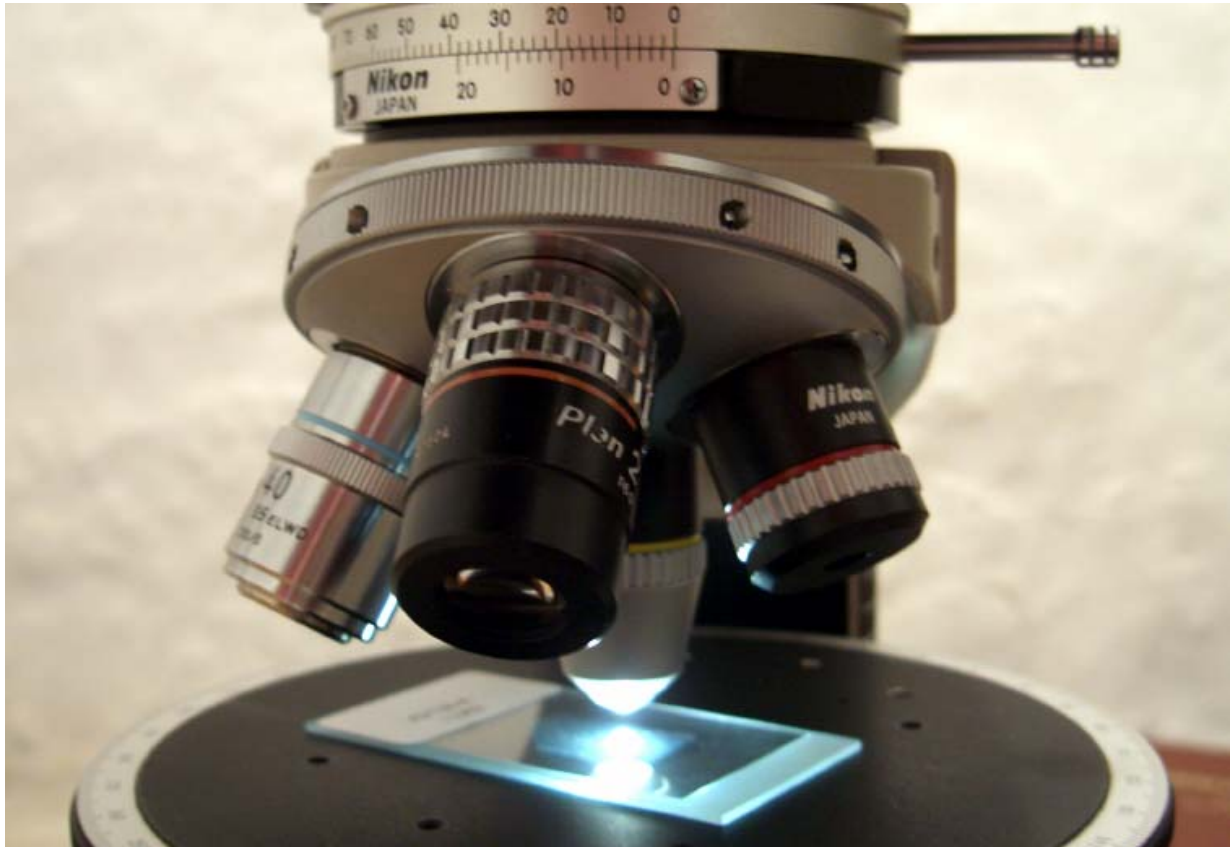


Sedimentological Services



& Training Courses

Blackbourn Geoconsulting

**Sedimentological consultancy & analytical
services for the hydrocarbon industry**

Carriden House, Carriden, West Lothian, EH51 9SN, UK

Tel: +44 (0)1506 826777, Fax: +44 (0)1506 826888

www.blackbourn.co.uk, info@blackbourn.co.uk

Sedimentological Services

Blackbourn Geoconsulting, established in 1989, has a team of experienced staff offering a high-quality geological consultancy and analytical service to the hydrocarbon industry.

In addition to general consultancy, the company undertakes core logging and field work, and has excellent facilities “in-house” for optical petrography and photomicroscopy, computing and drafting, and the production of high-quality reports. Other analyses, such as SEM, XRD, XRF and isotope studies can be arranged, with full quality control.

