FRG ERG SMRG

UNIVERSITÀ DI PAVIA

UNIVERSITY OF LEEDS

Fluvial, Eolian & Shallow-Marine Research Group

Phase 6
Jan 2024 to Dec 2026

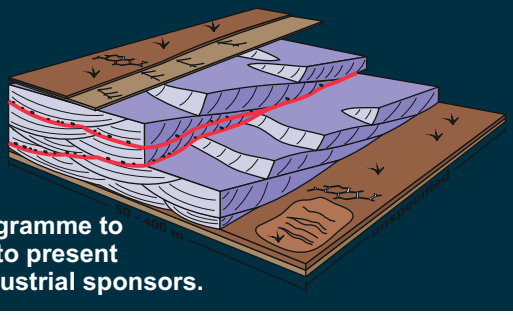
https://frg.leeds.ac.uk/

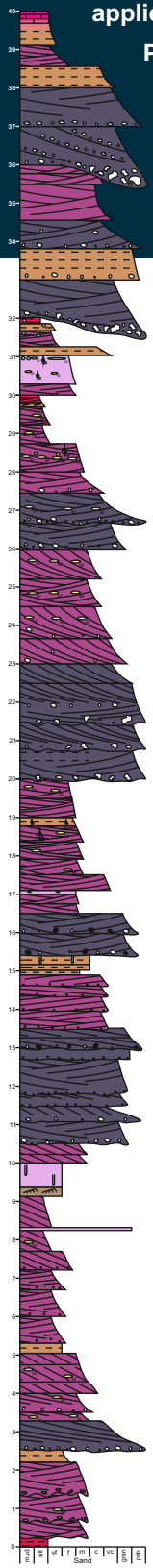
Internationally recognized research leader in the study and analysis of fluvial, aeolian & shallow-marine sedimentary systems and their preserved successions.

An industry-facing research group integrating multi-disciplinary expertise in applied fluvial, aeolian and shallow-marine sedimentary research.

Principal aim: to conduct cutting-edge research into the application of fluvial, aeolian and shallow-marine sedimentology to issues relating to subsurface characterization for the sustainable use of natural resources and in the context of the energy transition.

Specific objectives: develop a state-of-the-art knowledge transfer programme to distil current thinking and trends in applied sedimentology research; to present summary results and models in a format suitable for direct use by industrial sponsors.





Overview

A Joint Industry Project (JIP) with a research programme focussed on cutting-edge applied fluvial, aeolian and shallow-marine sedimentological research, with emphasis on characterization and prediction of subsurface sedimentary architecture and heterogeneity, and a web-delivered Knowledge Transfer programme.

Principal FRG-ERG-SMRG 2024-26 Deliverables

- **Company-wide access to:**
  - Cloud-based applications acting as graphical user interfaces to the world's largest databases of sedimentary architecture: the Fluvial Architecture Knowledge Transfer System (**FAKTS**), the Database of Aeolian Sedimentary Architecture (**DASA**), and the Shallow-Marine Architecture Knowledge Store (**SMAKS**)
  - Research results & knowledge transfer arising from the development and application of our specialist fluvial geomodelling software: **PB-SAND** (Point Bar Sedimentary Architecture Numerical Deduction)
  - Research results arising from our aeolian stratigraphic modelling software (**DuneModeller**)
  - Access to the entire back catalogue of research from all previous phases (> 1800 documents)
  - Searchable bibliographic database and recommended literature summaries
  - Digital online training and self-learning materials, video case studies and virtual outcrop guides
  - Cutting-edge novel and innovative approaches to modelling subsurface sedimentary successions
  - Dedicated sponsors' meetings (e.g., Europe and USA)
  - Options for specially tailored field courses and training courses
  - Dedicated live and online webinar series

- **Research outputs include:**
  - Fluvial, aeolian & shallow-marine depositional models for subsurface prediction and correlation
  - Atlases depicting morphology of modern fluvial, aeolian & shallow-marine sedimentary systems
  - Studies in process sedimentology
  - Novel and innovative approaches to subsurface characterization of sedimentary successions
  - Studies on external controls and autogenic dynamics of continental and marine sedimentary systems
  - High-resolution studies of fluvial, aeolian & shallow-marine stratigraphic architecture
  - Novel methods and techniques in sequence stratigraphy applied to subsurface successions
  - Studies in seismic stratigraphy and geomorphology
  - Quantitative numerical models for bridging the gap between sedimentological datasets and subsurface modelling workflows
  - Studies of tidally influenced fluvial, fluvio-deltaic and fluvio-lacustrine modern sedimentary systems, in outcrop and in the subsurface
  - Software for numerical sedimentological & tectono-stratigraphic modelling and basin analysis

Membership & Costs

- New sponsors are welcome to join at any time.
- Full access to results from earlier phases.
- Discounted rate for returning sponsors.
- Get in touch to discuss membership options and pricing.

Phase 1 – 5 Partners & Sponsors

Aker BP, Anadarko, Areva (now Orano), BHP, Cairn India (Vedanta), Chevron, CNOOC, ConocoPhillips, Equinor, Murphy Oil, NERC, Nexen, Occidental, Petrotechnical Data Systems, Saudi Aramco, Shell, Tullow Oil, Woodside, YPF.

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Research & Knowledge Transfer Programme: Deliverables

Research Outputs: The entire back catalogue of all research outputs from the Fluvial, Eolian & Shallow-Marine Research Group over the past 20 years. This currently amounts to over **1800 documents** in the form of reports, theses, papers, posters, conference presentations, videos, knowledge transfer resources and software. Additionally, it includes summary metrics relating to sedimentary architecture and facies distributions for fluvial, aeolian, paralic and shallow-marine systems, and their preserved successions.

Bibliographic Database: A composite bibliographic database of fluvial, aeolian, paralic and marine references that brings together the search results from many different search engines, plus literature not caught by conventional searches, and which provides a comprehensive list in one easy-to-search location. This database is updated regularly to incorporate all the latest research results. Books and special publications are being included, in addition to journal references.

Recommended Literature: Searchable lists of recommended reading where FRG-ERG-SMRG group members review the literature and recommend what we consider to be key papers in a variety of fields relating to fluvial, aeolian, paralic and shallow-marine literature.

FAKTS, DASA & SMAKS: web-based access to the largest analogue databases of sedimentary architecture. Data on the geometry, proportion and topology of sedimentary units can be interrogated using specialist in-house could-based applications. The apps permit database filtering and data download and charting.

Sponsors' Meetings: Dedicated online and in-person sponsors' meetings. The venue for in-person meetings will vary; typically Europe & USA; associated with international conferences; sponsor representatives to pay for their own travel and subsistence costs.

Atlas of Fluvial and Aeolian Facies: An annotated graphical encyclopaedia of facies examples for a wide range of fluvial, aeolian, paralic and shallow-marine systems and successions.

Fundamentals of Geoscience: A set of over 150 self-learning guides detailing everything from the basics of clastic sedimentology, to more detailed resources that provide guidance in the interpretation of fluvial, aeolian and shallow-marine stratigraphy, to guides detailing advanced concepts in sequence stratigraphy and correlation.

