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Turbidites Research Group

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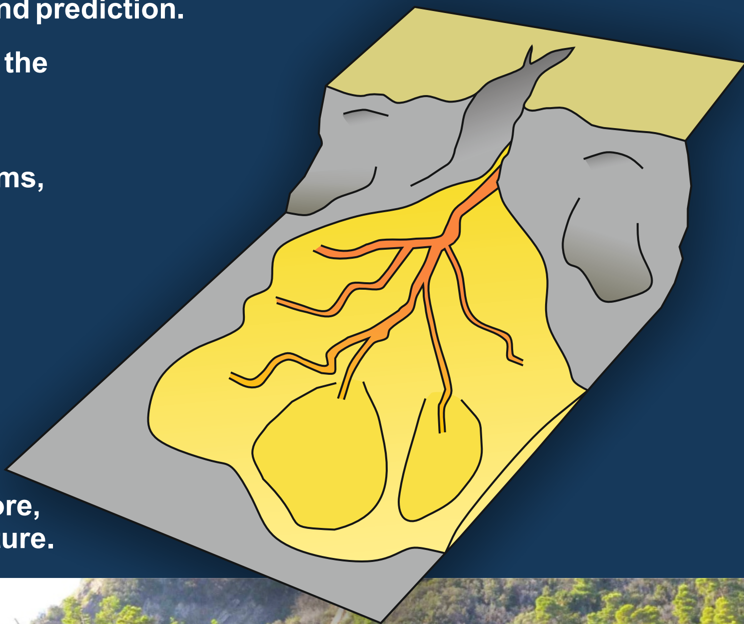
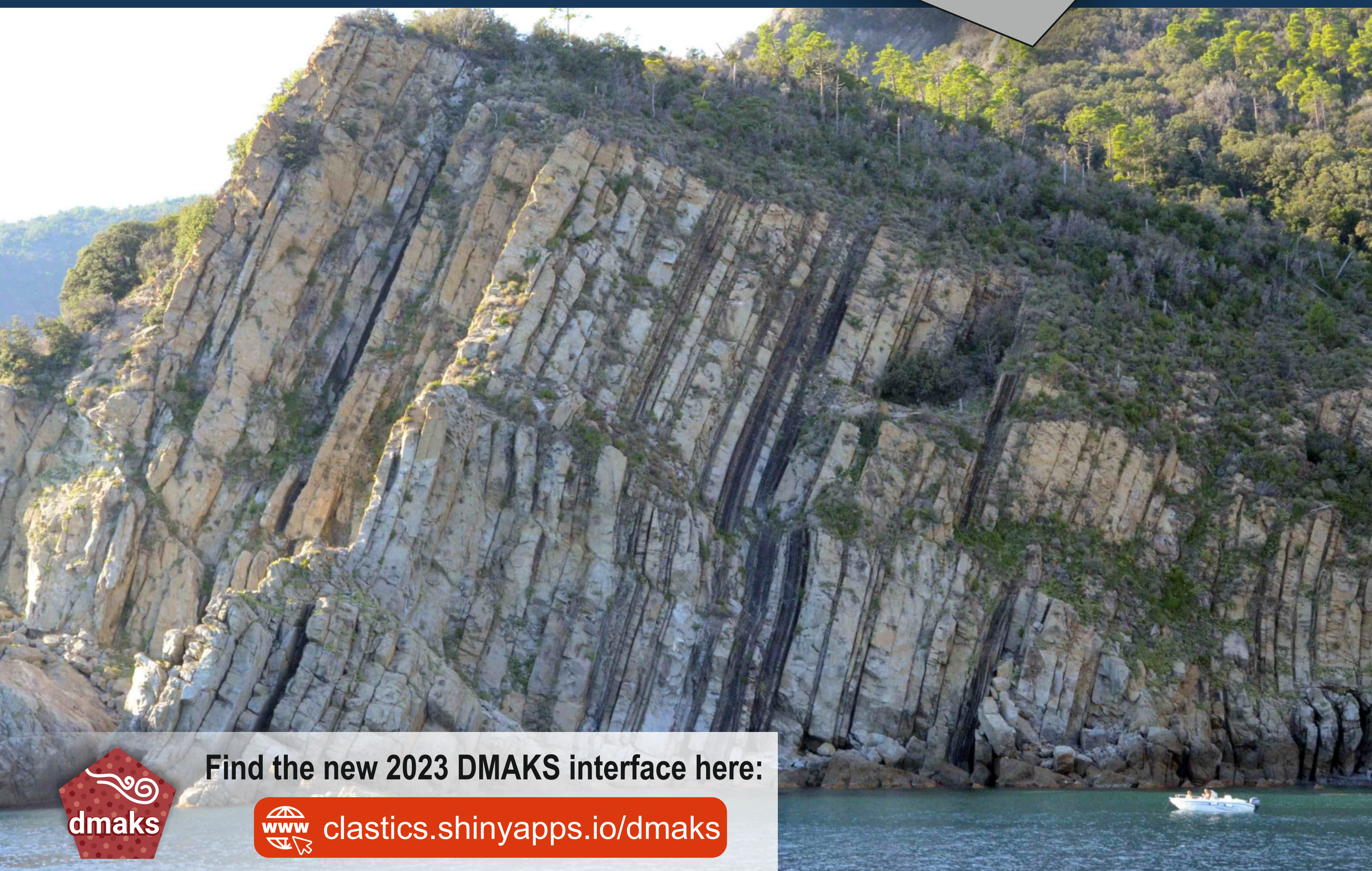
DMAKS: Deep-Marine Architecture Knowledge Store

A quantitative database of the sedimentary architecture of deep-water depositional systems, which can be applied to problems of reservoir characterization and prediction.

The database serves as a tool with which to achieve the following primary goals:

- **generate bespoke quantitative facies models for deep-marine and deep-lacustrine depositional systems, applicable as composite reservoir analogues;**
- **guide well correlation of deep-marine sandstone bodies;**
- **condition object- and pixel-based stochastic reservoir models;**
- **predict the likely heterogeneity of geophysically imaged geobodies;**
- **inform interpretation of lithologies observed in core, to guide conceptual models and predict 3D architecture.**





dmaks

Find the new 2023 DMAKS interface here:

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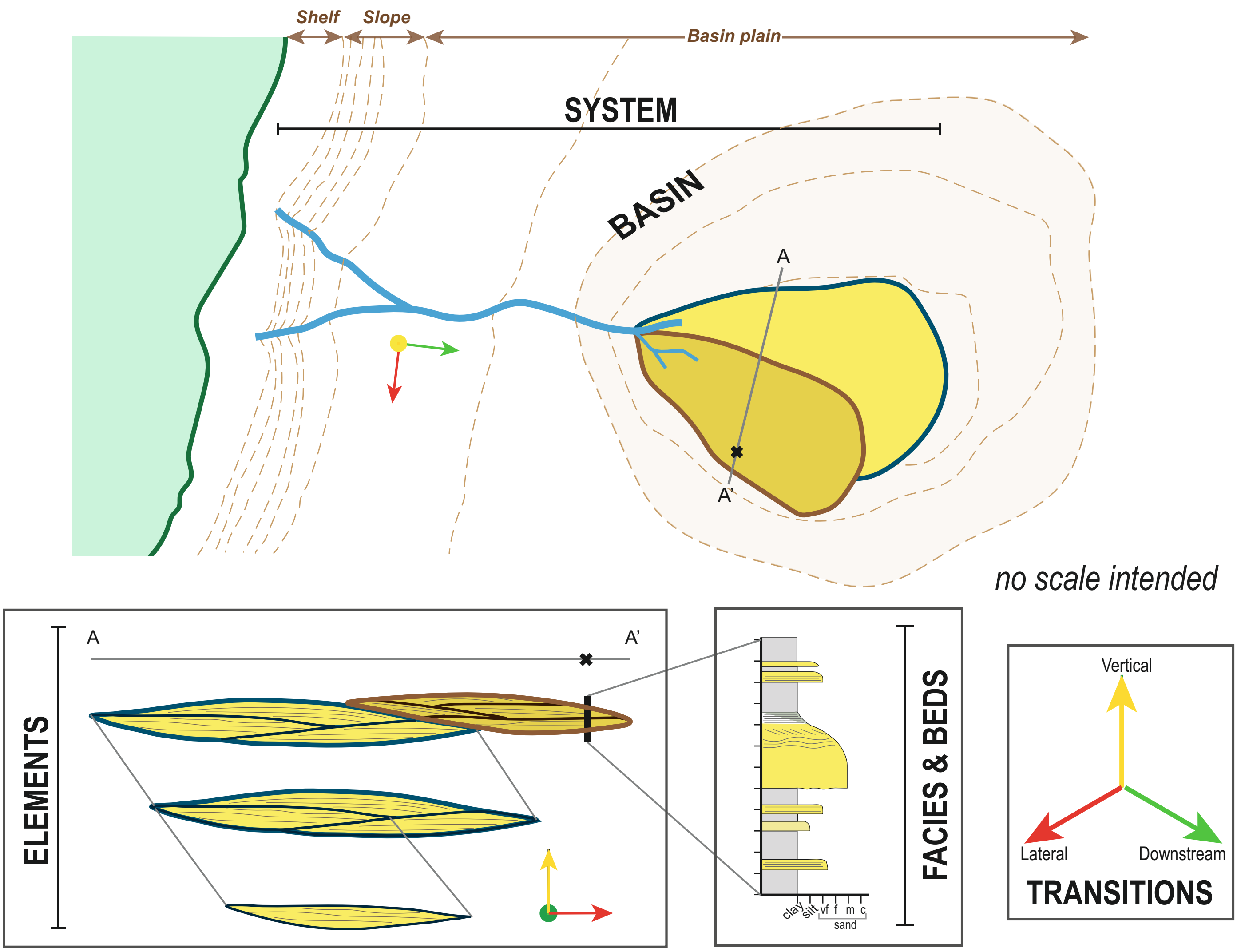
Introduction: the Deep-Marine Architecture Knowledge Store (DMAKS)

