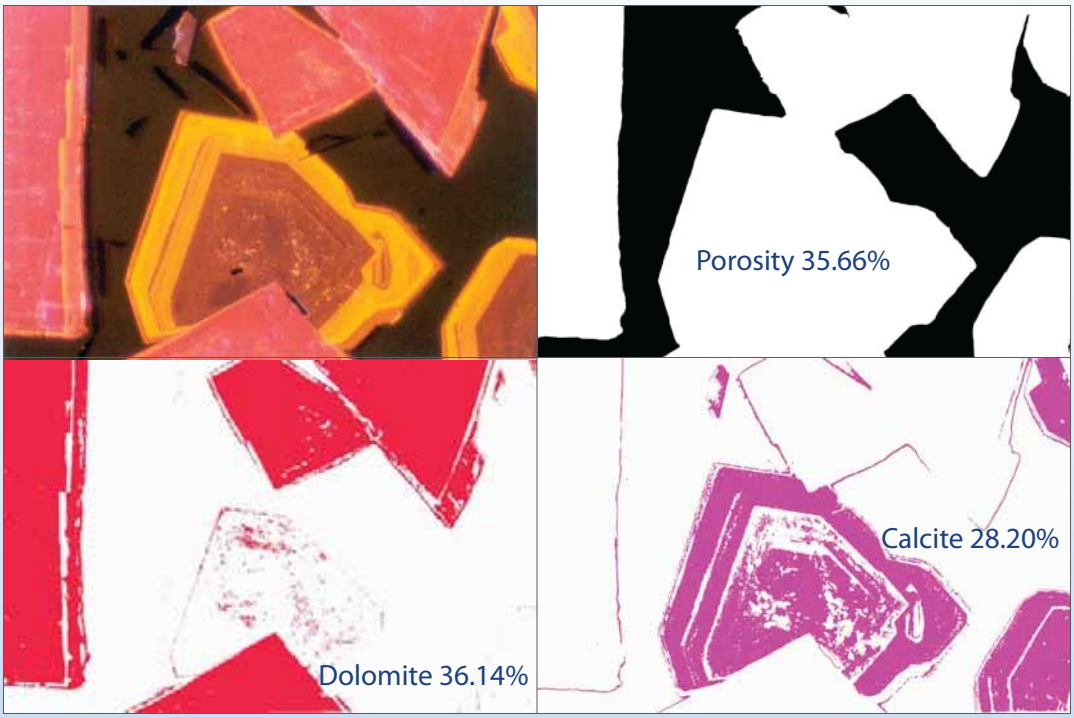
Descriptive and quantitative petrography

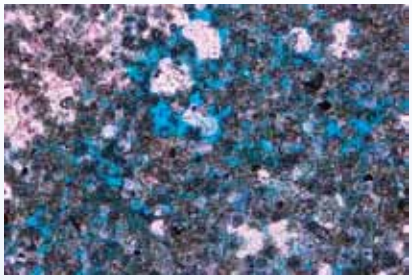


Cambridge Carbonates Ltd

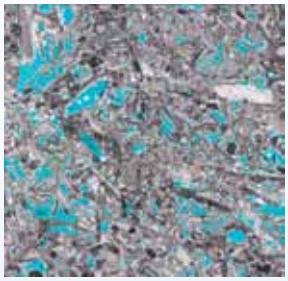
Expertise in carbonate and evaporite systems

Digital Imaging

We work with high resolution digital images of samples at obtained various scales ranging from SEM, thin sections at different magnifications, whole thin section scans and from photographs of core and outcrop. Many of the techniques described below can also be used to 'recover' old data by scanning photographs from reports.

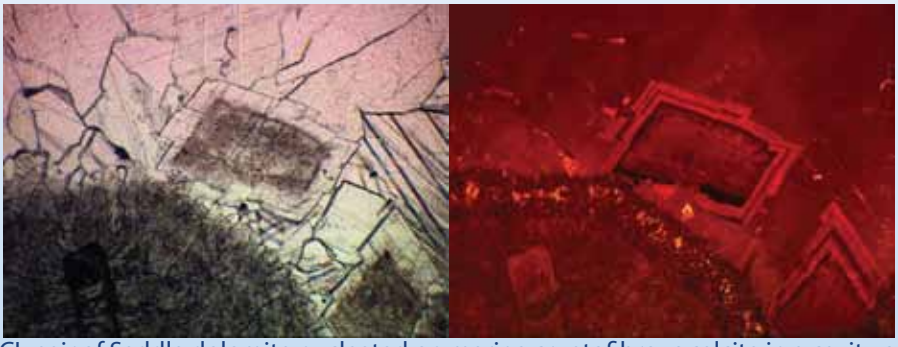


Dolomitised peloid grainsone with anhydrite cement, Eocene, Kuwait, field of view 5mm

