Oolithica GEOSCIENCE

Oolithica Geoscience

Experts in Applied Sedimentology, Sequence Stratigraphy and Seismic Stratigraphy

Jurassic onlap of Triassic Fore Reef Talus Slope

Scan me

Specialists in:

- Carbonate Sedimentology
- Clastic Sedimentology
- Seismic Sequence Stratigraphy
- Analytical Services
- Office Training
- Field Seminars

Oolithica Geoscience
Kenden, Charlton Drive
Cheltenham GL53 8ES, U.K.

T: +44 1242 579666
E: enquiries@oolithica.net
www.oolithica.com

About Oolithica

Oolithica is a leading provider of applied sedimentology, sequence stratigraphy and seismic stratigraphy services to the international oil and gas industry. Our team of highly experienced professionals provide critical geological insights into carbonate and siliciclastic reservoir systems throughout the exploration, appraisal and development cycles.

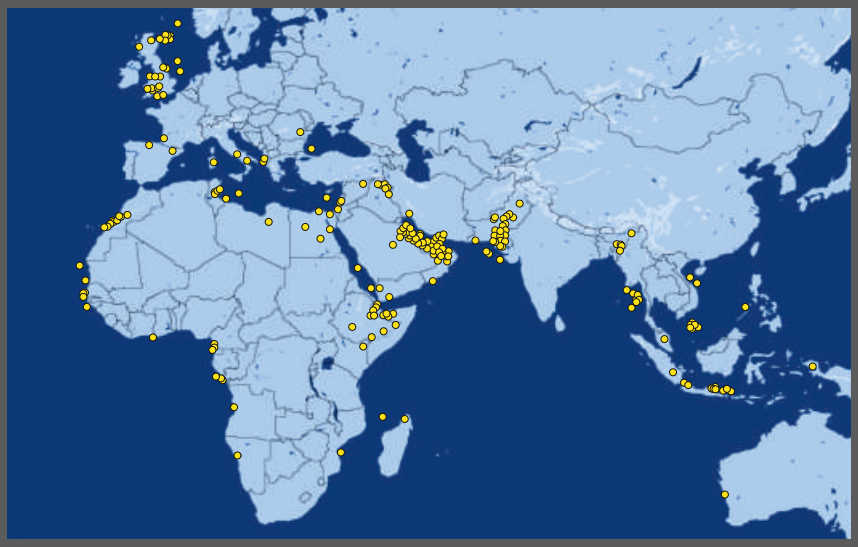
Our strengths include:

- extensive first-hand experience in key hydrocarbon provinces
- expertise in the meaningful integration of outcrop, well and seismic datasets
- unrivalled fieldwork experience and expertise (particularly in the Middle East, Pakistan and East Africa)
- excellence in the design and delivery of innovative work programmes
- availability of in-house cathodoluminescence and fluid inclusion facilities
- areas of specialist expertise (including ditch-cuttings petrography and integrated diagenetic studies)
- specialist back-up from an established network of world-class associates

The emphasis that we place on the meaningful integration and linkage of multidisciplinary G&G datasets enables us to derive optimal value from our clients datasets.

Since its inception Oolithica has successfully undertaken more than 200 projects, primarily in NW Europe, West Africa, North Africa, East Africa, the Middle East, Pakistan and SE Asia.

Our client-base includes national oil companies such as Saudi ARAMCO and Sonatrach, large multi-nationals (including Shell and Exxon) and small to medium-sized independents (e.g. Premier Oil, Cairn, Hunt Oil)



A Brief History

Oolithica GeoScience was formed in 1994, and quickly established itself as a leading provider of high-quality geological services to the international oil and gas industry. The three founding Directors worked together previously with both Gearhart GeoConsultants and Halliburton Energy Services, and form a key part of the current technical team at Oolithica. Alessandro Lanfranchi joined us in 2008, bringing additional expertise in carbonate sedimentology and sequence stratigraphy, and has since undertaken a wide range of projects worldwide.

The Team

Neil Laker, MSc
Expert in applied sedimentology, high-resolution sequence stratigraphy and seismic stratigraphy. Neil has more than 30 years hands-on experience in Peri-Tethyan and African play fairways.

Alessandro Lanfranchi, PhD
Specialist in carbonate sedimentology, stratigraphy and diagenesis, with particular expertise in seismic stratigraphy of carbonate deposystems. In recent years he has worked extensively on Atlantic margin play fairways.

Christopher Toland, PhD
Expert in carbonate sedimentology, sequence stratigraphy and advanced analytical techniques. Chris has over 30 years industrial experience, and is a recognized authority on the Mesozoic of the Middle East.

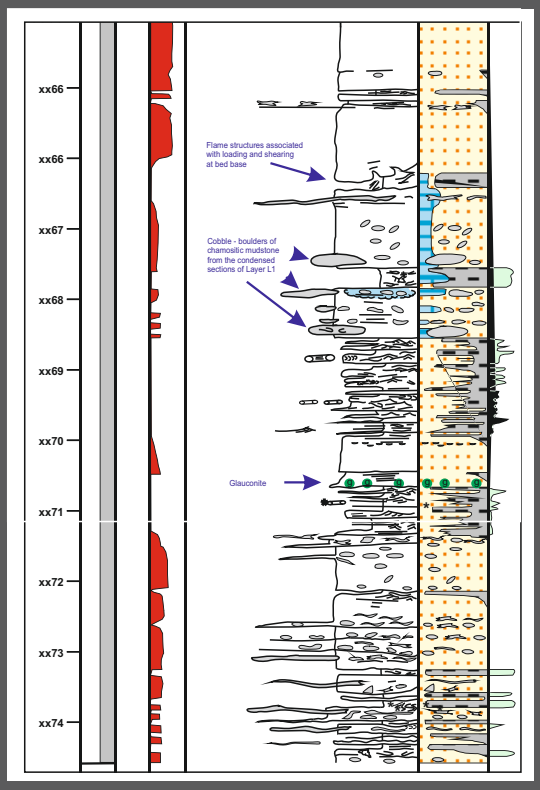
Graham Pazdzierski, PhD
Expert in carbonate and clastic sedimentology, sequence stratigraphy and seismic stratigraphy. Graham has more than 35 years Middle East, North and East Africa, Pakistan and Far East experience.

CORE DESCRIPTION AND DATA INTEGRATION

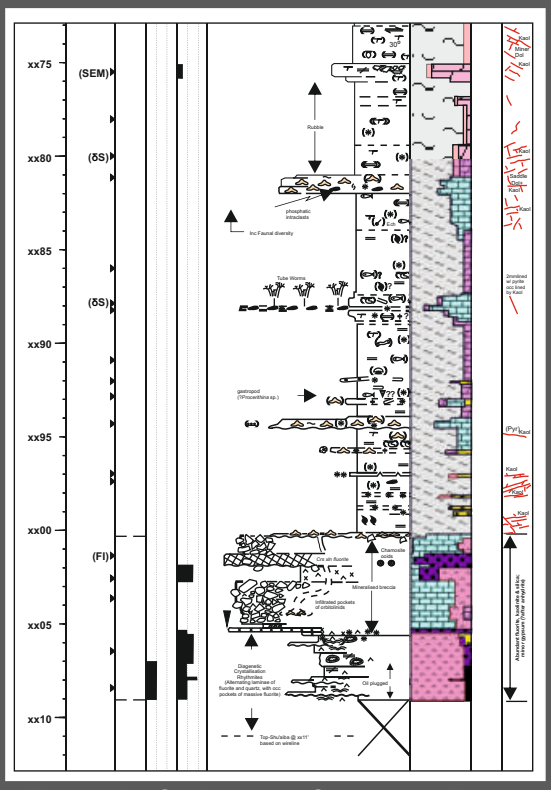
Core description is a key aspect of most subsurface studies, providing critical input into depositional, diagenetic and reservoir models. Oolithica's core logs provide a detailed graphic record of lithology, clay content, grain size, physical and biological sedimentary structures, fossil content, visual porosity, fracture characteristics and hydrocarbon shows. Depth shifts are determined by reconciling core logs against CCA and wireline datasets.

Depositional facies and stacking patterns initially identified at the core-description stage, are further refined based on the integration of other datasets, such as microfacies / lithofacies / palynofacies characteristics.

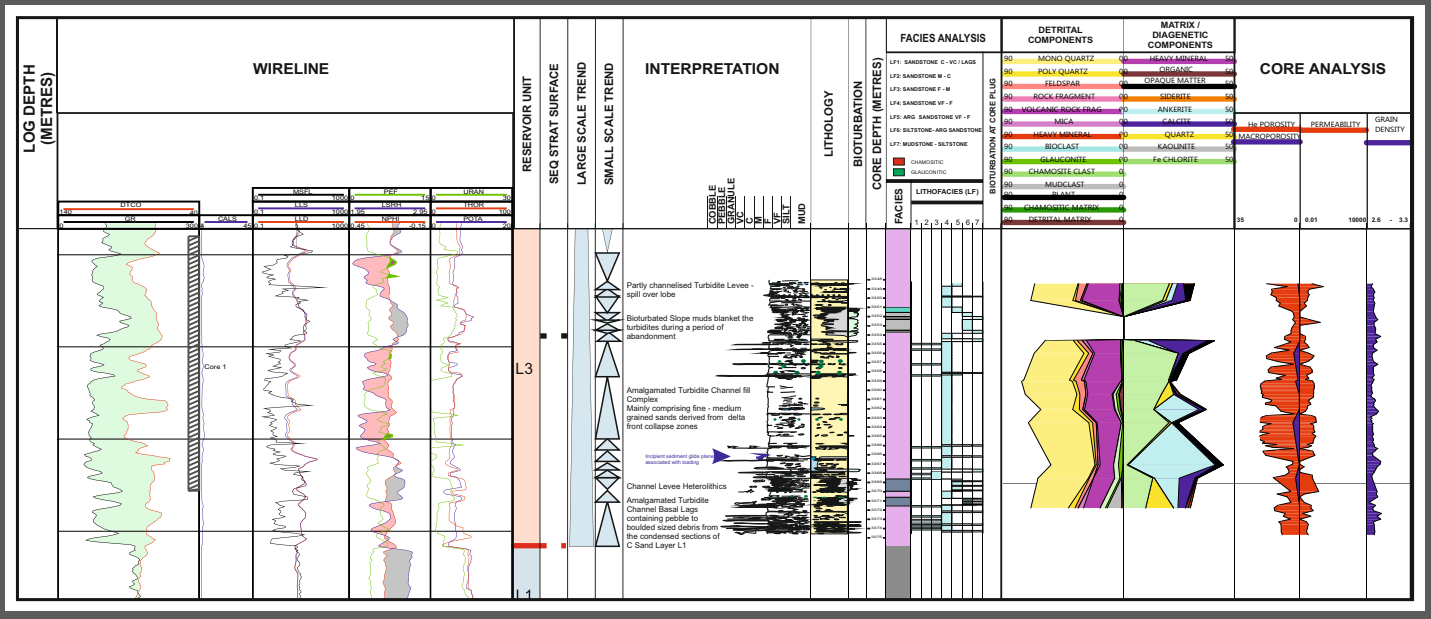
Typically, we describe core at 1:50 scale, and the graphic logs are re-drawn at 1:200 scale for integration with wireline and petrophysical datasets (including dipmeter/image logs where available). Correlation panels incorporating these datasets are reconciled with seis-strat observations, providing the basis for final interpretation.