Workflows For Subsurface Interpretation: Guidance in how to design and implement workflows for the interpretation of subsurface fluvial, aeolian, paralic and shallow-marine successions.

Geostatistics: Examples of the application of novel geostatistical methods for subsurface characterization and prediction.

Taught Short-Courses: In-house bespoke taught short-courses available as an add-on.

Forward Stratigraphic Modelling Software: Access to fluvial and aeolian stratigraphic modelling software (e.g. **PB-SAND** and **DuneModeller**) for assessing sedimentary heterogeneity; the software serves as a set of tools to assist with the development of geocellular models. Software start-up guides provide instruction on usage. Output can be used to generate training image libraries.

Company-Wide Access: All employees of the sponsor company worldwide gain access to the entire dataset and full set of resources, including the full back-catalogue of research results from previous phases of FRG-ERG-SMRG.

Rolling Programme of Research Projects: We will aim to start an average of 2 new PhD studentships or 1 post-doctoral research project per year; projects are designed to focus our research efforts in areas of applied sedimentology that are of primary interest to our sponsors.

Company Visits: Visits to the sponsor companies can be arranged as an add-on.

FRG-ERG-SMRG Sponsor Field Trips: The option for members of sponsor companies to attend group field training courses to study a range of modern and/or ancient sedimentary successions, including fluvial, fluvio-deltaic, aeolian and shallow-marine systems, depending on the interests of the sponsor companies. Trips will typically be to locations where FRG-ERG-SMRG researchers are active.

Webinars: Regular programme of online talks and presentations; cover key topics in applied sedimentology.

Dedicated website: https://frg.leeds.ac.uk

Above. Sandstone of shallow-marine origin recording transgression across coal-bearing, argillaceous coastal plain deposits, Cretaceous Neslen Formation, Utah, USA.

Research & Knowledge Transfer Programme: Deliverables

FAKTS

Fluvial Architecture Knowledge Transfer System

clastics.shinyapps.io/fakts

The **Fluvial Architecture Knowledge Transfer System** is a relational database tool for analysing numerical and descriptive data and information about fluvial architecture coming from fieldwork and peer-reviewed literature, from both modern rivers and their ancient counterparts in the stratigraphic record. The database encapsulates all the major features of fluvial architecture (style of internal organization, geometries, spatial distribution and reciprocal relationships of genetic units), classifying datasets – either in whole or in part – according to both controlling factors (e.g. climate type, tectonic setting), and context-descriptive characteristics (e.g. channel/river pattern, dominant transport mechanism). The database is populated with facies and architectural data taken from both the literature and derived from of in-house field studies.

- Web-based front-end for simple FAKTS queries to enable derivation of quantitative output.
- Obtain width-thickness-length aspect ratio distributions for architectural elements (e.g. channels or splays).
- Calculate facies transition probabilities in both vertical and horizontal dimensions (parallel & perpendicular to palaeoflow).
- Track changes in proportions of facies or elements spatially within a depositional system.
- Filter search criteria to ensure that results remain highly relevant to the reservoir interval being characterized.
- Predict element shape & size as a function of independent external controls (climatic regime, basin type, subsidence rate).

DASA

Database of Aeolian Sedimentary Architecture

clastics.shinyapps.io/dasa

The **Database of Aeolian Sedimentary Architecture** records the architecture and spatio-temporal evolution of a broad range of modern and recently active aeolian systems, and of their preserved deposits in ancient successions. DASA currently stores data on a variety of aeolian and associated non-aeolian entities at multiple scales (e.g., depositional, geomorphic & architectural elements, lithofacies, bounding surfaces), including attributes that characterize their type, geometry, spatial relations, hierarchical relations, temporal significance, and textural and petrophysical properties. Associated metadata are also stored (e.g., prevailing climate, tectonic regime, age).

- Assess stratigraphic relationships between aeolian and associated fluvial, lacustrine and paralic depositional systems.
- Quantify the geometry of aeolian architectural elements, and hierarchical and spatial relationships between them.
- Calculate the probabilities of vertical and lateral transition from one type of aeolian deposit or landform to another.
- Consider the nature of aeolian bounding surfaces at different scales, and their nested, hierarchical relationships.
- Predict aeolian lithofacies types, proportions and distributions, and facies controls on grain-scale textural parameters.

SMAKS

Shallow-Marine Architecture Knowledge Store

clastics.shinyapps.io/smaks

The **Shallow-Marine Architecture Knowledge Store** is a relational database devised for the storage of hard and soft data on the sedimentary architecture of ancient shallow-marine and paralic siliciclastic successions, and on the geomorphological organization of corresponding modern environments. The database allows incorporation of data from the published literature, which are uploaded to a common standard to ensure consistency in data definition. The database incorporates data on geological entities of varied nature and scale (i.e., surfaces, depositional tracts, architectural elements, sequence stratigraphic units, facies units, geomorphic elements), including attributes that characterize their type, geometry, spatial relations, hierarchical relations, and temporal significance. Geological entities are assigned to depositional systems, or to parts thereof, that can be classified on multiple parameters (e.g., shelf width, delta catchment area) tied to metadata (e.g., data types, data sources).

- Examine data from wave-, tide-, and fluvial dominated shallow seas, from backshore to shelf-edge settings.
- Quantitative characterization of modern and ancient shallow-marine and paralic clastic depositional systems.
- Serves as a repository of analogue information for subsurface reservoir successions.
- Can be applied to aid the development of depositional models for particular.
- Assess the sensitivity of depositional systems to particular controlling factors.

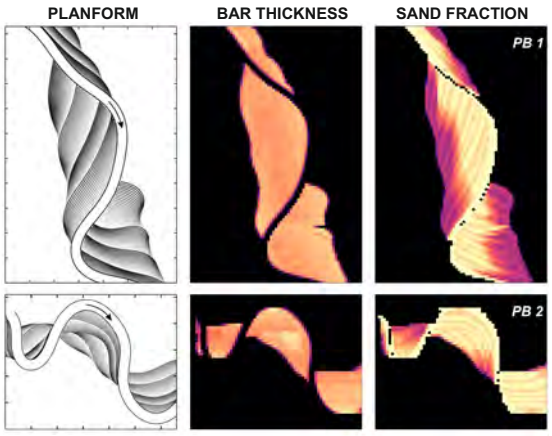
Collectively, the three databases contain data relating to **over 700 case studies**.

Research & Knowledge Transfer Programme: Deliverables

PB-SAND

Point Bar Sedimentary Architecture Numerical Deduction

The **Point-Bar Sedimentary Architecture Numerical Deduction** is a modelling tool for the reconstruction and prediction of the complex spatio-temporal evolution of fluvial meanders, their generated 3D lithofacies distributions and resulting heterogeneity. The model permits the reconstruction of point-bar geometries and internal sedimentary architectures using a deterministic approach to simulate accretion patterns as they evolve over a series of time steps. The input trajectories that control the planform morphology of point bars can be digitized from seismic images, from remotely sensed images of modern systems, or devised based on field observations of ancient outcropping successions.