The Deep-Marine Architecture Knowledge Store (DMAKS) is a relational database devised for the storage of hard and soft data on the sedimentary architecture of ancient deep-marine and deep-lacustrine 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., architectural elements, beds, lithofacies), including attributes that characterize their type, geometry, spatial relationships, hierarchical relationships, and temporal significance. Furthermore, geological entities are assigned to case studies, basins, depositional systems, and to parts thereof (e.g., stratigraphic intervals), each of which is described by multiple parameters (e.g., continental margin type, feeder-system type) and types of metadata (e.g., data types, data sources).

DMAKS permits the quantitative characterization of modern and ancient deep-water depositional systems. It serves as a repository of analogue information for subsurface successions, and as a research tool, applicable to aid the development of facies models or to assess the sensitivity of depositional systems to particular controlling factors, for example.



Idealized summary diagram that illustrates the geological entities that are characterized in DMAKS: sedimentary basins and depocentres, depositional systems, architectural elements of different hierarchies, beds and facies. Hierarchical and spatial relationships are digitized to record the topology of sedimentary units.

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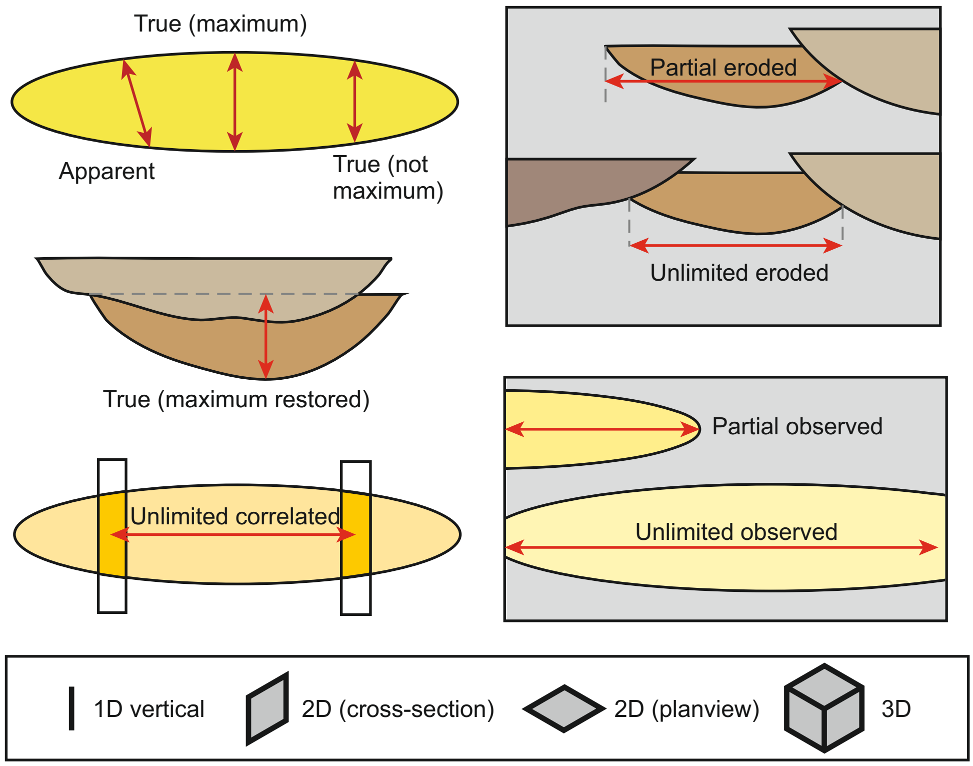
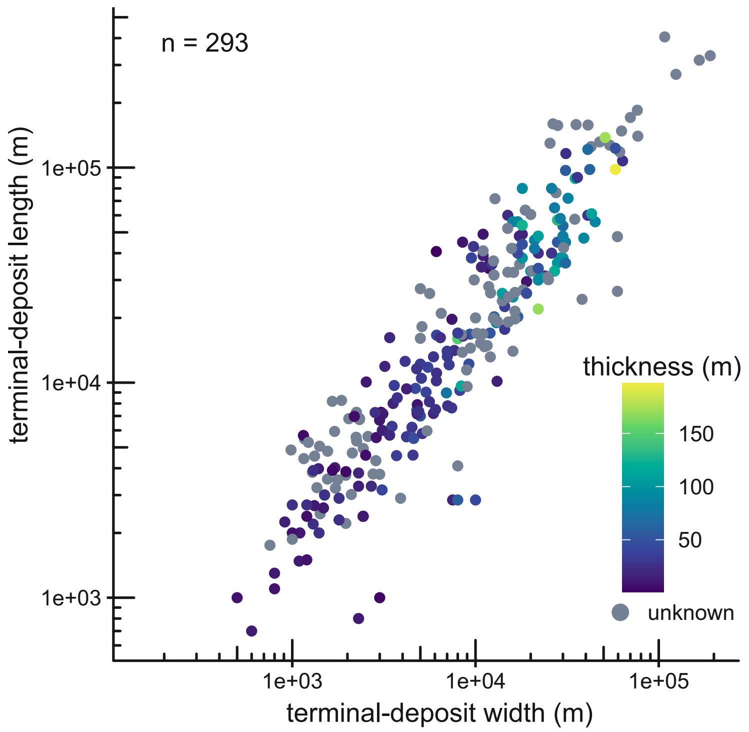
DMAKS data & outputs: architectural-element geometries

DMAKS stores data on the length, width and thickness of architectural and geomorphic elements and facies.

These dimensions are all taken with respect to a reference system orientated relative to the dominant local (palaeo-)flow direction, except for levee elements, whose dimensions are measured relative to the (palaeo-) flow direction in their genetically related channel. Metadata describing the quality and completeness of the measurements are also stored.

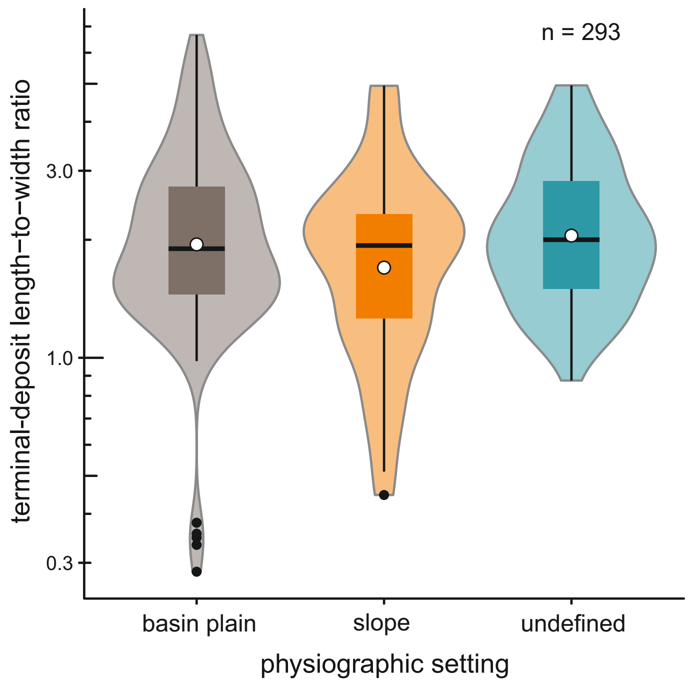
DMAKS can be queried to extract statistics relating to these quantities, and associated derivative metrics (e.g., width-to-thickness aspect ratios), with consideration of the hierarchical arrangement of the units.





