The Geometry and Heterolithic Fill of Tide Influenced Channels in the Gulf of Carpentaria, Australia

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Summary

The interaction between fluvial and tidal processes in channelized systems often results in the deposition of highly heterogeneous and complex stratigraphic architectures (e.g., inclined heterolithic strata: IHS). The objective of this ongoing research is the development and refinement of conceptual facies models for the three-dimensional distribution of IHS using a large sample of modern tide-influenced channel bodies from the Gulf of Carpentaria (n = 150), coupled with a detailed field study from a representative system within the region. Understanding the controls on the distribution of IHS has major implications for improved modelling of conventional oil and gas reservoirs, and can maximise bitumen recovery and extraction from oil sands. A new phase of this research (*WAVE* Phase III) will further improve our understanding of IHS facies distributions, geometry and heterogeneity in tide-influenced coastal systems.

Introduction

Lateral accretion packages (LAP) form an important reservoir target in continental and marginal marine successions around the globe. These often form at the convex banks of sinuous channels and can comprise either homogenous or heterolithic deposits (Thomas et al., 1987). Hydrodynamic conditions resulting from tidal effects can result in a range of fill types with varying signatures, such as tidal bundles and inclined heterolithic strata (IHS; e.g., Longhitano et al., 2012). While LAP within tidal reaches are often comprised of IHS, these strata are not restricted to such reaches and many examples have been presented for fluvial reaches upstream of the tidal limit (e.g., Thomas et al., 1987). Given that ancient IHS deposits contain significant hydrocarbon reservoir deposits (e.g., the McMurray Formation: Wightman and Pemberton, 1997; Fustic et al., 2012; Figure 1a), determining the controls on their distribution and composition is currently an active research field (e.g., cyclical controls on IHS point bar heterogeneity: Labrecque et al, 2011; the geomorphology and sedimentology of IHS point bars: Hubbard et al., 2011; down-valley point bar translation: Fustic et al., 2012; IHS point bar sedimentology and ichnology: Musial et al., 2012; downstream patterns of IHS sedimentology and ichnology: La Croix et al, 2013). The Gulf of Carpentaria (GoC) in northern Australia is a modern example of a low accommodation epicontinental seaway and laterally accreted, tidally influenced channels are extensively distributed along this shoreline (Figure 1b). These channels demonstrate significant geometric and fill variability and are the focus of this research.

Approach

More than 150 active channels from the shoreline of the GoC were mapped in ArcGIS using the Arc2Earth plug-in. Proxies for wave, tide and fluvial influence (derived from the OzCoasts website) were related to the planform geometries of channels to determine relationships between process and form. Most channel networks draining into the GoC have undergone extensive avulsion and complicated networks of paleodistributary, tide-influenced channels also traverse the coastal plains. The Mitchell River system is the largest fluvial system draining into the GoC, and a complicated network of active and paleodistributary channels similarly traverse its lower fan and delta. These channels were mapped in detail to determine cross-cutting relationships, their planform geometries and the timing of channel activity relative to climate drivers.

Field investigations focused on the geometry and composition of active paleodistributary channels on the Mitchell River lower megafan and delta. Channel belts vary in composition away from the coast, where laterally accreted channels on the delta plain give way to narrower, single thread channels belts on the fan. Hand augering, vibracoring and outcrop data (e.g. Figure 2) were used to determine the composition of channels and channel belts with varying morphologies. Active channels were also surveyed using sonar to determine their geometry and their dry-season channel beds were sampled to determine their sediment composition. These data have enabled us to construct a conceptual facies model encompassing the various channel body types on the lower fan and delta.

Conclusions

Findings thus far suggest that there is a systematic trend in the composition of IHS channel deposits with increasing distance from the coast; the fraction of within-channel fine material and heterolithics decreases upstream. This has significant implications for predicting the reservoir properties of analogous subsurface systems. The new conceptual facies model includes four broad channel body types (Figure 3): i) tidal channel body fills, never connected to fluvial systems (T), ii) channel body fills seaward of the maximum saltwater incursion (Tf and Ft), iii) channel body fills seaward of the upstream limit of the backwater effect (Ft), and iv) channel body fills upstream of the backwater effect (i.e. beyond marine influence; F). It is anticipated that this new facies model will have direct application to reducing uncertainty during exploration and production. Future research plans (*WAVE* Consortium Phase III) include more comprehensive geometric analyses of channel bodies, extensive coring of the body fills of the Mitchell and Gilbert River fans and deltas, the refinement of this preliminary facies model, as well as the development of 3D geomodelling at both the reservoir field and full delta scales.

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Figure captions

Figure 1: (a) A seismic time slice from the McMurray Formation, illustrating a lateral accretion package (LAP) (modified from Fustic, 2008) and (b) LAP within the Mitchell River delta, Australia, demonstrating similar planform morphology and scale to the McMurray.

Figure 2: An example of inclined heterolithic strata (IHS) preserved within an abandoned channel belt in the Holocene Mitchell River delta, Australia. Exposed minimum thickness of IHS is 3m.

Figure 3: Predicted distribution of channel fill types and proposed channel fill models for tide-influenced channel bodies in the Mitchell River Delta and megafan (map modified from Lane, PhD in progress). (Channel body classification: F- Fluvial; Ft – Fluvial-dominated, tide-influenced; Tf – Tide-dominated, fluvial-influenced; T – tidal).