Example Clastic Core Log Extract



Example Carbonate Core Log Extract



Example 1:200 Core Summary Chart Extract

Oolithica GEOSCIENCE

ANALYTICAL SERVICES

Thin Section Petrography

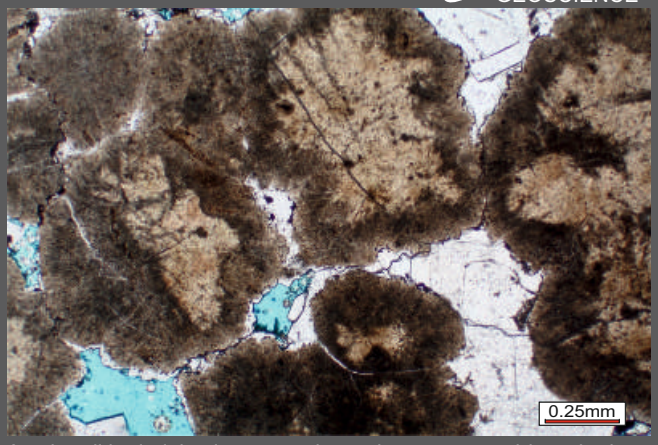
This powerful analytical tool provides more “bang per buck” than almost any other technique when characterising clastic, carbonate and evaporite sequences. It is typically combined with other analyses such as CCA / SEM / XRD to provide a more complete picture of rock properties, but can also be performed as a stand-alone service.

Petrographic analysis yields information on many rock properties, including:

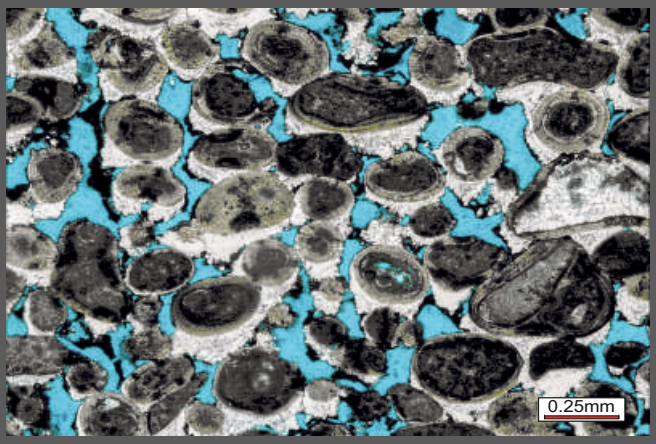
- Lithology type / rock classification
- Rock texture (grain size, sorting, roundness, grain contacts / compaction, small-scale sedimentary structures)
- Grain and matrix mineral composition
- Fossil & microfossil assemblages
- Sediment provenance / presence of ductile components
- Depositional environment and sedimentary processes
- Lithofacies / microfacies (utilized in subsequent depositional sequencing)
- Diagenetic overprint and the distribution and nature of cement phases
- Fracture system characteristics
- Pore type(s), their morphology, abundance and distribution characteristics
- Pore evolution
- Reservoir / formation sensitivity issues

Petrographic analysis forms a cost-effective basis for selection of more advanced analytical techniques.

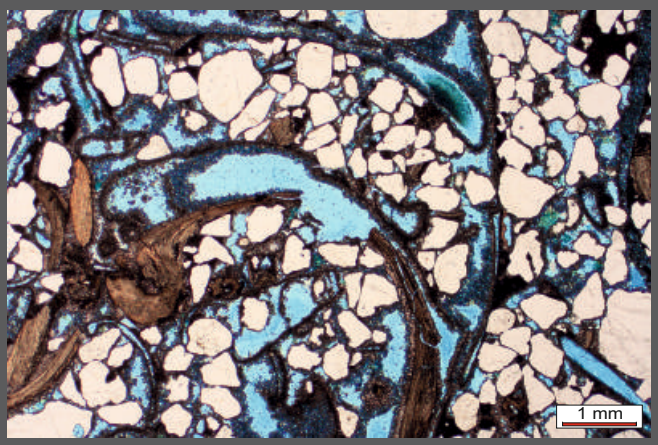
Petrographic information can be provided as fully quantitative data, with spreadsheet and text supported by photomicrographs, or as semi-quantitative estimations, which can reduce cost where appropriate.



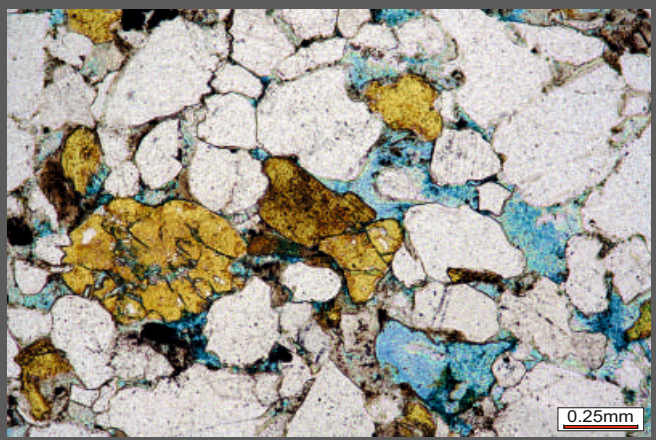
A spherulitic dedolomite reservoir, partly re-cemented here by late-stage halite.



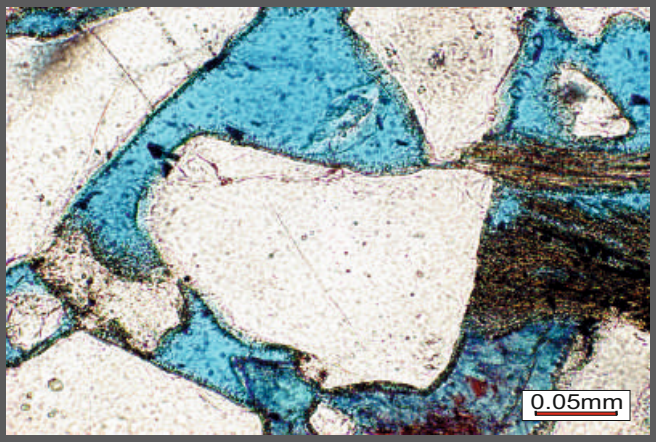
Ooid grainstone with prominent pendent (microstalactitic) cements and vadose fast-flow micro-channel pores which impart a preferred permeability direction.



A bioclastic sandstone with common variably-leached pelecypod debris. Primary interparticle and secondary mouldic pores are lined by isopachous calcite rim cements.



An immature sandstone with much K-feldspar (stained yellow), suggestive of a granitic source terrain. Secondary porosity after leached labile grains is partly occluded by authigenic kaolinite.



Detail of excellent primary interparticle porosity. Very thin chlorite cement rims have inhibited quartz overgrowth cements which occlude porosity elsewhere in this same reservoir.

Oolithica GEOSCIENCE

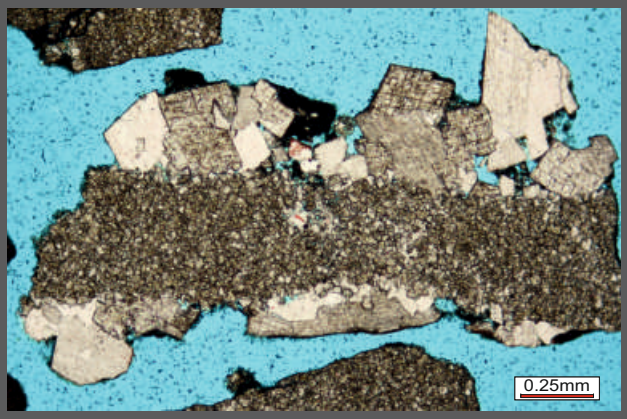
ANALYTICAL SERVICES

Ditch Cuttings Petrography

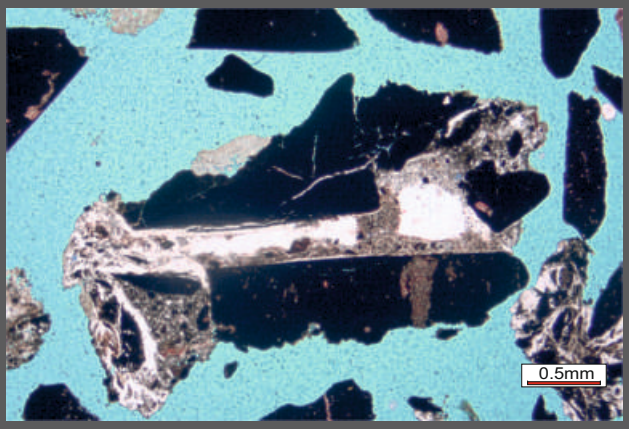
Ditch Cuttings petrography can provide significant insight into well sections in the absence of core. The detailed data we collect are carefully reconciled with wireline, and can provide near core log quality interpretation, especially when used in combination with FMI. The technique works for all lithologies, once appropriate corrections for drilling circumstances are applied, and providing that the cuttings are representative of the sections drilled. Where core and/or SWC are available, further QC, calibration and validation can be applied. Combining techniques can also facilitate advanced depositional facies analysis and sequence stratigraphic discrimination.

