FRG ERG SMRG

UNIVERSITÀ DI PAVIA

UNIVERSITY OF LEEDS

Fluvial, Eolian & Shallow-Marine Research Group

Phase 7
Jan 2027 to Dec 2029

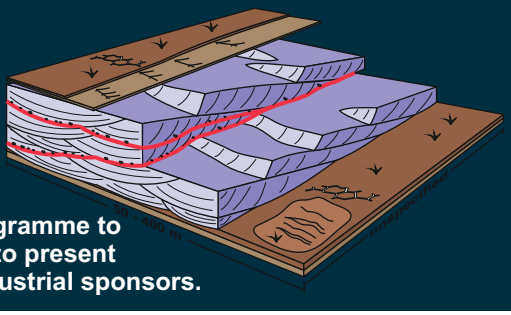
https://frg.leeds.ac.uk/

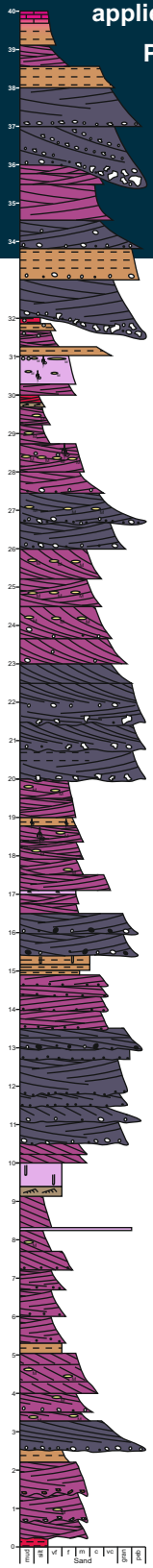
Internationally recognized research leader in the study and analysis of fluvial, aeolian & shallow-marine sedimentary systems and their preserved successions.

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 2027-29 Deliverables

- **Company-wide access to:**
  - Cloud-based apps 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 and knowledge transfer arising from our stratigraphic modelling software for the simulation of bedform morphodynamics and resulting facies heterogeneity (**DuneModeller**, **DASH**)
  - Access to the entire back catalogue of research from all previous phases (> 2000 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

- 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 – 6 Partners & Sponsors

Aker BP, Anadarko, Areva (now Orano), BHP, Cairn India (Vedanta), Chevron, CNOOC, ConocoPhillips, ENI, 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 **2000 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 incorporates research results of applied significance. 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 cloud-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, Aeolian and Marine 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 (**PB-SAND**, **DASH** 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

Find out more about how FAKTS can be applied **here**

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

Find out more about how DASA can be applied **here**

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

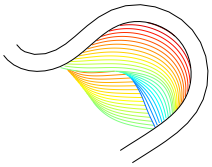
Find out more about how SMAKS can be applied **here**

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.

The DBs contain data on **>700 case studies** and **>158k** sedimentary units.

Research & Knowledge Transfer Programme: Deliverables

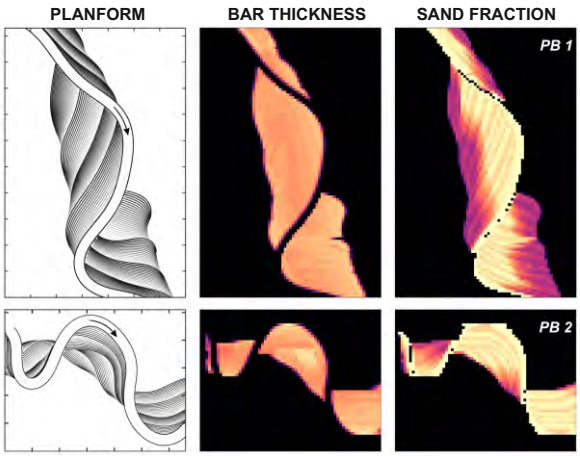


PB-SAND

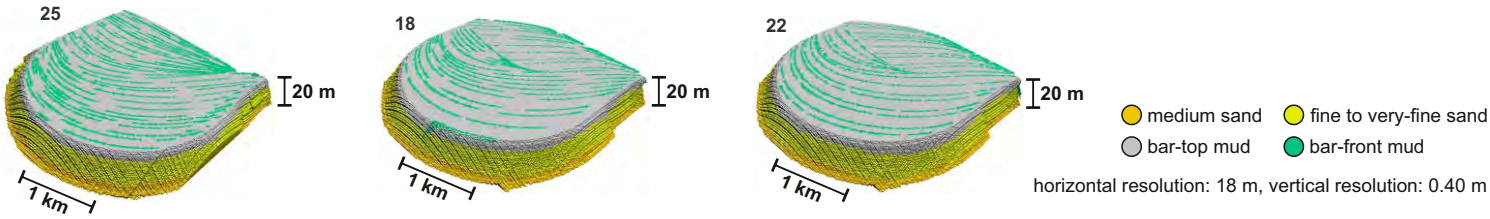
Point Bar Sedimentary Architecture Numerical Deduction

Find out more about how PB-SAND can be applied **here**

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.