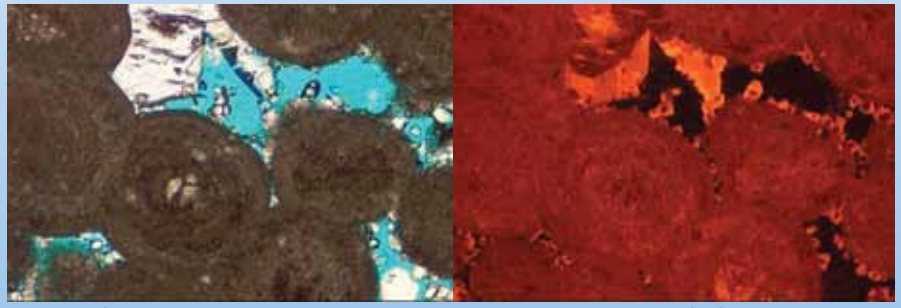


Thin section scan: Cretaceous North Africa. Field of view 2cm

Pairs of high resolution cathodoluminescence (CL) and ppl images are acquired digitally. This allows us to enhance images of samples with very low level, or transient luminescence that cannot otherwise be captured by standard photography.



Ppl/CL pair of Saddle dolomite nucleated on marine cryptofibrous calcite in a cavity of a carbonate mud mound; mid Permian, Barents Shelf, Norway. FoV 1.25mm



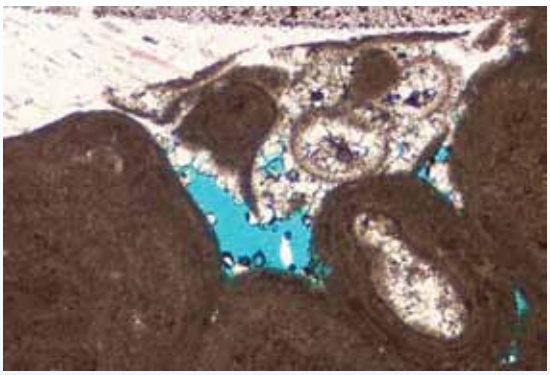
Ppl/CL pair of ooid grainstone with zoned calcite spar, Jurassic Gulf of Mexico. FoV 1.25mm

Descriptive Petrography

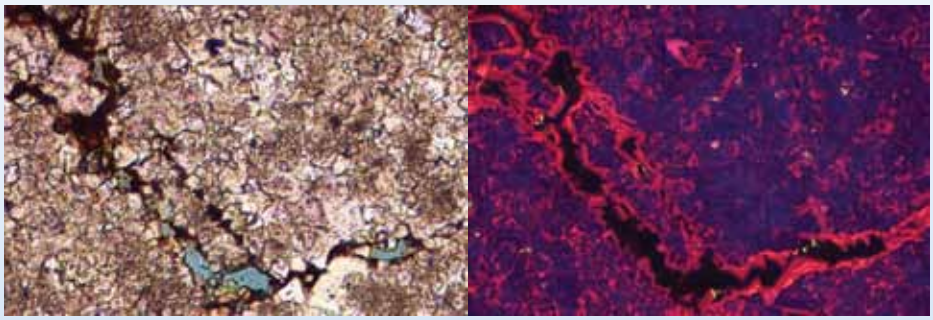
Microfacies, diagenesis and porosity description

For each sample description we provide:

- Dunham classification.
- Depositional textures, bioclasts, non-skeletal allochems, intraclasts and terrigenous grains.
- Sedimentary structures and other key environmental indicators.
- Diagenetic sequence of cementation, compaction, dissolution, fracturing, stylolites, etc. dolomitised described and interpreted.
- Pore system and key diagenetic events affecting porosity and permeability.



Ooid bioclats grainstone, Gulf of Mexico. FoV 5mm



Fractures in dolomite lined by zoned dolomite cement. Italy.

Cathodoluminescence (CL)

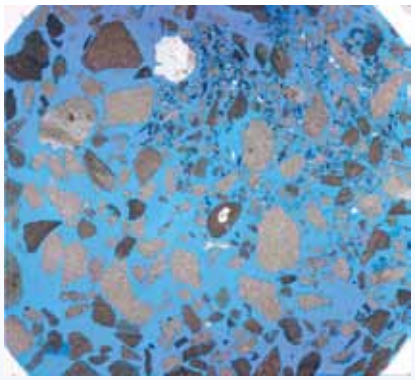
CL is an essential tool in understanding porosity in carbonates because it establishes the sequence of cementation, dissolution, fracturing and compaction that enhance or reduce porosity. Establishing a firm diagenetic sequence provides a framework for fluid inclusion or isotopic sampling. CL maps of a thin section can also be produced by tiling individual CL images to guide isotopic, laser probe and fluid inclusion sampling. Our CL-based description of diagenesis includes:

- Morphology and CL character all carbonate and non-carbonate cements.
- Determination of cement stratigraphy to show the sequence of cementation.
- Description of pore system as it evolved through burial.
- Integration of compaction, dolomitisation, dissolution, fracturing, fracture-infills and stylolites into the cement stratigraphy.
- Timing of key diagenetic events that affect porosity and permeability.

