



# Introduction

We are a geological consultancy that provides expertise in carbonate and evaporite systems primarily to the oil and gas industry, but also to mineral extraction and waste industries.

Our bespoke services focus on carbonate reservoirs and include:

- Evaluation and interpretation of all vintages and types of geological data.
- Regional studies and play evaluations.
- Reservoir characterisation studies.
- Data provision for static carbonate reservoir models.

Cambridge Carbonates Ltd.'s principal geographical regions of expertise, are the Middle East, North Africa, Mexico, circum Mediterranean areas, Northern and Eastern Europe, South Atlantic Margins, South East Asia and the Former Soviet Union.

Cambridge Carbonates Ltd also has a range of multi-client expert reports available to purchase, including regional reports on key basins, and detailed palaeogeography maps.



# The Team



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# Regional Expertise

## Expertise in carbonate and evaporite systems

Cambridge Carbonates Ltd. was established in 1993 and has more than 120 man years' experience in the evaluation of carbonate reservoirs worldwide. We offer interpretation of proprietary data as well as broader consulting services to our clients. Our aim is to solve your problems, rather than just to do consultancy work.

In exploration projects we contribute to prospect analysis by re-interpreting diverse (and often old) data, we can recommend appropriate outcrop or

sub-surface analogues and integrate many data types to produce play maps.

In the production environment we help with well targeting and planning and can suggest programmes of data gathering from wells. We are familiar with the use and application of advanced techniques such as fluid inclusions, isotope and image analysis of pore systems and we can recommend the best way to use them to understand your reservoir.



## Mexico

Cambridge Carbonates Ltd have considerable experience of working in Mexico and on Mexican subsurface data, having studied the area since the early 1990's. Our experience is primarily in the SE of Mexico (offshore and onshore) and Tampico-Misantla areas, looking at both Mesozoic and Cenozoic carbonate plays. Our regional expertise enables us to offer bespoke services to clients, including reviews of existing plays, development of new play concepts, aiding seismic interpretation, core logging, petrographic and diagenetic services.

## Southern Atlantic margins

We have worked on pre- and post-salt carbonate systems on both sides of the Atlantic. We are undertaking a comprehensive study of the microfacies of Brazilian pre-salt carbonates and a comparative study of pre-salt carbonates from Africa. We have also examined post-salt mixed carbonate-clastic lacustrine and continental margin systems from Africa.

## Middle East

We have undertaken numerous exploration, regional, fieldwork and reservoir characterisation projects, with particular focus in the Iraq (including Kurdistan), Iran, Oman, UAE, Kuwait, Syria and other countries bordering the eastern Mediterranean. Cambridge Carbonates were also a key contributor to the seminal "Arabian Plate Sequence Stratigraphy" Sharland et al. (2001) book, as well as the 2010 "Petroleum Geology of Iraq" book. Our considerable experience in this area has enabled us to develop an impressive in-house database, with which we have produced several Multiclient Expert Products.

## Europe

We have worked the Palaeozoic carbonates extensively in the North Sea, Poland and Former Soviet Union, and also Mesozoic reservoirs in France. The circum-Adriatic area in particular (Italy, Greece etc.) is a specific area of expertise, having logged more than 1000m of core from these Cretaceous and Cenozoic reservoirs. In this area we have worked fractured, karsted and resedimented reservoirs both from the subsurface (Italy; Greece) and also undertaken fieldwork in equivalent reservoirs.

## Arctic Region

Our expertise on the Norwegian and Russian sides of the Barents Shelf is focussed on late Palaeozoic carbonate, evaporite, clastic and siliceous depositional systems using data from the sub-surface and outcrop on Svalbard. We have undertaken a range of single well regional and studies with the aims of understanding the local and regional controls on reservoir development, including the formation of karst systems.

We have logged most of the late Palaeozoic core on the Norwegian side of the Barents Shelf; details of some of these reports are in the brochure. Regional studies based on seismic stratigraphy and well correlation integrated with our well information have been used in preparation for licencing rounds on the both Russian and Norwegian sectors.

We have also been invited to join FORCE workshops in Norway as keynote speakers.

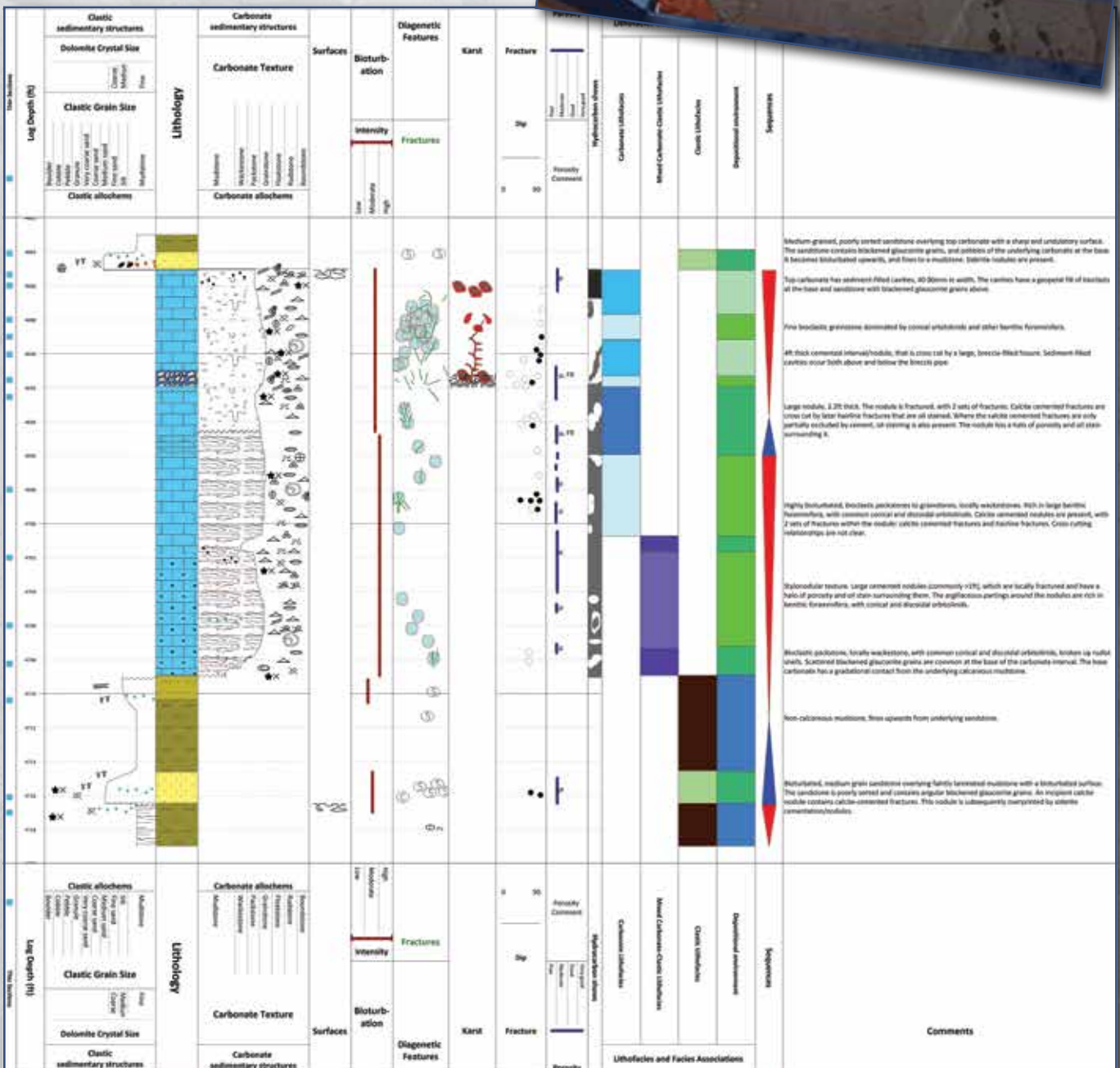
## Central and SE Asia

Cenozoic carbonates of SE Asia have been a particular area of interest for Cambridge Carbonates. Having worked on numerous reservoir characterisation and exploration projects from locations such as offshore Vietnam, Sumatra, Java, China, Philippines, Borneo, Luconia and east Sulawesi, our most recent work included reservoir characterisation and evaluation of the giant Antelope field. We have also undertaken fieldwork in this area.

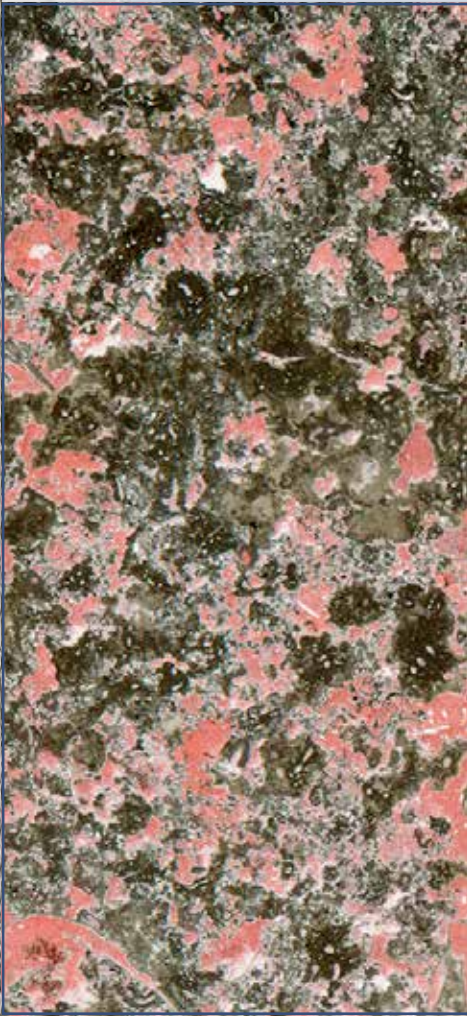
# Core Logging

At Cambridge Carbonates we have logged and described many thousand meters of core. Our core log format has evolved through our experience of describing and interpreting carbonate and mixed carbonate-evaporite-siliciclastic successions of all ages in core and outcrop.