Above: example DMAKS output on the thickness, width and length of terminal deposits (lobe and sheet elements) that can be characterized in planform.

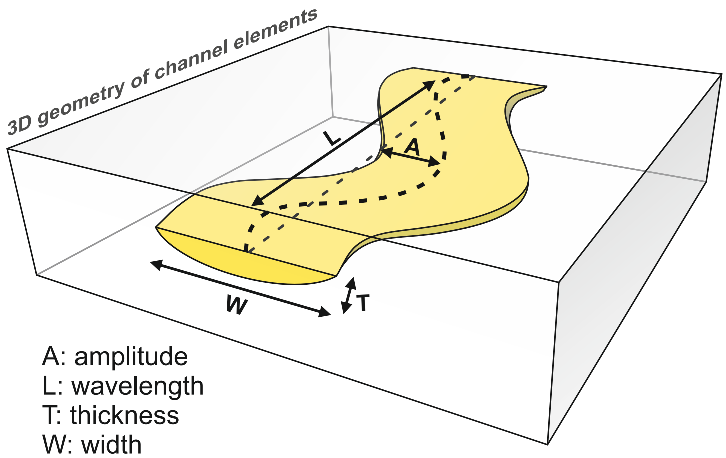
Below: example DMAKS output on the frequency distributions of length-to-width aspect ratios of terminal deposits, grouped by type of depositional setting. Note logarithmic scale.

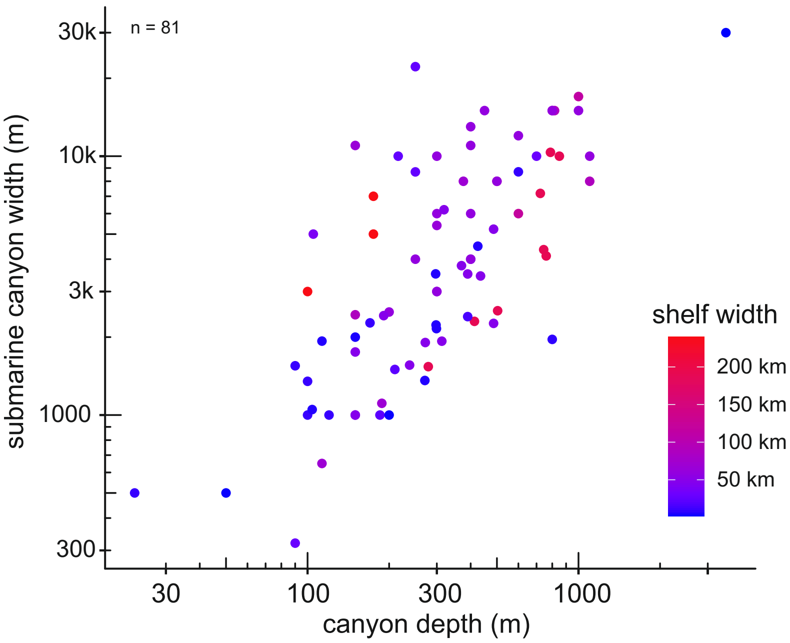


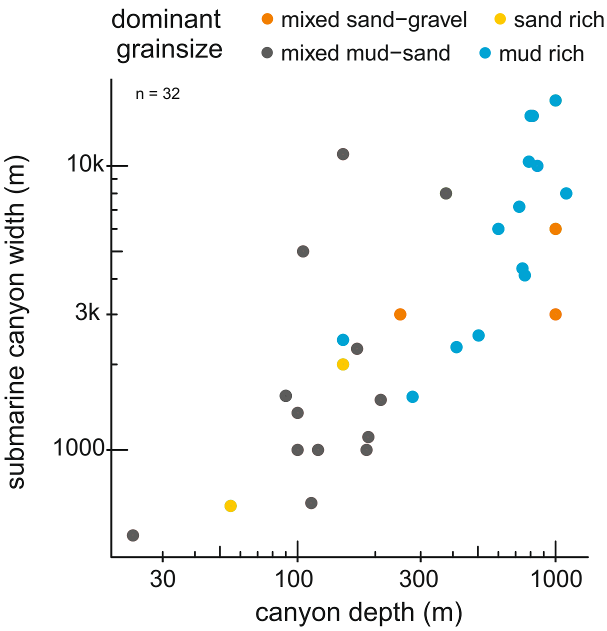
DMAKS data & outputs: architectural-element geometries

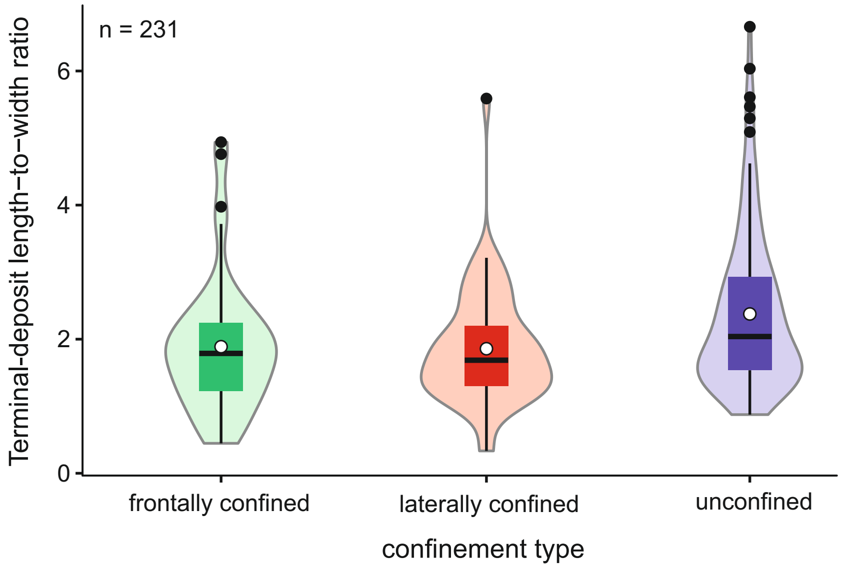
In addition to dimensional parameters, attributes are included in DMAKS to characterize the 3D geometry of sedimentary units and modern forms more fully. These include measures of orientation, gradients of element base and top, and descriptions of planform geometries (sinuosity, wavelength, amplitude).

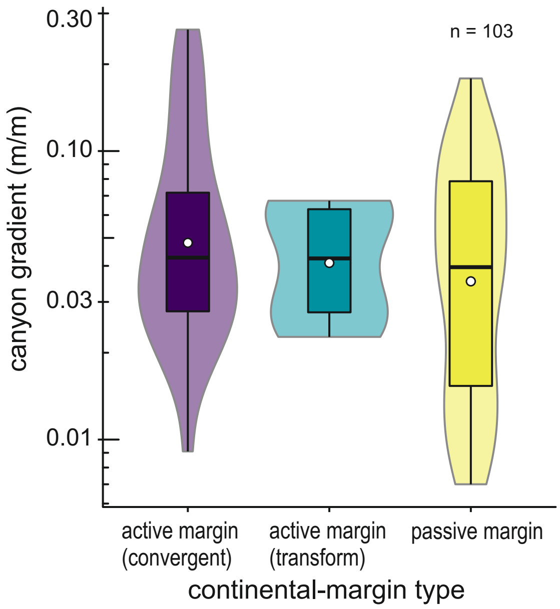
Output statistics on genetic-unit geometries can be filtered on qualitative and quantitative attributes used to characterize the depositional setting (e.g., slope systems) and its associated geological boundary conditions (e.g., dominant feeder-system grainsize).





