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Pre-Quaternary sea-level changes: records and processes

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INTRODUCTION

This Special Issue of *Basin Research* focuses on the long-term record of sea-level change from the Jurassic to the Miocene. The papers arose from a multidisciplinary international symposium *SEALAIX'06: Sea Level Changes: Records, Processes and Modeling* held in Presqu'Ile de Giens, France from 25 to 29 September 2006 and convened by Gilbert Camoin, André Droxler, Craig Fulthorpe and Ken Miller. The symposium was sponsored by the International Association of Sedimentologists (IAS), the Society for Sedimentary Geology (SEPM), TOTAL, the Centre National de la Recherche Scientifique (CNRS), the Provence-Alpes-Côte d'Azur Region, and the French Association of Sedimentologists (Association des Sédimentologistes Français, ASF). All sponsors are gratefully acknowledged.

Scientific themes of SEALAIX'06 included the records, sedimentary processes, and modeling of sea-level changes in carbonate, siliciclastic and mixed margins and deep sea settings. The symposium was structured around: (1) Quaternary sea-level changes, (2) icehouse Earth sea-level changes (last 33 Ma), (3) greenhouse Earth sea-level changes (250–33 Ma) and (4) Paleozoic sea-level changes. SEALAIX'06 was attended by 160 participants from 21 countries (including 17 funded students and young scientists). Participants represented diverse specialities and research interests, including sedimentology, geochemistry, geophysics, modeling, geodynamics, geomorphology, paleoceanography and biology. Five keynote presentations, 45 short talks and 75 posters were presented. Workshop sessions were held on: (1) current knowledge, (2) future issues, (3) controversies regarding sea-level records, processes, and modeling, and (4) strategies to address sea-level changes within international Earth Sciences programs (e.g., IODP, IMAGES, PAGES, MARGINS). Abstracts were assembled in a Special Publication of the Association of French Sedimentologists (Camoin, Droxler, Fulthorpe and Miller, Eds, 2006. Sea-level records, processes and modeling, *A.S.F. Spec. Publ*).

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SPECIAL ISSUE

Short-term global sea-level (eustatic) changes have the most direct human impact, but the present and the recent past provide only a 'snapshot' of the constantly varying climatic and tectonic states that have existed during the history of the Earth. In order to understand the environmental and societal impact of potential future eustatic trends, it is vital to document how the Earth system has operated under different past conditions. Therefore, we must also evaluate pre-Quaternary icehouse conditions and the greenhouse of the Mesozoic and early Paleogene, as well as anomalous events such as the ~55 Ma Paleocene-Eocene Thermal Maximum. Furthermore, an understanding of long-term eustatic history is critical to reading the stratigraphic record of climatic and geological processes because relative sea level and the position of the shoreline control the deposition, erosion and transport of marine sediment. Such understanding is also essential to understanding how basins fill and to achieve the long-sought goal of predicting margin lithologies in the absence of drilling: it is no coincidence that theories linking eustasy to sequence stratigraphy were developed within the oil industry (e.g., Mitchum *et al.*, 1977; Vail & Mitchum, 1977). Finally, constraining the long-term history of sea-level change provides data of direct use to researchers in other disciplines because of the relationships between eustasy and ice-sheet growth and decay, nutrients and ocean productivity, carbon storage and ocean chemistry.

Although the goal of reconstructing past sea level appears simple, the task is complex because the stratal geometries that define sedimentary sequences worldwide result from a complex interplay of processes acting in three dimensions. Eustasy competes with climatic and paleoceanographic variations, tectonism (variable rates of subsidence), rates of sediment supply and submarine current activity to influence relative sea-level and stratigraphic development and preservation. Reading the stratigraphic record, therefore, requires evaluation of multiple processes (including eustasy) at various temporal and spatial scales (Nittrouer & Kravitz, 1995).

The papers in this Special Issue describe research carried out on both carbonate and siliciclastic depositional environments and sedimentary systems addressing the sedimentary response to eustatic change (e.g., sedimentary architecture, carbonate production, siliciclastic input) and the timing and amplitudes of eustatic change. A common thread running through the papers is the application of sequence stratigraphy to these problems. Sequence stratigraphy hinges on the identification of the unconformity-bounded units (sequences) that are the building blocks of the stratigraphic record (Vail & Mitchum, 1977). Sequence stratigraphy is one of the principal techniques for evaluating the timing and amplitudes of sea-level change (both relative and global), as well as the stratigraphic response to such changes. This set of papers applies sequence stratigraphic techniques to outcrop, core and reflection seismic data.