Major services provided are:

- General **sedimentological consultancy** and advice.
- High-quality **optical petrography** (including image analysis) and SEM examination.
- Detailed **core logging**, to client's specification. Final logs may be either hand-drawn or computer-generated using standard software graphics packages or by arrangement, the clients' preferred proprietary system.
- **Facies analysis** and regional sedimentological interpretations.
- Other analyses (e.g. **XRD (whole rock and clay fraction)**, cathodoluminescence, heavy mineral analysis, isotope analysis) are usually subcontracted, but with full monitoring, quality control and interpretation of results by Blackbourn Geoconsulting.
- Multidisciplinary studies: Blackbourn Geoconsulting maintains professional contracts with consultants working in various disciplines, including **biostratigraphy**, **geochemistry**, **structural geology** and **geophysics**. A team of consultants may be brought together to serve precisely the needs of any particular project. Members of the team may be nominated by Blackbourn Geoconsulting, or chosen by the client.
- **Sedimentological courses**, including **fieldtrips**, either in the UK or abroad.

For further details of the services we provide, please contact Dr Graham Blackbourn. We would be very pleased to discuss work requirements with potential clients, without obligation, and to tender for projects.

Dr Graham Blackbourn

graham@blackbourn.co.uk

Blackbourn Geoconsulting

Carriden House, Carriden, West Lothian, EH51 9SN, UK

Tel: +44 (0)1506 826777, Fax: +44 (0)1506 826888

www.blackbourn.co.uk, info@blackbourn.co.uk

Outline of Available Services and Facilities

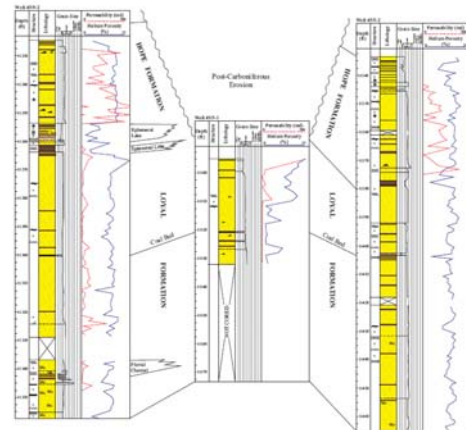
Consultancy

Highly qualified and experienced staff are available on a daily or hourly basis.

Core Logging

We have considerable experience in producing detailed sedimentological logs specific to the requirements of the client. Depending on the specifications of the client, logs are usually provided at 1:20 or 1:50. Logs at larger scales or smaller “quick look” scales can be provided as required. The cores can be presented either as:

- Hand-drawn logs
- Computer-drawn logs incorporating scanned core images and other data
- Computer-generated logs using the client's graphics software packages



Core log correlation

In addition to the standard representation of lithology, grain size and sedimentary structure, details on the logs are tailored to the needs of the client; and can include core images, porosity, permeability, descriptions, sample depths etc.

Optical Petrography



In-house optical petrography

- **Thin section preparation** from rock chips, plugs or selected cuttings (including picking of cuttings for sectioning, if required), including impregnation with dyed resin and staining for carbonate and feldspar. Preparation of polished thin sections.
- **Full thin section description** including texture, mineralogy, diagenesis and inferred reservoir characteristics. Modal analysis of detrital grains, authigenic phases and porosity by point counting. Representative photomicrography. Details of thin section descriptions are geared to suit the client's needs.
- Brief scans and **outline descriptions** of thin sections without modal analysis can be provided as an infill between samples described in greater detail, or for rapid lithological identification.

- **Long-axis measurement** of 100 framework grains to determine mean grain size and sorting parameters.
- **Image analyses** of thin sections. By linking microscope to PC via a frame-grabber, more complex calculations on grain size, grain orientation, grain separation etc. can be undertaken, including photographic quality reproduction of images analysed.

Other Analyses

- **SEM examination** including EDS analysis and photomicrography.
- **XRD analysis:** whole rock and clay fraction, including preparation.
- **Heavy mineral analysis:** point count of minerals separated by disaggregation, sieving and heavy liquid floatation. Included decalcification if required.
- **Sieve analysis** of poorly- or un-consolidated sand or silt. Includes sorting through six or more screens, weighing and plot of results, and stereomicroscopic examination of different size fractions.
- **Stereomicroscopic description** of rock chips or washed cuttings.