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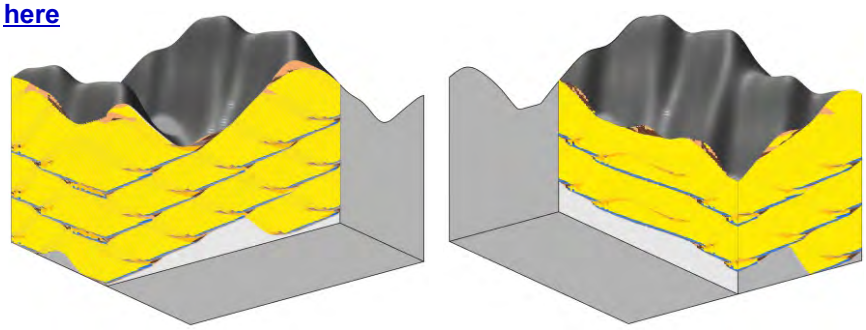
DASH

Dune Architecture Sedimentary Heterogeneity Forward Stratigraphic Model

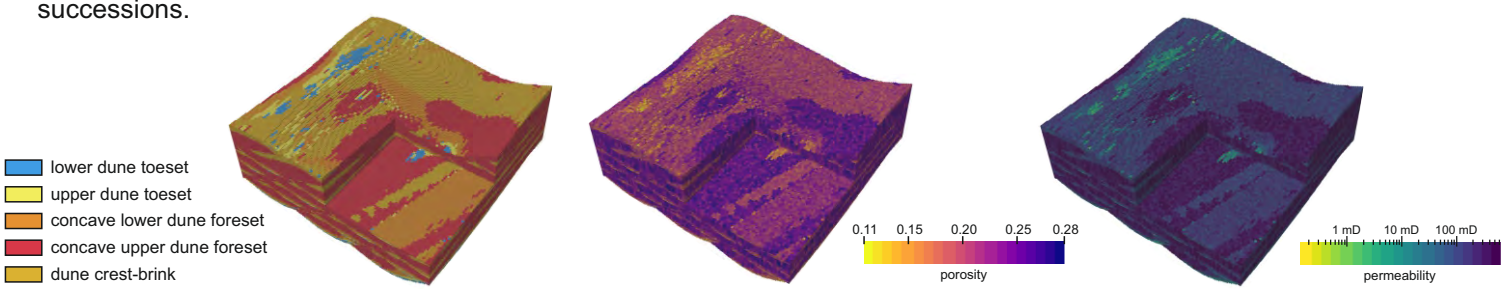
Find out more about how DASH can be applied **here**

DASH is a 3D 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.



DASH is based on an open-source modelling approach originally developed by David Rubin, USGS

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



Research & Knowledge Transfer Programme: Deliverables

Fluv-Lit

Fluvial Literature Review & Summary

Aeo-Lit

Aeolian Literature Review & Summary

Literature reviews and recommendations 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.

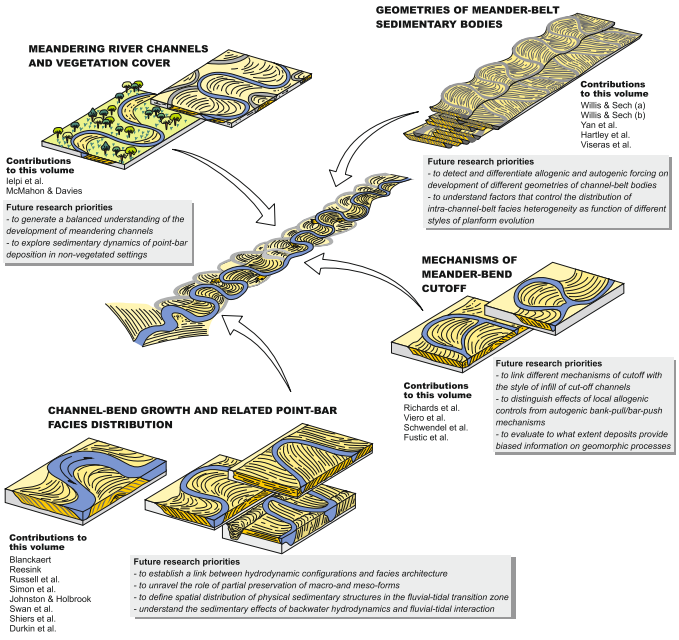
ATLAS

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.

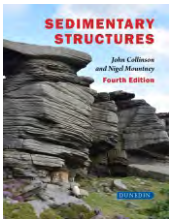
Books

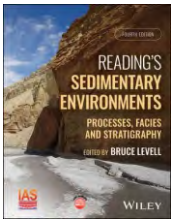
Articles, Text Books, Thematic Special Publications & Self-Learning Guides



Research from Phases 1 – 6 has directly led to the publication of >190 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), (ii) written a major research-led textbook (“Sedimentary Structures”, Collinson and Mountney, Dunedin), (iii) authored a book chapter of “Reading's Sedimentary Environments, 4th Edition” (Wiley).

Details of all published works are available on the publications page at **frg.leeds.ac.uk/**





Proposed Themes for FRG-ERG-SMRG Phase 7 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 analogues, 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.

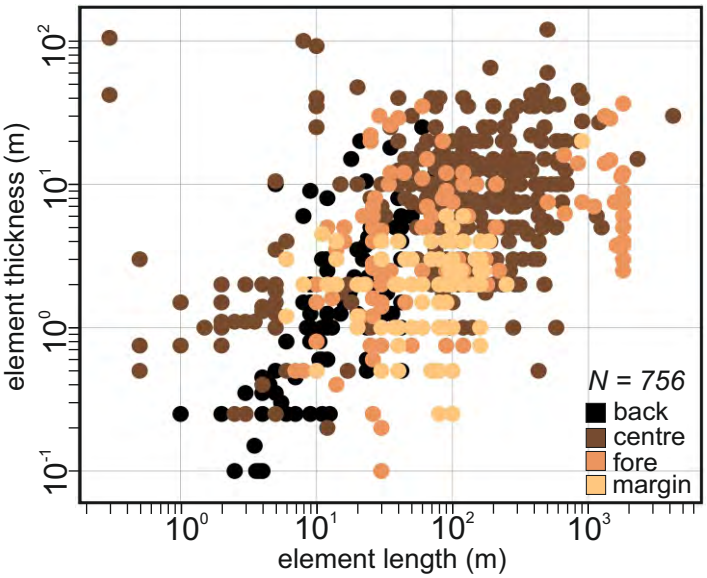
Above. Channel bodies of the Paleocene Esplugafreda Formation, Spain.