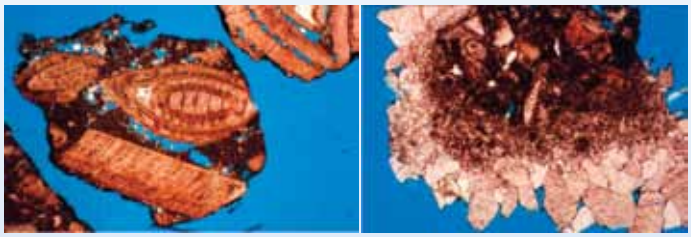
Semi-quantitative Petrography

Microfacies analysis of cuttings

Much information about depositional environments, sequence stratigraphy and porosity can be obtained by the systematic examination of cuttings in thin section. The abundance of microfacies is recorded in each thin section through the carbonate interval. Matrix and macropore indicators are also noted. The vertical distribution of microfacies types, first down-hole occurrences and caved microfacies can now be recognised. Used with biostratigraphy and logs, this analysis allows a detailed interpretation of the high resolution sequence stratigraphy of carbonate successions.



Scanned cutting thin section, Cretaceous. South Africa



Nummulitic carbonates with porosity; euhedral cement (right) indicates open pore Eocene, Libya. FoV 5mm

Combined petrophysical and microfacies analysis of cuttings

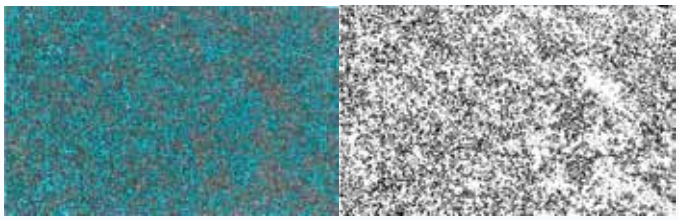
Microfacies analysis of cuttings can be integrated with log data. Electrofacies are identified by cluster analysis and are then matched with the cuttings microfacies. The succession can be re-assembled with different microfacies types tied to specific log responses that enables a well-constrained interpretation of the high resolution sequence stratigraphy to be undertaken.

Point counting

Point counting measures the abundance of grain types, cements and other components from thin sections. It may not be suitable for fragmented samples such as cuttings or SWCs but is ideal for thin sections prepared from core plugs and chips. 300 points per sample are counted and components are recalculated as a percentage. For quantitative porosity characterisation we recommend using image analysis described below.

Quantitative Petrography by Image Analysis

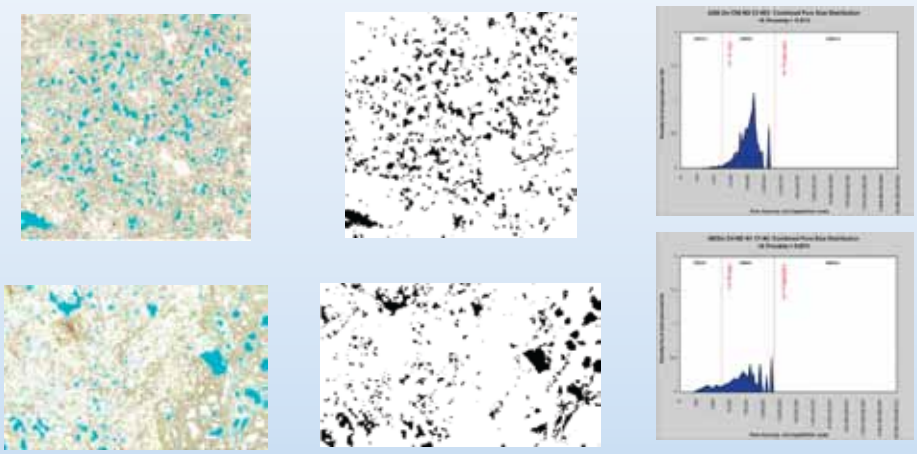
Permeability in a carbonate reservoir is controlled by the pore size distribution and the amount of porosity. Producing pore size distributions from petrographic data allows us to rank samples in terms of reservoir quality.



Scanned thin section (left) and pore mask (right) recent oolitic carbonates, Cancun. FoV 3cm

• Pore size distributions can be obtained at various scales by analysis of digital images such as back-scatter SEM, scanned thin sections, images of core (slabbed and 360°) and outcrop images. Images in old reports can also be used.