SEM facility at the University of Edinburgh

Photography

High-quality photographs of core chips, field samples and cores up to 45cm long can be taken using in-house facilities. Longer core lengths can be photographed by hand-held camera, or can be sub-contracted for quality full-format photography if required.

“Hot Shots”

Rapid “hot-shot” turnaround is normally available of most services. Hot-shot costs are subject to 100% uplift, but these may be reduced or waived where the analysis forms part of a large project and advance notification of their requirement has been given.

Provision of Reports

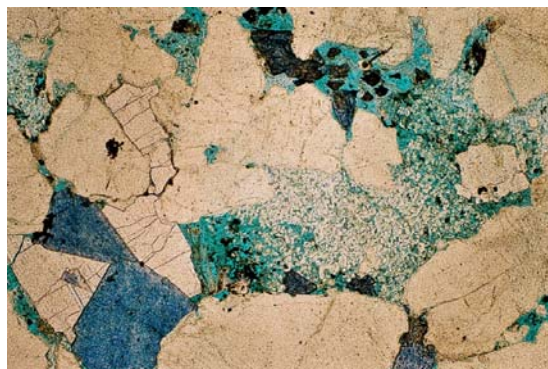
Up to **5 copies** of data or reports will be provided at no extra cost.

“In-House” Facilities and Sub-Contracting

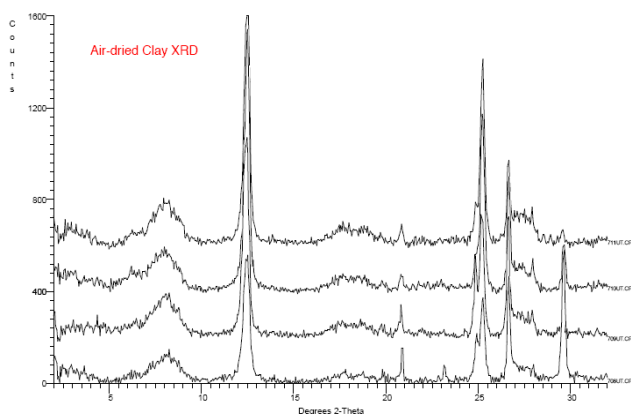
All interpretive work and the majority of the analytical work detailed above are undertaken by Blackbourn Geoconsulting personnel using in-house facilities.

These include facilities for **optical petrographic microscopy**; stereomicroscopy; computerised data handling; macrophotography; and grain size analysis by sieving. A workshop is available for sample preparation.

In common with all other sedimentological consultancies, a proportion of preparatory and analytical work is undertaken externally. Operations requiring major capital equipment, certain specialised skills or hazardous preparation techniques fall in the category.



Photomicrograph of a sandstone sample (ppl)



Clay fraction XRD results

The following aspects are, at present, sub-contracted:

- XRD analysis
- Thin section preparation
- Heavy mineral analysis

SEM analysis is undertaken by Blackbourn Geoconsulting on a rented machine.

It is emphasised that **all interpretation is undertaken by Blackbourn Geoconsulting.**

In order to maintain the highest standards of quality and competitive pricing, the sub-contractors used vary from time to time. However, those used for any work will be made known to the client, who is welcome to nominate an alternative (subject to reasonable cost adjustment if appropriate).

Other specialised techniques can be provided on a sub-contracted basis if requested by the client. Initial interpretation may be undertaken by the sub-contractor. Although Blackbourn Geoconsulting will take reasonable steps to ensure that such work is of the highest quality, the responsibility for the accuracy of these analyses and interpretation rests with the relevant sub-contractor.

Examples of such analyses include:

- Stable isotope analyses
- Fluid inclusion studies
- Radiometric dating of rocks and minerals
- Cathodoluminescence
- Conventional core analyses and SCAL analyses
- Geochemical analyses

Training Courses

Courses are provided on various aspects of **clastic sedimentology**, **facies analysis**, **core logging**, and **clastic diagenesis**. Courses are tailored to the client's specific requirements, and can be held either in the client's offices, at Blackbourn Geoconsulting's offices, or elsewhere.

The set of course outlines provided here should be regarded as a "menu", and each may either be taken in its entirety, or used as the basis to design an appropriate course by picking and mixing the required elements and, if necessary, suggesting new areas of interest from the field of applied clastic sedimentology.