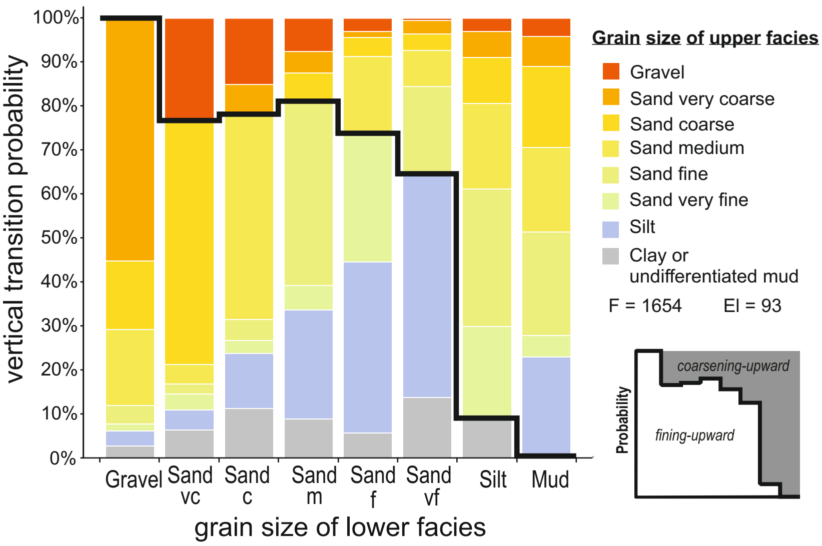


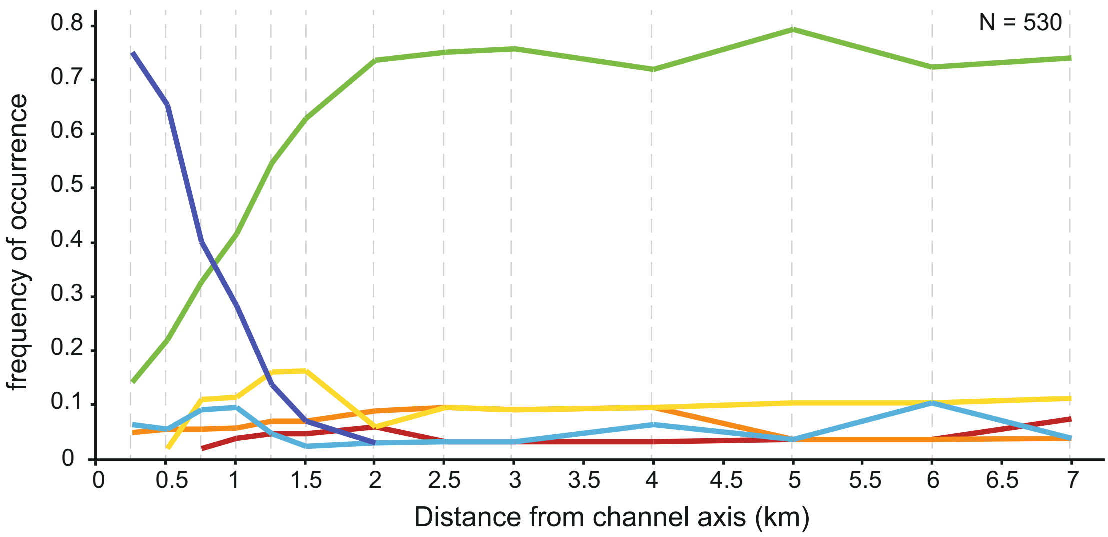




DMAKS data & outputs: spatial relationships

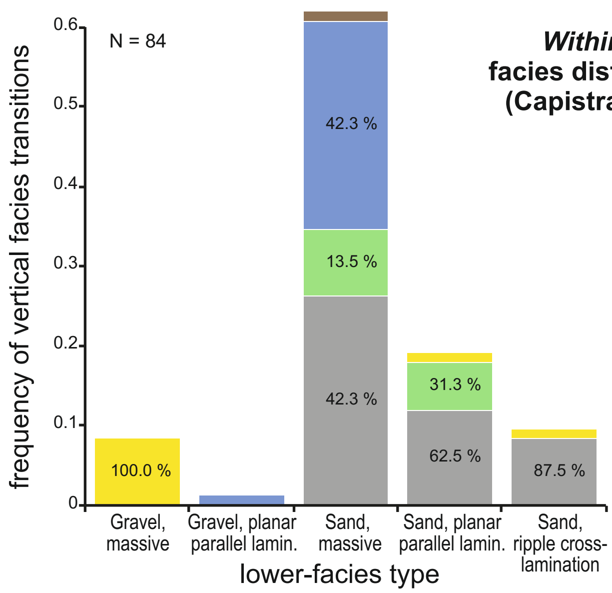
In DMAKS, the spatial relationships between sedimentary units of a given rank (elements, facies units) are recorded in the form of transitions in the vertical, downdip and strike directions. This enables: (i) quantification of transitions statistics describing the relative arrangement of the units; (ii) characterization of stacking patterns of channel or lobe elements; (iii) extraction of metrics describing static connectivity; (iv) estimation of the likelihood of occurrence of a deposit of a certain type at a given distance away from an observed element; (v) derivation of attributes associated with spatially and genetically related units (e.g., channel vs levee NTG ratios).



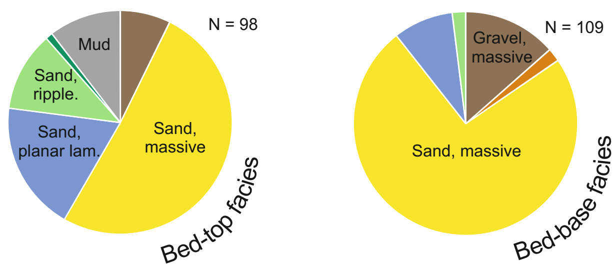


Relative likelihoods of encountering an element of a certain type laterally away from a channel-axis facies association.

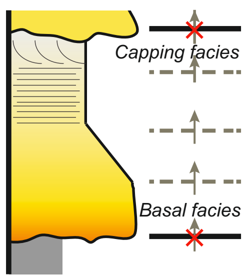
Transitional element type:
- Same channel
- Different channel
- Levee
- Lateral splay
- Terminal deposit
- Mass transport deposit



***Within-bed* facies distributions (Capistrano Fm.)**



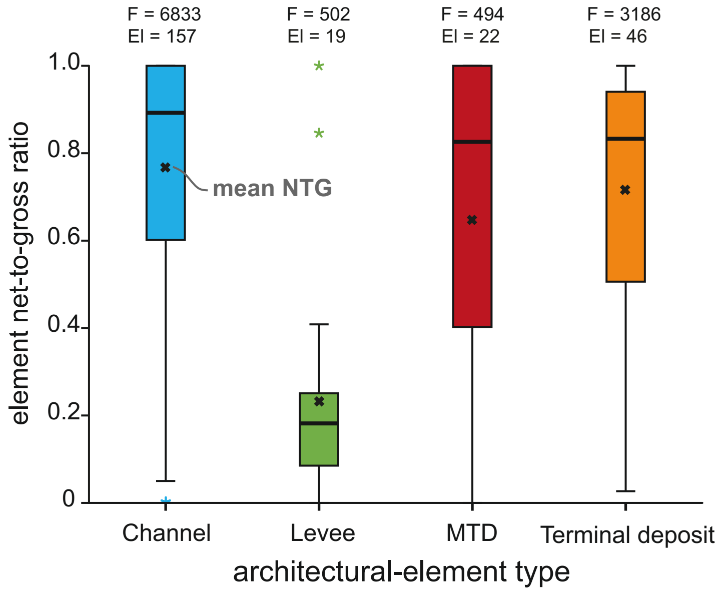
Facies type:
- Gravel, massive
- Gravel, planar parallel laminated
- Sand, massive
- Sand, planar parallel laminated
- Sand, ripple cross-lamination
- Sand, cross-stratification
- Mud (including silt and clay), massive



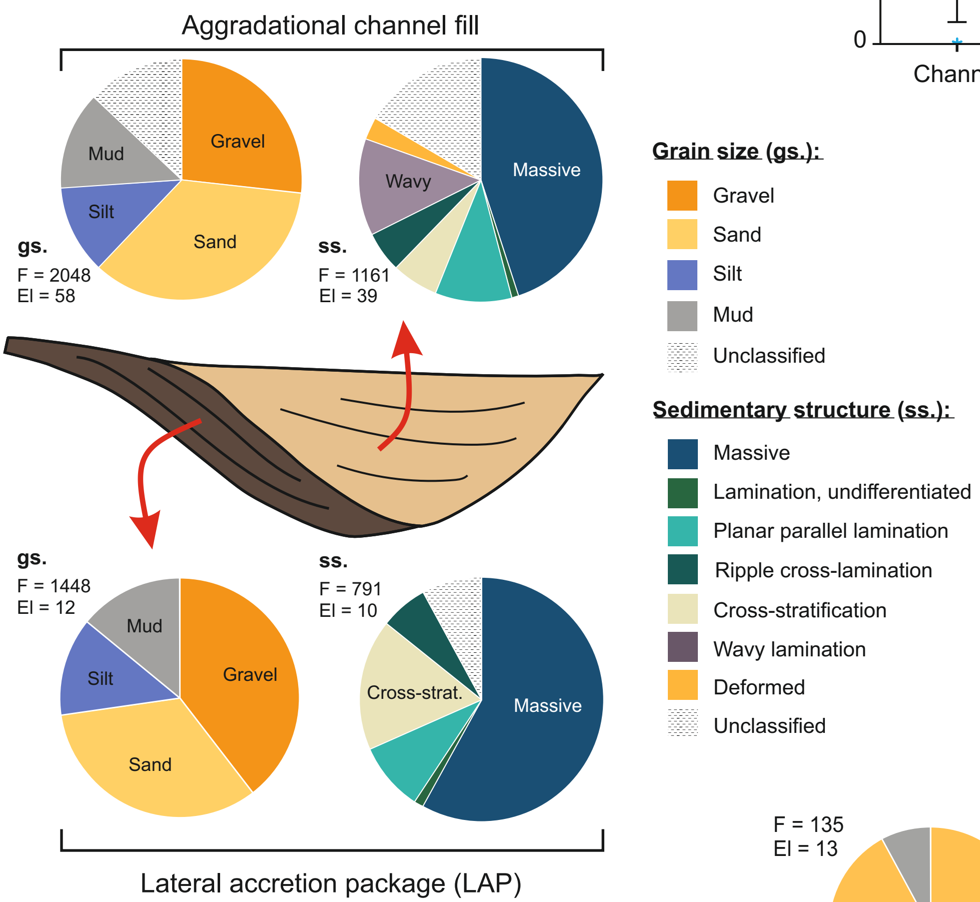
DMAKS data & outputs: genetic-unit proportions and net-to-gross ratios