Petrographic analysis of cuttings can effectively capture many rock properties that are traditionally determined in outcrop, core and SWC samples. Additionally, incorrect biostratigraphic age attributions resulting from down-hole caving can often be recognized based on petrographic assessment of the microfossil host lithology.

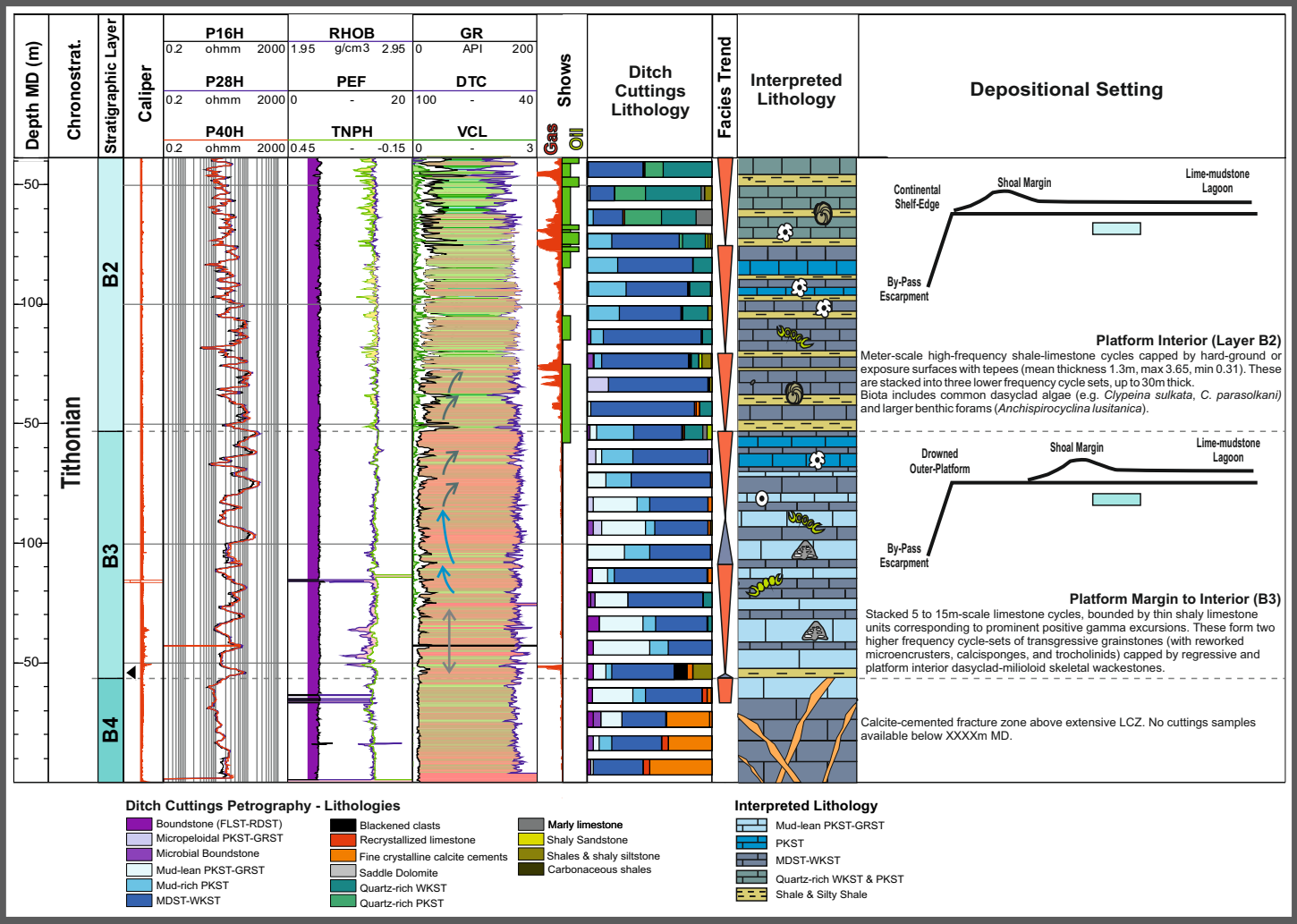
Oolithica uses petrographic analysis of cuttings as a standard technique for unravelling the complexities of uncored well sections.



Detail of a dolomicrite with partly open macro-fractures lined by coarse saddle dolomite cements of burial origin (cuttings sample).



Detail of a brecciated mudstone with evidence of multiphase fracturing, as captured in ditch cuttings. The fractures are healed by several generations of selenite cement and internal sediment.



Example Ditch Cuttings Petrography Summary Chart

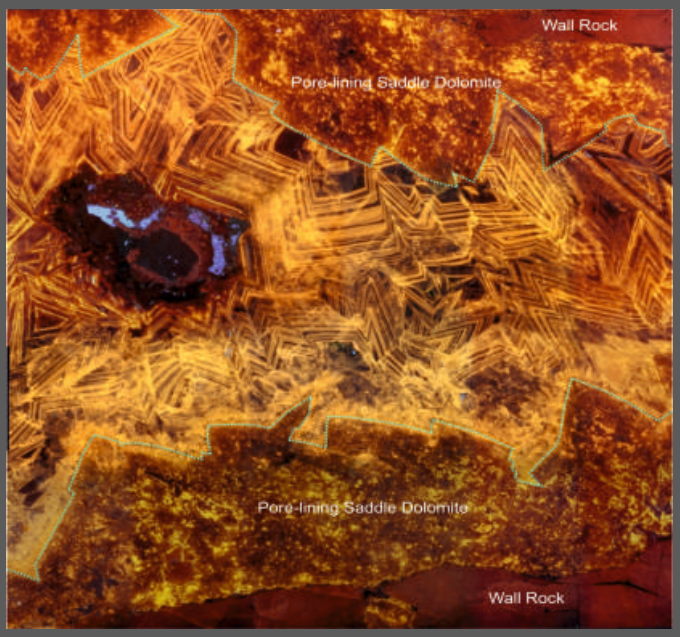
ANALYTICAL SERVICES

Cathodoluminescence

Cathodoluminescence (CL) analysis is a relatively cheap yet powerful technique that has numerous practical applications in petroleum geology. It can:

- help differentiate detrital grains from overgrowth cements
- reveal detailed cement stratigraphies
- reveal ghost fabrics within otherwise featureless fabrics
- provide a first-pass indication of the presence of meteoric calcite cements
- provide indications of the frequency of pore fluid recharge / flushing history (e.g. fault valving / sea level fluctuations)

Oolithica has two in-house Technosyn cold cathodo-luminescence systems. Images are captured using a state-of-the-art wide field ultra low light camera system.

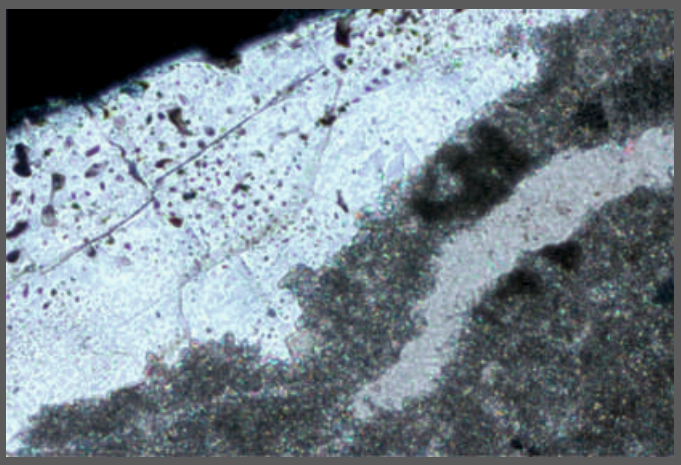


CL analysis of this sample reveals pore-lining saddle dolomite overlain by finely-growth-zoned calcite cements. Fluid inclusion analysis of this same sample indicates that the saddle dolomite was precipitated at a temperature of 108°C, coincident with hydrocarbon charging, while the zoned calcite formed as a result of seismic valving during subsequent inversion and fault-breaching.

Fluid Inclusion Analysis / Thermometry

Fluid inclusions provide unique data on the temperature, salinity and pressure at which pore-filling cements precipitated. This data can be used to refine burial, structural and diagenetic histories, including timing of hydrocarbon migration, accumulation and breaching / re-migration. Fluid inclusions can also be used to determine dolomitization mechanisms, enabling mixing zone, sea-water, evaporative and burial dolomites to be discriminated.

Oolithica has an in-house USGS-Reynolds fluid inclusion system, with epifluorescence attachment to aid recognition of petroleum inclusions (including qualitative assessment of API value).

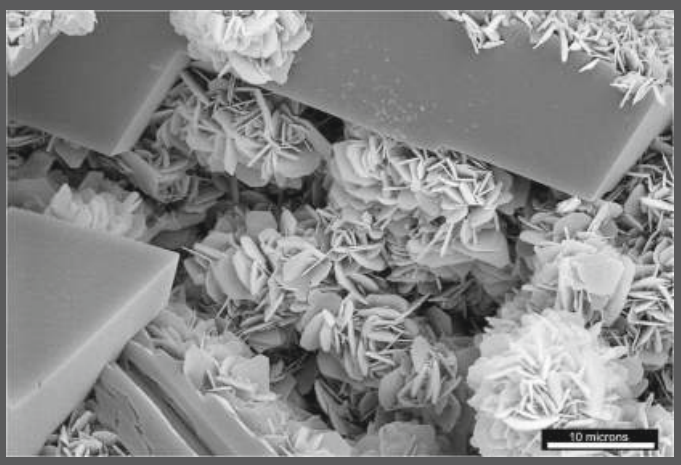


Fracture-filling celestite cements with oil-bearing fluid inclusions. Co-existing aqueous inclusions in this sample yield homogenization temperatures of 98°C corresponding to a burial depth of ~2.9km based on integration with burial history modelling.

SEM/XRD

SEM is a powerful tool for visualising reservoir pore and grain framework systems. It is particularly useful combined with XRD for understanding the impact of clay mineral occurrence and habit on reservoir behaviour. Key applications in petroleum geology include the determination of:

- pore geometry, size & interconnectivity
- framework grain:cement / interstitial clay relationships
- clay mineral morphology, location and habit
- formation damage assessment
- resolving factors affecting Sw & unexpectedly tight horizons
- diagenetic sequencing and phase relationships



SEM image of an interparticle pore lined by Fe-chlorite rosettes that are partly overgrown here by late-stage calcite rhombs.