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 undertaken 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.

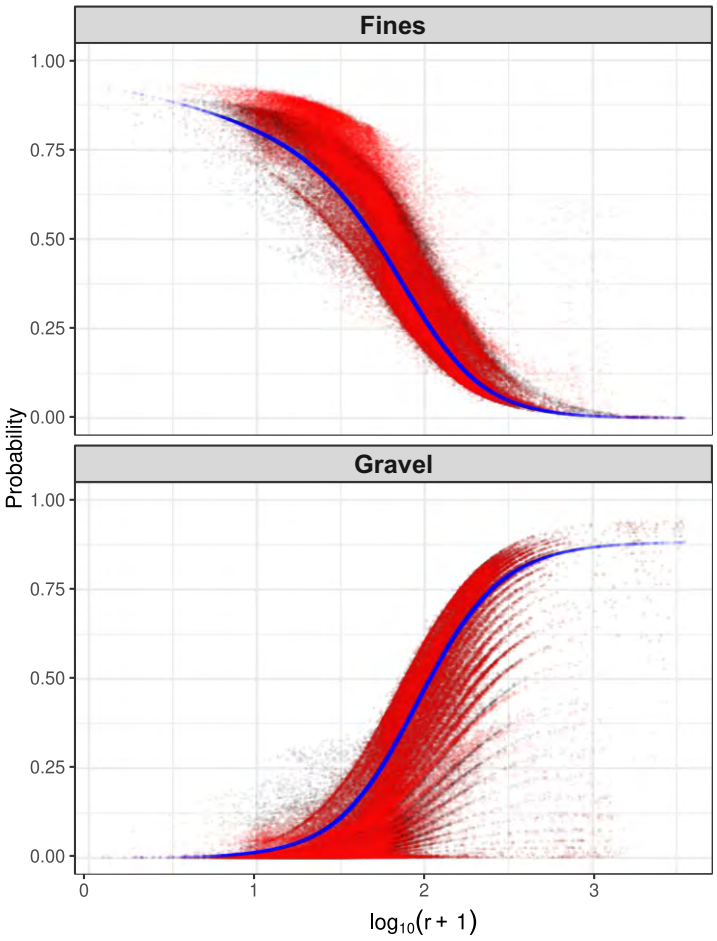


Above. Relationship between length and thickness of aeolian architectural elements colour coded by position in erg systems. Data from DASA.

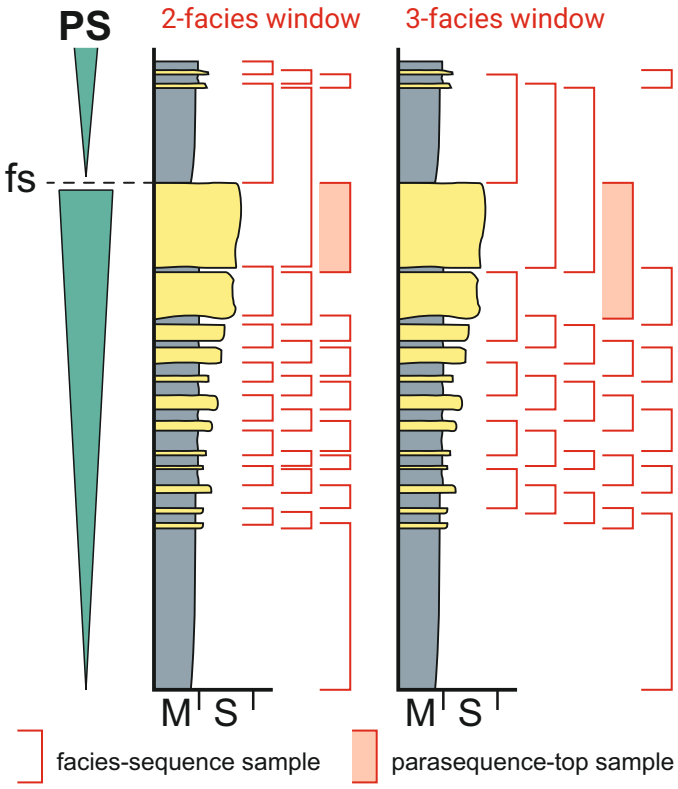
Proposed Themes for FRG-ERG-SMRG Phase 7 Research Projects

Theme 4: Improved use of geophysical soft data for costraining clastic reservoir models

This research aims to develop novel workflows for the optimized use of geophysical soft data in geomodelling continental and shallow-marine subsurface successions using geostatistical tools based on multiple-point statistics (MPS). Geophysical data will be employed as lithological predictors through borehole calibration using statistical methods based on standard regression techniques and new statistical-learning approaches. Case-study applications will be completed on continental and marine successions of Pliocene and Quaternary age and exhibiting a range of sandbody types and architectures. The approaches will be trialled using electrical resistivity estimations derived from airborne time-domain electromagnetic surveys, but the workflows will be broadly applicable to any type of geophysical data that may act as lithological proxies (e.g., seismic attributes). This ensures applicability of the developed workflows to clastic subsurface successions present over a wide range of depths.



Above. Models linking probabilities of reservoir-modelling facies to electrical resistivity values determined via geophysical surveys.