In DMAKS, data on the occurrence and size of genetic units can be employed to obtain a quantification of the proportion of sedimentary units within higher-scale units, depositional systems, or portions thereof (e.g., stratigraphic intervals). DMAKS users can therefore quantify net-to-gross ratios of sedimentary units at mutiples scales, based on their own specification of 'net reservoir' deposits.

Data can also be derived for characterizing spatial variations in facies architecture across facies associations associated with different subenvironments or parts thereof (e.g., proximal vs distal, lobe axis vs fringe).



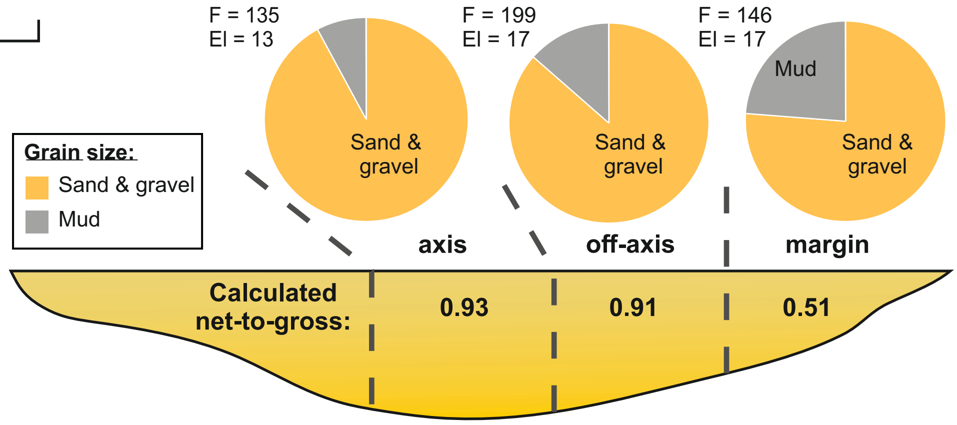
Above: distributions of net-to-gross ratios for different architectural-element types, based on a net-reservoir category that includes sands and gravels.



Left: DMAKS outputs on the overall facies organization (grain size and sedimentary structures) of channel fills and lateral-accretion packages.

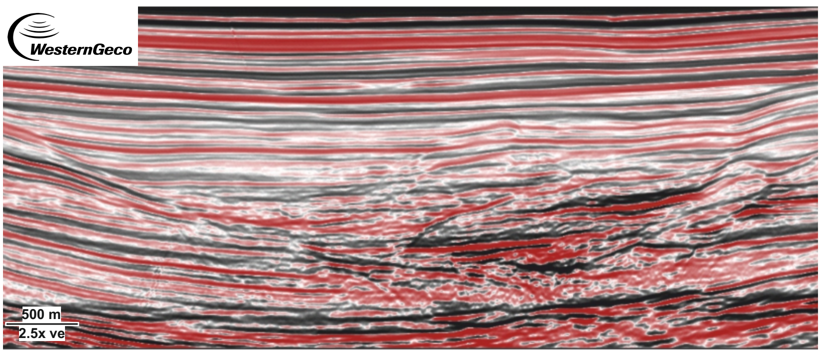
Below: variations in modal facies proportions, and in associated net-to-gross ratio, across different facies belts (channel axis, off-axis, and margin) of channel architectural elements.

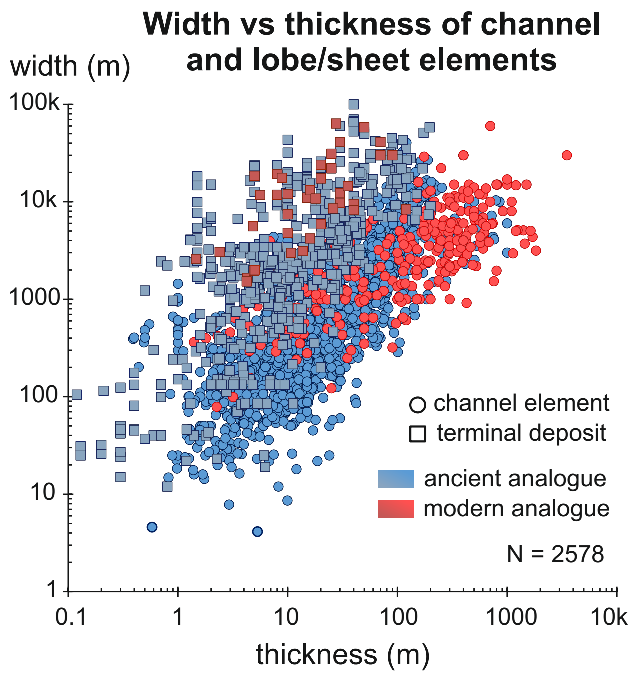
Using DMAKS, bespoke quantitative facies models can be compiled that describe the grain size and sedimentary structures of facies that form given architectural-element types, and the way in which these facies are arranged into facies successions and distributed spatially within a subenvironment.



How can DMAKS be applied for subsurface characterization?

- Build quantitative facies models that describe the distribution of architectural elements within slope and basin-floor settings; characterize the scale, orientation and stacking of channel, lobe and sheet elements and their connectivity with one another.
- Build models that describe the likely internal facies arrangements present in individual architectural elements; determine the relative proportions of facies that make up certain elements and predict their vertical, cross-stream and downstream transitions.
- Predict the expected dimensions of architectural elements away from the borehole; predict the most likely arrangement of neighbouring elements.
- Filter the output from the database such that only data from suitable deep-water systems that meet the specified search criteria are returned.
- Compare differences in sedimentary architecture for different types of turbidite systems associated with different external controls: for example, compare differences in scale and connectivity of sand bodies from submarine fans of active or passive margins, or associated with sediment sources delivering finer or coarser inputs, or linked with icehouse or greenhouse climates.
- Compile exhaustive comparative statistics for different types of deep-water systems: for example, calculate channel-deposit proportions, width-to-thickness ratios and connectivity metrics for different depositional settings.
- Analyse the topology of facies or architectural elements, as characterized by transition statistics, hierarchical relationships (containment of elements in higher-scale ‘parent’ elements) and drainage networks (relating to distributary, tributary and avulsive channels).
- Extract statistics on width-to-thickness ratios of any type of element, filtered on parameters on which the systems are classified.
- Undertake a full analysis of lithofacies make-up for any architectural element type, and produce distribution of net-to-gross ratios based on bespoke ‘net’ specifications.
- Compare published case studies and subsurface data quantitatively.
- Make statistical comparisons between modern systems and their ancient preserved successions; check the validity (or otherwise) of your preferred modern system as an analogue for your subsurface reservoir succession.





