Towards the quantitative prediction of sandstone body connectivity within distributive fluvial systems through numerical modelling and field studies

John Howell, Adrian Hartley, School of Geosciences, University of Aberdeen
Amanda Owen, Department of Geology, University of Glasgow

Project Outline

Fluvial reservoirs are traditionally challenging, primarily due to the heterogeneity associated with complex facies architecture. The performance of fluvial reservoirs is primarily controlled by sandbody connectivity controlled to the stacking arrangement of channel belts. Recent advances in understanding the large scale spatial distribution of fluvial facies from both modern and ancient systems has led to the development of the Distributive Fluvial System Model (DFS). This model provides a qualitative framework to predict the distribution of different channel stacking patterns depending on location within the DFS (proximal, medial or distal). The model is at present largely qualitative and does not currently account for accommodation driven controls predicted by Leeder, Allen and Bridge in the original LAB model. Attempts to quantify the DFS model are hindered by the limited number of suitable case studies from outcrops that provide continuous exposure across the scale of an entire DFS.

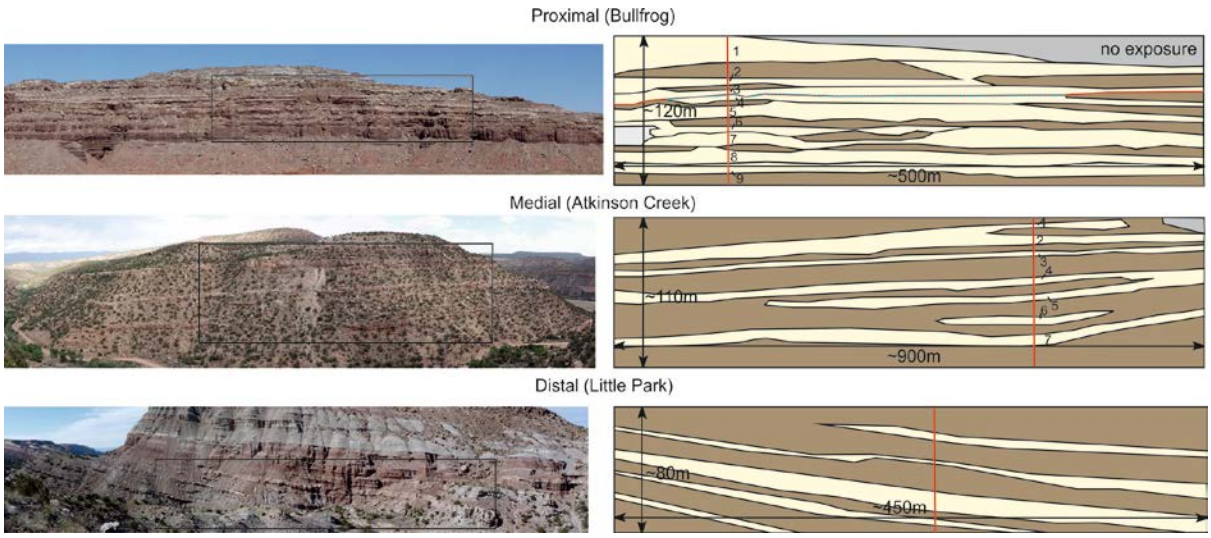
This project will address the problem from a process based modelling approach, where the different parameters can be constrained in a way that is not achievable in outcrop. An experimental design will be established that will numerically recreate a point sourced fluvial system. The model will include parameters such as channel belt size, downstream changes in channel belt size and character, avulsion frequency, and accommodation creation rates. Realistic ranges for these parameters will be constrained from literature and from selected field studies from a range of DFS including the Ebro system (Spain), the Morrison Formation, SW USA, the previously unstudied Colton Formation (Utah), and the modern Mitchell DFS in the Gulf of Carpentaria, Australia.
Results will include a series of models which cover the spectrum of accommodation, sediment supply and climate scenarios. Models will be compared by analysis of connectivity within different portions and quality controlled against the case study examples. The result will be a new and greatly improved model for understanding and predicting reservoir connectivity in fluvial systems.