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

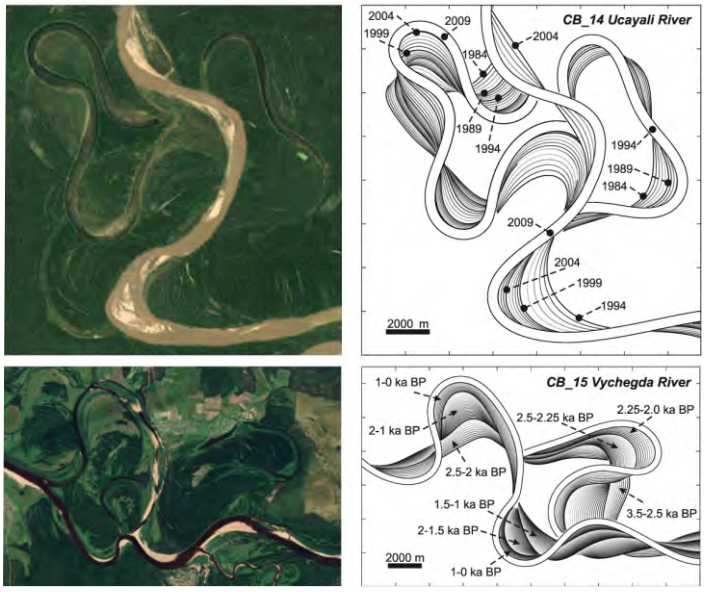
Theme 5: Machine-learning approaches to interpretations of borehole data

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 and architectural-element classifications, which are 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.

Proposed Themes for FRG-ERG-SMRG Phase 7 Research Projects

Theme 6: Generation of a training image library for MPS geocellular modelling

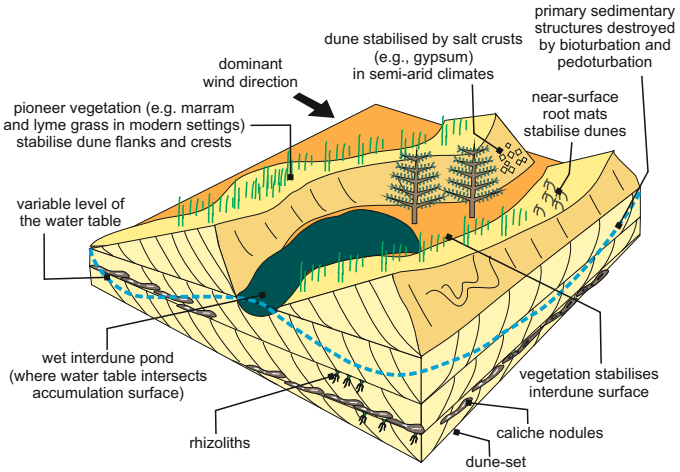
Geostatistical modelling algorithms based on multi-point statistics replicate geological patterns drawn from training images. Geologically realistic training images are therefore required to achieve geologically plausible reservoir models. This work will aim to generate a set of 3D geocellular training 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, DASH). 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.



Above. Example applications of PB-SAND to model the temporal evolution of meandering rivers. 3D forward numerical modelling in PB-SAND can be employed to generate MPS training images for modelling fluvial reservoirs.

Theme 7: 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: DASH. 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 DASH 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. Characteristic features of stabilizing aeolian systems.

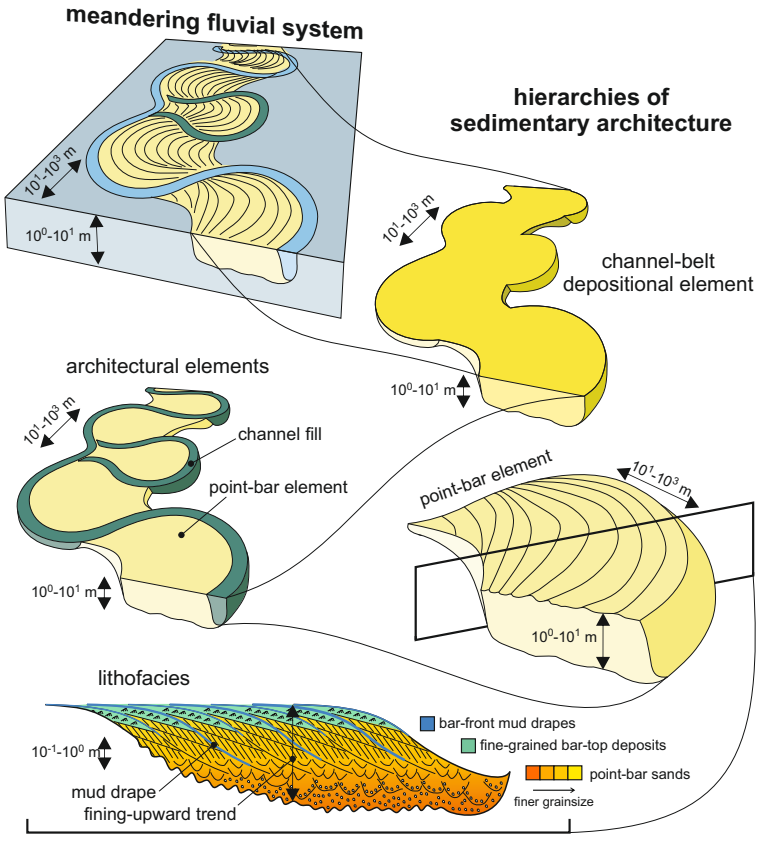
Theme 8: Influence of sedimentary heterogeneity on the performance of low-enthalpy geothermal applications

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.