OTHER ANALYTICAL SERVICES

In addition to our in-house analytical capability, we offer a wide range of related analytical services which are undertaken in collaboration with an established network of world-class associates.

These services include:

Elemental Analysis
ICP-OES, ICP-MS, and QEMSCAN analysis

Radiometric Dating
Whole-rock or single-grain laser ablation analysis. The most widely-used isotopes in sedimentary geology are:

- K/Ar, Ar/Ar, K/Th (dating of igneous intrusives / extrusives, feldspar overgrowths, illite cements)
- U/Pb (dating of calcite cement)
- Os/Os (dating of barren claystone sequences)

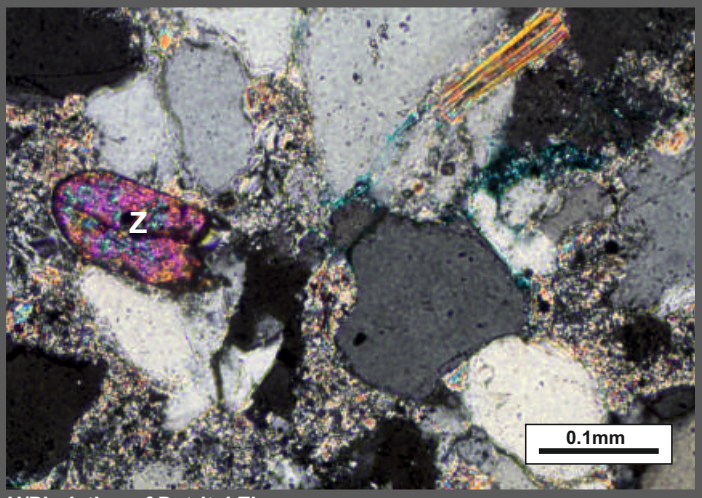
Fission Track Thermochronology
Zircon and Apatite Fission Track Analysis

Heavy Mineral Analysis
Optical petrography enables us to determine the relative abundance of heavy minerals and to calculate provenance sensitive heavy mineral ratios. This can be augmented by ICP-MS and/or electron microprobe analysis.

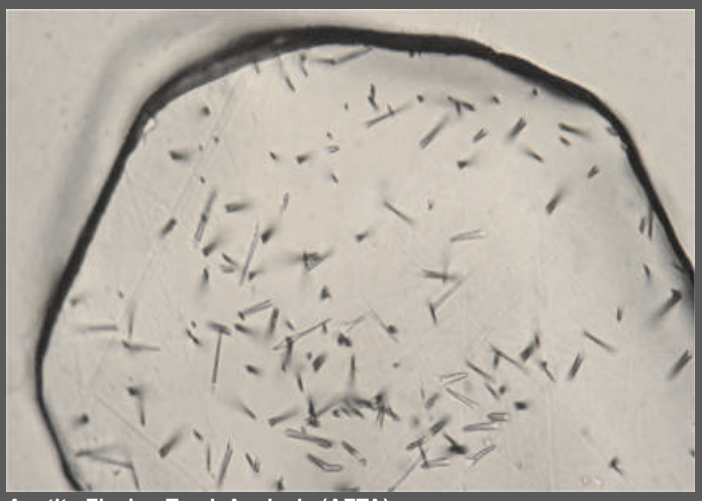
Stable Isotope Analysis
C/O, Sr/Sr, S (whole rock or single-grain laser ablation)

Organic Geochemistry Services
Screening geochemistry (Pyrolysis-TOC), visual kerogen analysis, GC-MS and other advanced analysis

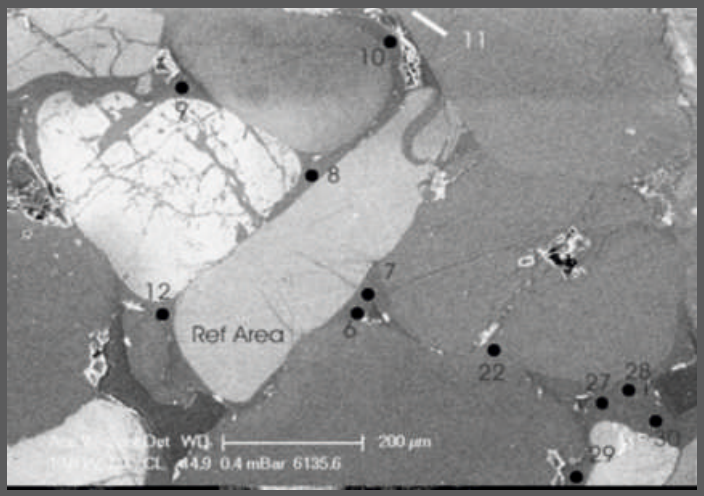
Biostratigraphic Services
Micropalaeontology, palynology, calcareous nannofossils, radiolaria, macropalaeontology



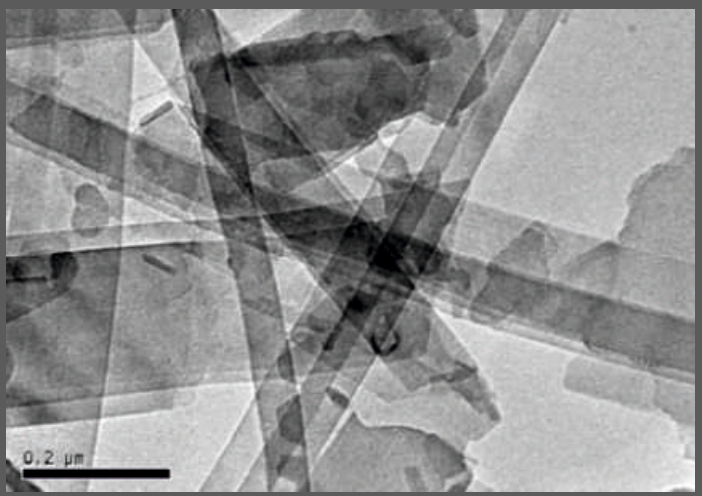
U/Pb dating of Detrital Zircon


Apatite Fission Track Analysis (AFTA)


Biostratigraphic Analyses



Laser Ablation C/O-isotope Analysis



K/Ar dating of Authigenic Illite

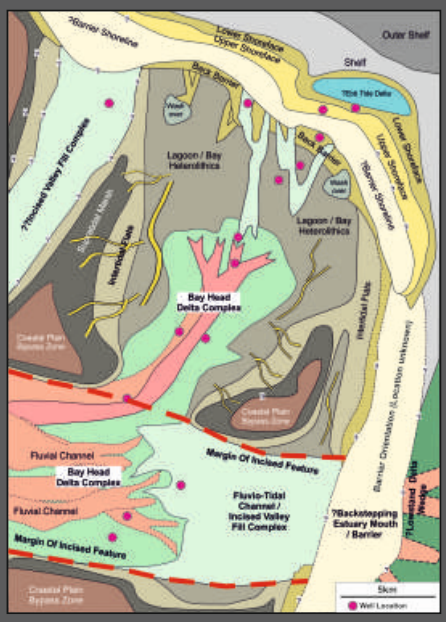
DEPOSITIONAL MODELLING

Depositional facies modelling forms a crucial basis for determining the nature and lateral extent of facies and reservoir properties away from known data points. It is important during both exploration and development phases and requires the integration of datasets from a variety of sources including:

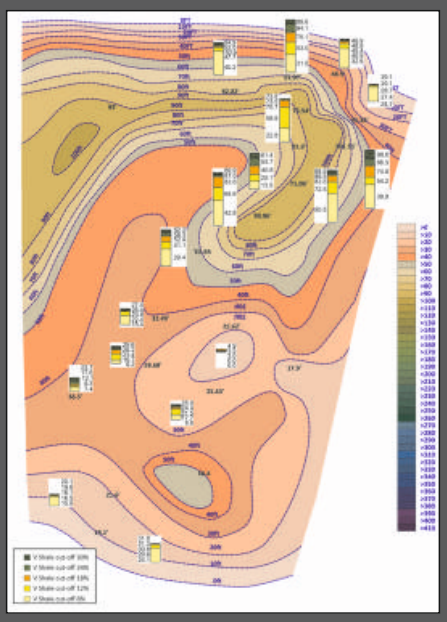
- Sedimentological core descriptions including information on grain size, facies types, clay contents, sedimentary structures and facies stacking patterns
- Ichnofacies interpretations
- Bioclast types and associations
- Relevant petrographic data
- Biostratigraphy data, particularly biofacies information
- Image log facies and dips indicating transport direction
- Seismic facies and seismic attribute maps
- Analogue models (particularly outcrop analogues)
- Variations in accommodation space based on knowledge of the underlying geodynamic controls

Depositional faces modelling can be used to:

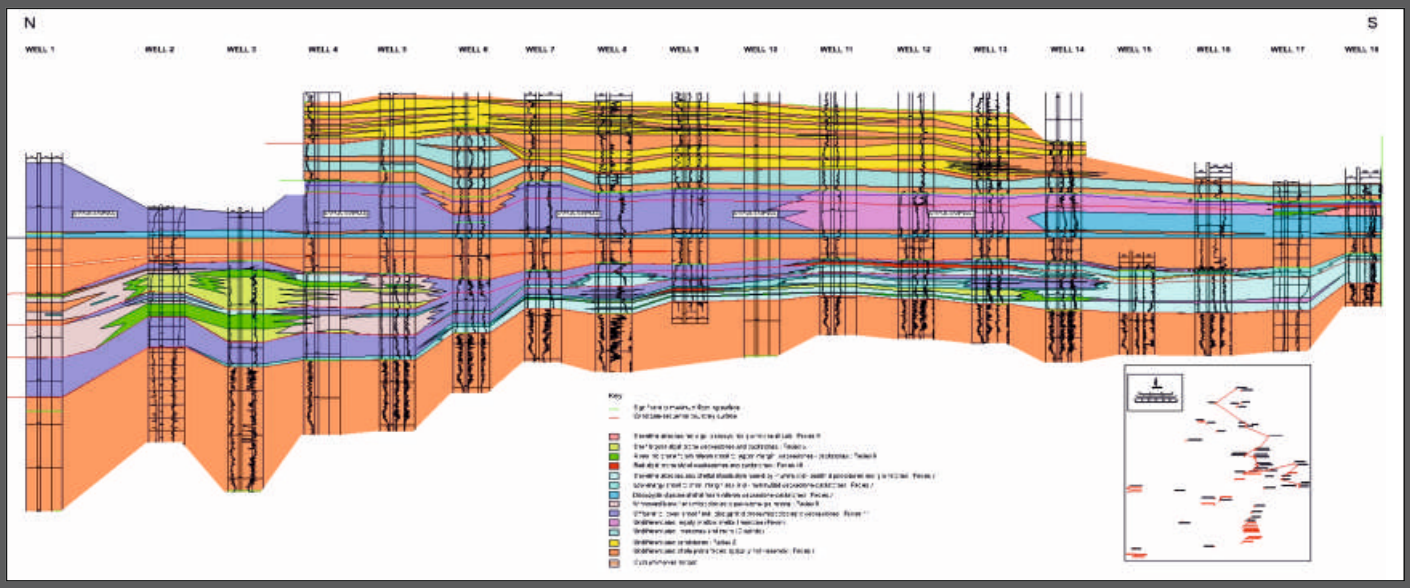
- determine optimal drilling locations
- provide input into the construction of GDE maps for play fairway analysis
- provide input into reservoir property maps and static reservoir models.