Depending on our clients' needs our core logs are typically created using CoreCad software. This produces not only a professional log, but also enables export of quantitative data so that it can be integrated into other G&G evaluation software.



# Petrographic Services

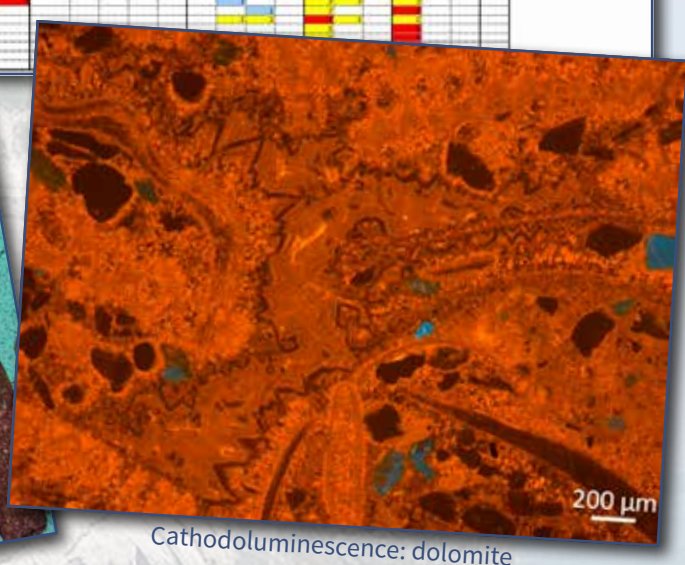
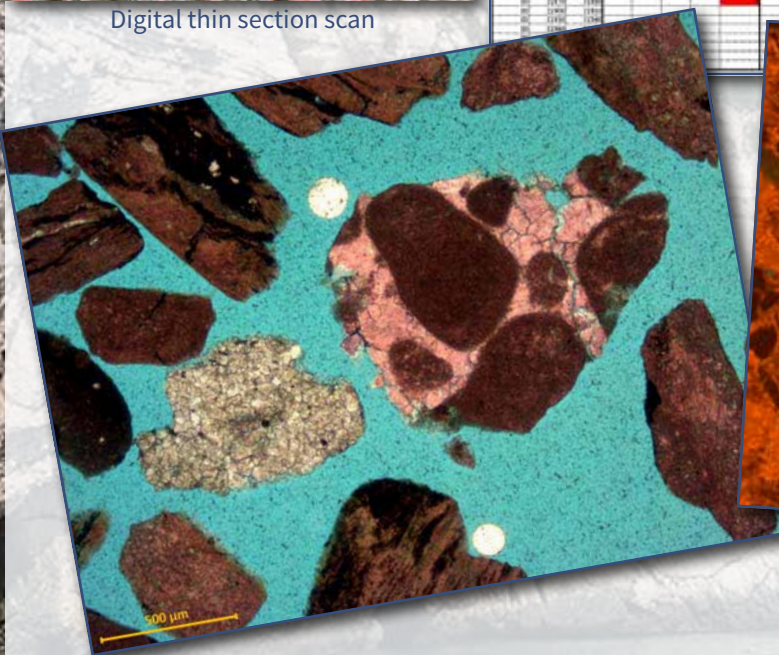


Digital thin section scan

Applications of petrographic studies:

- Digital imaging of thin sections and pore systems
- Microfacies and porosity data in support of core descriptions.
- Microfacies analysis and porosity information from cuttings samples for facies and sequence stratigraphic interpretation of uncored wells.
- Paragenetic sequences using cathodoluminescence.
- Rock typing for reservoir modelling.
- Matching rock types and pore systems to wireline log response and calibration of petrophysical models.

Cuttings microfacies log



Cathodoluminescence: dolomite

We use Nikon polarising microscopes with PixelLINK camera for petrographic imaging and a dedicated low light camera for CL imaging. We also produce high resolution ppl and polarised light scanned thin section images in-house. Image analysis and quantitative petrographic data (compatible with Touchstone) may also be collected using Petrog and Image ProPlus software.

# Carbonate diagenesis

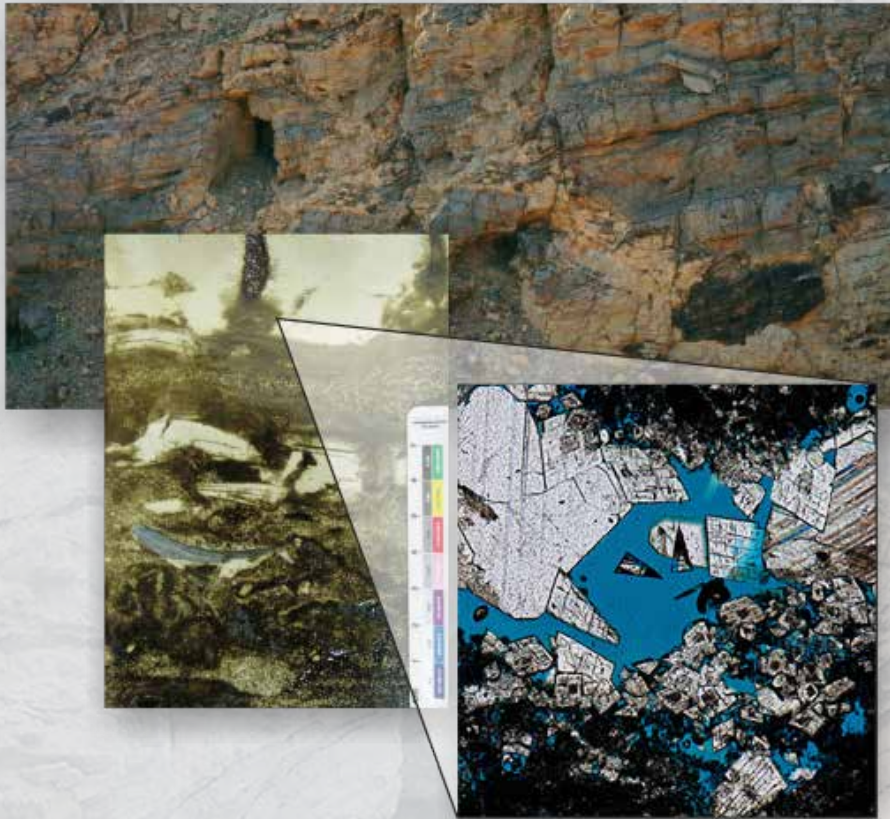
Cambridge Carbonates offer expertise in carbonate diagenesis, plus the description and interpretation of microfacies.

We produce diagenetic models which provide key results such as timing of fluid flow and evolution of reservoir properties throughout the entire diagenesis. Resultant diagenetic models are useful to optimise the understanding of rock-types.

To achieve these studies, we follow a well defined workflow integrating:

- Macroscopic qualitative and quantitative observations (cores and/or outcrops)
- Microscopic qualitative and quantitative investigations (observations on stained thin sections, cathodoluminescence, SEM)
- Geochemistry (stable C & O isotopes, Sr isotopes, trace/major elements) and thermometry (fluid inclusion analysis), keeping in mind the constraint provided by the sequence stratigraphic framework and burial history.

## Diagenetic and Petrographic Workflow - Example

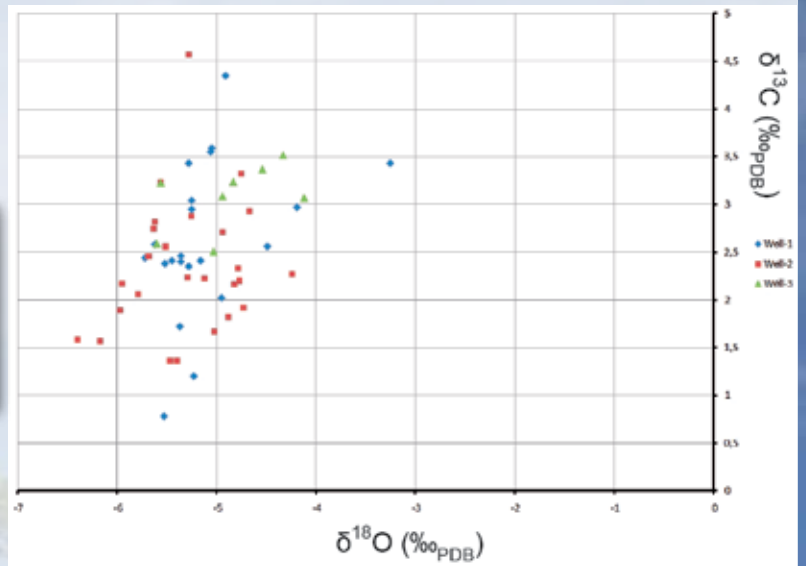
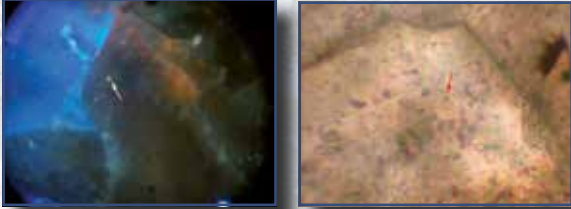


1. Outcrop observations
2. Core analysis
3. Petrographic investigation
4. Advanced petrographic analysis  
e.g. Cathodoluminescence (CL)