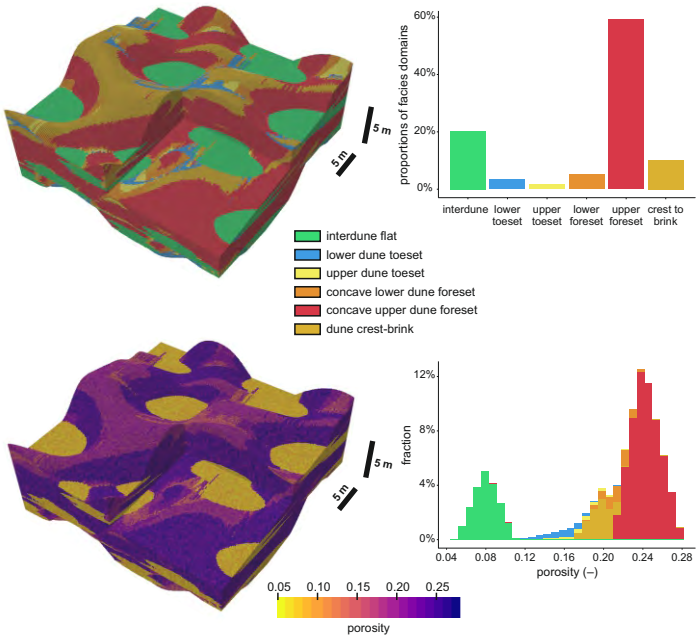
Proposed Themes for FRG-ERG-SMRG Phase 7 Research Projects

Theme 9: 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. Idealized models depicting relevant scales of sedimentary heterogeneity of meander-belt successions of economic interest.



Above. Example geocellular grids illustrating the facies and petrophysical (porosity) heterogeneity of an aeolian succession. The facies model is generated using DASH, 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 10: Flow-based upscaling of aeolian sedimentary heterogeneity

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, DASH. A suite of object-based models will be created to describe fine-scale facies heterogeneity (lamina-set scale), whereas outputs of DASH 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 grid cell assuming that direct data are only available at the core-plug (lamina-set) scale.

Proposed Themes for FRG-ERG-SMRG Phase 7 Research Projects

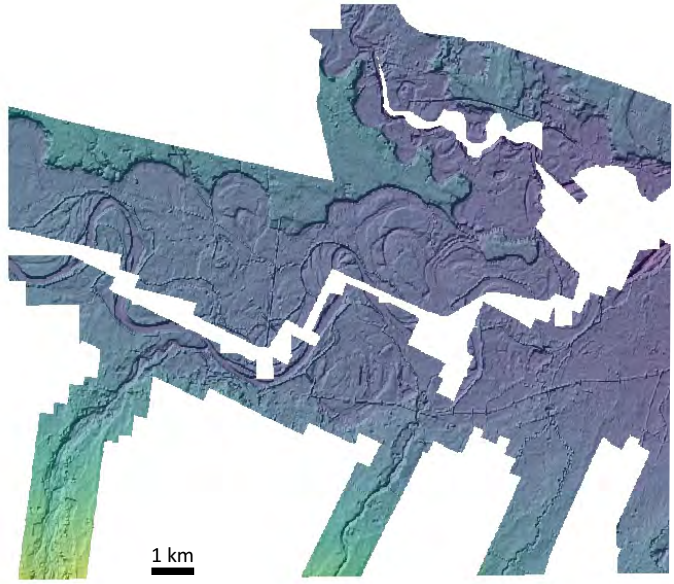
Theme 11: Upstream and intra-basinal controls on channel avulsion and resulting channel-body geometry and connectivity

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) distributary channels on the delta plain of the Ebro delta, Mediterranean Sea, Spain.

Theme 12: Sequence stratigraphy of fluvial systems in tectonically active basins

This research aims to develop conceptual sequence stratigraphic models and correlation strategies applicable to tectonically active basins hosting axial and transverse fluvial systems exhibiting out-of-phase responses to eustatic change and contrasting sediment-delivery processes. To elucidate the dynamic interactions and evolution of related axial and trunk river systems, Quaternary successions and geomorphic elements from a sector of the central Po Valley (Northern Italy), shaped by rivers draining the Alps and the Apennines and converging into the Po River, will be studied. The study will bring together results of field-based geomorphological and sedimentological investigations, analyses of remote-sensing datasets, chronological constraints and borehole and geophysical data from the subsurface. By integrating this broad range of geological datasets, the study will enable a detailed characterization of the co-evolution of the different river systems at different spatial and temporal scales; in turn, this will allow us to address fundamental and applied research questions, relating to the relative importance of tectonic, climatic and eustatic controlling factors on the continental sedimentary record of active basins that are infilled during icehouse times.



Above. LiDAR topography along the Po River and its tributaries on a sector of the central Po Basin, Italy.

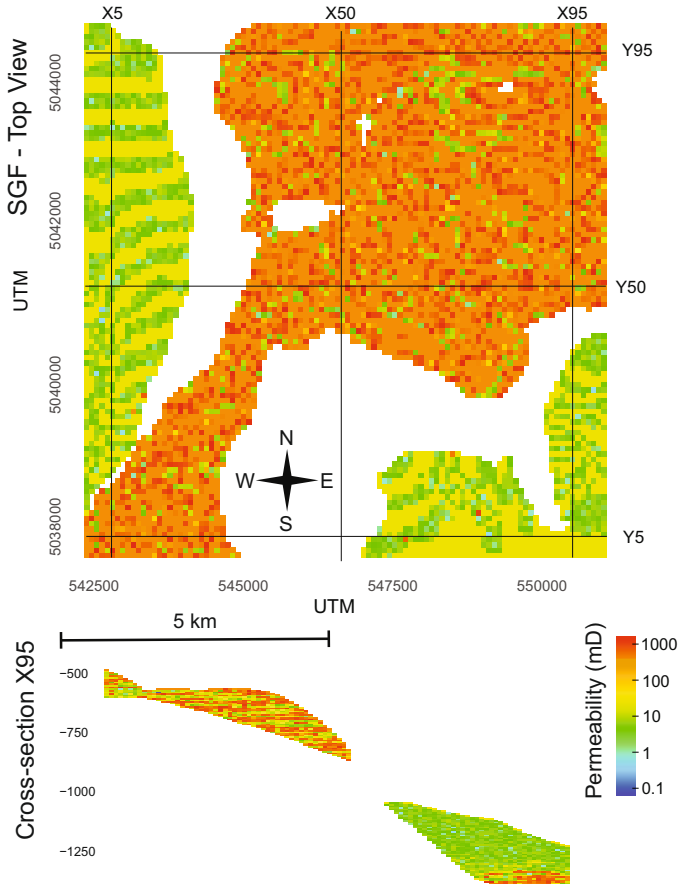
Theme 13: Fluvial-aeolian interactions

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 7 Research Projects

Theme 14: Geometry and static connectivity of lacustrine and marine architectural elements