Example GDE Map
(Siliciclastic Shoreline play fairway)



Example Isopach and Net Sand Map



Example Facies Correlation Model (Tertiary carbonate play fairway)

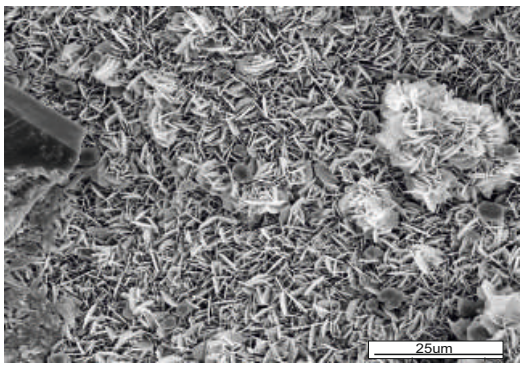
DIAGENETIC MODELLING

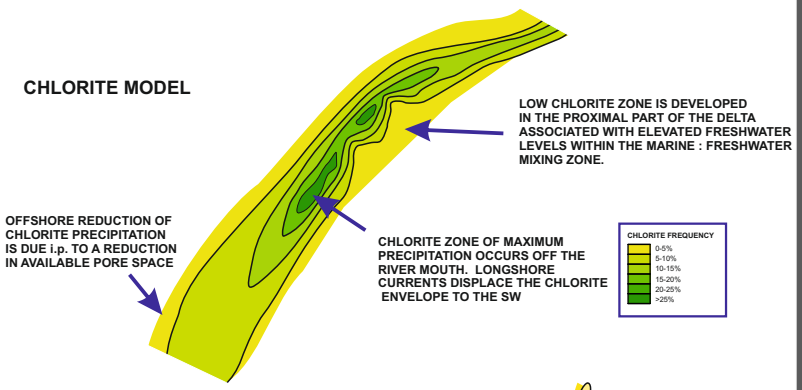
Diagenetic studies can provide answers to a great variety of reservoir and exploration issues from determining spatial variation in diagenetic overprint and reservoir properties within basin fill successions to focussing on the causes of specific anomalies in reservoir behaviour.

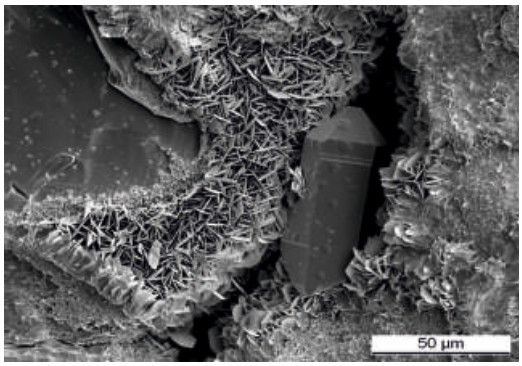
These studies can be used to:

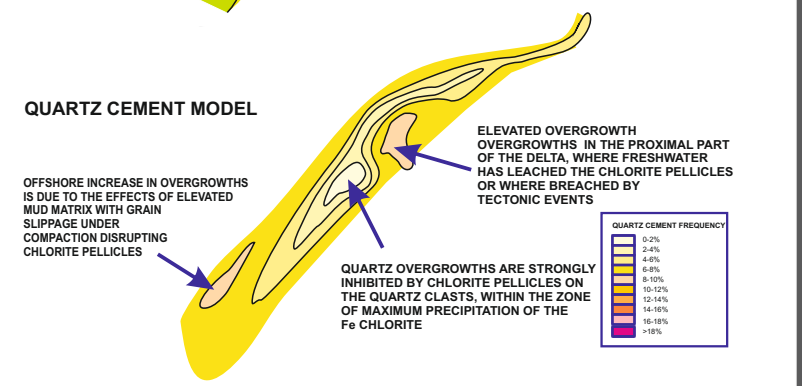
- Document diagenetic overprint & variations relative to facies and burial history
- Document porosity evolution and explain controls on the resulting pore network distribution
- Aid identification of undrilled sweet zones
- Identify underlying controls on permeability distribution
- Constrain the timing of hydrocarbon migration and emplacement
- Constrain the timing of structuration, breaching and re-migration events
- Recognise palaeo-OWC's
- Provide input into play fairway risk maps

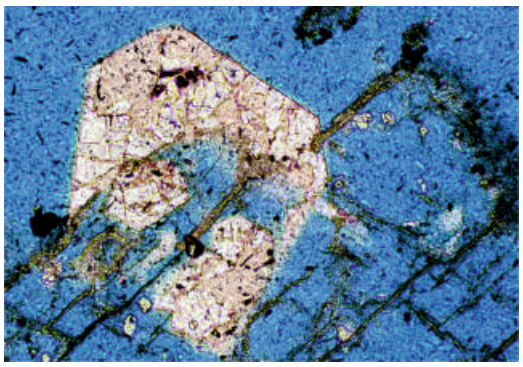
Work programmes that integrate appropriate analyses, with tectono-stratigraphic modelling and burial history analysis can achieve outstanding results.