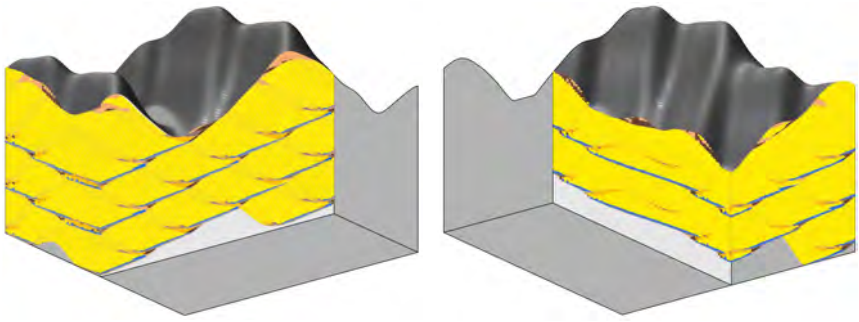


Model complex channel migration and bar accretion behaviour, and populate the modelled 3d volume with lithofacies stochastically.

DuneModeller

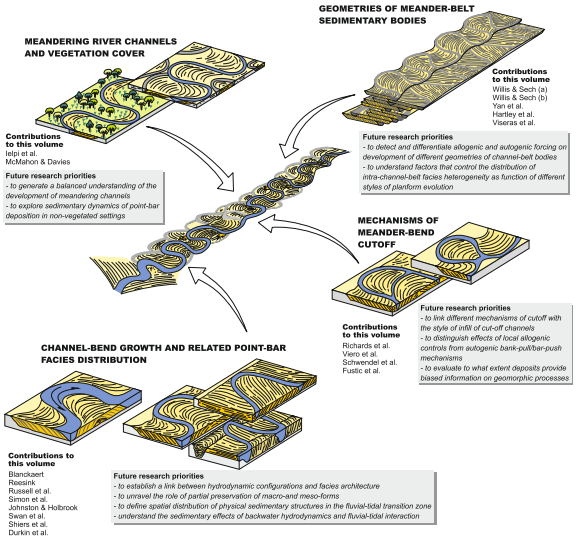
Forward Stratigraphic Modelling for Prediction of Aeolian Dune Architecture

DuneModeller is a numerical model for predicting the response of aeolian systems to external and intrinsic controls. The range of synthetic stratigraphic architectures generated by the model accounts for all the principal aeolian stratigraphic configurations. Modelling results have enabled the erection of a scheme for the classification of dune system type whereby the many elaborate stratal architectures known to exist in nature can effectively be accounted for. The approach is used to model facies and petrophysical variability and to predict flow pathways and contaminant transport in heterogeneous subsurface dune and interdune successions.



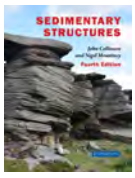
DuneModeller is based on a modelling approach originally developed by David Rubin

Model complex dune and interdune morphodynamics under variable conditions of bedform climb and constrain the spatial distribution of facies domains in three dimensions.



Books

Articles, Text Books, Thematic Special Publications & Self-Learning Guides



Research from Phases 1 – 5 has directly led to the publication of >150 papers in leading international academic journals. Additionally, results have also been published in thematic special publications, and as field guides. The FRG-ERG-SMRG research team have also (i) edited entire specialist book volumes (e.g., IAS Special Publication 48: "Meandering Rivers and their Sedimentary Products in the Rock Record", Wiley), and (ii) have written a major research-led textbook ("Sedimentary Structures", Collinson and Mountney, Dunedin). Future book chapters relating to issues in applied-facing sedimentology are currently being prepared. Details of all published works are available on the publications page at **frg.leeds.ac.uk/**

Research & Knowledge Transfer Programme: Deliverables

Fluv-Lit

Fluvial Literature Review & Summary

Aeo-Lit

Eolian Literature Review & Summary

Fluv-Lit and **Aeo-Lit** are bibliographic and literature review databases that allow industry professionals to keep abreast of advances reported in the academic literature, and incorporate the latest thinking into their work. Additionally, these tools allow people new to non-marine clastic sedimentology to quickly develop an understanding of these depositional environments. These online searchable databases provide:

- A comprehensive listing of the entire field of literature relating to fluvial and aeolian sedimentary environments.
- Listings and reviews of new publications.
- Ratings and lists of recommended papers by theme.
- Summaries of key recommended papers.

Review and recommendation is undertaken by experts in the field, and tailored for industry-professional end-users.

FoG

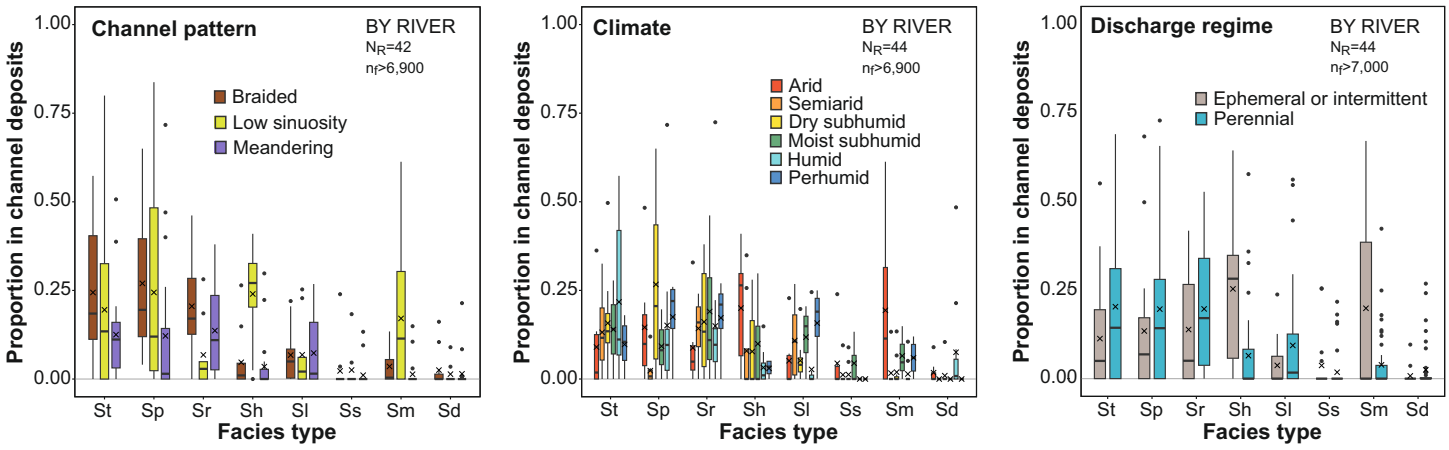
Fundamentals of Geoscience

- **Fundamentals of Geoscience** is a set of self-contained e-learning resources designed to enable users to gain knowledge in sedimentology & applied reservoir geology quickly and effectively.
- The resources serve as a refresher of core concepts for specialist geologists.
- Acts as a point of access to more specialised and detailed discussions through the provision of a series of integrated references.
- Serves as a source of high-quality graphic artwork that can be used by sponsors to illustrate their own presentations.