This study will characterize the expected variability on the shape, size and static connectivity of sand- and gravel-prone bodies of varied origin (e.g., distributary-channel fills, mouth-bar elements) in paralic successions of both marine and lacustrine settings, including those associated with coarse-grained depositional systems. The study will be based on collation of geological analogue data from a wide range for paralic successions seen in outcrop and in the subsurface, which will be stored in FAKTS and SMAKS. Geomodelling tools will be employed to produce static models, to be used for scopes of quantitative analysis and created considering a range of parasequence stacking patterns, shoreline trajectories and river-system sizes.



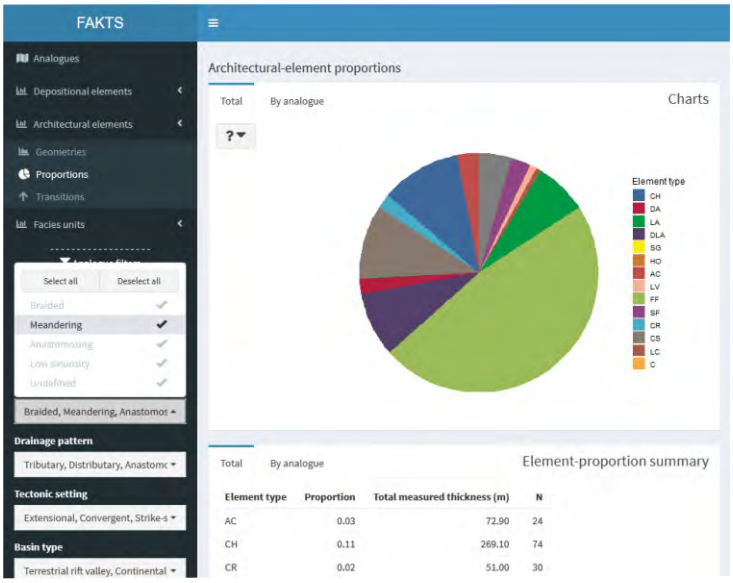
Above. Permeability grid of a static reservoir model of a coarse-grained alluvial-paralic FSST to LST succession being targeted for low-enthalpy geothermal use.

Theme 15: Relationships between facies heterogeneity, diagenetic processes and petrophysical characteristics

This research aims to unravel relationships between diagenesis of fluvial, aeolian and paralic 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 clastic strata. The work that will be undertaken includes: (i) the collation of data into FAKTS, SMAKS and DASA, (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 16: 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, SMAKS and DASA databases will be expanded to enable the storage of the necessary data for sedimentary units at different scales (elements and facies) and the related metadata. The collated dataset will additionally support connected research efforts focussing on the dynamic modelling of low-enthalpy geothermal operations.

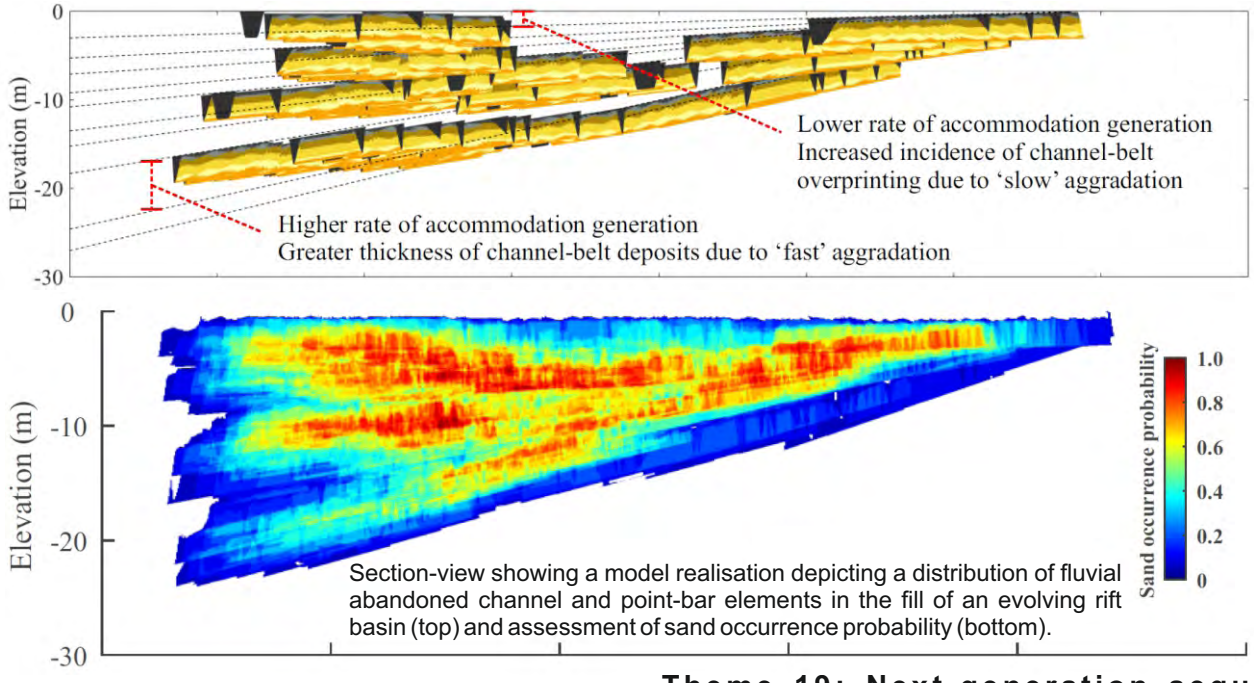


Above. View of the FAKTS app, showing output on average proportions of architectural-element types in all selected analogues. The app allows the application of filters to the database on attributes describing the depositional systems and on metadata describing datasets and source analogue studies.