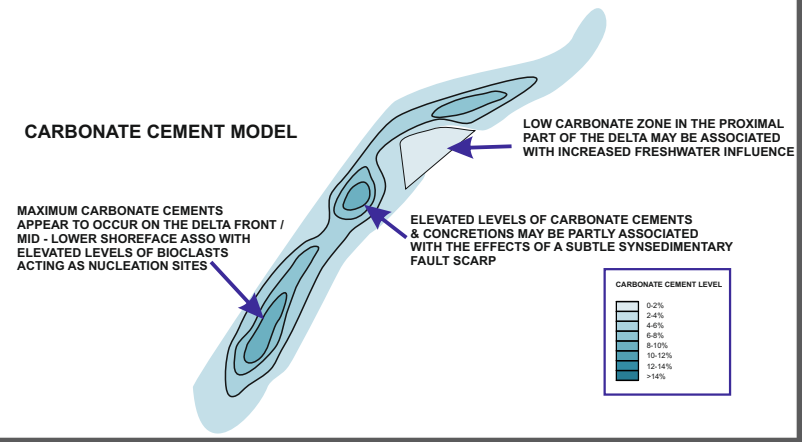








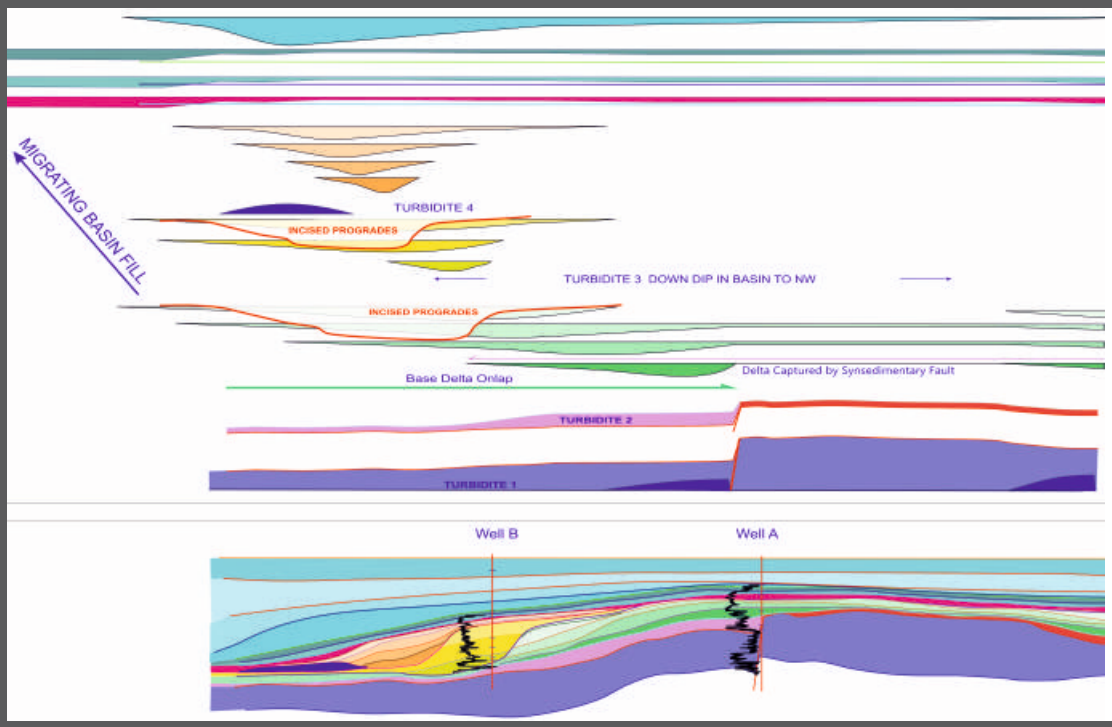




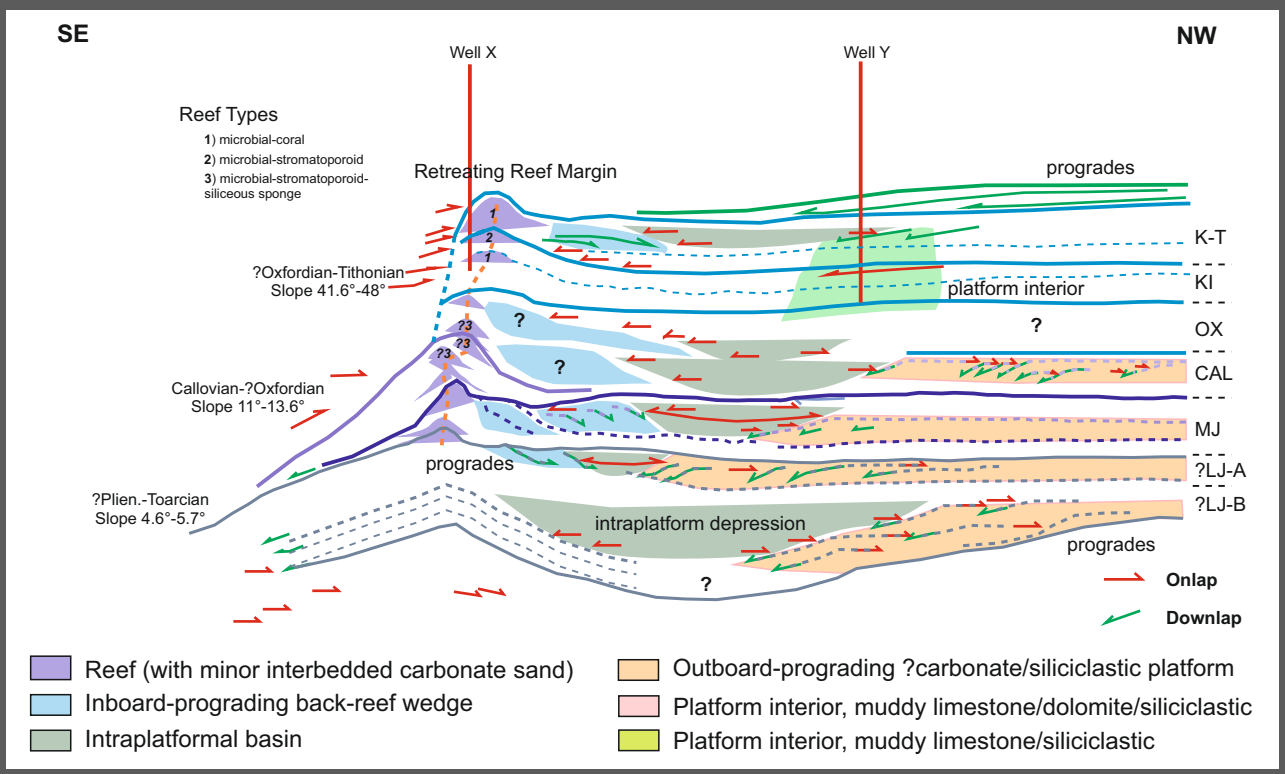
Example Modelling of Cement Distribution in a Shoreface Sandstone Reservoir
(Length of sand body ~30km)

SEQUENCE STRATIGRAPHIC ANALYSIS

Sequence stratigraphy forms an important analytical tool to understand the local controls on depositional sequence development, and the variations between different settings within basins, as well as more regionally, or even globally. It facilitates integration of datasets of varying scales within a unified framework of stratigraphic surfaces, which bound genetically - linked depositional facies systems. As such it forms a strong predictive tool for play fairway analysis and detailed reservoir characterisation studies. Proper analysis allows the evolution of the component depositional systems and their prospective locations to be better defined within the subsurface. It provides a means to understand early pore water flushing events that affect diagenesis within the sediment pile under shallow burial, which is particularly important in carbonates and in chlorite cemented plays.



Example Siliciclastic Sequence Stratigraphic Study



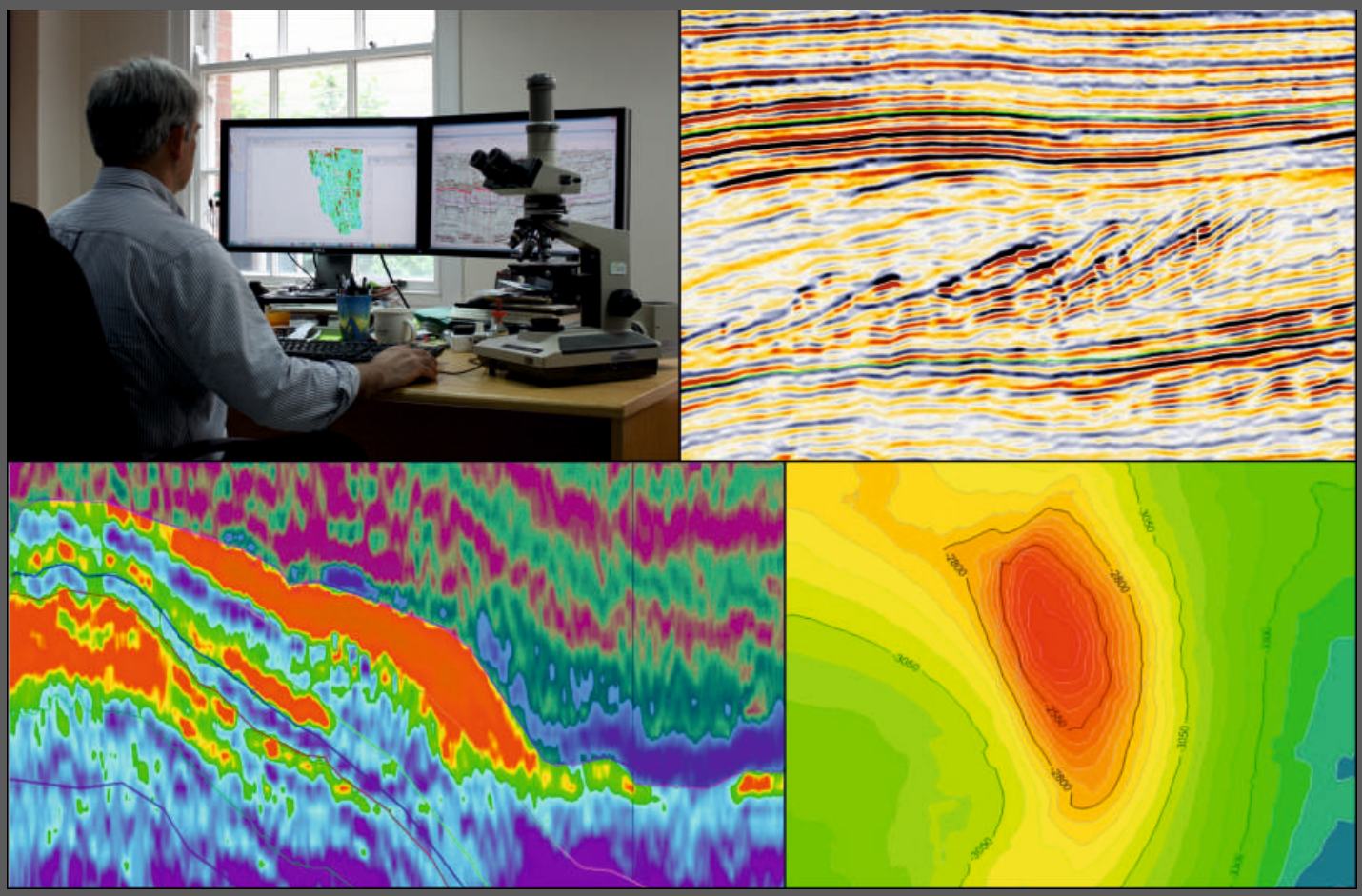
Example Carbonate Sequence Stratigraphic Study

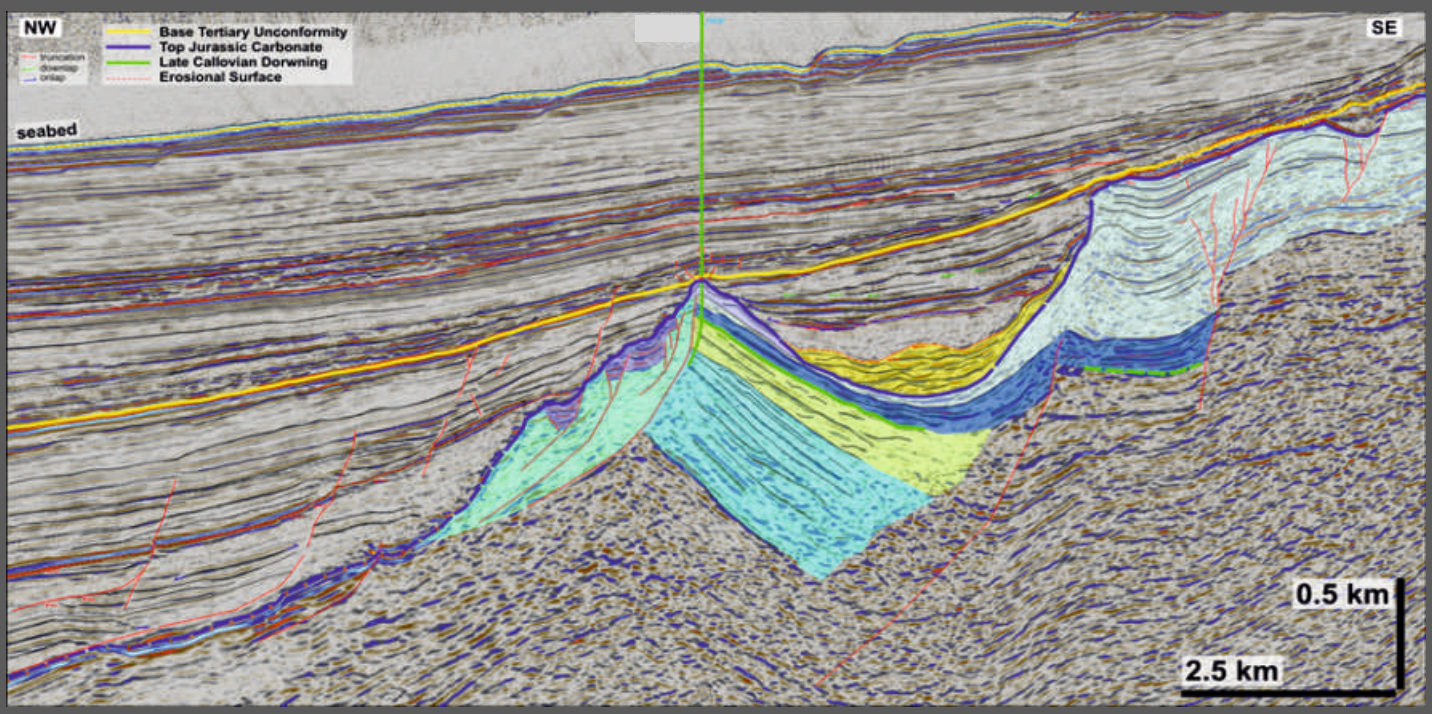
Oolithica GEOSCIENCE

SEISMO-STRATIGRAPHIC ANALYSIS

'Seis-Strat' analysis allows the evolution and internal relationships of depositional systems to be de-convolved within a time equivalent framework of hierarchical surfaces. This architectural framework can then be populated with seismic facies, and further constrained by integration of other subsurface and outcrop datasets, which can extend interpretations to a subseismic scale.