ATLAS

Atlas of Fluvial & Eolian Facies

- The **Atlas of Fluvial and Eolian Facies** is an illustrated encyclopaedia of facies examples from a range of fluvial and aeolian system types, which can be used to characterize subsurface core & consider palaeoenvironmental significance.
- Enables non-specialists to recognise and become familiar with a range of common and unusual types of fluvial and aeolian facies, the likely processes involved in their generation, and their likely palaeoenvironmental origin and significance.
- Provides a list of possible modern and ancient outcrop analogues to assist with the interpretation of core.
- Serves as a source of images and graphics that can be used by sponsors to illustrate their own presentations.

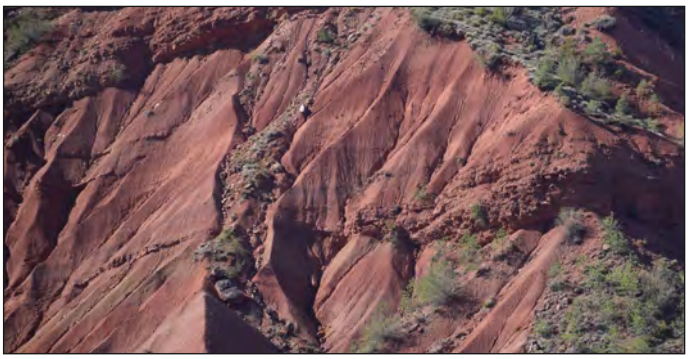


Above. Left-hand graph: proportions of different sandy facies types in channel bodies interpreted as the product of braided, low-sinuosity or meandering rivers. Middle graph: proportions of different sandy facies types in channel bodies interpreted as the product of rivers developed under the influence of different climate regimes. Right-hand graph: proportions of different sandy facies types in channel bodies interpreted as the product of rivers characterized by ephemeral or intermittent versus perennial flow. Data from modern sandy bedload rivers; similar data can be generated for ancient preserved fluvial successions. Data from FAKTS. Use data such as these to guide subsurface (e.g., core) data interpretations and conceptual model development.

Proposed Themes for FRG-ERG-SMRG Phase 6 Research Projects

Theme 1: Development of quantitative facies models for fluvial, aeolian and shallow-water systems

Quantitative facies models describing the sedimentary characteristics exhibited by types of depositional systems, sub-environments and genetic units (e.g., low-latitude coastal plains, dryland fluvial fan, damp aeolian interdunes) will be generated using FAKTS, DASA and SMAKS. The work will focus on a broad range of fluvial, aeolian, lacustrine and shallow-marine settings. The compiled facies models will consist of sets of quantitative outputs on the proportion, geometry, reciprocal spatial relationships and distribution of sedimentary units at multiple scales (facies, architectural elements, large-scale depositional elements, sequence stratigraphic units). Facies models will be constructed based on the synthesis of many case studies included in the databases. The models will be applicable as synthetic geological analogue, to be employed to (i) guide interpretations of subsurface and outcrop datasets, and to (ii) assist predictions of subsurface architecture and heterogeneity with explicit consideration of uncertainty associated with sedimentological variability.



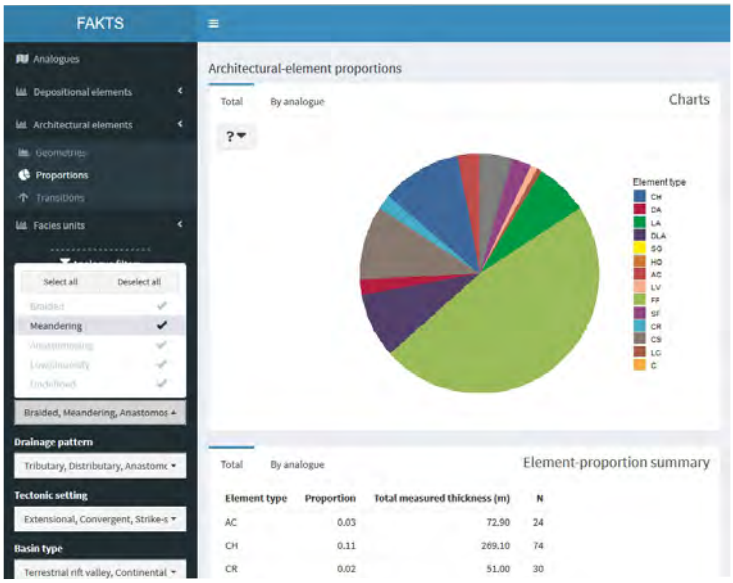
Above. Channel bodies of the Paleocene Esplugafreda Formation, Spain.

Theme 2: Analogue studies of subsurface architecture and facies heterogeneity

This work will consist in the collation of data on modern and ancient geological analogues to subsurface successions of applied interest as groundwater aquifers, potential reservoirs for carbon capture and storage, reservoirs hosting geothermal resources or potentially acting as repositories for temporal energy storage or long-term radwaste disposal. The sedimentary architecture and facies organization of outcropping ancient succession will be characterized by integrating facies analysis, architectural-element analysis and sequence stratigraphic practice. The geomorphology and sedimentology of modern depositional systems will be characterized by integrating remote-sensing data with in-situ observations. Additional data will be collated from existing literature studies on analogues of interest, in part based on sponsors' requests. All the data will be coded according to the standards of FAKTS, SMAKS and DASA, and loaded onto their respective databases. To enhance impact, the functionalities of the cloud-based database apps that serve as graphical user interfaces will be expanded and improved.

Theme 3: Meta-analyses for assessing the importance of controls on sedimentary architecture

This is the continuation of a major, fruitful research initiative of the group. The work will consist in a set of studies aiming to determine the relative roles of a range of allogenic controls and autogenic dynamics in controlling the preserved sedimentary architecture and facies make-up of fluvial, aeolian, paralic and shallow-marine successions. The research will be undertake through the compound analysis of large volumes of data drawn from (i) original field studies conducted on modern and ancient systems by members of the research group, and (ii) the published scientific literature. All sedimentological and stratigraphic data will be coded to a common standard to facilitate comparisons, and populated into the FAKTS, SMAKS and DASA databases. The datasets will be analysed statistically with consideration of available constraints on variables describing tectonic, climatic, and eustatic controls. Outcomes of the studies will elucidate the predictive power of geological boundary conditions and of inherent autogenic behaviours, and hence find application in contexts requiring subsurface predictions.



Above. View of the FAKTS app, showing output on average proportions of architectural-element types in all selected analogues. The app allows the application of filters to the database on attributes describing the depositional systems and on metadata describing the datasets and the source analogue studies.