Ramajo and Aurell employ facies analysis to constrain paleobathymetries across a Jurassic (Callovian-Oxfordian) carbonate platform in the northern Iberian basin of Spain. They identify two transgressive-regressive cycles, both containing higher order cycles, and provide provocative evidence for a eustatic fall at the Callovian-Oxfordian transition, possibly related to global cooling, that contrasts with interpretations of rising global sea level during this period (e.g., Haq *et al.*, 1987).

Tcherepanov *et al.* also focus on a carbonate setting, using seismic and well data to document the Eocene to Miocene carbonate phase of deposition in the Gulf of Papua. They propose that eustasy was the main control on stratigraphic architecture because of similarities between sequence stacking patterns in the gulf and those in other carbonate (e.g., Maldives, Bahamas) and siliciclastic settings worldwide, a pattern described as the stratigraphic signature of the Neogene by Bartek *et al.* (1991).

Four papers address the New Jersey margin, which has been the location of the most comprehensive academic sea-level research program to date. Both onshore and offshore scientific drilling under the auspices of the Ocean Drilling Program (ODP) is complemented by extensive seismic surveys. Kominz *et al.* use corehole data from the New Jersey coastal plain to estimate eustatic amplitudes for the last 108 my using backstripping analysis. Amplitude determination is complex because of the multiple parameters that must be constrained and this paper openly confronts the uncertainties involved. Browning *et al.* used the onshore New Jersey coreholes to analyze the latest Early Cretaceous to Miocene interval (~110–7 Ma) focusing on facies evolution. They identify eight depositional phases which replace one another on a ~10 my-scale in response to changes in accommodation, shifts in sediment supply and provenance, and long-term global sea-level changes.

Two of the New Jersey papers address three-dimensionality and along-strike variability of sequences and the roles of local processes in modulating eustatic control on sequence architecture. Both highlight the need for extensive seismic grids for selection of drillsites in order to target locations where sequences are sufficiently expanded and well defined. Monteverde *et al.* use seismic and onshore core data to calibrate and map early Miocene sequences beneath the inner and middle shelf, where lowstand deposits form local depocenters that probably reflect the distribution of fluvial inputs. Cross-shelf sediment dispersal was dominant during periods of falling relative sea level, whereas along-strike sediment redistribution could dominate at other times. Fulthorpe and Austin use seismic data from the outer shelf and slope to examine overlying middle-late Miocene sequences tied to ODP drill sites. They also find considerable along-strike variation in sequence architecture, possibly related to differential subsidence, in spite of the linearity (in plan view) of paleoshelf edges. Along-strike sediment transport may mute the influence of individual fluvial point sources and may explain the lack of distinct fan deposits and rarity of onlap.

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REFERENCES

Bartek, L.R., Vail, P.R., Anderson, J.B., Emmet, P.A. & Wu, S. (1991) Effect of cenozoic ice sheet fluctuations in Antarctica on the stratigraphic signature of the Neogene. *J. Geophys. Res.*, **96**, 6753–6778.

Haq, B.U., Hardenbol, J. & Vail, P.R. (1987) Chronology of fluctuating sea levels since the Triassic (250 million years ago to present). *Science*, **235**, 1156–1167.

Mitchum, R.M. Jr., Vail, P.R. & Thompson, S. (1977) Seismic stratigraphy and global changes of sea level, part 2: the depositional sequence as a basic unit for stratigraphic analysis. In: *Seismic Stratigraphy–Applications to Hydrocarbon Exploration* (Ed. by C.E. Payton), *AAPG Memoir* **26**, 53–62.

Nittrouer, C.A. & Kravitz, J.H. (1995) Integrated continental margin research to benefit ocean and earth sciences. *Eos*, **76**, 121–124, 126.

Vail, P.R. & Mitchum, R.M. Jr. (1977) Seismic stratigraphy and global changes of sea-level, part 1: overview. In: *Seismic Stratigraphy – Applications to Hydrocarbon Exploration* (Ed. by C.E. Payton), *Am. Assoc. Petrol. Geol. Memoir* **26**, 51–52.