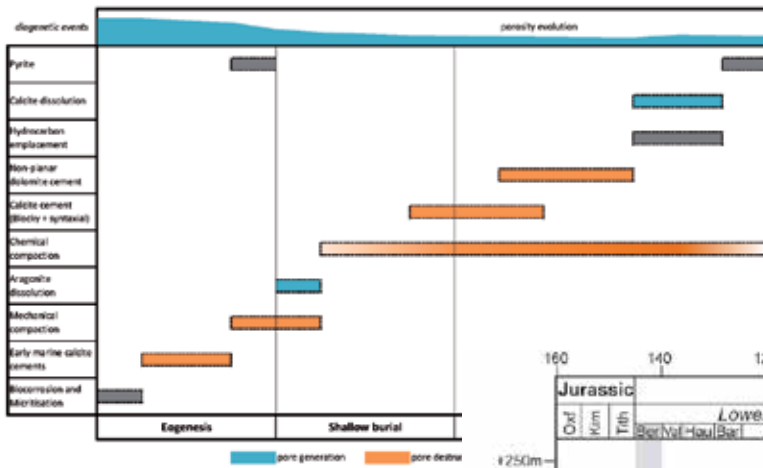


Width of view = 2890 $\mu$ m

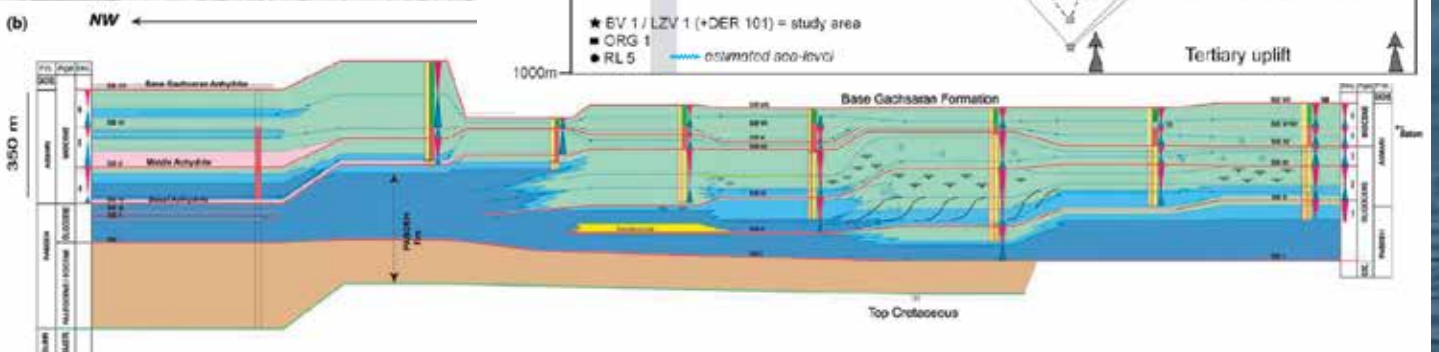
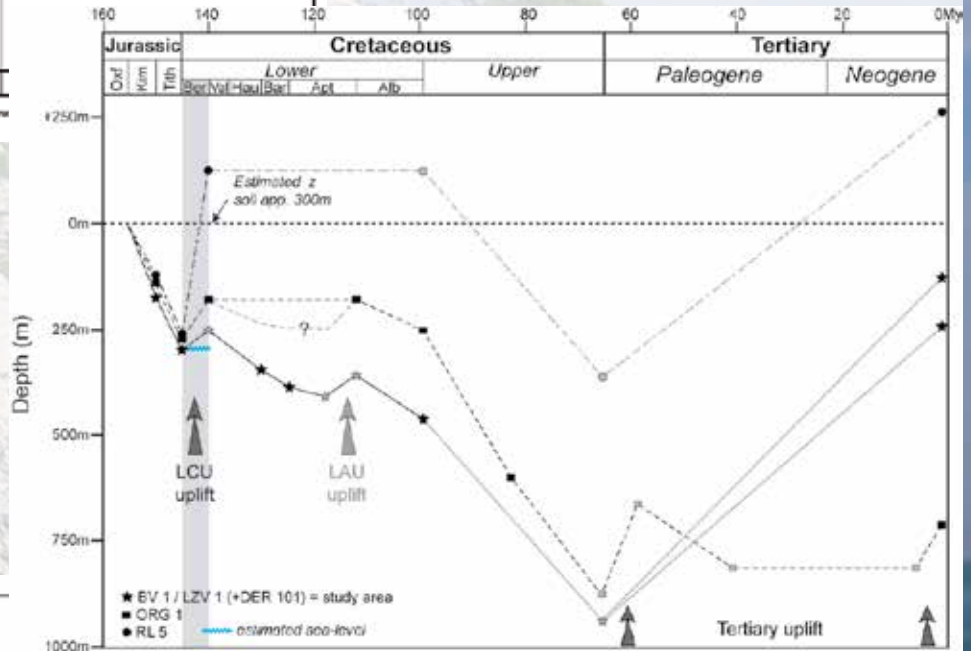
5. Application of geochemical and thermometric techniques e.g. fluid inclusion and oxygen isotope analysis



6. Production of paragenetic sequences: based on the findings from 1-5.



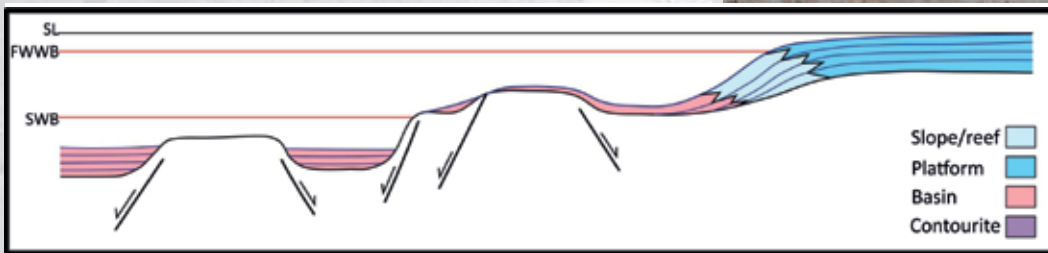
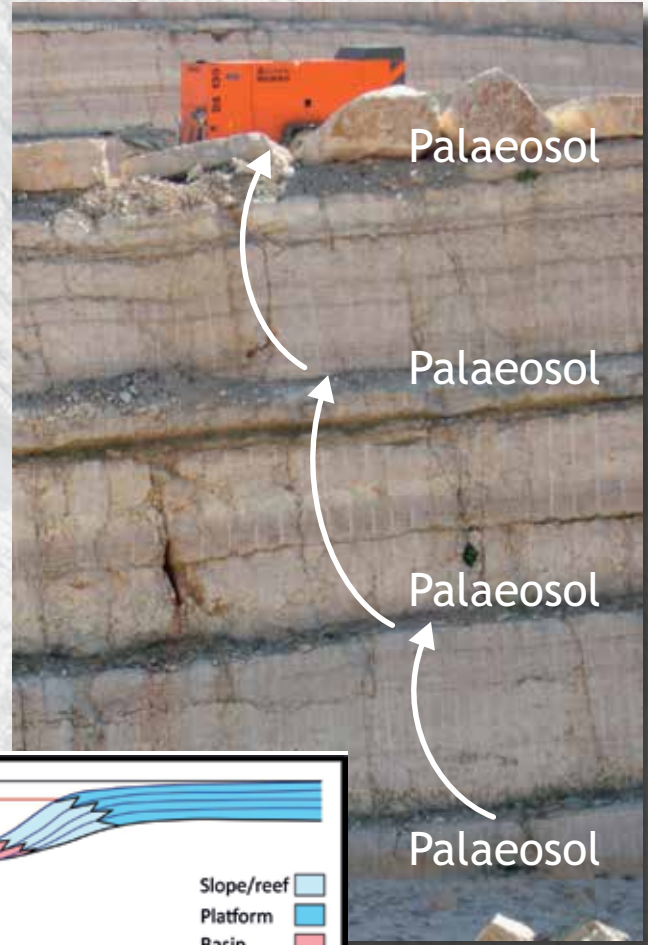
7. Burial history and sequence stratigraphy integration - provide crucial constraints for placing the paragenetic sequence into a reservoir/basin history.



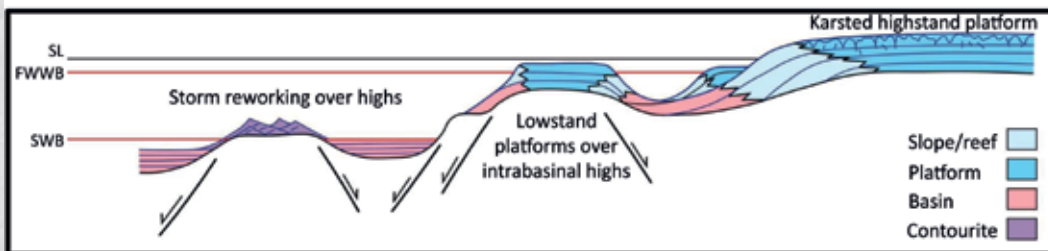
# Carbonate Sequence Stratigraphy

Carbonate sequence stratigraphic analysis allows better understanding of reservoir layering and the geometry of flow units. This fundamental service is performed in conjunction with seismic stratigraphy, biostratigraphy and microfacies analysis.

