Linking knickpoint morphodynamic processes to the stratigraphic products of modern and ancient submarine channels

Daniel Bell[1], Stephen Hubbard[1], Maarten Heijnen[2], Michael Clare[2], Matthieu Cartigny[3], Sophie Hage[1,4], Rebecca Englert[1], Paul Nesbit[1], Joris Eggenhuisen[5], Brian Romans[6], Gwyn Lintern[7], Cooper Stacey[7], John Hughes-Clarke[8]

[1] Department of Geoscience, University of Calgary, University Drive NW, Calgary, T2N 1N4, AB, Canada; [2] National Oceanography Centre, European Way, Southampton SO14 3ZH, UK; [3] Departments of Geography and Earth Sciences, University of Durham, South Road, Durham DH1 3LE, UK; [4] Univ Brest, CNRS, Ifremer, Geo-Ocean, F-29280 Plouzané, France; [5] Department of Earth Sciences, Universiteit Utrecht, Heidelberglaan 8, 3584 CS Utrecht, Netherlands; [6] Department of Geosciences, Virginia Tech, Blacksburg 24060, VA, United States; [7] Natural Resources Canada, Geological Survey of Canada, Box 6000, 9860 West Saanich Road, Sidney, BC, Canada; [8] Earth Sciences, Center for Coastal & Ocean Mapping, University of New Hampshire, 24 Colovos Road, Durham 03824, NC, USA.

Summary

In comparison to rivers, which are relatively easy to access and monitor, submarine channels are difficult to observe. This has inhibited our ability to link morphodynamic and flow processes to the stratigraphic record in submarine channels; models are commonly drawn from rivers due to their planform similarities, or from experiments which often do not scale well to natural systems. In this study we utilise repeat bathymetric surveys of an active submarine channel to constrain the stratigraphic products of upstream migrating knickpoints over ten years. We contrast these findings to ancient submarine channel-fills and the established cut-and-fill models to offer an alternative stratigraphic evolution model for submarine channel-fills opposed to those drawn from rivers or reliant on allogenic controls.

Abstract

Near-continuous monitoring of terrestrial channels (i.e. rivers) through field-observations and remote sensing reveals the lateral migration of barforms is a primary control on their evolution. This produces high aspect ratio channel belts containing laterally accreting sedimentary bodies and couples sedimentary processes to the rock record (Fig. 1). Conversely, submarine channels are notoriously challenging to monitor, and natural flow conditions are challenging to recreate in physical experiments. The planform similarity of submarine channels to rivers means application of the point bar model to submarine channels is often tantalizing. However, trajectories of submarine channel belts have significant aggradational components, lower aspect ratios, and stratigraphic architectures which are typically dominated by cut-and-fill patterns rather than laterally accreting bodies (Fig. 2). Thus, despite decades of research, the link between sedimentary processes and the depositional record are comparatively poorly understood in comparison to rivers. Crucially, recent advances in monitoring technology and techniques now allow us to image submarine channel morphologies at high resolution at regular time intervals, and intra-channel moorings can record the occurrence and flow structure of the turbidity currents within them. These advances present paradigm shifting opportunities to link the morphodynamic and flow processes of deep-water systems to the rock record.

In this study, we analyse the depositional geometries of an active submarine channel using seven repeat bathymetric surveys (Bute Inlet, Canada); and an exhumed submarine channel system using field mapping and a digital outcrop model (Tres Pasos Fm., Chile).

Over decadal timescales, the evolution of the submarine channel in Bute Inlet is dominated by upstream migrating (100s of m/year) knickpoints, with minor lateral migration. Vertical incision is focused in the channel axis at the head of a knickpoint, whilst deposition occurs downstream of the knickpoint; consequently, successive upstream migrating knickpoints rework the deposits of previous knickpoints. This process produces a repeated pattern of cut-and-fill characterised by lenticular-, flute-, and wedge-shaped deposits which are comparable to those observed in the Tres Pasos Formation. We suggest that the cut-and-fill packages, discontinuous lenses and wedges of sediment, and lack of obvious lateral accretion in the Tres Pasos Formation channel-fills can be explained by repeated knickpoint migration; thereby coupling the rock record to morphodynamic processes. We hypothesise that upstream migrating knickpoints are a primary morphodynamic agent in submarine channels, comparable in function to point and braid bars in rivers. Accordingly, the role of knickpoints has been previously unappreciated in many systems and may provide an improved channel-fill model for re-appraisal of a host of previously studied systems.