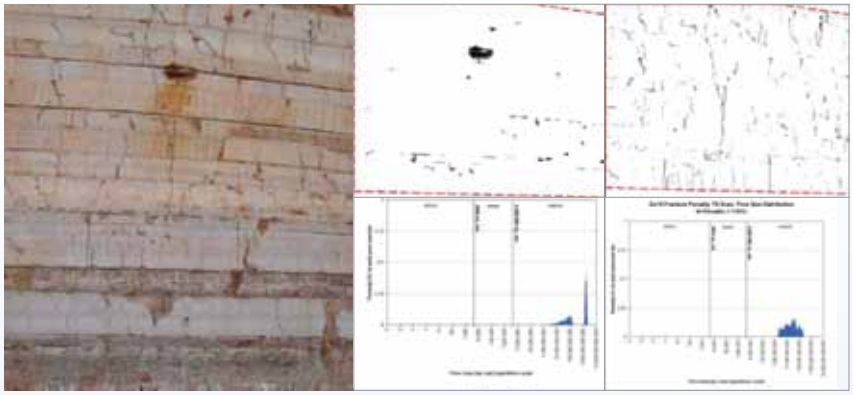
• From each image a digital pore mask is produced from which measurements of abundance of pore types, total porosity and shape data are carried out.



Jurassic dolomite (top) and Upper Cretaceous dolomite collapse breccia, both from Mexico. Left: scanned thin section, Middle: pore map, Right: Pore size distribution

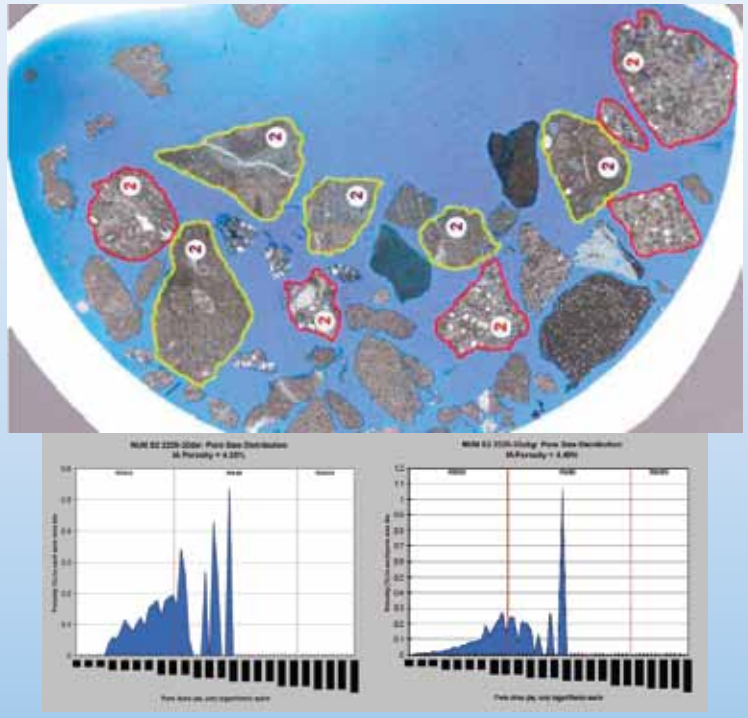
• The shape of pores can also be analysed by image analysis. This allows the relative amounts of fracture and vuggy pores in a reservoir to be quantified giving an idea of the storage and flow capacities of a reservoir.
• Image analysis can quantify the amount of microporosity so that petrophysical calculations of moveable oil and water saturation can be constrained.

Macropore systems can be characterised from images of core or outcrop analogues.



Pre-Miocene karst macropore system in Cretaceous platform carbonates, italy. Left, quarry face, middle 0.84% vuggy porosity: right fractures enlarged by dissolution 1.63% porosity

Image analysis is used to characterise the macropore system from 360° core images.



Pore size distributions from cuttings: Left, dolowackestone (yellow), right ooid grainstone (red), Cretaceous southern Aftrica

Image analysis can also obtain pore size distributions from non-conventional samples such as cuttings samples. Image analysis may also be used in quantitative diagenetic studies to determine the abundance of cement types in cathodoluminescence images.

Pre-Cambrian dolomite, Arabian plate

Prices

Please contact us for a quotation as we often use these services in conjunction with other interpretation work and we prefer to quote for the whole project.

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Expertise in carbonate and evaporite systems

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We recommend that we arrange thin section preparation and image scanning ourselves because we require images of specific quality standards. We can advise clients on thin section preparation and on scanning other images. Additional work required to bring thin sections or other images provided by the client will be charged.
Thin section preparation, courier, drafting and report preparation will be charged in addition to the unit analytical cost. Depending on the specific scope of the study, there will be an additional day rate charge to cover integration and interpretation of data.