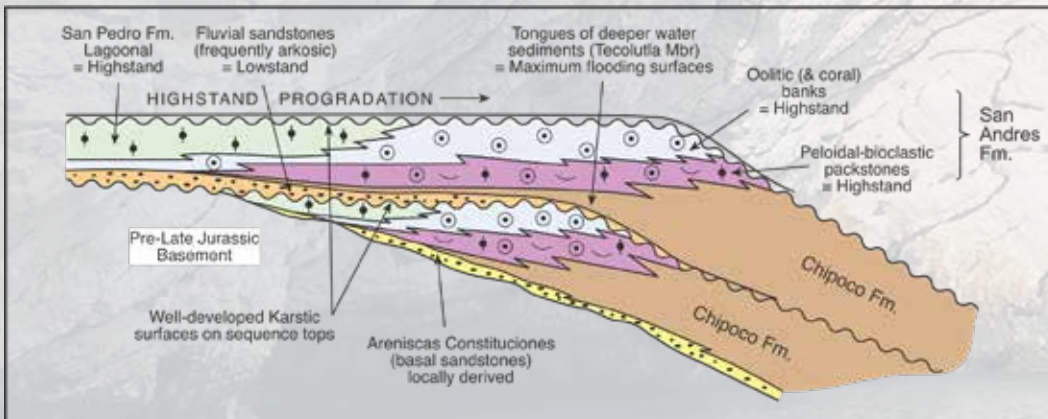
We have extensive experience of undertaking field-wide studies using log-defined facies and sequence stratigraphic schemes, from which detailed models can be built and used as input into simulation models.



Highstand carbonate systems

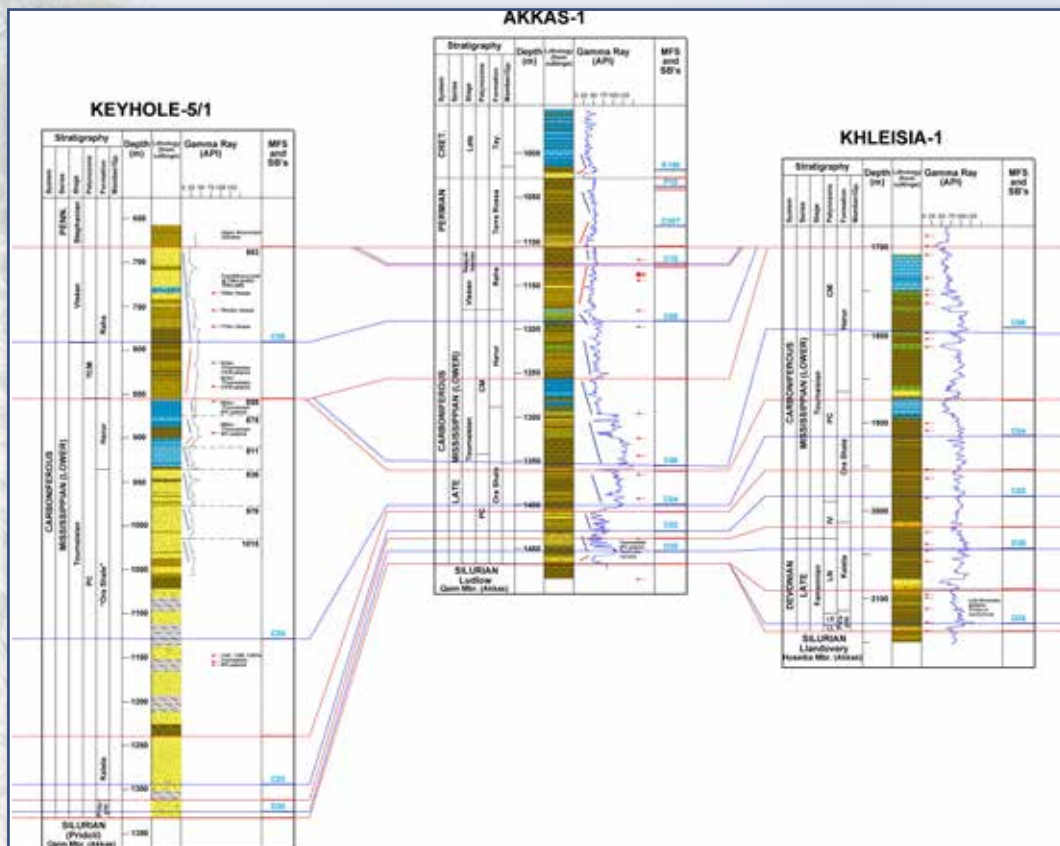


Lowstand carbonate systems



# Reservoir Characterisation

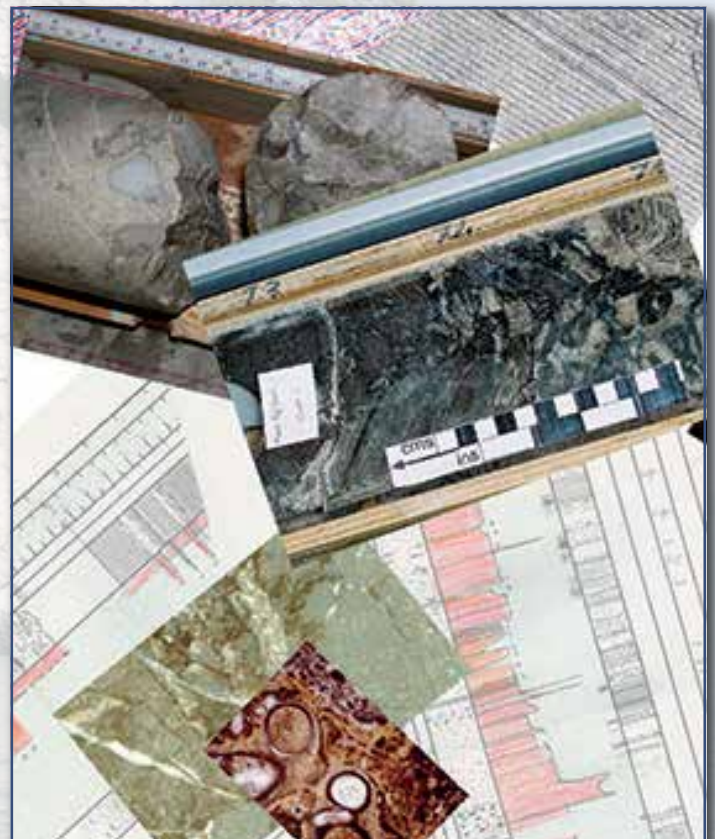
The starting point of many studies is the collation and interpretation of basic geological data. We use Petrel software in house to enable us to visualise and interpret seismic and well data. ArcGIS software is used for the development of our palaeogeography maps.



Carbonate reservoirs can present a suite of unique reservoir characterisation challenges, particularly if reservoirs have been strongly diagenetically altered (i.e. dolomitisation; karstification; fracturing). We can develop static reservoir models, taking into account both depositional trends and diagenetic overprints, by integrating core, cuttings, SWC, poroperm data, logs, seismic, well test and production data to define flow units. These can be used in volumetric determination and future planning. A bespoke work-plan would be developed in order to fully address reservoir characterisation issues.

Think of us when you are:

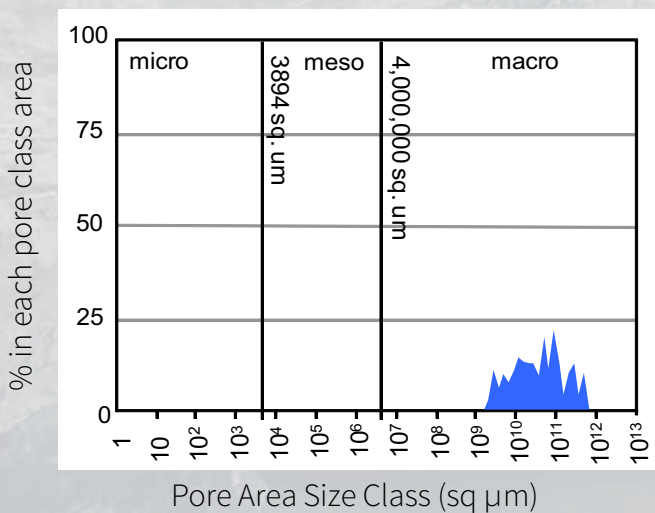
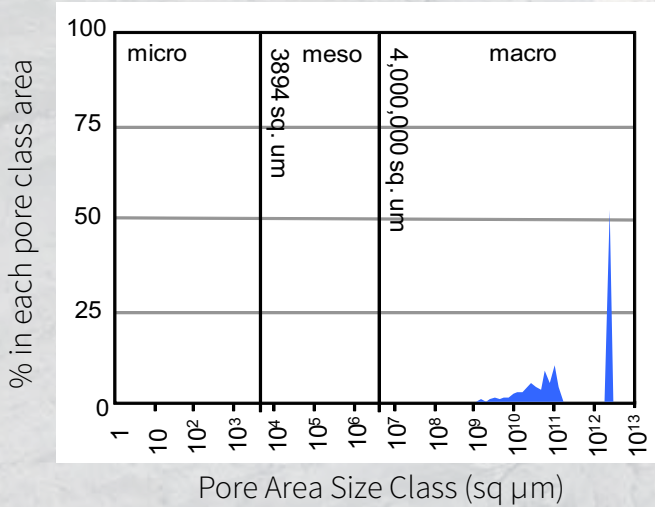
- Developing a mature field, where a new look at old data is needed.
- Considering the re-activation of an abandoned field.
- Planning to exploit an under-developed reservoir.
- Reviewing a new asset or thinking about acquiring an asset.



# Understanding Porosity Systems

Cambridge Carbonates have developed innovative techniques that characterise micro- to macroscale pore systems by image analysis, thus helping you to understand the links between porosity and permeability in carbonate reservoirs.