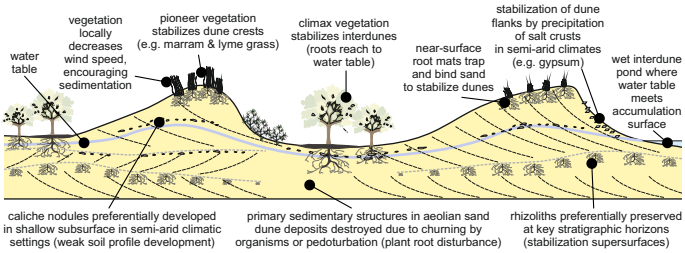
Proposed Themes for FRG-ERG-SMRG Phase 6 Research Projects

Theme 4: Generation of a training image library for MPS geocellular modelling

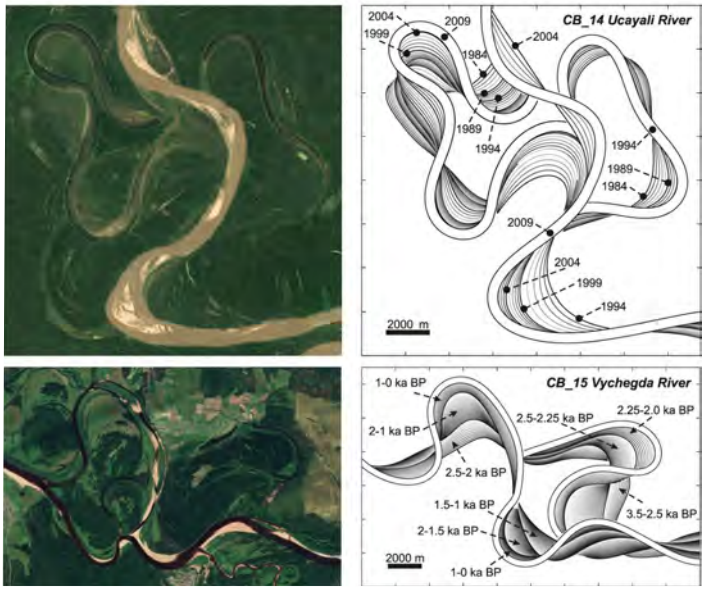
Geostatistical modelling algorithms based on multi-point statistics replicate geological patterns drawn from training images. Geologically realistic training images are therefore required to achieve geologically plausible reservoir models. This work will aim to generate a set of 3D geocellular training images that are suitable to model different types of fluvial and aeolian successions and that contain different types of sedimentary units, based on the application of analogue data from FAKTS and DASA. Analogue data will be used to generate training images through: (i) their use for constraining stochastic geocellular models, and (ii) as applied to forward stratigraphic modelling software that simulates the architecture of point bars and meander belts (PB-SAND) and of aeolian dune and interdune systems (DuneModeller). Each training image will be paired with a set of suitable modelling parameters to facilitate its application to MPS algorithms employed in subsurface studies (SNESIM, FILTERSIM, DS). The suitability of the training images to condition novel facies-modelling tools based on generative adversarial networks or other machine-learning approaches will also be trialled.

Theme 5: Controls on the static connectivity of aeolian dune and interdune deposits

This work will aim to assess how the static connectivity of aeolian dune and intedune deposits is impacted by factors controlling dune-field evolution and preservation. The study will be undertaken using our in-house stratigraphic forward modelling tool: DuneModeller. The modelling effort will be conducted by systematically varying a range of variables that are know to control the architecture of aeolian successions, including dune type (e.g., barchanoid, linear), dune size (height and wavelength), interdune geometry, bedform celerity, and aggradation rate. Vector-based DuneModeller outputs will be converted into geocellular grids and analysed in terms of static connectivity metrics of the accumulated and preserved geobodies. Additional work will look into the impact of the same controls on the dynamic connectivity of aeolian facies domains with contrasting petrophysical properties.



Above. Summary of the form and origin of stabilizing agents of biogenic and chemical origin in aeolian successions.



Above. Example applications of PB-SAND to model the temporal evolution of meandering rivers. The resulting meander-belt architectures exhibit several point-bar elements containing multiple internal reactivation and adjustment bounding surfaces. These typically give rise to internal lithofacies heterogeneity. Preserved successions of these types of deposits tend to be highly compartmentalized. Forward numerical modelling using PB-SAND can account for and predict such heterogeneities in 3D.

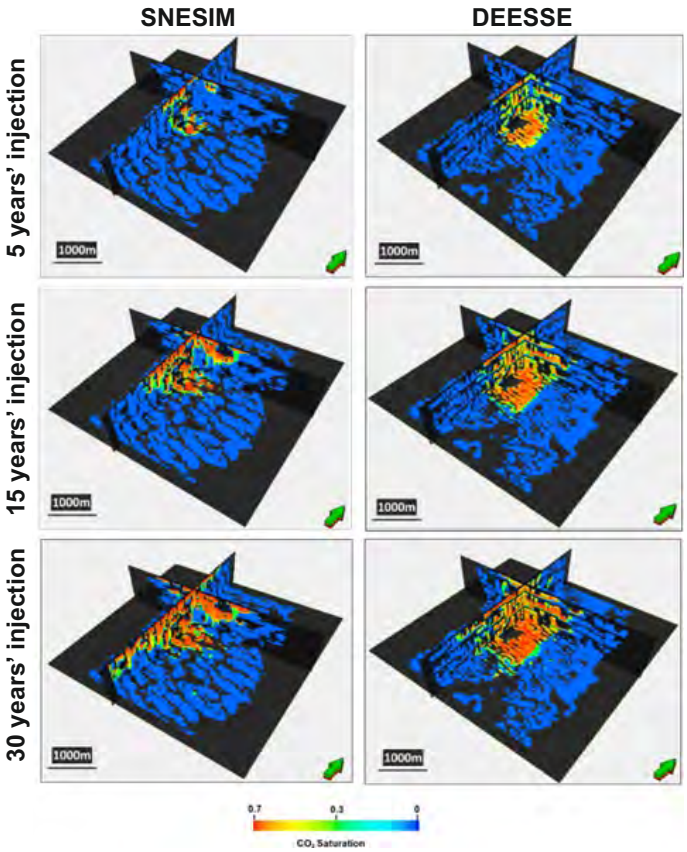
Theme 6: Influence of sedimentary heterogeneity on the performance of low-enthalpy geothermal applications

This research project aims to investigate the impact of sedimentary heterogeneities on the efficiency and longevity of projects of geothermal exploitation of clastic successions. The research will consist of the following main activities: (i) characterization of heterogeneities of clastic strata using geological analogues that are representative of subsurface successions of interest for geothermal applications; (ii) construction of a suite of geocellular models incorporating different styles of sedimentary heterogeneity, in part using bespoke modelling tools that are developed in-house; (iii) application of static models to the simulation of heat transport (e.g., using MODFLOW/MT3D) for different scenarios of geothermal exploitation (e.g., doublet, GWHP, ATES). One of the expected outcomes of the project will be the systematic categorization of heterogeneities in terms of their magnitude of influence on different geothermal applications. This will enable predictions of thermal behaviour that can be applied for development planning of low-enthalpy geothermal resources in clastic successions, including meander-belt deposits and mixed fluvial-aeolian stratigraphic units.