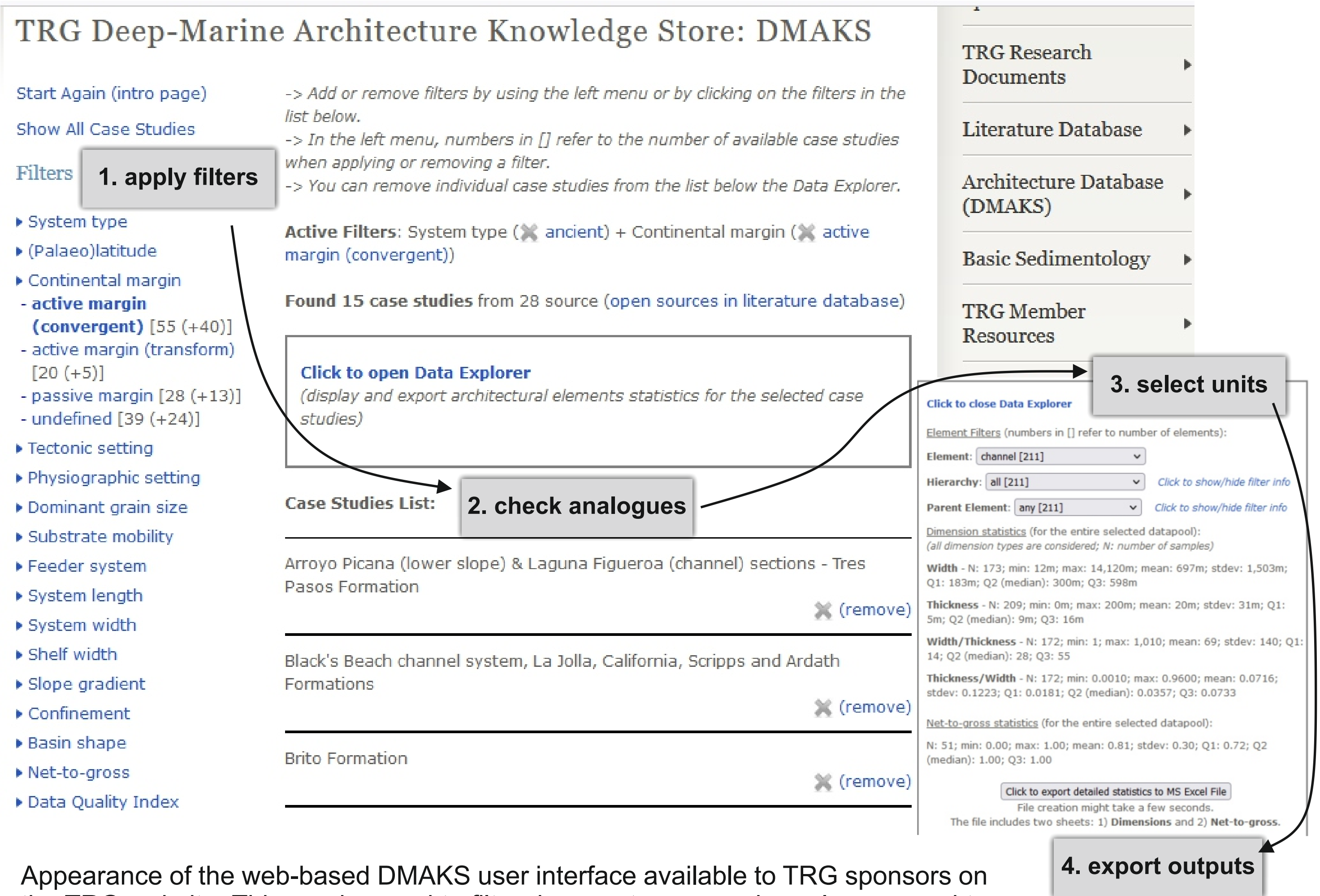
DMAKS incorporates data from outcrop, subsurface and modern analogues.

How can you interrogate DMAKS ?

Users can access DMAKS in the following ways:

- TRG sponsoring companies can query DMAKS through a **web-based front-end** available on the sponsors' pages of the TRG website. The interface allows filtering analogues on their attributes and elements on hierarchy and type. Only summary statistics relating to architectural-element geometry and net-to-gross ratios can be extracted, as MS Excel spreadsheets.
- TRG sponsors can also query DMAKS through a new **cloud-based application** with charting capabilities: shinyDMAKS. The app enables analyses of element and facies geometries, porportions and topology – expressed by outputs shown in charts and tables. The app is modular and expandable.
- Employees of TRG sponsors can **get in touch** with our team with requests for specific database outputs that cannot be obtained through the website interface or the app. We can interrogate the database by means of tailored SQL queries, and provide results in the form of data summaries and/or graphical material. We can also provide guidance on the application of database outputs to subsurface studies.
- Subscribers to **Ava Clastics**, a commercial product developed by PDS, can interrogate DMAKS by means of a user interface with charting capabilities, and which enables seamless linkage with the reservoir-modelling tools of Schlumberger Petrel.

DMAKS interface on the TRG website



Appearance of the web-based DMAKS user interface available to TRG sponsors on the TRG website. This can be used to filter deep-water reservoir analogues, and to extract summary statistics on architectural-element dimensions and net-to-gross, downloadable as Excel files.

DMAKS cloud-based graphical user interface: *shinyDMAKS*

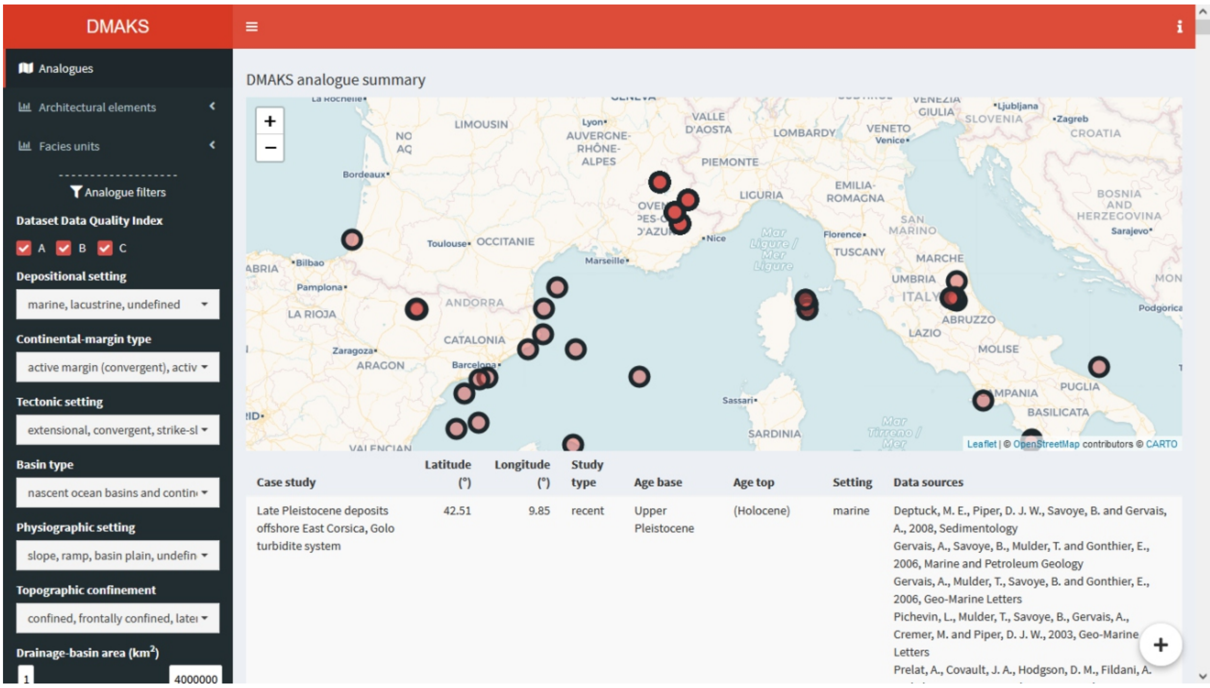
The new DMAKS interface consists in a cloud-based application developed in-house by TRG: it can be opened anywhere using a web browser (Edge or Chrome) and does not require installation.

The new DMAKS app allows users to browse the DMAKS analogues, apply filters to the database, and display analogue data in summary tables and charts that are updated in real time.

