3D Architecture and Internal Facies Variation of Large-Scale Alluvial Fan Deposits: Implications for the interpretation of the Permian Brockram Facies of Northern England

Amy Gough [1]*
Stuart M. Clarke [1]
Philip C. Richards [2]
Antoni E. Milodowski [3]

[1] Basin Dynamics Research Group, School of Physical and Geographical Sciences, Keele University, UK.

* corresponding author: a.gough@epsam.keele.ac.uk

Alluvial fans are key environments in the proximal setting of arid continental basins. Their facies and element geometry are influenced by interactions between the varied depositional processes of the fan, including debris-flow, fluid-flow, fan-surface fluvial, overbank, and the evolving climate. Spatial and temporal variations in facies architecture can be pronounced and localised, making the interpretation of the relative position within the fan system from limited and disparate outcrop problematical, such as with the outcrops of the Brockram Facies, northern England. Furthermore, strong variations in facies architecture over short distances can have important implications for fluid migration through ancient fan systems, heightening the importance of a sound interpretation.

In this work we examine well-exposed fans from the Permian succession of the Cutler Group of the Paradox Basin, U.S.A as an analogue for the Brockram Facies. We develop three-dimensional sedimentological models through the proximal, medial and distal fan. In each model, particular attention is given to the characteristic depositional processes, their spatial interactions and their evolution through time, in order to emphasise those features that are particularly characteristic of spatial and temporal position within the fan system, thus providing the basis for an interpretation from the limited and disparate outcrop of the Brockram Facies.

The Cutler fans were deposited in a continental basin subject to arid-monsoonal climatic cycles, varied sediment supply and changing base level. Proximal deposits consist of facies attributed to bed-rock failure, with input from fluid-flow dominated processes and proximal debris flows. The mid-fan succession is predominately composed of sediment gravity flows and fan-surface fluvial systems with intercalations of incised channel architecture, sheetflood sedimentation and sieve facies. The distal fan is dominated by fluid gravity flows and braided fan-surface fluvial systems. Within each of the spatial models, the facies and architecture are influenced by climate cyclicity. Periods of aridity are characterised by debris flow dominated facies, whilst periods of elevated humidity are characterised by fluid flow dominated facies. A systematic and progressive increase in fluid or debris flow facies can be a clear indicator of climatic cycles.

The work is applied to the poorly exposed Brockram Facies of the Eden Valley, UK.