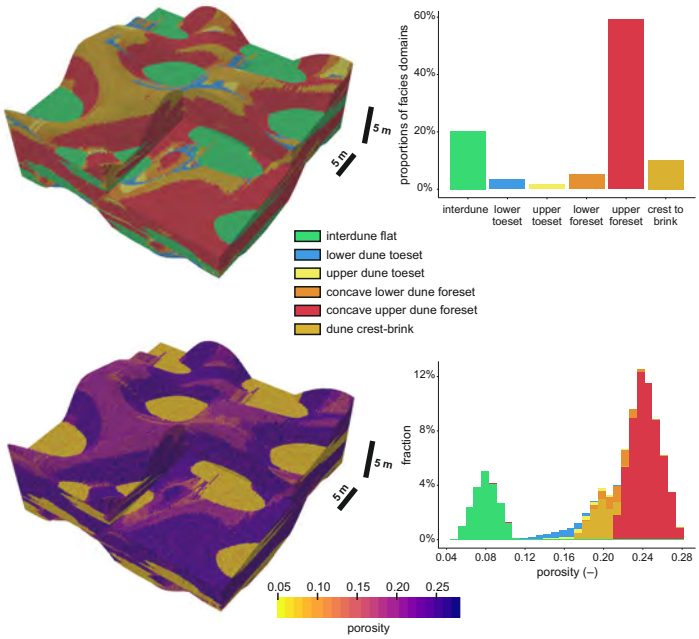
Proposed Themes for FRG-ERG-SMRG Phase 6 Research Projects

Theme 7: Impact of sedimentary architectures on carbon capture and underground storage

This work will assess the influence of different forms of sedimentary architectures and lithological heterogeneities on the feasibility of programmes of subsurface carbon capture and storage in clastic strata, with a special focus on interbedded fluvial-aeolian successions. The research will leverage on the large amount of data present in the FAKTS and DASA databases of geological analogues. These data will be used to build idealized geocellular models capturing relevant types of sedimentary heterogeneity (reflected in distributions in net-to-gross ratios, proportions, geometries and topological relationships of geobodies), and to constrain realistic distributions of petrophysical properties in the ensuing static property models. Dynamic simulations of CO_2 injection will be performed on the static models over a scale of several decades. Outputs of the dynamic modelling study will be assessed quantitatively in terms of injectivity, capacity, injected-plume geometry and CO_2 phase variations. Alternative reservoir-modelling approaches will trialled to jointly assess the impact of the modelling techniques on the resulting dynamic connectivity.



Above. Comparison between dynamic simulations of CO_2 injection, displacing the original brine, in a geocellular model of a fluvial valley fill containing point-bar and mud-plug elements.



Above. Example geocellular grids illustrating the facies and petrophysical (porosity) heterogeneity of an aeolian succession. The facies model is generated using DuneModeller, constrained to reproduce architectures observed in outcrop in the Helsby Sandstone Formation, UK. The porosity model is created geostatistically and conditioned on the facies model.

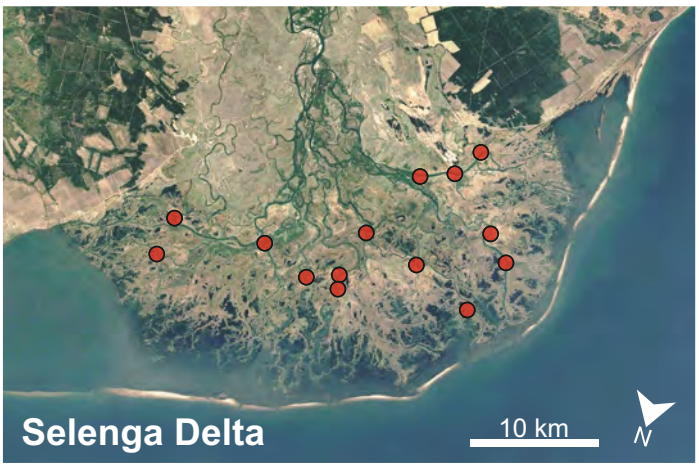
Theme 8: Flow-based upscaling of aeolian successions

This research aims to develop a new workflow for the petrophysical characterization of aeolian subsurface successions. The study will be based on the integrated application of stochastic object-based modelling algorithms and our own vector-based numerical modelling software DuneModeller. A suite of object-based models will be created to describe fine-scale facies heterogeneity (lamina-set scale), whereas outputs of DuneModeller will be used as numerical descriptions of the lithological heterogeneity of dune and interdune deposits at the scale of facies domains (e.g., relative dominance of grainflow and grain-fall strata). The modelling outputs will be used for evaluation of representative elementary volumes at the scale of the facies assemblages (e.g., interdune, dune plinth), which will be undertaken for different types of architectures, characterized by variations inf facies-domain proportions and geometry that reflect differences in the boundary conditions to the system (e.g., bedform type and size; angle of climb of dunes). The devised workflow will be applicable in subsurface studies to obtain realistic upscaled values of porosity and permeability at the scale of the geocellular gird cell on the assumption that direct data are only available at the core-plug (lamina-set) scale.

Proposed Themes for FRG-ERG-SMRG Phase 6 Research Projects

Theme 9: Upstream and intra-basinal controls on channel avulsion and resulting channel-body geometry and connectivity

This study will attempt to discriminate the relative importance of potential controls on the avulsion frequency of fluvial and alluvial fans in hinterland settings, and of lowland deltas and coastal plains. The study will be undertaken through the compound analysis of data on the Holocene avulsion histories of multiple rivers, drawn from the published scientific literature. The studied river systems will be characterized in terms of (i) paths of active or abandoned channels, (ii) past avulsion events, and/or (iii) location and extent of delta lobes. These features will be studied using data from historical records or maps, remote sensing (satellite images, aerial photos, LiDAR or InSAR elevation data), and in-situ observations on geomorphology and/or shallow subsurface stratigraphy. The avulsion histories of the case studies will be reconstructed thanks to available radiometric dates, historical accounts, archeological evidence, and dated historical maps, satellite images, or aerial photos. Data analysis will allow to tease out the potential controls exerted by a number of upstream (e.g., discharge variability) and intrabasinal (e.g., inherent geomorphology) factors. The results have implications concerning the size, geometry and static connectivity of fluvial channel bodies in subsurface successions.



Above. Location of historical (Holocene) avulsion events on the delta plain of the Selenga delta, Lake Bajkal, Russia.

Theme 10: Relationships between depositional and pedogenic processes and common controls

This research aims to analyse relationships between characteristics of fluvial sedimentary architectures over a range of scales and pedogenic features. This will be done to evaluate the potential influence of common controls that may act on both pedogenesis and the development of fluvial architectures. For example, climate and relative sea-level changes act as common controls on both soil drainage conditions and channel-body amalgamation. These controls determine feedbacks between the geomorphic and sedimentological organization of fluvial systems and overbank pedogenic processes. Pedogenic processes are controlled by the configuration of fluvial systems, for example by the proximity to river channels and by the nature of overbank materials. In turn, pedogenesis controls reservoir quality, for example by determining overbank-sediment texture and in-channel intraclast composition and resulting eogenesis. The work will include, but will not be limited to, field-based studies of stratigraphic architectures and palaeosols of successions of the Paleogene Tremp Group in the Tremp-Graus Basin (Spain). Results will have implications concerning our ability to use subsurface observations (e.g., core data) on pedogenic features to predict sedimentary architectures.

Above. ~30 m-thick succession of vertically stacked palaeosols with thin sandstone beds of fluvial crevasse-splay origin; a protracted episode of floodplain aggradation. Jurassic Morrison Formation, south of Green River, Utah, USA.