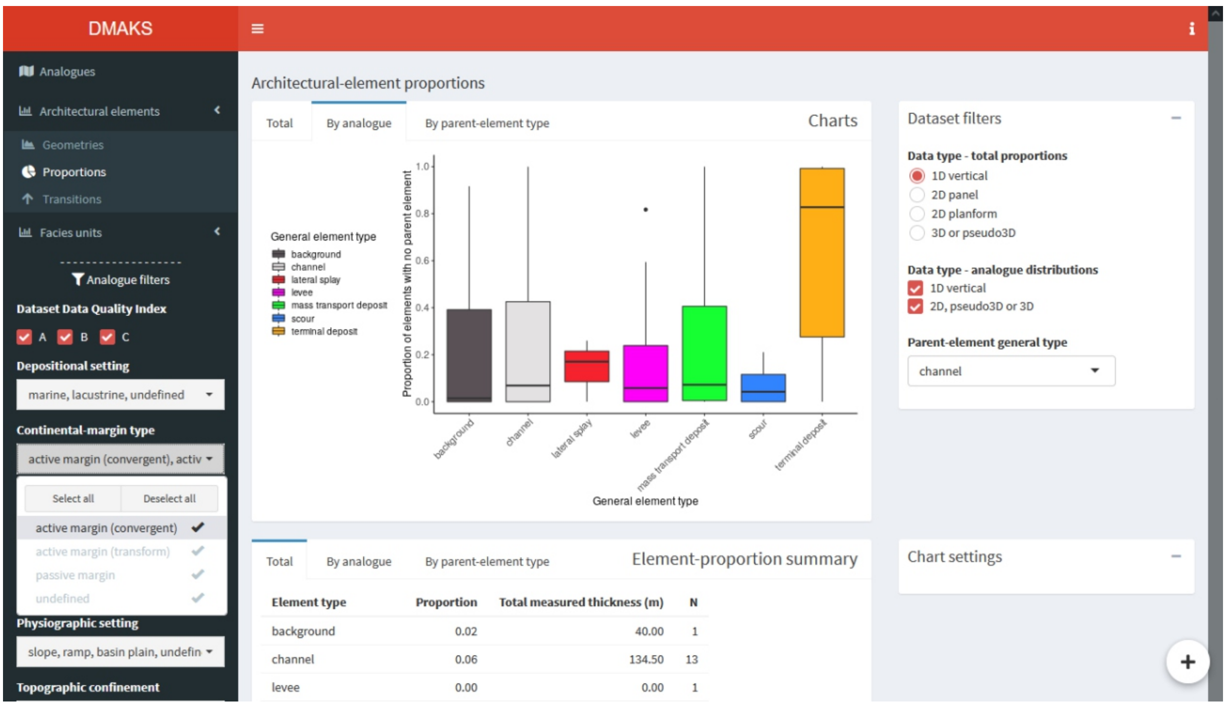
The new interface is modular: additional query and charting capabilites can be added to those now present in the existing app to suit user requirements.

Access the new 2023 DMAKS app at:

https://clastics.shinyapps.io/dmaks/



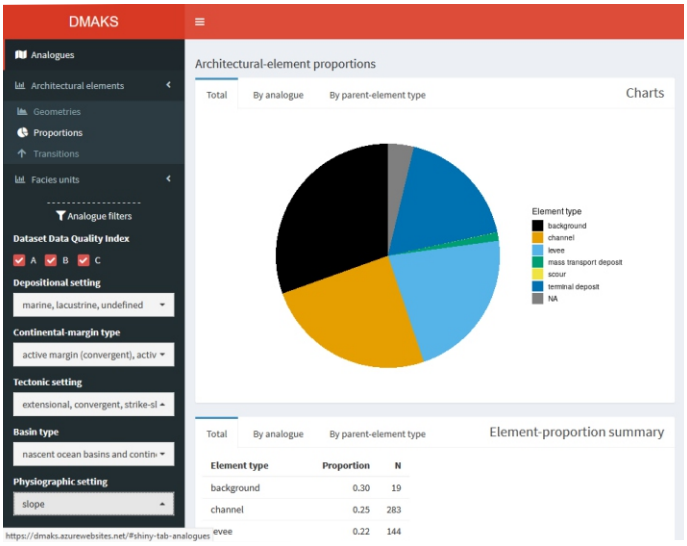
Left. Browse all DMAKS analogues and extract summary information. Apply filters to select relevant deep-water depositional systems.



Right. Extract analogue data presented in tabular and graphical forms, for sedimentary units at different scales (architectural elements of different hierarchies and facies units).

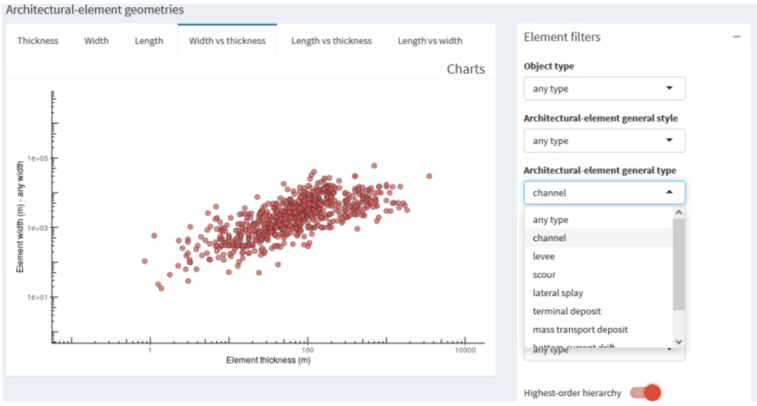
DMAKS

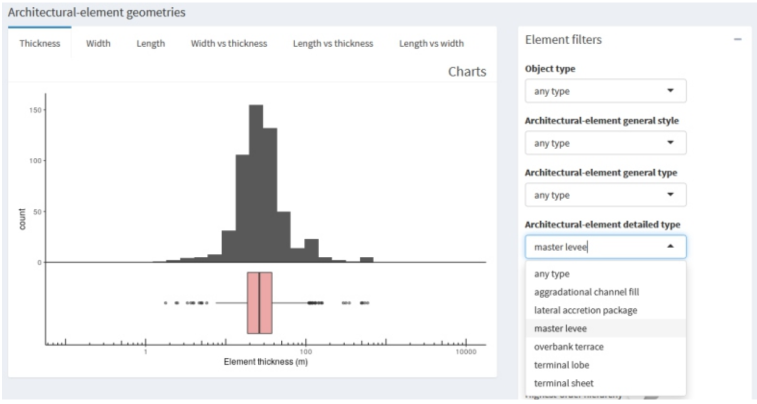
DMAKS interrogation: cloud-based graphical user interface

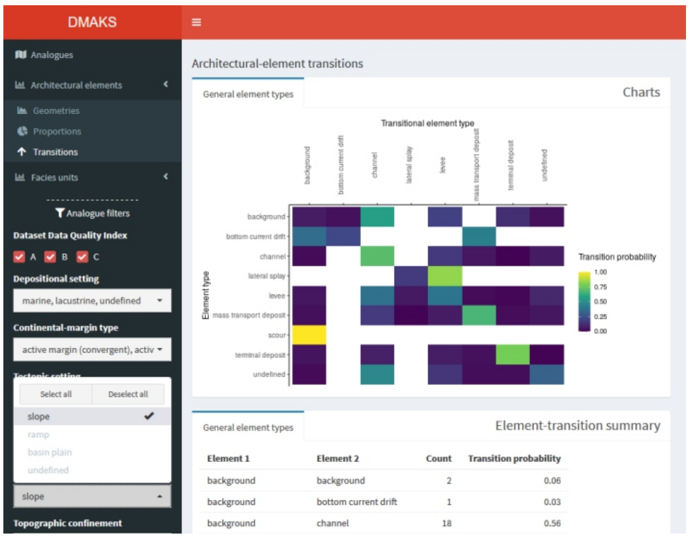


Above. Example DMAKS output on average proportions of architectural-element types in all selected analogues. The app allows applying filters to the database on attributes describing the depositional systems and on metadata describing the datasets and the source analogue studies.

Below. Example DMAKS output on the geometry of architectural elements. Database outputs are presented in two boxes, for charts and tables. In each box, users can toggle between tabs to display different output types.

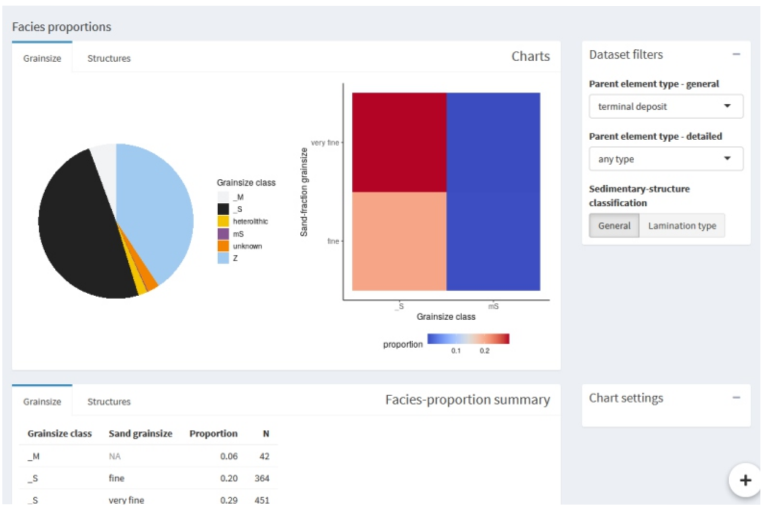






Above. Example DMAKS output on facies-unit transition statistics describing trends in element stacking, shown as summary table and heat map. The outputs can be filtered employing global filters applied to all presented outputs in the session, as well as using filters that are specific to a particular type of output: in this example, facies transitions can be filtered on the type of architectural elements being characterized.