Proposed Themes for FRG-ERG-SMRG Phase 7 Research Projects

Theme 17: Prediction of facies heterogeneity and brine migration pathways for CCS risk assessment around legacy wells

Carbon Capture and Storage (CCS) underpins the UK's net-zero strategy, with the UK North Sea offering large-capacity storage in depleted fields and saline aquifers. A critical challenge is to assess containment risks associated with legacy oil and gas wells, which may act as preferential pathways for CO_2 and pressure-driven brine migration. Traditional risk assessments often rely on static geological models derived from seismic data and limited well-derived stratigraphic data. These models frequently fail to resolve sub-seismic stratigraphic heterogeneities, such as thin baffle units or high-permeability "thief zones", which strongly influence fluid migration in storage complexes. This project will use PB-SAND and DASH models to predict detailed 3D facies architectures applicable to characterise brine migration pathways, providing improved risk indicators for the repurposing of legacy wells in representative UK North Sea CCS settings.



Section-view showing a model realisation depicting a distribution of fluvial abandoned channel and point-bar elements in the fill of an evolving rift basin (top) and assessment of sand occurrence probability (bottom).

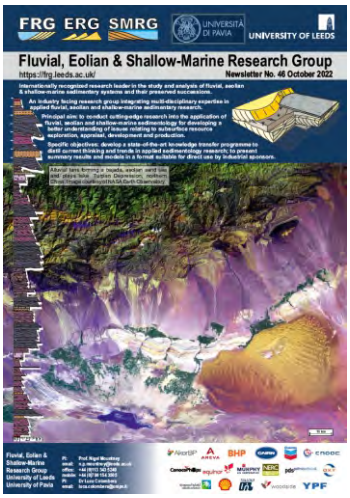
Theme 18: Integrating fluvio-aeolian architecture and fault dynamics: 3D seabed-to-subsurface modelling for secure CO_2 storage

The permanent sequestration of CO_2 in offshore geological formations is essential for achieving Net Zero climate targets, with the North Sea serving as a global proving ground for large-scale implementation. However, these target reservoirs are characterised by highly complex, mixed fluvio-aeolian depositional architectures. Furthermore, faulting within these formations can constrain storage capacity, accelerate pressure buildup, and function as conduits for vertical leakage to the seabed. To effectively evaluate CO_2 plume migration and associated containment, it is essential to accurately predict sedimentary architecture, facies heterogeneity and structural compartmentalisation influenced by faulting. This research will develop a comprehensive 4D seabed-to-subsurface numerical modelling framework to integrate PB-SAND and DASH numerical models of fluvio-aeolian depositional systems with multiscale fault dynamics to predict CO_2 migration pathways, assess fault-seal integrity, and quantify potential containment risks. By superimposing high-resolution stratigraphic models derived from PB-SAND and DASH with structural fault networks, this study will analyse the implications of faulting on CO_2 storage at a macro scale, including the impact of minor structural variations that may alter fluid pathways and bypass localised barriers. The findings from this research will enable operators to optimise injection strategies. This objective is critical to supporting a just and secure transition to green energy.

Theme 19: Next-generation sequence stratigraphy models to better understand the nature of the sedimentary record

This work will apply our advanced numerical modelling software to demonstrate how sediment supply, base-level change, climate, tectonic subsidence and accommodation collectively act to determine the nature of the stratigraphic record in continental and shallow-marine systems. We will show how our modelling outcomes have implications for how we predict gross depositional environments in a range of basin types.

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.

FRG-ERG-SMRG research staff & associates

- **Prof Nigel Mountney** (Leeds, Principal Investigator)
- **Prof Luca Colombera** (Pavia, Principal Investigator)
- **Dr Na Yan** (Leeds, Principal Investigator)
- **Dr Adam McArthur** (Leeds, Principal Investigator)

- Dr Hamed Aghaei (Pavia; geothermal modelling)
- Prof Alessandro Amorosi (Uni. Bologna, Italy)
- Dr Manoela Bállico (UFRGS, Brazil)
- Prof Giorgio Basilici, Unicamp, Brazil)
- Prof Bernard Besly (Besly Earth Science Ltd)
- Soma Budai (Pavia)
- Dr Sonia Campos-Soto (Madrid, Spain)
- Dr Richard Collier (Leeds)
- Prof John Collinson (John Collinson Consulting Ltd)
- Dr Grace Cosgrove (Leeds; oversees DASA development)
- Dr Adriana del Pino Sanchez (Leeds)
- Dr Rob Duller (Uni. Liverpool)
- Prof Andrea Di Giulio (Pavia)
- Prof Quentin Fisher (Leeds)
- Prof Massimiliano Ghinassi (Uni. Padova, Italy)
- Sam Haynes (Leeds, administrator Geosolutions)
- Prof David Hodgson (Leeds)
- Prof John Holbrook (TCU, Texas)
- Prof Wonsuck Kim (Yonsei Uni., South Korea)
- Dr Jiaguang Li (China Uni. Geosciences Wuhan)
- Dr Wei Li (China Uni. of Petroleum Beijing)
- Prof Bill McCaffrey (Leeds)
- Dr Giacomo Medici (Uni. Sapienza, Rome, Italy)
- Prof Jungang Pang (Xi'an Petroleum Uni., China)
- Dr Georgios Pantopoulos (Pavia)
- Dr Marion Parquer (Geological Survey of Canada)
- Prof Jeff Peakall (Leeds)
- Dr Arjan Reesink (Lancing College)
- Prof Philippe Renard (Uni. Neuchâtel, Switzerland)
- Dr Juan Pedro Rodríguez-López (Madrid, Spain)
- Dr Maurício Santos (UFABC, Brazil)
- Prof Claiton Scherer (UFRGS, Brazil)
- Prof Gonzalo Veiga (La Plata, Argentina)
- Dr Ru Wang (Leeds)
- Prof Jared West (Leeds)
- Dr Cees Willems (HVC Groep, The Netherlands)
- Prof Dali Yue (China Uni. of Petroleum Beijing)
- Dr Junfeng Zhao (Northwest Uni., China)