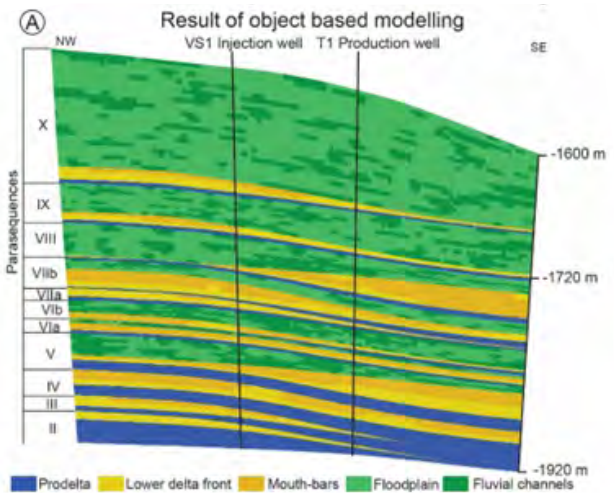
Theme 11: Fluvial-aeolian interactions

This work will focus on the characterization of styles of morphodynamic interactions between modern aeolian and fluvial systems, and on the preserved expression of these interactions in the stratigraphic record. The work will encompass outcrop studies and analyses of sets of time-lapse remote-sensing datasets. A particular focus will be placed on the analysis of currently unexplored feedbacks between the autogenic geomorphological evolution of coastal river systems (e.g., location and frequency of distributary avulsions) and the style of aeolian interaction (e.g., channel ridge reworking). Implications for subsurface architecture and heterogeneity will be considered.

Proposed Themes for FRG-ERG-SMRG Phase 6 Research Projects

Theme 12: Static connectivity of lacustrine and marine paralic sandstone bodies

This study will characterize the expected variability on the static connectivity of sandstone bodies of different origin (e.g., distributary-channel fills, mouth-bar elements) in paralic succession of both marine and lacustrine settings. The study will be based on the analysis of a large number of geocelullar models for paralic successions built using stochastic modelling algorithms constrained on data from a range of analogues stored in FAKTS and SMAKS. The static models to be employed for scopes of analysis will be created considering a range of parasequence stacking patterns, shoreline trajectories and river-system sizes. Selected outputs will be used for characterization of the subsurface architecture of low-enthalpy geothermal reservoirs of the Pannonian Basin (eastern Europe). Implications on geothermal doubles operation will be specifically considered.



Above. Preliminary object-based model for a sector of the Pannonian Basin, based on well analysis and SMAKS analogues.

Theme 13: Relationships between facies heterogeneity, diagenetic processes and petrophysical characteristics

This research aims to unravel relationships between diagenesis of fluvial sandstones and sedimentological characteristics of depositional units, with the scope to improve the ability to predict reservoir quality, especially in data-poor situations. Lithofacies heterogeneity controls petrophysical heterogeneity directly, through the textural, structural and compositional properties of sediments, and indirectly, by determining the distribution of diagenetic features in preserved successions. Climate and tectonics act to determine the facies architecture, sediment composition and diagenetic history of alluvial strata. The work that will be undertaken includes: (i) the collation of data into FAKTS, building on current work, (ii) quantitative data analysis, and (iii) the development of predictive models linking depositional products, their diagenetic imprint, and the resulting poro-perm properties to descriptors of geological boundary conditions.

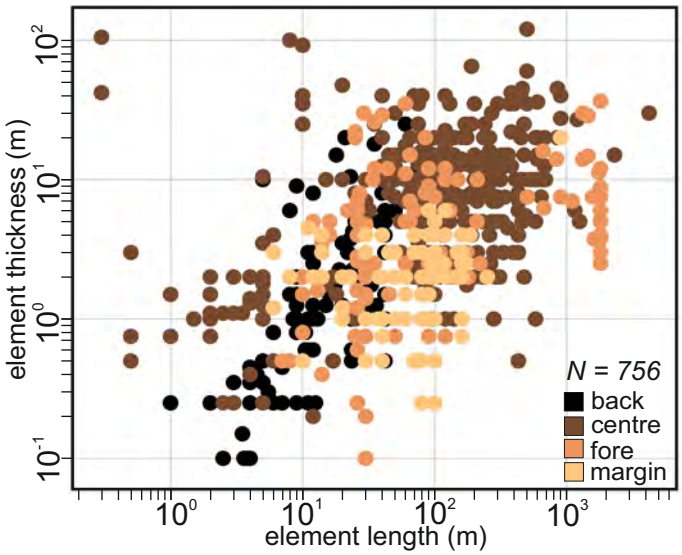
Theme 14: Parent-rock influence on grainsize shedding and downstream facies development

The aim of this work is to investigate relationships between grainsize distributions, the nature and composition of the source rocks that produce them, and the resulting tendency of sediment to segregate in hydrodynamic niches that can variably give rise to different downstream variations in facies make-ups.

The work will take the form of an integrated study consisting of: (i) the analysis of remotely sensed imagery on the stream-bed configuration of rivers with contrasting sediment supplies, constrained quantitatively at local scale by means of petrographic data; (ii) the comparison of rock-record examples for which the relative contribution of parent rocks is known or can be confidently inferred; (iii) morphodynamic modelling using Delft3D, performed with systematic variations in input grainsize distributions. Results of this work will elucidate parent-rock controls on facies heterogeneity and facies-tract development.

Theme 15: Facies control on the thermal conductivity of fluvial successions used for shallow-geothermal operations

This work will aim to assess facies controls on the thermal conductivity of fluvial successions, based on the analysis of a large dataset obtained from existing scientific literature sources and technical reports. The FAKTS database will be expanded to allow for storage of the necessary data for units at different scales (elements and facies) and metadata. The collated dataset will additionally support related research efforts connected with dynamic modelling of low-enthalpy geothermal operations.e

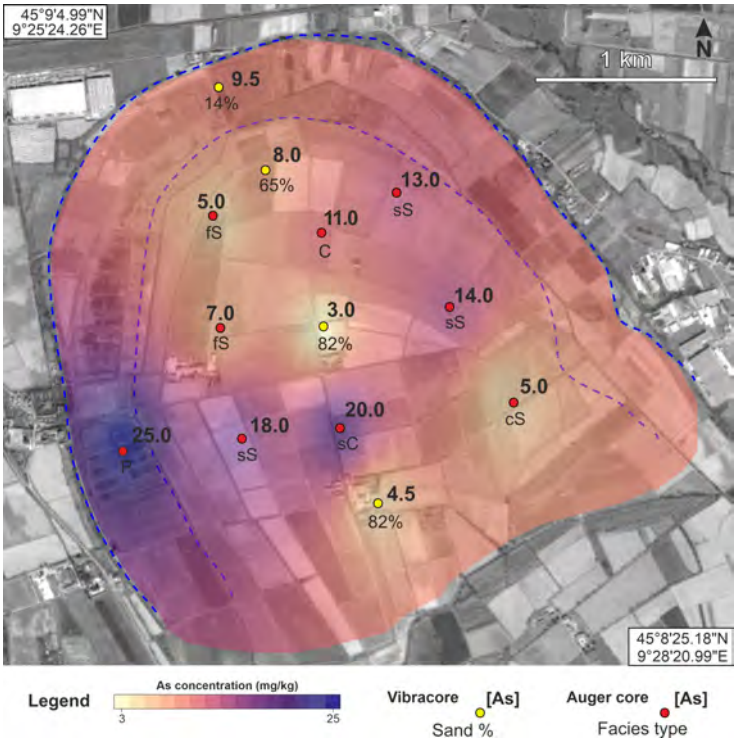


Above. Relationship between length and thickness of aeolian architectural elements colour coded by position in erg systems. Data from DASA.