We are also experienced in detecting and describing dual porosity systems such as karst, fracture and breccia reservoirs by using production data, logs and outcrop and sub-surface analogues.



# Field Trips and Courses

As well as providing expert services, we also have a number of bespoke courses that can be run for our clients.



## Carbonate reservoir characterisation workshop

We can offer 1 to 5 day workshops in Carbonate Reservoir Characterisation. The workshop can be tailored to the specific needs of the clients, or can be provided as a more generic workshop.



## Basque-Cantabrian Basin (Spain) course

NE Spain provides excellent analogues for two of the principle reservoir types in SE Mexico: Salt high associated carbonate breccias and extensive high temperature dolomite bodies. This field course runs over 5 days and is aimed at production geologists, petrophysicists and engineers.



## Cyprus Field course

3 to 5 day field course which provides a general overview of the geology of Cyprus, including the discussion of controls on sedimentation and potential onshore analogues for plays in the offshore Levantine Basin.



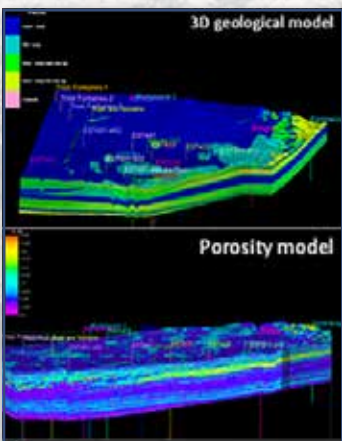
## Zechstein carbonates and collapse breccias of north-east England Field course

1 to 3 day field course discussing the carbonate facies and diagenesis of different sedimentary sequences in the Zechstein of north-east England.



## Derbyshire Field course

This is a 2 to 5 day field course discussing the facies and diagenesis of the 4<sup>th</sup> and 5<sup>th</sup> order sequences in different tectonic settings.



## Jurassic carbonate platforms of NE France: from outcrop to 3D reservoir modelling

This 3 to 5 days field course provides an excellent illustration of an integrated workflow leading to high resolution 3D models, through a review of the constraints to the static model acquired from the field scale to the subsurface data, including sedimentary architectures, distribution and evolution of petrophysical properties through diagenesis.

For further information on each course refer to the website: [www.cambridgecarbonates.com](http://www.cambridgecarbonates.com)

# Expert Reports

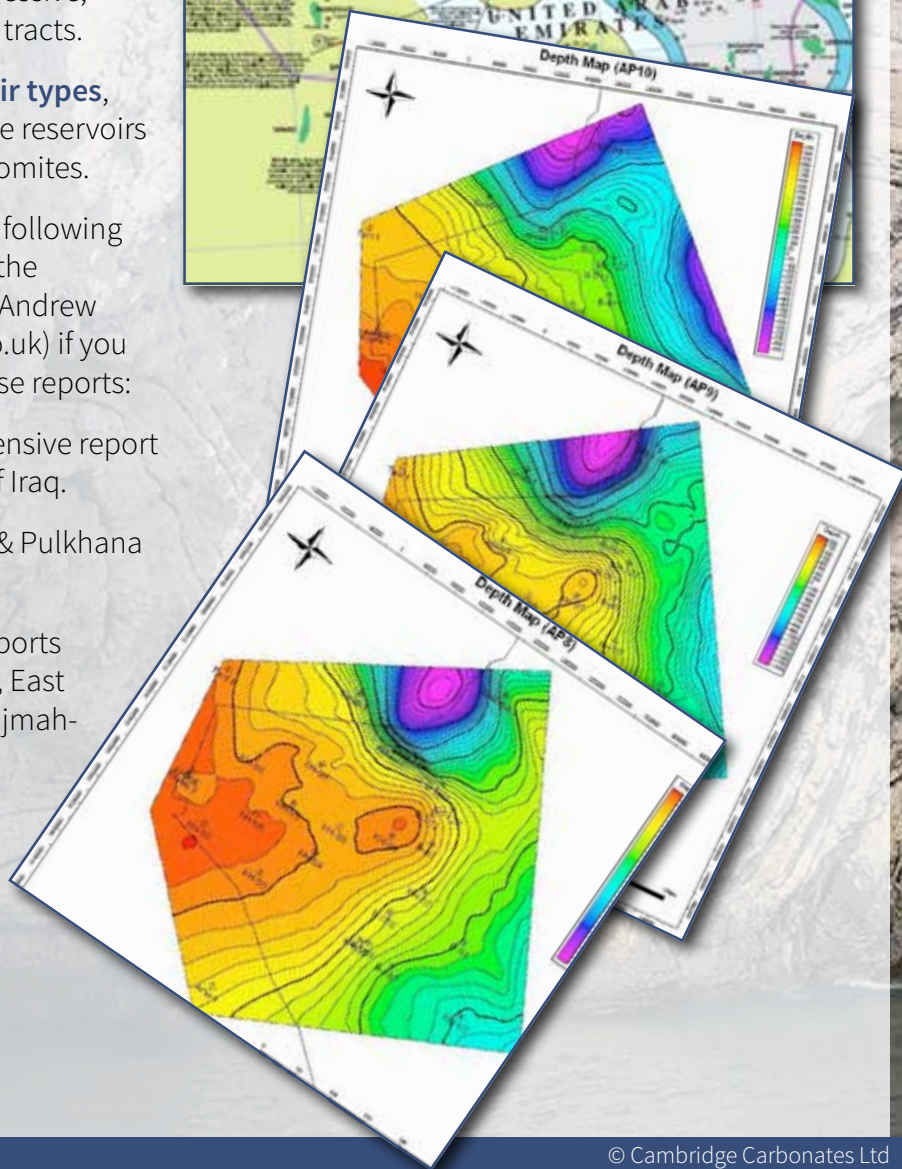
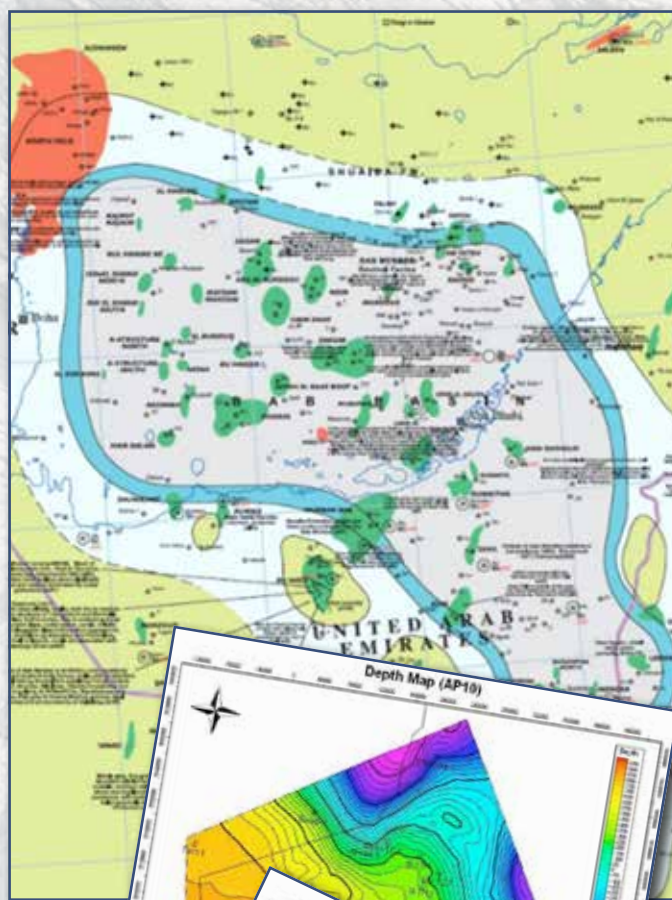
## Introduction

As well as providing bespoke services to our clients, we also have a number of Multiclient Expert Reports available for purchase. These reports reflect Cambridge Carbonates years of experience and expert knowledge in key areas, and include:

- **Area specific reports**, such as carbonate reservoirs of the Circum-Adriatic, Iraq, Barents Shelf or SE Asia.
- **Palaeogeography map sets**. These have been developed and continually updated since the 1990's, and are based on Cambridge Carbonates' expert knowledge in the areas integrated with both up-to-date and more obscure publically available data. The palaeogeography maps are based on a 3<sup>rd</sup> order sequence stratigraphic framework, with maps for each of the highstand, transgressive, lowstand and maximum flood systems tracts.
- Reports of **specific carbonate reservoir types**, such as tectonically fractured carbonate reservoirs and hydrothermal/fracture-related dolomites.

Our key expert reports are outlined in the following pages. In addition to these, we also have the following **legacy reports**. Please contact Andrew Horbury ([andy@cambridgecarbonates.co.uk](mailto:andy@cambridgecarbonates.co.uk)) if you would like any further information on these reports:

- The Western Desert of Iraq: A comprehensive report on the geology of the Western Desert of Iraq.
- Evaluation of the Area around Jambur & Pulkhana in NE Iraq.
- Evaluations of Iraqi fields. Individual reports available on the following fields: Badra, East Baghdad, Garraf, Kifl area, Majnoon, Najmah-Qaiyarah, Nau Doman area and Siba.



