MICROPALAEONTOLOGY NOTEBOOK

Sequence stratigraphy and eustatic sea-level change: the role of micropalaeontology

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Following the May 1992 meeting in Dijon, which initiated an international project on the "Sequence Stratigraphy of European Basins", it seems an appropriate time to consider the contribution micropalaeontology can make to the science of sequence stratigraphy. In this short note, we assume that readers are familiar with sequence stratigraphic terminology; if not, see Van Wagoner *et al.* (1988).

WHAT ARE THE CHALLENGES FACING SEQUENCE STRATIGRAPHY?

Demonstrating global eustatic sea-level change. We accept that the basic sequence stratigraphy model put forward by Peter Vail and his colleagues (see Van Wagoner *et al.*, 1988 for a summary) is a powerful tool for describing many sedimentary successions, and that the associated eustatic sea-level curve (Haq *et al.*, 1987) has some validity. Our own observations on numerous sedimentary sequences around the world suggest that local *and* global eustatic events exist, and that relative sea-level curves can be constructed, but it should be remembered that the timing and magnitude of many global eustatic events ***are still to be established.*** As most workers in the field will be aware, much of the evidence to support the Haq *et al.* curve has not been published. The Sequence Stratigraphy of European Basins Project will go some way to rectify this, but it should be borne in mind that there can be an unfortunate tendency to use the Haq *et al.* curve for dating in its own right - i.e. fitting relative sea-level changes seen in a succession to the curve. If this is done, then the global eustatic curve will become no more than a self-fulfilling prophecy.

Recognising sequence boundaries, maximum flooding surfaces and systems tracts in individual successions. The basic sequence stratigraphic model is established. Geologists are now attempting to identify sequence boundaries, maximum flooding surfaces and systems tracts in numerous successions around the world. Systems tracts and sequence boundaries were originally defined by seismic geometries. Later they were recognised by stratal patterns and facies variations in outcrop, and in the subsurface by wireline log responses. However, micropalaeontology can also play an important role in recognising systems tracts and key surfaces.

HOW CAN MICROPALAEONTOLOGY HELP?

Before answering this question it is important to stress that the application of micropalaeontology to sequence stratigraphy has not yet been established by the publication of controlled case studies. Much work needs to be undertaken to prove the applications of micropalaeontology. However, these are some of the possible applications that need to be explored:

Dating: For building a local sea-level curve that can contribute to a global curve, it is important to establish the age of a succession and this is an obvious role for micropalaeontology with its applicability to both outcrop and well sections. Micropalaeontologists will be aware that microfossils are often a more suitable tool than macrofossils for dating a succession because of their relative ease of extraction, abundance and often their known relationship to established zonal schemes and hence geologic time.

Correlation: Sequence stratigraphic models are based on a relative (or preferably absolute) chronostratigraphic framework which requires a detailed but robust biozonation scheme of the type often provided by micropalaeontology. Many micropalaeontologists have a good perception of age control and correlation across facies because they work on microfossil groups that inhabited a range of palaeoenvironments.

Maximum flooding surface recognition: Because of its widespread nature and thus correlation potential, one of the most critical surfaces to recognise in the sequence stratigraphic analysis of a succession is the maximum flooding surface (MFS). A number of workers (e.g. Loutit *et al.*, 1988; Vail & Wornardt, 1990) have emphasised the point that the MFS can often be recognised by an palaeontological abundance peak, especially of planktonic microfossils, together with the potential condensation of biozones. We agree, but urge readers to consider the point that plankton abundance peaks can occur for other, more localised, reasons (e.g. climatic controls on upwelling). Taphonomic controls should also be considered. It should be remembered that microfossil abundance can also occur on other downlapped surfaces and/or condensed intervals (e.g. the top of a lowstand fan or flooding surfaces within a transgressive systems tract). Similarly, a number of workers (e.g. Ellison, 1989) have suggested changes in the abundance of mangrove pollen type can be used to determine relative sea-level changes in suitable successions. Again this needs to be applied critically, considering other possible controls on abundance.

Sequence boundary recognition: The relative sea-level fall leading to the formation of a sequence boundary causes a basinwards shift in facies and the development of an unconformity on the shelf. This should be reflected in a dramatic change in microfossil assemblages, together with missing biozones (if the zonation is of sufficient resolution). Techniques such as graphic correlation can be used to demonstrate the presence of a hiatus. In the sediments directly overlying the unconformity reworking of microfossils from the underlying sequence may be observed, together with the contemporaneous transportation of biota into lowstand fans (although in carbonate settings highstand shedding can result in similar patterns of redeposition).

Systems Tract Characterisation: Systems tracts prograde, retrograde or aggrade, depending on their position during sea-level change. From the detailed study of biofacies, shallowing-up or deepening-up trends can be established, which indicate likely systems tract. Furthermore, it seems possible that for given environmental settings at given geological times, systems tracts could be characterised by particular assemblages (i.e. the composition, diversity and density of assemblages and the morphology and size of individuals) that are themselves the response to relative sea-level change. Opportunistic taxa may characterise a transgressive system tract, whilst species diversification takes place during the highstand systems tract. This is a particular application of micropalaeontology that requires further research.

CONCLUSIONS

Our main message is one of caution. Most active micropalaeontologists will be aware that our subject area (not withstanding the classic limitations of sampling, preservation, resolution, endemism, etc.) has a critical role to play in building sequence stratigraphic models and developing relative sea-level curves. One only has to examine the brochures of biostratigraphic service companies to see that many micropalaeontologists have seized the opportunity to use micropalaeontology as more than just a simple "dating" tool. We agree, but would remind readers that the applications of micropalaeontology to sequence stratigraphy are model driven and yet to be proven. We advocate that the empirical evidence behind the models be sought out and documented.

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