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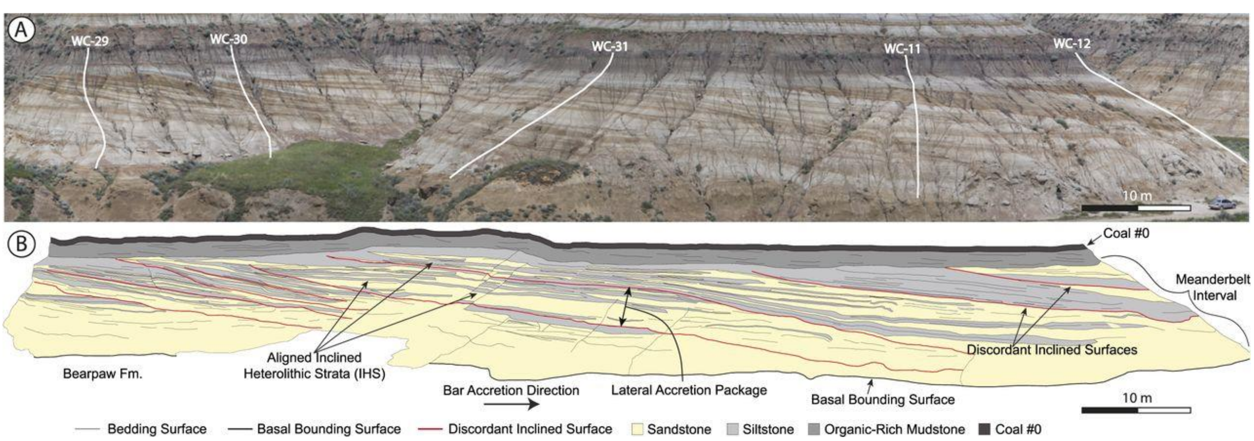

Figure 1: Lateral accretion of point-bar deposits, Horseshoe Canyon Formation, Alberta (Durkin et al., 2015)

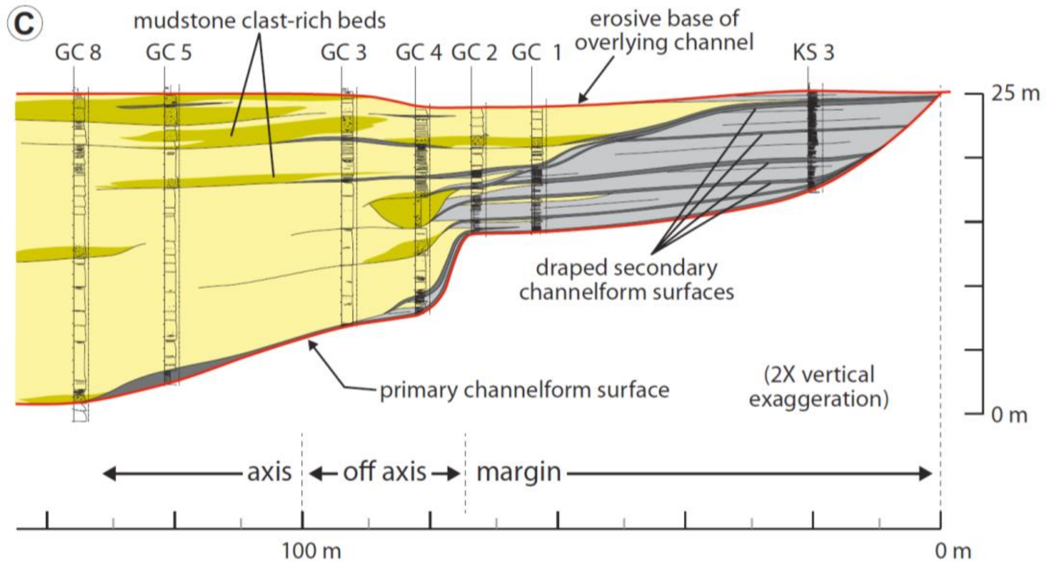

Figure 2: Stratigraphic expression of cut-and-fill packages, and absence of lateral accretion, typical of outcropping submarine channel-fills, Tres Pasos Formation, Chile (Hubbard et al., 2014).

References

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