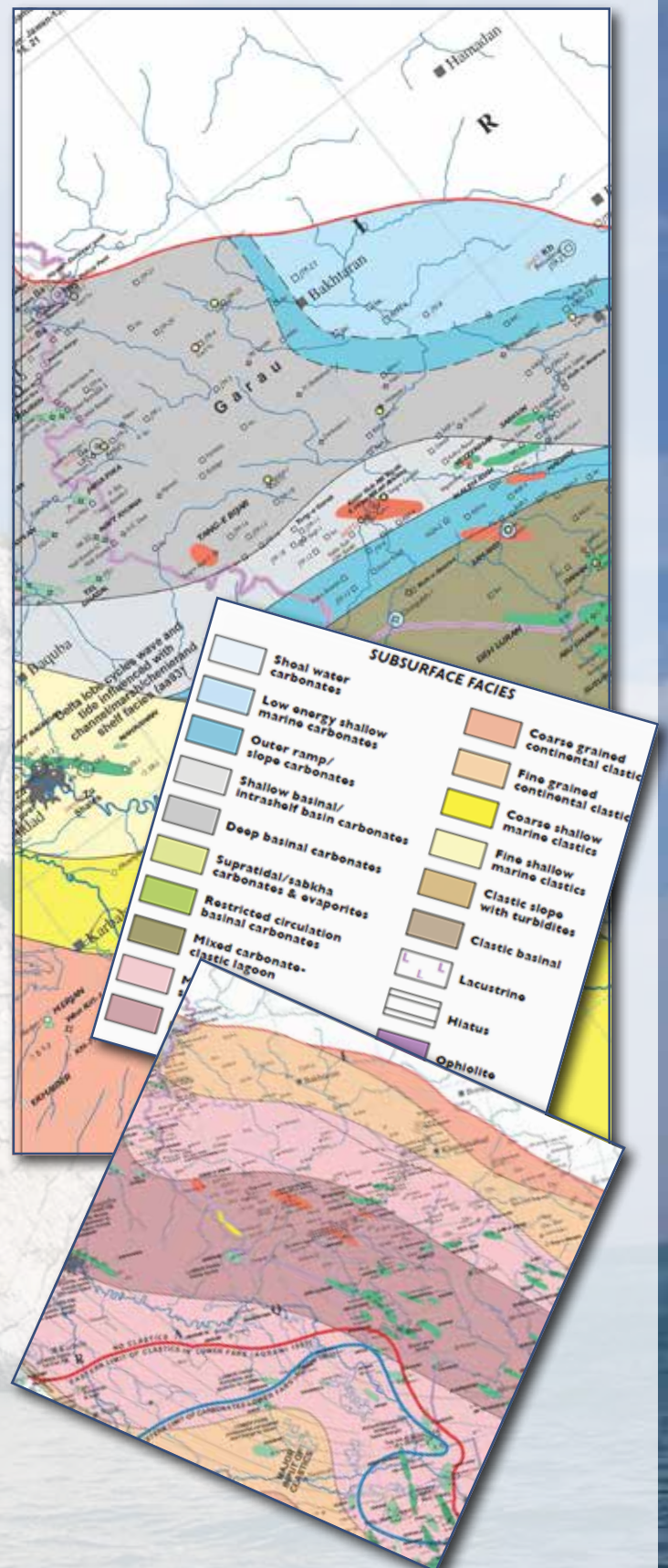
# Palaeogeographic Maps of Arabian Plate Foreland Basin

**Palaeogeographic database for Arabian Plate Foreland Basin** consisting of recently assembled and updated compilation of extensively researched geo-referenced maps.

Maps are based on the sequence stratigraphic framework of Sharland et al. (2001, 2004), with critical sequences and systems tracts defined. For each 3rd order sequence a map is available for the highstand, transgressive and lowstand system tracts.

Maps have been progressively constructed since 1993, using data derived and collated from publicly available sources. A voluminous quantity of information published in the last decade is currently being integrated.

For a full listing of available maps, and examples/samples and costings, please contact Dr Andrew Horbury (details below).



For further information contact: Andrew Horbury  
E: [andy@cambridgecarbonates.co.uk](mailto:andy@cambridgecarbonates.co.uk)

## Hydrothermal, burial and fracture-related dolomites: insights into reservoirs and analogues

**Porous, coarse crystalline dolomites** are generally related to **fractures and faults** and often precipitated from **hot fluids** under **shallow to deep burial conditions**. These dolomites may form excellent reservoirs in a variety of tectonic settings world-wide, such as the Albion-Scipio trend (USA); Ladyfern field (Canada); Arab-D reservoir of the Ghawar field (Saudi Arabia) and Tawke field (Iraqi Kurdistan) among others. Despite their considerable importance for hydrocarbon reservoirs, the origin of these dolomite types and their reservoir characteristics are poorly known.

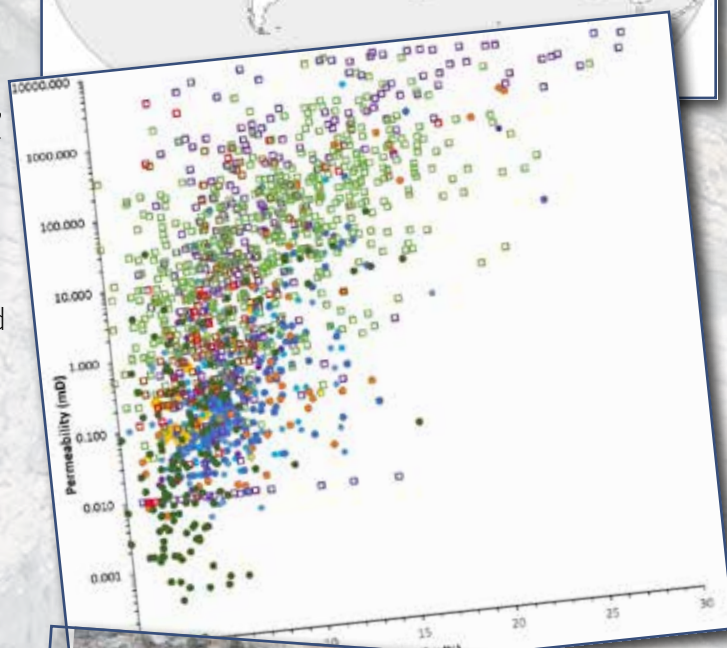
Many dolomite bodies often form the reservoir itself, such as the Vernon or Crystal fields (USA) and recent discoveries have been made in underexplored areas such as onshore SE Mexico. Understanding the occurrence of these dolomite bodies is also important for reservoir management as they often form sweet-spots associated with porosity and permeability enhancement as a result of fracturing and/or dissolution.

In this report, based on a selection of case studies, we discuss the key characteristics of fracture-related dolomite reservoirs and summarise the parameters controlling the development of fracture-related dolomite reservoirs. The emphasis lies on:

- Their **reservoir characteristics**, including porosity-permeability ranges, dimensions of the dolomite bodies, reserves and production rates
- **Tectonic setting** and **host rock** in which these dolomite bodies form
- The geological “**recipe**” for the formation of these dolomites

For additional information please contact Julie Dewit: [julie@cambridgecarbonates.co.uk](mailto:julie@cambridgecarbonates.co.uk)

Overview of case studies discussed in the report



# Tectonically Fractured Carbonate Reservoirs

## - A Synthesis of Analogues

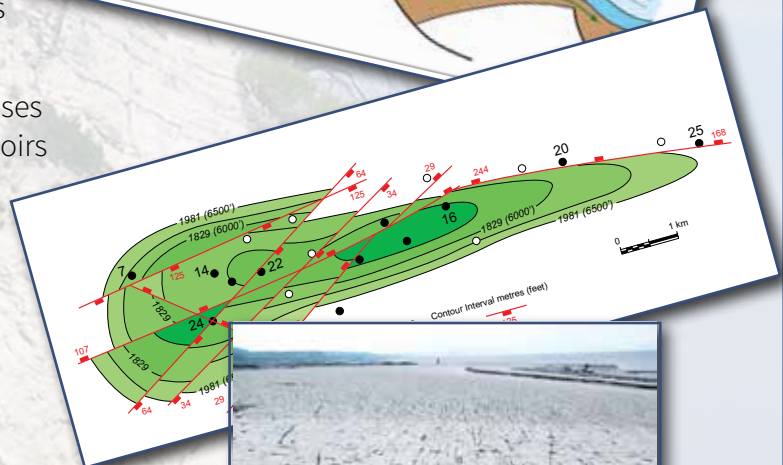
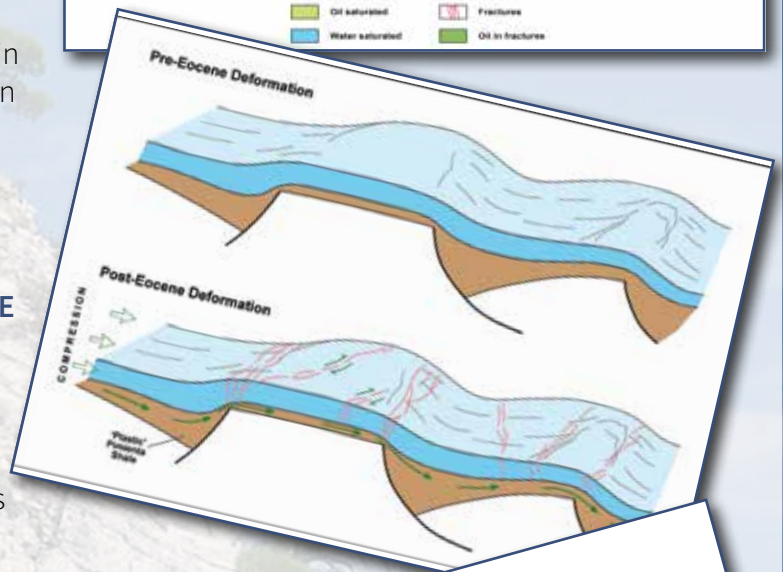
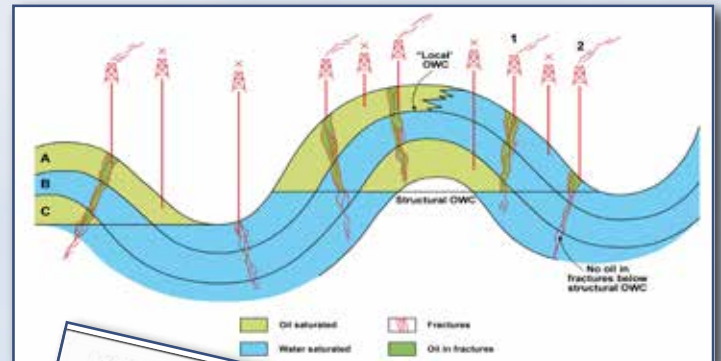
A comprehensive multiclient report providing detailed analogues and case histories of **tectonically fractured carbonate reservoirs**.