Proposed Themes for FRG-ERG-SMRG Phase 6 Research Projects

Theme 16: Geogenic arsenic contamination in meander-belt aquifers

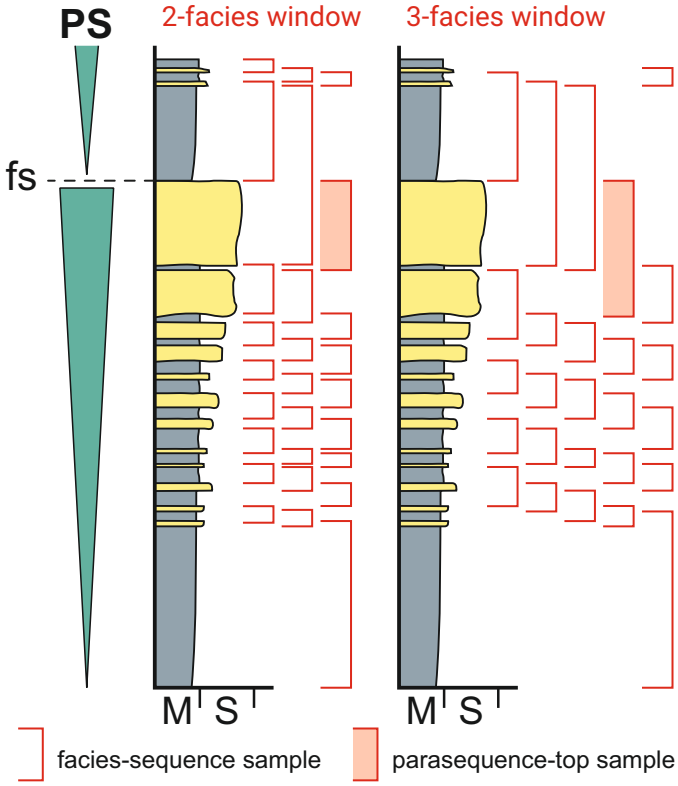
Meander-belt deposits that form aquifer units in Quaternary successions are commonly affected by natural contamination by arsenic, which is released by organic-rich abandoned channel fills and accumulates in point-bar elements. Understanding how the internal architecture of point-bar elements and the permeability contrasts of their deposits controls mobility and concentration of arsenic is important for planning the remediation of aquifers affected by arsenic pollution (e.g., Indo-Gangetic Plain). This research aims to improve our understanding of facies controls on spatial variability in arsenic concentration in unconfined aquifers hosted in point-bar units, through an integrated study of the sedimentology, geomorphology, water and sediment geochemistry, and hydrogeology of Holocene meander-belt deposits of the Po Valley (Italy). Geophysical characterization of the shallow subsurface could be undertaken to complement this dataset. This work will generate knowledge on point-bar facies heterogeneity and generic insight in fluid circulation and contaminant transport in sandy point-bar elements.



Above. Arsenic concentrations in the deposits of point-bar and channel-fill elements of the Po Valley, Italy. The distribution of contaminants is principally controlled by the action of sedimentary processes responsible for the construction of the point bar. The distribution of primary lithofacies types dictates fluid flow pathways through the deposits.

Theme 17: Machine-learning approaches to interpretations of borehole data

This research aims to develop new approaches based on machine learning for the interpretation of facies associations and sequence stratigraphic units based on borehole data. Machine learning algorithms are increasingly being applied to perform the recognition and classification of lithofacies based on well-log data, which are typically calibrated against cored intervals acting as training datasets. The application of artificial intelligence to other tasks of subsurface characterization is however more difficult where the resulting interpretations require fuller understanding of the geological significance of subsurface observations. This is the case for sequence stratigraphy, which is highly interpretive, and for which suitable training datasets cannot be readily produced using core data alone. This study will lead to the development of novel workflows for supervised machine-learning classifications of facies logs based on the application of training datasets consisting of tens of thousands of facies units from hundreds of classified geological analogues contained in the FAKTS, SMAKS and DASA database. The outputs will be applicable in subsurface studies requiring conceptual models of sedimentary heterogeneity and categorization of sedimentary units for subsequent geocellular modelling.



Above. Example training datasets for machine-learning recognition of parasequence tops from facies logs.

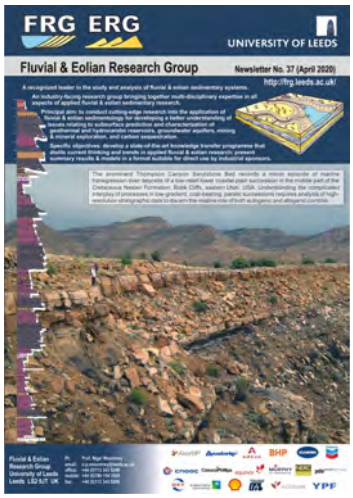
Fluvial, Eolian & Shallow-Marine Research Group

Phase 6
Jan 2024 to Dec 2026

Summary of Phase 6 Research Themes

- Database-informed quantitative facies models
- Methods for quantification of static & dynamic connectivity
- Accommodation regime and alluvial architecture
- Training-image libraries for MPS reservoir modelling
- Sedimentary architecture of fluvial overbank successions
- Alluvial facies architecture and overbank pedogenesis
- Facies control on petrophysical heterogeneity
- Alluvial and aeolian aquifers for low-carbon energy
- Compartmentalization of meander-belt successions
- Internal sedimentary architecture of point bars and splays
- Sedimentology of dryland distributive fluvial systems
- Tectonic controls on architecture in rift & foreland basins
- Numerical modelling of non-marine architecture
- Predicting 3D aeolian architecture from 1D core data
- Database-informed quantitative aeolian facies models
- Sedimentology of the fluvial-to-marine transition zone
- Influence of marine processes on channel networks
- Accommodation & sediment supply controls
- Sedimentation in fluvial-, wave- and tide-influenced deltas

Newsletter Updates



The research group: people

FRG-ERG-SMRG is a community with expertise in clastic sedimentology & stratigraphy comprising of staff based at Leeds and Pavia, and of academic associates at other institutions.

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Dr Hamed Aghaei (Pavia; geothermal modelling)

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Nigel Mountney is Professor of Sedimentology at the University of Leeds. For the period 2014-2018 he acted as Chief Editor of *Sedimentology*, the leading international journal in the field, and was a bureau member of the International Association of Sedimentologists (IAS). He is former Director of the Institute of Applied Geosciences (IAG), and is currently Director of Research Impact and KE at the University of Leeds.

Dr Luca Colombera is Assistant Professor at the University of Pavia. He has specialist expertise in the development of geological analogue databases, and in devising and applying methods for predicting subsurface sedimentary architecture. Together, Nigel and Luca lead the FRG-ERG-SMRG research programme.