Exploring controls on continental shelf width: Is the shelf-edge lock-in effect real?

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Introduction: Continental shelves are some of the most significant bathymetric features on Earth, yet despite their scale and importance in controlling coastal evolution and sediment routing into deep water, both things with significant societal impact, many aspects of how and why the continental shelves have formed remains relatively poorly understood. For example, what controls shelf width, how does shelf width evolve through time on continental margins, and what impact does this have on sediment routing and coastal evolution. Recent work has focused on better understanding the sediment budgets responsible for continental shelf formation (e.g. Carvajal et al. 2009), leading to some progress with basic insights into what controls the width of shelves. However, it is possible that shelf width is a function of more than just sediment supply volume. Burgess et al. (2008) suggested that shelf width may also be controlled by the dynamics of clinoform progradation, such that the early history of clinoform progradation locks-in and sets future shelf width, which is then largely insensitive to subsequent changes in accommodation and supply.

Project Summary (max 700 words inc introduction): The purpose of this project is to explore, develop and refine the ideas first developed in Burgess et al. (2008) to better understand how the history of basin-margin clinoform formation controls shelf width. Burgess et al. (2008) argued that shelf width should more accurately be referred to as topset width, given that outside of icehouse periods coastal plains perhaps extended to the shelf edge in many cases. The numerical forward modelling in the paper showed that topset width may be set by initial progradation on a continental margin, and once set, remain a persistent feature of the margin for millions of years. However, since only one numerical stratigraphic forward model was used in that analysis (Dionisos, Granjeon and Joseph 1999), it could be that this was just an artefact of the particular model formulation in Dionisos. This PhD project would have three main aims:

1. To use other numerical stratigraphic forward models e.g. SedSim (Griffiths 2001) and SedFlux, Hutton and Syvitski, 2008) to run model scenarios with similar accommodation and supply parameters to the Dionisos models in Burgess et al. (2008) (fig. 1). Results from these models would then be analyzed to determine whether similar shelf-edge lock-in processes occur. If the same process occurs, or not, we will then need to understand why.

2. Use all three models, plus possibly some simple new algorithms for shelf-edge delta formation and slope failure, to better understand how steepening foreset gradient during progradation may limit clinoform progradation and hence shelf topset width on basin margins.
3. Comparison of these various model results with existing scenarios for delta and shelf evolution derived from industry seismic data sets, to further assess how realistic the numerical model processes are likely to be.

The PhD student working on this project will receive an excellent training in source-to-sink concepts, seismic stratigraphy and numerical forward modelling, particularly focused on large-scale evolution of basin margin strata.

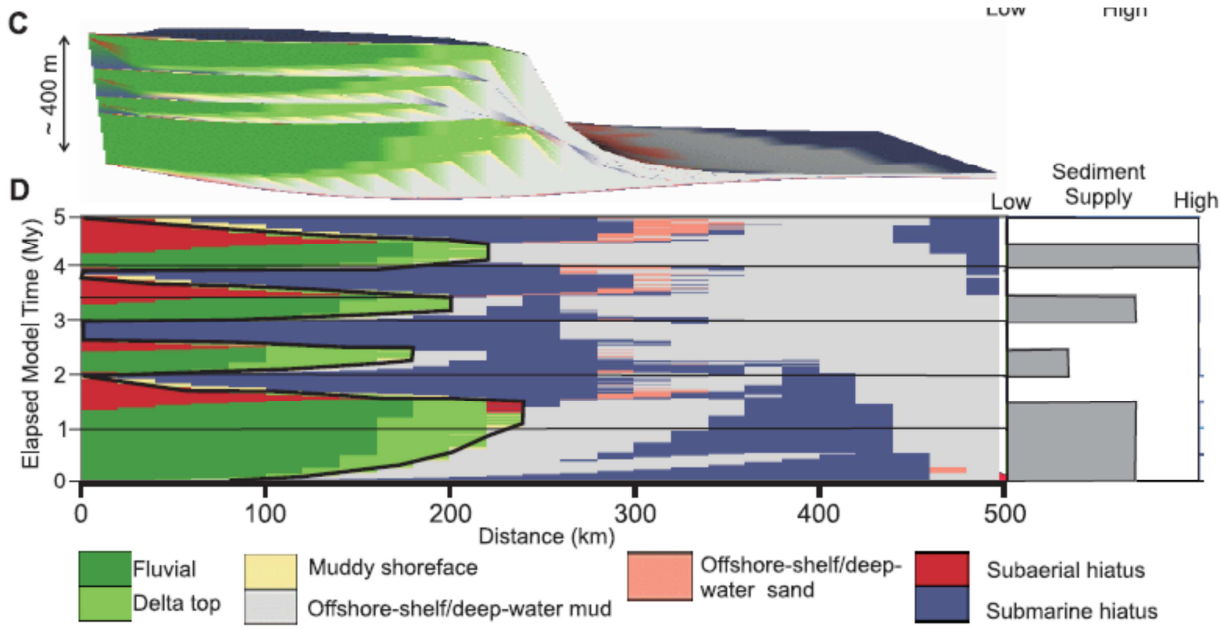

Figure 1. A cross section and a chronostratigraphic diagram from Burgess et al. (2008) showing the results of time-varying sediment supply operating in on–off pulsed mode. The model run shows how an initial position of the shelf–slope break is established during the first sediment-supply pulse. Subsequent pulses of relatively reduced sediment supply still prograde across a significant portion of the shelf width, and pulses of increased supply do not extend significantly beyond the originally established shelf–slope break because of the self-regulating effects of the bathymetry beyond the delta front. A key questions this project will address is whether this effect is realistic or not.

References

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