The report provides an overview of fractured carbonate fields which are successfully producing at sustainable economic rates. Approximately 50% of all carbonate-reservoired oil and gas fields worldwide are naturally fractured. This number is high compared to their siliciclastic counterparts. It is therefore important to not only be able to predict fractures in carbonates, but also to understand their impact on production.

The report highlights three principal areas of economically sustainable fractured carbonate production: the **Zagros fold-and-thrust belt** of Arabia, and basal reservoirs of **NE Mexico** and **SE Mexico**. It also gives useful insights into fractured carbonate reservoirs from fields in the Adriatic area, USA and SE Asia. The report includes details of reservoir geology (facies and matrix porosity, fractures and permeability) and production trends and pitfalls.

A **detailed database** is also available, and comprises more than 70 naturally fractured carbonate reservoirs from around the World. Reservoir properties have been analysed, with data such as porosity, depth, permeability, oil gravity, recovery factor, STOOIP being plotted, and trends discussed.

This multiclient report is presented in pdf format, with an associated excel database of reservoir properties.



For further information contact: Jo Garland  
Email: [jogarland@cambridgecarbonates.co.uk](mailto:jogarland@cambridgecarbonates.co.uk)

## Southeast Asian carbonate systems and reservoir development: an up-to-date synthesis

This is a revised version of our comprehensive multiclient report reviewing the **existing and future hydrocarbon potential in Cenozoic carbonate systems of SE Asia**. The report presents an up to date appraisal of the sedimentological and sequence stratigraphy of Cenozoic carbonate reservoirs in light of recent research in SE Asia and on evolving concepts of carbonate sedimentology in general.

The report includes a review of Cenozoic carbonate systems, high resolution sequence stratigraphy, diagenesis of Cenozoic carbonates, origin and prediction of sub-surface CO<sub>2</sub>, distinguishing volcanic structures from carbonate build-ups, and trends in reservoir porosity and permeability.

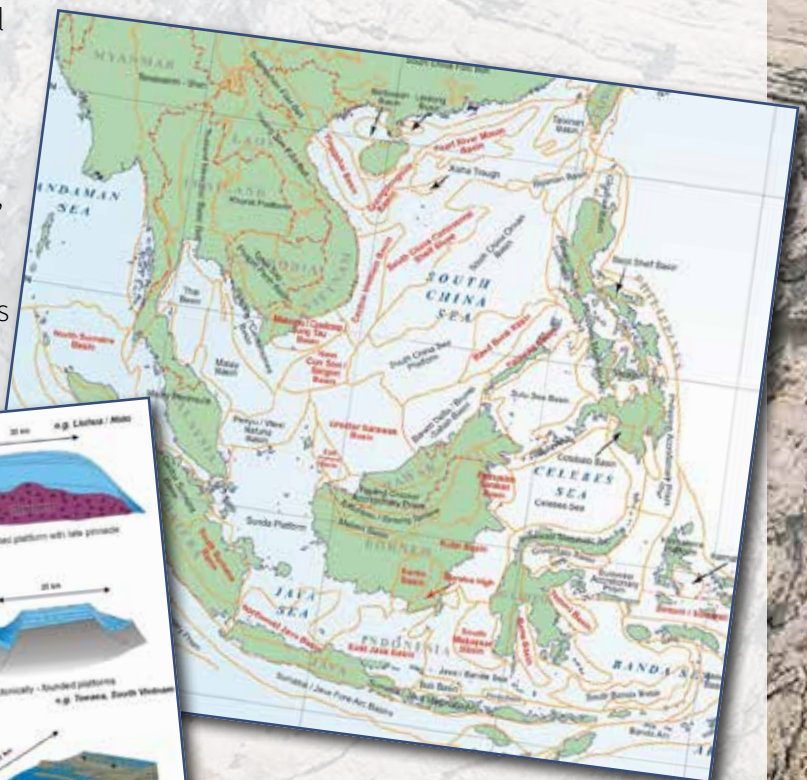
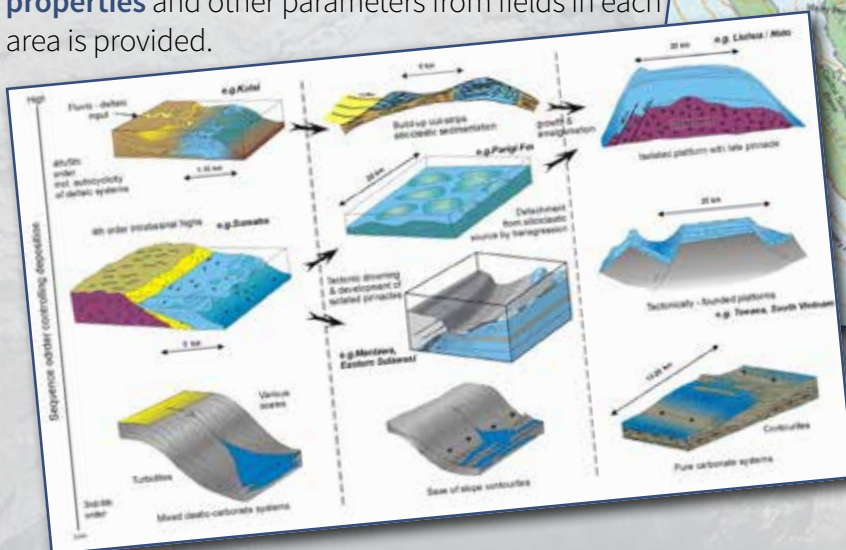
The **detailed basin reviews** are the main focus of the report. For each basin the report discusses the Cenozoic carbonate reservoirs, including the main **controls on reservoir quality** with the depositional facies, sequence stratigraphic context, diagenesis, porosity permeability properties and seismic expression being illustrated.

The future potential of the basins are also discussed, including any additional plays, the key uncertainties and any new concepts or methodologies that may lead to making further discoveries or adding reserves to existing fields. And finally a **dataset of reservoir properties** and other parameters from fields in each area is provided.

The areas of interest are:

- **North and South Sumatra** and adjacent offshore areas.
- **Java** and adjacent offshore areas; including a separate chapter on the new finds in Pliocene carbonate contourites.
- Offshore south and east **Vietnam** and the **South China Sea**.
- Offshore **Sarawak, Philippines** and **Natuna Seas**.
- **East Kalimantan, Sulawesi** and adjacent offshore areas.
- **West Papua** and **Papua New Guinea**.

New for the updated version is an associated GIS project. The **GIS project** contains **georeferenced map figures** and also a geodatabase of reservoir parameters.



Further information: Jo Garland  
E: [jogarland@cambridgecarbonates.co.uk](mailto:jogarland@cambridgecarbonates.co.uk)

This report can be purchased as a whole or by individual chapter, module or basin.

# Review and Insights into Carbonate Plays of the Circum-Adriatic

A comprehensive multiclient report evaluating the **existing** and **future hydrocarbon potential** of carbonate systems of the **circum-Adriatic region**, one of the most important geological provinces of the Mediterranean for the production and storage of hydrocarbons.

The report presents an up-to-date review and provides valuable insights into seven key carbonate plays of the circum-Adriatic area, with a strong focus on exploration-related issues. Emphasis is placed on the **main carbonate reservoirs** and their potential on a regional basis, so as to provide a **framework for exploration**. This comprehensive report is organised into two volumes, and an additional GIS shapefile project.

## Volume 1 (268 pages)

- An introduction to the geology of the circum-Adriatic (plate evolution and palaeogeographic evolution within a regional context).
- **Petroleum systems** of each country, with source rocks and migration, **carbonate reservoirs** and **plays, seals** and **traps** all discussed.
- A discussion on the future potential of that country, including underexplored plays.
- **Worldwide analogues** of the **key reservoir types** in the Circum-Adriatic, including comprehensive sections on analogues for **resedimented slope carbonates, karstified carbonates, fractured carbonate reservoirs, carbonate alluvial fans** and **Paleogene bank carbonates**.