Oolithica's deep understanding of clastic, carbonate and evaporite depositional systems, allied with expertise in these seismic techniques, provides uniquely informed interpretations which reduce both exploration and development risk. Our multidisciplinary approach allows the role of geodynamics to be assessed, helping better define the presence and nature of stratigraphic traps, as well as enhancing play fairway analysis and recognising opportunities that might otherwise be missed.

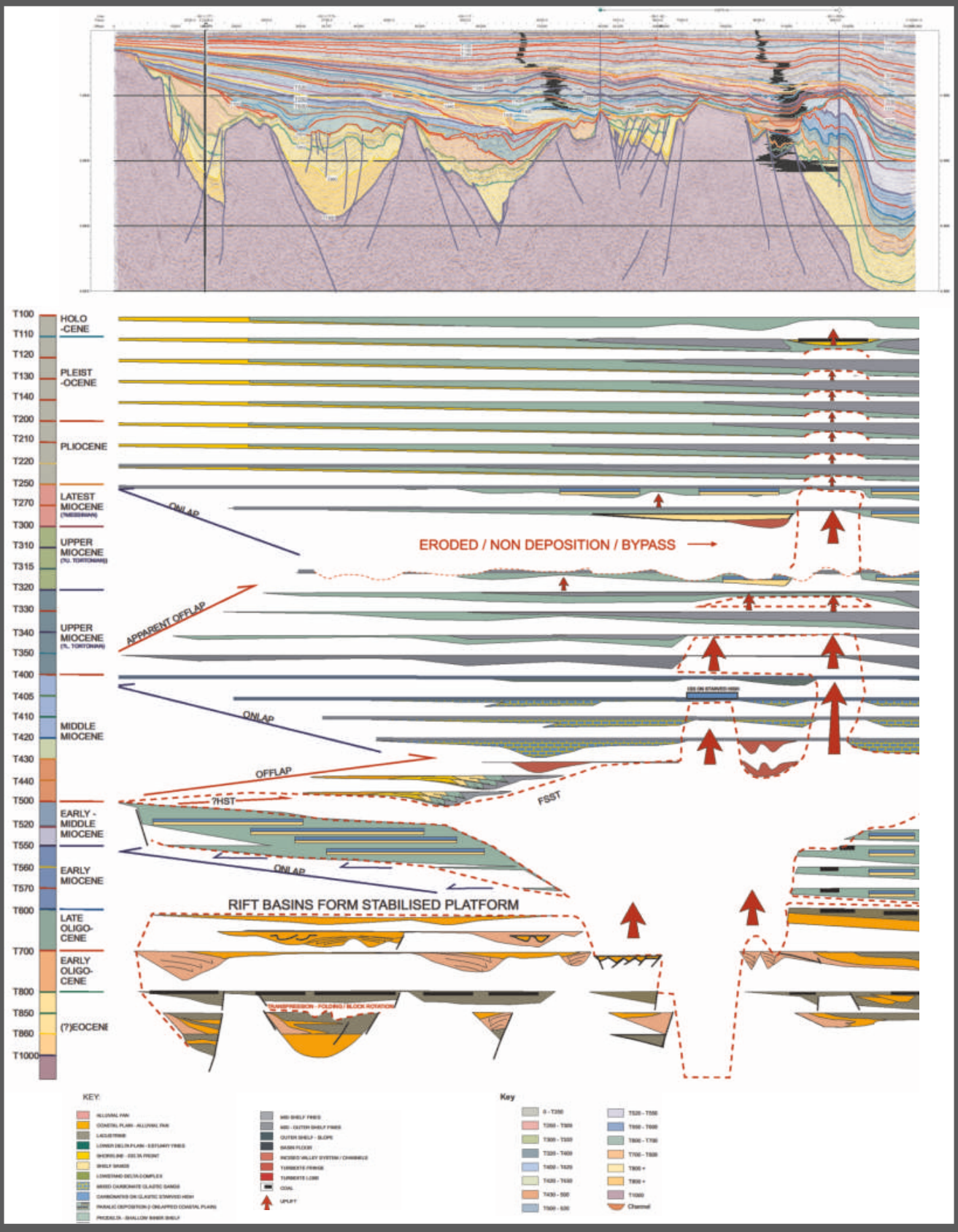




Example Seismic Stratigraphy Study (Atlantic Margin)

TECTONO-STRATIGRAPHIC ANALYSIS

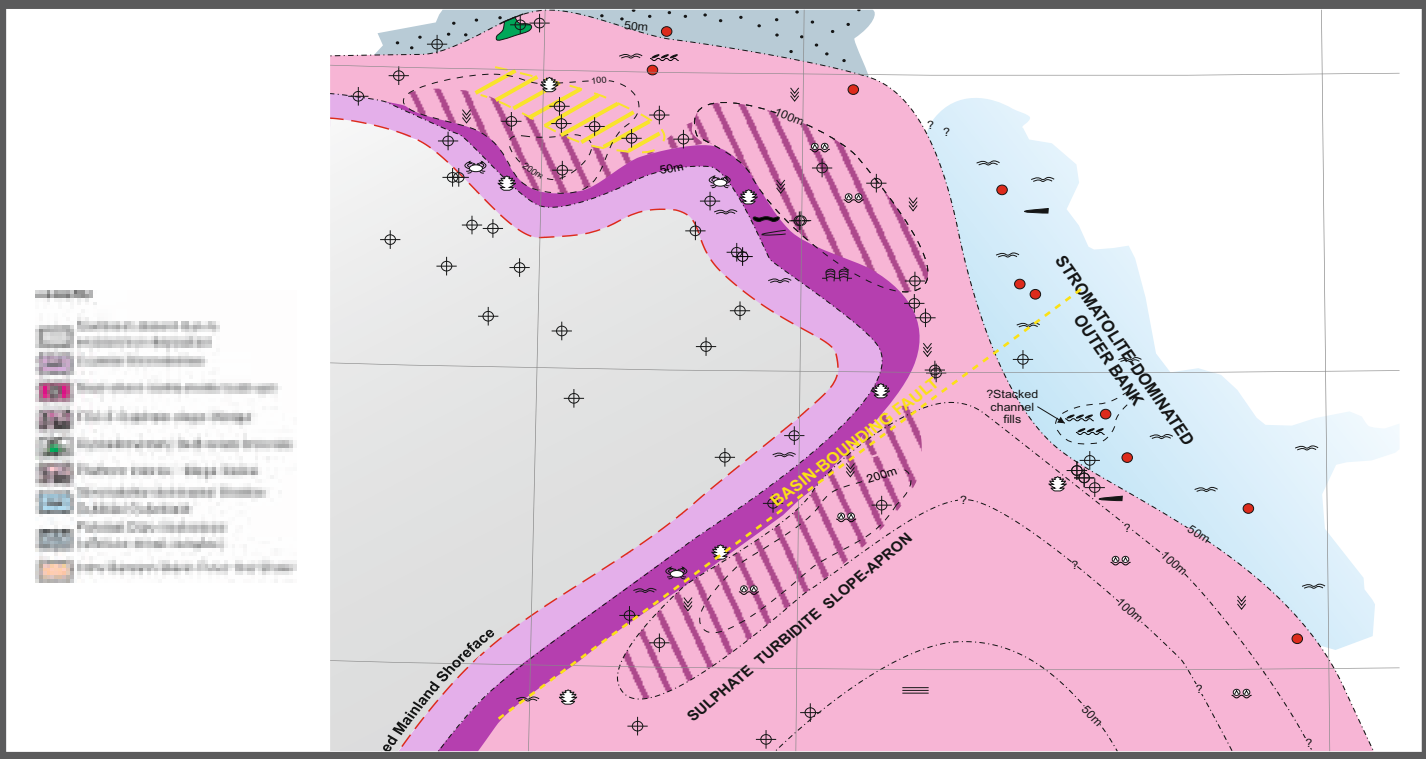
Tectono-stratigraphy underpins our understanding of evolving petroleum systems within basins. Properly addressed these studies elucidate changes in the stratigraphic architecture and facies distribution with respect to evolving structuration and burial history effects. The resulting framework can be used reveal more effectively the various play fairways developed, together with their component risks and potentials. Fundamental to Oolithica's approach is intelligent integration of all relevant multi-disciplinary datasets, allied to an in-depth understanding of carbonate, evaporite and clastic depositional systems.



