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Process-based Modelling of Sediment Distribution in Fluvial Crevasse Splays

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SUMMARY

Exploitation of unconventional resources could prolong the gas production in the North Sea. Low-net-to-gross fluvial intervals have tough-gas reservoir potential in thin-bedded crevasse splays. To assess economic risks associated to the development of these reservoirs, a reliable grain-size distribution model is required. Sparse areal data availability for reservoir models commonly results in the use of stochastic interpolation. Numerical models offer the possibility to support these methods with proven physical concepts.To this end, simulations were conducted with Delft3D process-based modelling software. Input parameters and the validation data sets for these models are derived from outcrop studies in the present-day Río Colorado fluvial system in the Altiplano Basin, Bolivia. The grain-size trends of the simulated surface sediments for a single flood event are consistent with the validation data. These trends were used to populate individual crevasses splays within a static model. This shows that process-based models are able to support sediment trends and depositional mechanisms of a crevasse splay. The combination of numerical models and discrete field data provides a solid case for sediment distribution predications. However, simulations still have a limited accuracy.

Introduction

The mature North Sea gas province suffers from a decline in the production of gas from conventional reservoirs. Exploitation of unconventional resources could prolong the gas supply in the future. Previous work identified low net-to-gross fluvial strata as a possible secondary target (Donselaar *et al.*, 2011). However, these intervals are traditionally not classified as reservoir rock in the conventional characterisations.

For the assessment of the economic risks associated with the uncertainties of these unconventional crevasse splay reservoirs, an objective prediction of the sediment size and its spatial distribution are required. Sparse areal data availability for reservoir models commonly result in the use of stochastic interpolation. Numerical models offer the possibility to support these methods with proven physical concepts.

The aim of this study is to create a grain-size distribution model of a crevasse splay deposit on a low-gradient coastal plain in a semi-arid endorheic basin. A process-based model combined with conventional outcrop data is used to create a solid sediment distribution predictive model.

Method

Input parameters and the validation data sets for the process-based model were derived from outcrop studies in the present-day Río Colorado fluvial system in the Altiplano Basin, Bolivia. Quantitative data sets of the channel/floodplain morphology (Donselaar *et al.*, 2013), discharge models (Li *et al.*, 2014), and grain-size distribution in crevasse splays were used for the present study.

For the simulation of a single crevasse splay sediment body the numerical process-based model Delft3D software was used (Fig. 1). It uses a finite-difference scheme to solve for the Navier-Stokes equations, simulating fluid flow, sediment transport, and morphological changes (Roelvink and Van Banning 1995; Lesser *et al.* 2004).

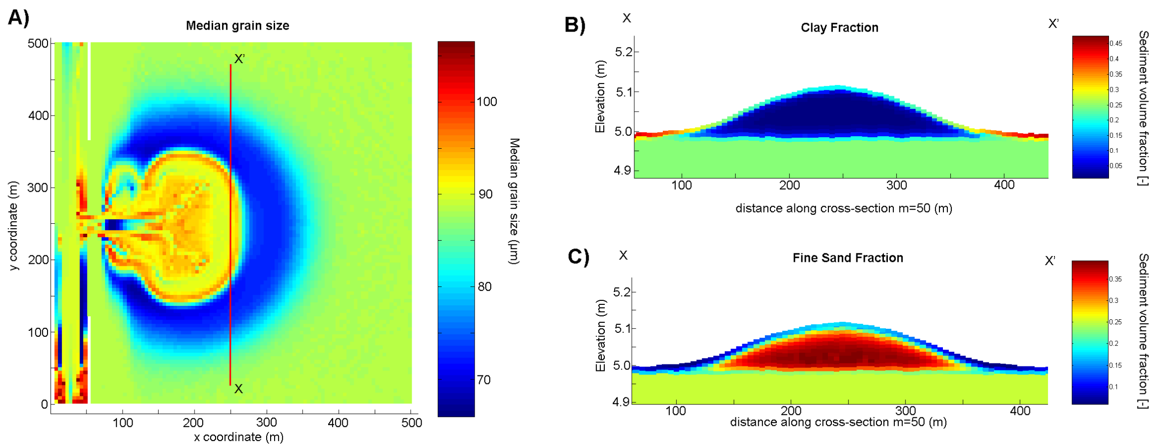

Figure 1 *Example of a model simulation output. A) The areal grain-size distribution. The values are vertically averaged over the thickness of the splay deposit. B) Cross section X-X'. The core of the crevasse splay consists predominantly of sand with minor clay deposition along the margins of the splay. A clay drape forms during the final stage of the crevasse splay deposition. C) The same cross section as in B, showing the fine sand fraction. A clear fining upward trend is visible.*

Results

The model shows an overall fit with the grain-size data from the fieldwork data. It captures the general trends, but it does not capture all the variations present in the measured data. The mean grain sizes of the simulated surface sediments for a single flood event shows a clear trend. Grain size decreases with increasing distance from distributary channels (Fig. 1). This is in line with the physical concept of decreasing sediment size for decreasing flow energy. Significant input parameters are the total discharge, sediment input and the levee composition.

Discussion

A numerical model can be a valuable aid to reservoir description. Combining a model that applies hydrodynamics and sediment transport, with validation field-based data, we use the individual strengths of different methods (Shenton, 2004). This concept will be tested in the future. Data from outcrop analogues in the Huesca fluvial fan (Nichols & Fisher, 2007) will be used to explore the general applicability of the model.

Industry standard reservoir modelling software offer stochastic algorithms to simulate the placement and dimensions of fluvial objects. Observed grain size trends can be used to populate individual crevasses splays within a static model. Dynamic flow calculations will be used to assess the economic risks. The numerical parameters of the process-based model will be optimized to ensure a representable upscaling.

Conclusion

Process-based models can be used to support and confirm sediment trends and depositional mechanisms of a crevasse splay. The combination of numerical and discrete field data provides a sound case for sediment distribution predications. Simulations, however, still have a limited accuracy.

Acknowledgements

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References

Donselaar, M.E., Cuevas Gozalo, M.C. and Moyano, S. [2013] Avulsion processes at the terminus of low-gradient semi-arid fluvial systems: lessons from the Río Colorado, Altiplano endorheic Basin, Bolivia. *Sedimentary Geology*, **283**, 1-14.

Donselaar, M.E., Overeem, I., Reichwein, J.H.C. and Visser, C.A. [2011] Mapping of fluvial fairways in the Ten Boer Member, Southern Permian Basin. *The Permian Rotliegend of The Netherlands,* SEPM special publication, **98**, 105-117.

Nichols, G.J. and Fisher, J.A. [2007] Processes, facies and architecture of fluvial distributary system deposits. *Sedimentary Geology*, **195**, 75-90.

Lesser, G.R., Roelvink, J.A., Van Kester, J.A.T.M. and Stelling, G.S. [2004] Development and validation of a three-dimensional morphological model.*Coastal engineering*, ***51*(8)**, 883-915.

Li, J., Donselaar, M.E., Aria, S.E.H., Koenders, R. and Oyen, A.M. [2014] Landsat imagery-based visualization of the geomorphological development at the terminus of a dryland river system. *Quaternary International*, **352**, 100-110.

Roelvink, J.A. and Van Banning, G.K.F.M. [1995] Design and development of DELFT3D and application to coastal morphodynamics. *Oceanographic Literature Review*, **11(42),** 925.

Shenton, A.K. [2004] Strategies for ensuring trustworthiness in qualitative research projects. *Education for information*, ***22*(2),** 63-75.