Below. Example DMAKS output on the proportion of different types of facies units in the filtered analogues, and for selected types of elements.



Planned DMAKS development through TRG 2023-2025 phase

As part of the programme for the 2023-2025 phase of the consortium, work will be undertaken by TRG members to:

- **Continue database population.**

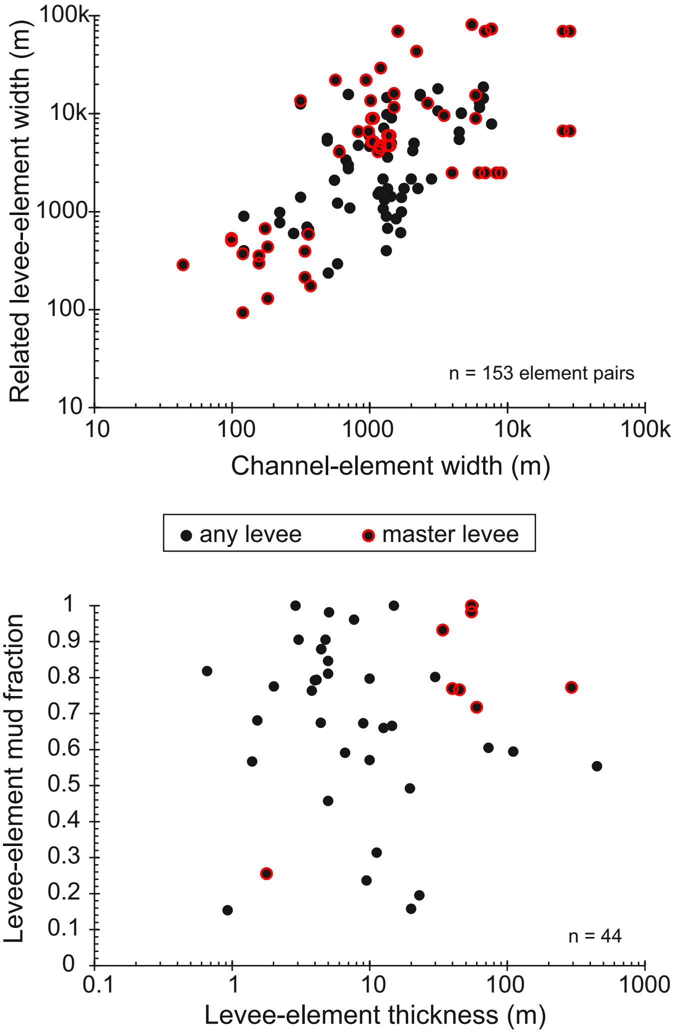
  Datasets on the sedimentary architecture and facies organization of deep-water systems will continuously be added to DMAKS, with the contribution of both literature-derived case studies and original TRG field data. We seek feedback from sponsors on preferred geological analogues for database inclusion.

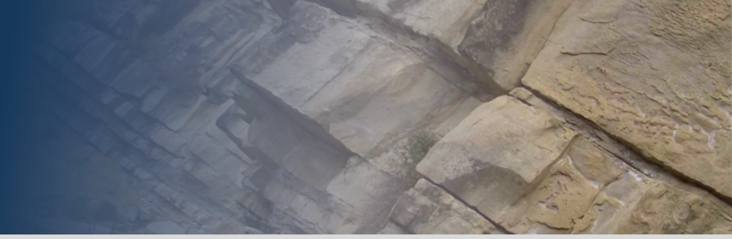
- **Improve delivery of analogue data to sponsors.**

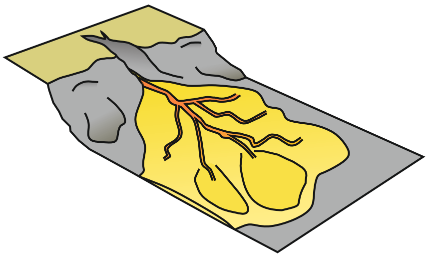
  The current offering will be enhanced through the improvement of the shinyDMAKS app, by expanding tables, charts and analogue-filter functionalities, by enabling download fo summary outputs, and by adding new modules to suit specific user requirements (e.g., variogram modelling, net-volume calculations).

- **Apply the database in research activities.**

  DMAKS will be actively employed for both fundamental and applied research. This includes the use of quantitative database outputs in (i) meta-analyses aiming to assess the importance of controls on sedimentary architecture or seabed geomorphology, (ii) for the compilation of facies models for types of depositional systems, subenvironments, or bed types, and (iii) as applied in the development of new approaches for subsurface characterization and modelling.

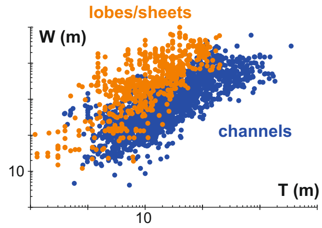






DMAKS

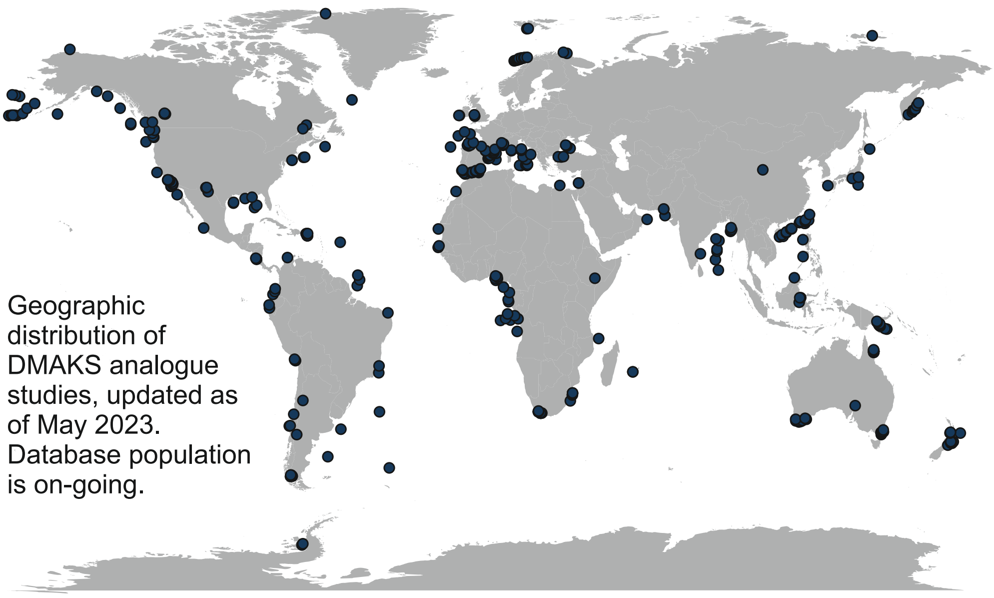
Deep-Marine Architecture Knowledge Store



SUMMARY – The **Deep-Marine Architecture Knowledge Store** is a relational database containing hard and soft data on the sedimentary and geomorphic architecture of ancient and modern deep-water clastic depositional systems. It incorporates data from the published literature and TRG studies, all coded to a common standard to ensure consistency in data definition. The database considers geological entities of varied nature and scale (architectural elements of different hierarchies, beds, facies), which are characterized by attributes describing their type, geometry, spatial relations (transitions in 3D, drainage network organization), hierarchical relations, and temporal significance. Geological entities are linked to case studies, depositional systems, basins, and parts thereof, each of which is described by qualitative and quantitative attributes (e.g., shelf-break depth, dominant grainsize) and associated with metadata (e.g., data types, data sources). This enables filtering of analogues on specification of depositional setting and geological boundary conditions: DMAKS serves as a repository of analogue data for subsurface reservoir successions, and it can be used to:

- Characterize modern and ancient deep-marine/lacustrine systems quantitatively.
- Build bespoke facies models for particular classes of deep-water sedimentary succession (composite analogues).
- Examine sedimentological data from different deep-water settings dominated by gravity-flow sedimentation.
- Aid the development of depositional models for particular types of deep-water reservoirs.
- Assess the sensitivity of depositional systems to particular controlling factors.
- Provide quantitative constraints for creating stochastic reservoir models and for sandbody well correlation.

DMAKS content: summary



Geographic distribution of DMAKS analogue studies, updated as of May 2023. Database population is on-going.

As of May 2023, DMAKS contains data associated with:

- 201 case studies
- 702 analogue subsets
- 8,400+ architectural elements
- 28,800+ facies units
- summary statistics on 3,000+ additional genetic units
- Data extracted from 370+ literature sources.

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