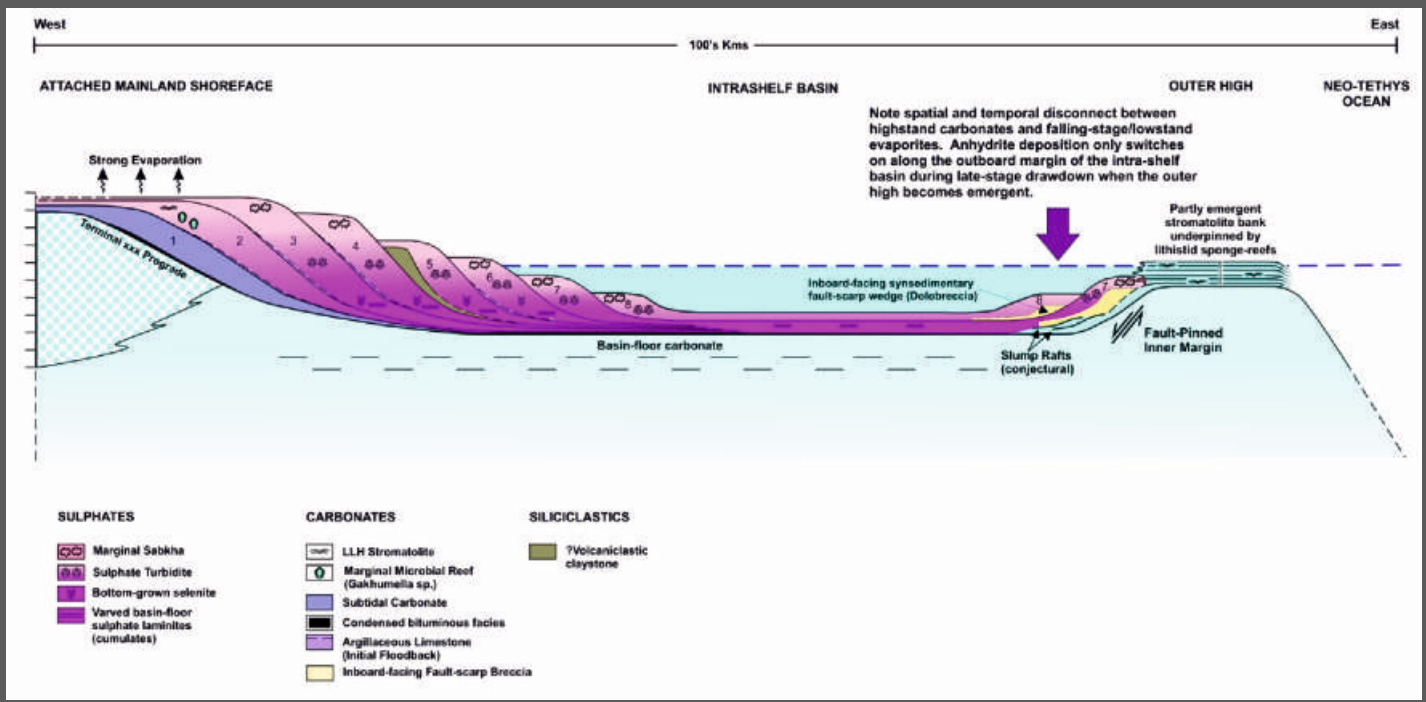
Example Tectono-Stratigraphic Study

REGIONAL-SCALE MULTIDISCIPLINARY STUDIES

Oolithica has undertaken numerous regional-scale studies spanning large parts of Arabia, Africa, Pakistan and Southeast Asia. These provide a powerful in-house knowledge-base in which to place more focussed reservoir-scale and single-well studies within a broader structural and palaeogeographic context. This is particularly important where far-field tectonism exerts a critical influence on sedimentation patterns. An appreciation of regional palaeo-geographic setting is also crucial to understanding the wider controls on depositional facies and stratal architecture. The system of Mesozoic shelf-edge 'outer highs' that flank the Arabian Plate - see below - are an excellent example of this.



Example Regional GDE Map (Redacted)



Simplified Regional-Scale Stratal Architecture
(~500km-long schematic dip-section based on seismic, well and outcrop datasets)

FIELDWORK

Fieldwork can provide extremely powerful and cost effective data and interpretations for exploration campaigns, as well as providing analogues for subsurface datasets and reservoir modelling tasks.

Oolithica has participated in a large number of field campaigns in remote parts of Africa, India / Pakistan and the Middle East, as well as in more mature European basins. This extensive regional experience enables us to provide unique geological insight and ground-truthing of sub-surface datasets.

Our fieldwork projects typically include:

- geological mapping, integrating satellite imagery and published information
- measuring stratigraphic sections
- interpretation of depositional environments and facies
- determining sediment transport directions
- sampling of outcrops for further analyses
- projection of outcrop data into the subsurface
- input into seismic acquisition programmes

Field campaigns are usually followed up with a detailed analytical and interpretation program, typically including petrographic, biostratigraphic and geochemical analyses.

Fieldwork in southern Arabia

Eastern Ethiopia Field Campaign

Fieldwork in Kurdistan

Fieldwork in Iraqi Kurdistan

Oolithica GEOSCIENCE

TRAINING SERVICES

Oolithica provides a wide variety of classroom- and outcrop-based training courses, details of which can be found at our website:

www.oolithica.com

In addition, we offer a mentoring service for 'Young Professionals' and are happy to create bespoke training programmes to match our clients requirements.

Arid Carbonate Coastline Deposystems

The Mesozoic of NE Arabia

Mixed Carbonate-Siliciclastic Deposystems

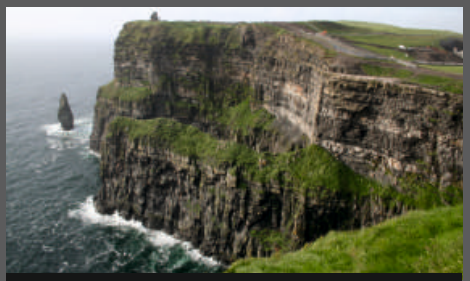
Jurassic Carbonate Shelf-Margin Deposystems

Estuarine and Wave-Dominated Shoreline Deposystems

Oolite Deposystems

Petroleum Systems

Piggyback Basin-Fill Successions



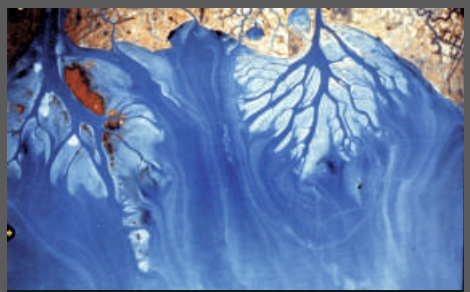
Deltaic and Turbidite Deposystems

Mixed Carbonate-Evaporite Deposystems

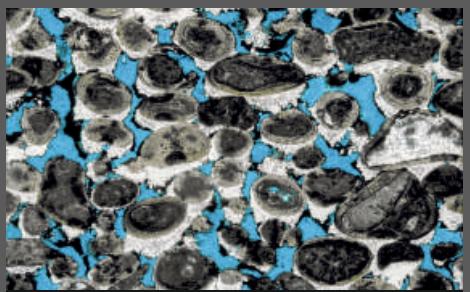
Rimmed Carbonate Platform Deposystems

Foreland Basin-Fill Successions

Clastic Sequence Stratigraphy

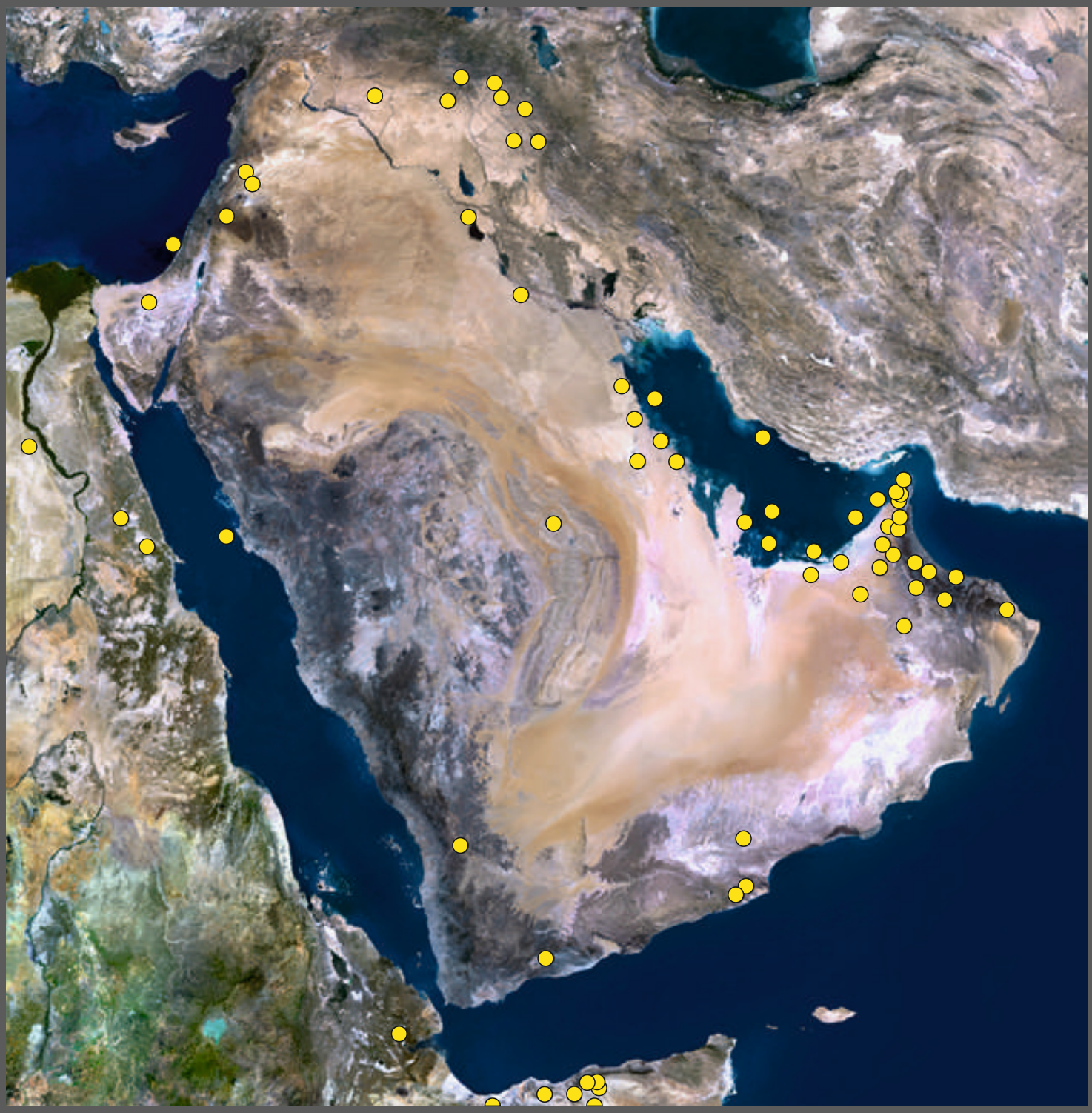


Clastic Sedimentology



Carbonate Petrography and Diagenesis

Oolithica GEOSCIENCE



Middle East and Horn of Africa Experience

CONTACT US AT:

Tel:	+44 1242 579666
E-mail:	enquiries@oolithica.net
W:	www.oolithica.com
Snail mail:	Oolithica Geoscience Kenden, Charlton Drive Cheltenham GL53 8ES United Kingdom

Scan me