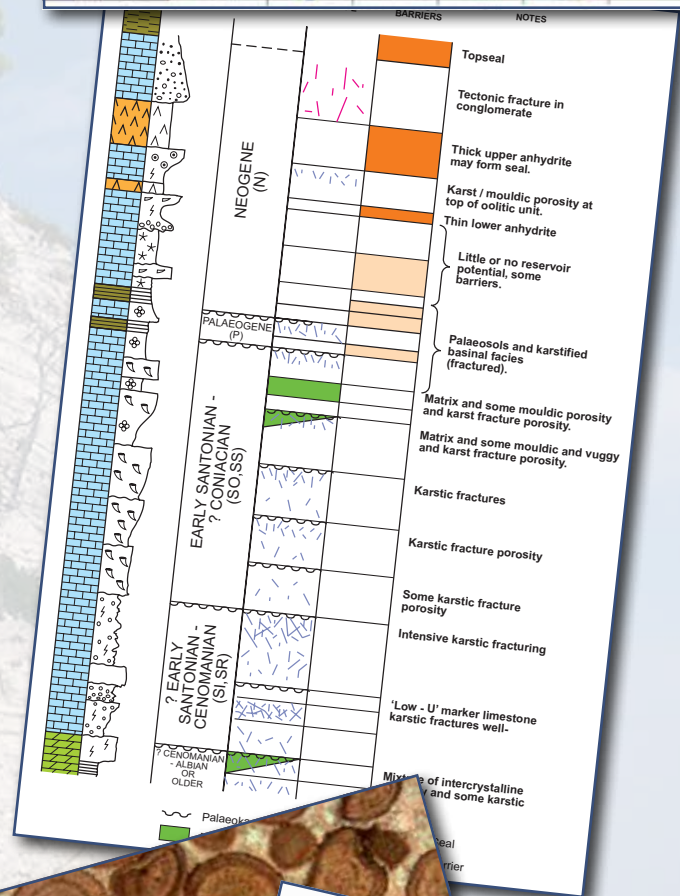
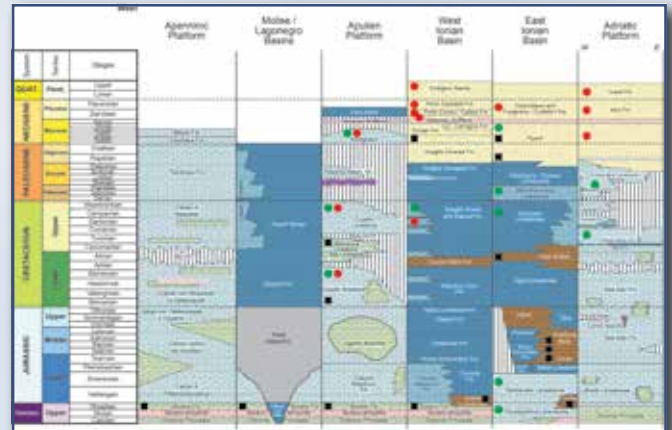
## Volume 2 (111 pages)

- A **microfacies atlas**: 420 thin-section photomicrographs, highlighting the range of microfacies exhibited on the shallow-water Apulian and Gavrovo platforms, and also from the deeper pelagic basins (from outcrop and subsurface locations in Greece and Italy).

## GIS Project

- **GIS Shapefiles** for selected figures/maps

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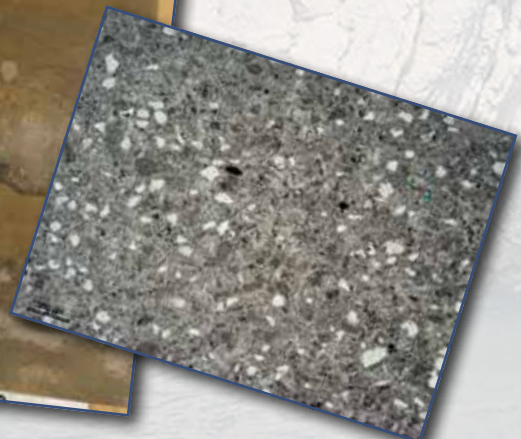


## Sedimentological study of karsted late Palaeozoic sediments; Wells 7120/2-1, 7120/1-3 and 7220/11-3 Loppa High, Barents Sea

These reports present detailed sedimentological descriptions of **karsted late Palaeozoic carbonate** and **spiculitic facies** of the Falk, Ørn and Røye Formations based on core from the released Loppa High wells **7120/2-1**, **7120/1-3** and **7220/11-3**. They are presented as 1 : 50 scale core logs in CoreCAD and supported by microfacies and diagenetic information from thin sections. The main topics addressed are:

- The sedimentological and sequence stratigraphic interpretation of the Falk Formation with the implications for reservoir layering.
- Recognition of cave floor, fill and collapse breccia facies and the implications for reservoir properties, layering and **architecture of karst systems**.
- **Contrasting expression of karst** in Ørn and Røye Formations.
- Diagenesis of carbonate and siliceous facies in karst systems.
- Depositional environments and microfacies of conglomeratic carbonates.

Lithology	Carbonate Texture						Dominant cement mineralogy	Porosity Comment	
	Mudstone	Wackestone	Floestone	Packstone	Grainstone	Rudstone	Boundstone		Diagenetic Features
								Poor	Actinular vugs and biomoulds
								Moderate	
								Good	Inter-crystal and bio-moulds
								Very Good	
									Inter-crystal and inter-granular
									Fractures infilled by



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## Northern Iraq Report

A report on the petroleum geology of **Northern Iraq**. Interpretation based upon twenty eight years experience in the area and published work.

### **The prospectivity of Northern Iraq is significant.**

It sits on the margin of two known hydrocarbon provinces, firstly the Mesopotamian basin with its major Jurassic source rocks and Cretaceous to Oligo-Miocene reservoirs in Late Tertiary anticlinal traps to the SE (Kirkuk-Makhul-Hamrin area) and secondly, the 'NW Iraq/NE Syria' hydrocarbon province with likely Triassic source rocks and Triassic-Middle/Late Cretaceous reservoirs in inverted half-grabens to the north.

The Khleisia High is largely unexplored, but possesses many strong geological similarities with the Euphrates Graben system of Syria, in which Silurian, Triassic and Late Cretaceous source rocks charge tilted fault-block traps in which reservoirs, consisting of a variety of lithologies, range in age from Carboniferous to Neogene.

The report provides an **overview of the regional geology** that is useful for explorationists.

Additionally it comprehensively presents publicly available, although often obscure, data and discoveries for the purposes of **field evaluation**.

It includes **88 maps** as **facies polygons** and point data are available as a GIS project.



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# Palaeogeographic Maps of Iraq

A **palaeogeographic database for Iraq**, consisting of maps from the Precambrian to Recent, based on the sequence stratigraphic framework of Sharland et al. (2001). It includes **92 sequences** that are defined, with a map for each **highstand, transgressive, lowstand** and **maximum flood systems tracts**.

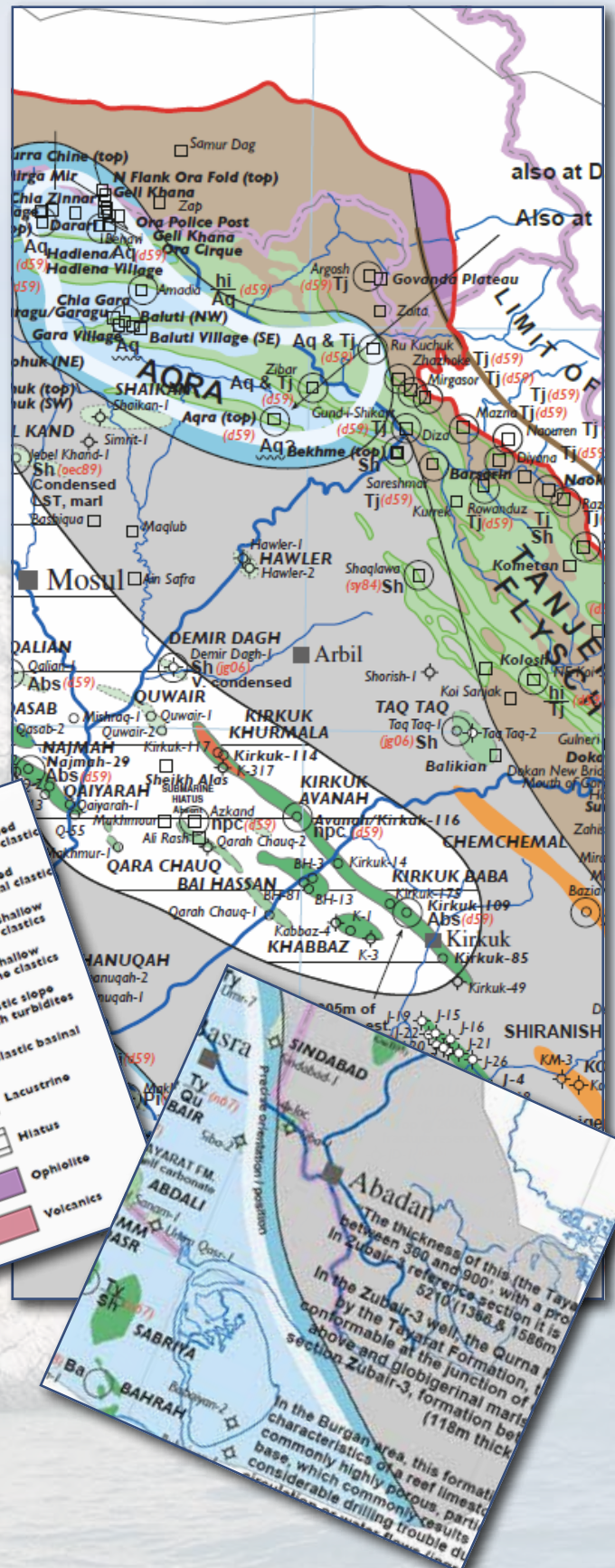
Cambridge Carbonates' palaeogeographic maps covering Northern Arabia have been developed progressively over the last 25 years.

The maps have been constructed using data derived and collated from publicly available sources. They are available either as the **full set** (372 maps) or as **'best of'** subset (100 maps) with a correspondingly reduced price.

Facies polygons are available as a GIS database that has been developed in ArcGIS10.

Contains:

- Tectonic elements
- Facies polygons for ArcGIS



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Slumped pelagic carbonates Gargano, Italy