Research context

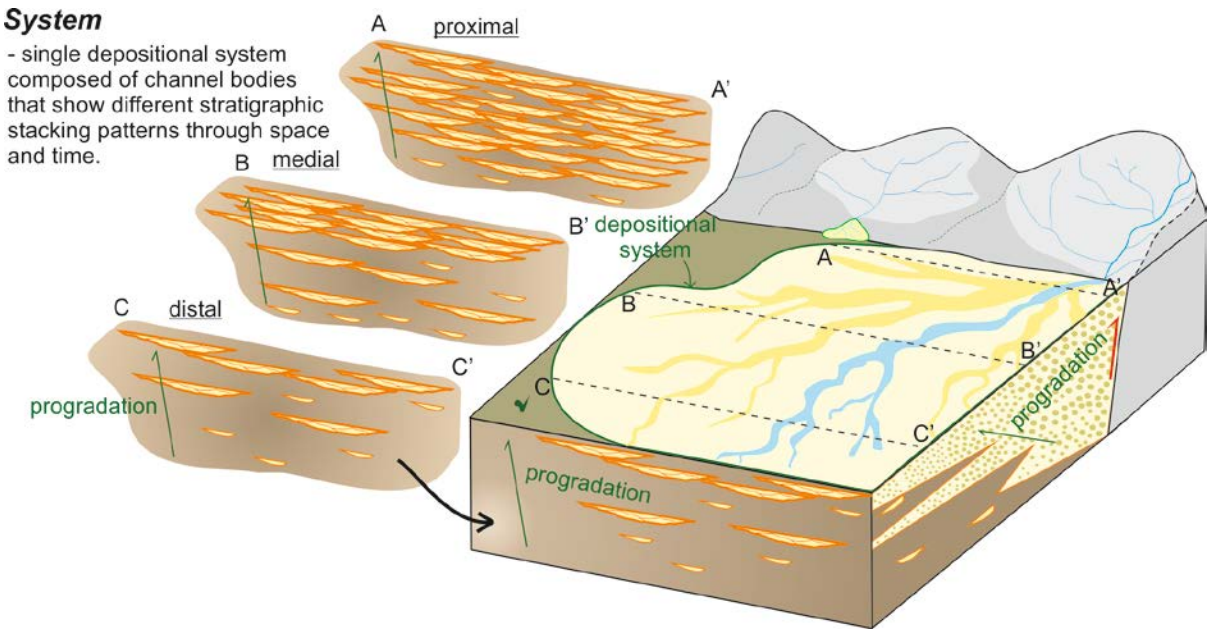
This research fits within the umbrella of two major JIPs with the University of Aberdeen. Hartley and Owen run FSRG which has been largely responsible for the development of the DFS concept and its application. Howell runs Safari which includes large volumes of numerical data pertaining to the geometries, connectivity and architecture of clastic reservoirs. The project will form a bridge between those research themes

References

Hartley, A.J., Weissmann, G.S., Nichols, G.J., Warwick, G.L. 2010 Large distributive fluvial systems: Characteristics, distribution, and controls on development. Journal of Sedimentary Research, 80 (2), pp. 167-183.
Owen, A., Nichols, G. J., Hartley, A. J., Weissmann, G. S., & Scuderi, L. A. (2015). Quantification of a distributive fluvial system: The Salt Wash DFS of the Morrison Formation, SW USA. Journal of Sedimentary Research, 85, 544–561.
Owen, A., Hartley, A. J., Weissmann, G. S., & Nichols, G. J. (2016). Uranium distribution as a proxy for basin-scale fluid flow in distributive fluvial systems. Journal of the Geological Society.
Rittersbacher, A., Howell, J.A., Buckley, S.J.2014 Analysis of fluvial architecture in the Blackhawk Formation, Wasatch Plateau, Utah, U.S.A., using large 3d photorealistic models. Journal of Sedimentary Research, 84 (2), pp. 72-87.



Proximal, medial and distal outcrops of the Salt Wash Member, a Distributive Fluvial System from Utah and Colorado. Outcrops such as these can provide excellent information on the fluvial stacking patterns and connectivity in DFS but are only one example, furthermore the input parameters are difficult to constrain. Numerical modelling within this project will vary controlled input parameters such as sediment supply and subsidence and produce a suite of DFS that can be analysed for connectivity and simulated reservoir performance (Owen et al. 2015)



Idealised model for channel stacking within a DFS. Note the increased conectivity in the updip portion of the fan. The goal of this project is to turn this schematic model into a quantitative and predictive tool that honours the relationship between controlling variables and the consequent rock record (Owen et al. in review).