Current & former research students

- Sharif Al Bahri (Leeds)
- Abrar Albloushi (Leeds)
- Mahmud Alkathery (now at Saudi Aramco)
- Mohammed Almasrahy (now at Saudi Aramco)
- Bassam Alshammari (Leeds)
- Oscar Arevalo (Leeds)
- Junaid Arif (Leeds)
- Manoela Bettarel Bállico (UFSC, Brazil)
- Steven Banham (now at Imperial College, London)
- Lei Bao (Leeds)
- Elisabetta Bosi
- Laura Bührig (Leeds)
- Catherine Burns (formerly at Leeds)
- Stephen Cain (now at Luk Oil)
- Shuo Cao (China Uni. Geosciences, Beijing)
- Sheng Chen (Leeds)
- Luca Colombera (Leeds)
- Grace Cosgrove (Leeds)
- Hang Cui (Leeds)
- Rob Duller (now at University of Liverpool)
- Shahid Ghazi (now at University of Punjab)
- Qiwei Gou (Leeds)
- Victor Hême de Lacotte (Lyon, Leeds)
- Qing He (Leeds)
- Jack Humphries (Leeds)
- Alison Jagger
- Oliver Jordan (now at Equinor)
- Wei Li (China Uni. Petroleum, Beijing)
- Giacomo Medici (Uni. Sapienza, Rome)
- Rossano Michel (Leeds, UFRGS)
- Jose Montero (Leeds)
- Andréa Morel (Pavia)
- Xiaojiao Pang (Leeds, Beijing)
- Hollie Romain (now at Shell)
- Catherine Russell (now at University of Leicester)
- Lucy Rushmer (Keele University)
- Maurício Santos (now at UNESP, Brazil)
- Samuel Scott (Leeds)
- Michelle Shiers (now as CASP, UK)
- Laura Simoncelli (Pavia)
- Roman Soltan (Leeds)
- Dave Somerville (Leeds)
- Jen Stuart (now at Shell)
- Joanne Venus (now at Shell)
- Oliver Wakefield (now at British Geol. Survey)
- Ru Wang (Leeds)
- Ke Yang (Leeds, Beijing)
- Yue Zhang (China Uni. Petrol., Beijing, Leeds)

Summary of Phase 7 Research Programme

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

Theme 2: Analogue studies of subsurface architecture and facies heterogeneity

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

Theme 4: Improved use of geophysical soft data for costraining clastic reservoir models

Theme 5: Machine-learning approaches to interpretations of borehole data

Theme 6: Generation of a training image library for MPS geocellular modelling

Theme 7: Controls on the static connectivity of aeolian dune and interdune deposits

Theme 8: Influence of sedimentary heterogeneity on the performance of low-enthalpy geothermal applications

Theme 9: Impact of sedimentary architectures on carbon capture and underground storage

Theme 10: Flow-based upscaling of aeolian sedimentary heterogeneity

Theme 11: Upstream and intra-basinal controls on channel avulsion and resulting channel-body geometry and connectivity

Theme 12: Sequence stratigraphy of fluvial systems in tectonically active basins

Theme 13: Fluvial-aeolian interactions

Theme 14: Geometry and static connectivity of lacustrine and marine architectural elements

Theme 15: Relationships between facies heterogeneity, diagenetic processes and petrophysical characteristics

Theme 16: Facies control on the thermal conductivity of fluvial successions used for shallow-geothermal operations

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Theme 19: Next-generation sequence stratigraphy models to better understand the nature of the sedimentary record

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Luca Colombera is Associate Professor at the University of Pavia, Italy. He has specialist expertise in characterizing geological analogues, and in devising and applying methods for predicting subsurface sedimentary architectures and heterogeneity, including developing novel statistical approaches. Luca leads on the development of our sedimentary architectural databases.

Nigel Mountney is Professor of Sedimentology at the University of Leeds, UK. He has specialist expertise in clastic and carbonate sedimentology and stratigraphy. He has acted as Chief Editor of *Sedimentology*, the leading international journal in the field. He is a former Director of the Institute of Applied Geosciences (IAG) at Leeds and is currently on the Board of Geosolutions Leeds.

Dr. Na Yan is a Research Fellow based at the University of Leeds, UK. She has specialist expertise in forward stratigraphic modelling, sedimentology & subsurface characterization of CO_2 storage systems. Her research focuses on facies heterogeneity and subsurface characterisation, especially in fluvial and aeolian reservoirs, with applications to large-scale storage.

Dr Adam McArthur is Senior Research Fellow based at the University of Leeds, UK. He has specialist expertise in sedimentology and seismic stratigraphy. In addition to his role in FRG-ERG-SMRG, Adam is also Director and Principal Investigator of the Turbidites Research Group at Leeds. He also leads the broader Sedimentology Research Cluster within the Institute of Applied Geoscience.