional environment, and four depositional phases are distinguished:

1. Extremely sediment-starved clastic deposition and widespread dysoxia (Late Cambrian to early late Tremadoc)
2. Very slow deposition of cool-water limestones (often glauconitic) on the midshelf with extremely condensed glauconite-rich clastics on the inner shelf (late Tremadoc-mid Arenig)
3. Slow deposition of cool-water limestones largely without glauconite throughout the inner and midshelf (Llanvirn-early Caradoc; transitional interval with deposition of shallow-water glauconitic limestones during the late Arenig)
4. Slow deposition of cool-water limestones in deeper-water settings associated with more rapidly accumulating local carbonate build-ups and warm-water limestones in shallower water (mid Caradoc-Ashgill)

Lithofacies models have been established for each of these depositional phases. Overall the craton was extensively flooded and the clastic supply to the epicontinental sea was therefore very limited. The Baltoscandian Ordovician successions are therefore extremely condensed. Along the western [present day direction] periphery the clastic influx increased from the Llanvirn onwards as a result of the ongoing closure of the Iapetus Ocean with development of a foreland basin adjacent to the rising Caledonide mountain belt. As a result of the slow deposition in combination with almost quiescent tectonic conditions the sea level record essentially reflects eustasy, making the area ideal for the analysis of sea level changes.

In connection with the IGCP 410 project the present author worked out an integrated sea level curve for the Ordovician of Baltoscandia (Nielsen in press, 2003). The reconstruction is based on an analysis of the successions in the Oslo Region, Scania, Siljan, southern and northern Estonia, supplemented by data from Västergötland, Öland and Jämtland. It was aimed at to analyse a depth transect across the Baltoscandian shelf, anchored in the outer shelf successions preserved in Oslo and Scania. This approach ensures easy identification of gaps relating to lowstands in the nearshore locations and at the same time the relatively nearshore sections provide a better resolution for the highstand intervals, represented by relatively uniform mudstone successions on the outer shelf.

The preserved Ordovician successions essentially comprise vertically stacked, non-prograding thin strata, and conventional sequence stratigraphy therefore does not apply. Omission surfaces (most of which are inferred to be submarine) are numerous particularly shorewards, and identifying the sequence stratigraphical importance of individual surfaces is virtually impossible within a given area. Erosion associated with even major stratigraphic gaps is in most cases surprisingly limited and revealed mainly by comparison with more complete successions elsewhere. Channelling is reported only from the highest Caradoc-Ashgill, indicating that the area was submerged throughout the Ordovician. Hence the sea-level changes were mainly deduced from lithofacies distribution whereas the recognition of unconformities was given less weight.

The Baltoscandian sea-level curve, which probably represents 3rd order oscillations, has been generated in three steps: 1) An initial interpretation was based on lithofacies analysis of the Ordovician succession in the Oslo-Asker district of southern Norway, which is dominated by shales and mudstones interbedded with nodular limestone units (see Owen et al. 1990 for review). 2) The resulting curve was then compared with data from the mainly calcareous deposits described from Sweden, notably the fairly complete succession preserved in the Siljan area (see Jaanusson 1982 for review). The Jämtland, Västergötland, Scanian and Öland successions have also to some extent been included, of which Scania and Jämtland represent the deepest and Öland the shallowest palaeo-depth on the shelf profile. The correlation with Swedish sections permitted a first check on the sequence of sea-level changes, but also provided a more detailed scaling of the highstand intervals, represented by relatively uniform mudstone units in the Oslo region. 3) The adjusted curve was finally compared with the
successions described from Estonia (also dominated by limestones, but often more argillaceous), where I focussed on a transect from southern to northern Estonia (for reviews of lithostratigraphy, see Männil & Meidla 1994 and Raukas & Teedumäe 1997). The successions of northwestern Estonia represent the most nearshore Middle-Upper Ordovician deposits preserved in Baltoscandia, whereas the deposits of southern Estonia and bordering Latvia represent deeper-water facies similar to those in central Sweden. This third step of pattern recognition again ensured that the succession of events was verified, and further details of the sea-level highstand intervals could be added and calibrated according to lithofacies.

The correlation of sea level changes has a vast but as yet essentially untapped potential for improving the correlation of Ordovician successions. An insight into sea level changes also provides an improved understanding of the traditional bio- and lithostratigraphic correlations and some pitfalls may be avoided. It is in this context stressed that highstand events are easier to correlate in terms of biostratigraphy, because the relatively more widely distributed deep-water faunas (graptolites/conodonts) spread across the shelves. A quick glance at the sea level chart also indicates a clear tendency for adaptive radiations among graptolites to match drowning events; this trend may also be valid for other groups. Lowstands leave conspicuous marks in the shelfal sedimentary record, and were originally the primary tool for correlation of depositional sequences (Vail et al. 1977). However, shallow water faunas tend to be endemic and are therefore notoriously difficult to correlate. Despite the fundamentally different correlation potential, no philosophy about sea level changes has been formulated regarding intercontinental chronostratigraphic correlation of the Ordovician. In this perspective it is a matter of concern that the base of the Middle Ordovician has been suggested at the base of an extended, composite lowstand, wherefore biostratigraphic correlation might be anticipated to prove difficult. To some extent the same may be said for the base of the Upper Ordovician, which, however, in detail seems to tie in with the terminal part of a highstand interval and thus may be anticipated to have a better potential for widespread bio-based correlation.

References