Courses available:

- Cores and Core Logging in the Exploration and Development of Hydrocarbons
- Diagenesis and Porosity Evolution in Clastic Hydrocarbon Reservoirs
- Subsurface Facies Analysis of Clastic Sequences from Cores & Geophysical Data
- Reservoir Geometry of Clastic Depositional Systems; Diagnosis, Prediction and Modelling
- Exploration for Sandstone Reservoirs: Depositional Systems & Basin Analysis
- Sedimentology of Selected Depositional Environments

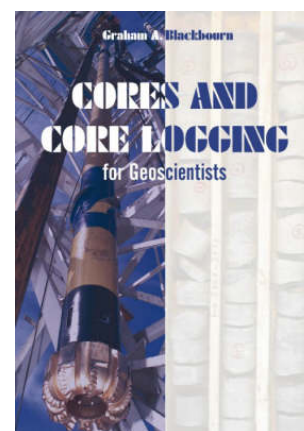
Cores and Core Logging in the Exploration and Development of Hydrocarbons

(3 days)

The aim of this course is to equip petroleum geologists, sedimentologists, petrophysicists and others with the knowledge to enhance significantly the benefit they can obtain from the study of cores. It will also be of value to those who handle and use cores and core logs, ranging from wellsite geologists and core laboratory personnel to the project supervisor.

Procedures for logging core, and the principles of interpreting it, are dealt with in detail, and include numerous practical exercises. Logging for structural and engineering investigations, in addition to sedimentological studies, will be considered. The importance of providing a clear and objective record is stressed, while recognising that the logger is also usually best placed to interpret the core, and that the interpretation forms an important aspect of most logs.

The relationship between the two- and three- dimensional facies models documented in most sedimentology textbooks, with the essentially one-dimensional sequence information provided by cores, is investigated. Throughout the course, emphasis will be laid on those features of a core most vital to the exploration for and development of hydrocarbon reservoirs.



Course participants receive a copy of Dr Blackbourn's book "Cores and Core Logging for Geoscientists"

Diagenesis and Porosity Evolution in Clastic Hydrocarbon Reservoirs

(5 days)

The course is suitable for experienced exploration personnel who need to predict variations in reservoir quality within successions of similar depositional facies, or to pinpoint good-quality reservoirs within generally unpromising facies. It is also of value to development geologists working on fields which have a diagenetic control on reservoir quality, as well as to sedimentologists who need to keep abreast of recent developments in applied diagenesis.

The course is largely lecture-based, and is illustrated with numerous case studies. There are some exercises, and where facilities permit a practical microscopy session, viewing thin sections, is included. Topics which are covered in this course include:

- The chemistry of clastic diagenesis
- Origins of pore fluids and their dissolved fluids.
- Organic-inorganic reactions.
- Effects of depositional environment and sediment provenance on subsequent diagenesis.
- Heat and fluid flow in the subsurface.
- The effect of faults and fractures on fluid flow and diagenesis.
- The influence of diagenetic textures on porosity and pore morphology.
- Relationships between pore morphology, permeability and other reservoir parameters; the use of image analysis techniques.
- The diagenetic trap.
- Diagenetic basin modelling.

Subsurface Facies Analysis of Clastic Sequences from Cores & Geophysical Data

(5 or 10 days)

The course outlines the main sources of data from both wells and seismic, and examines the types of inference which can be made on the basis of these data. The course is intended for relatively inexperienced exploration and production geologists who need to have a good overview of the potential and the limitations of different techniques. The course includes a significant element of practical work to allow participants to develop a feel for particular methods and to discuss them. The possibilities for examining cores as part of the course would depend on the availability of suitable material at or close to the course location. The following topics are dealt with:

- Principles of facies analysis, with particular reference to sequences seen in cores.
- The limitations and advantages of cores in comparison with outcrop.
- The design of appropriate facies schemes for particular problems.
- The potential and the limitations of vertical sequence analysis in different environmental settings.
- The calibration of cores to wireline logs.
- Basic interpretation of wireline logs for lithology.
- Wireline log patterns and motifs.
- Dipmeter records in sedimentary interpretation.
- The use and limitations of cuttings, sidewall cores and drilling records.

- Well-to-well correlation techniques: marker horizons; log signatures; integration of seismic; sedimentary sequence analysis.
- Correlation potential in different sedimentary settings.
- The broader geological framework as a constraint on depositional setting; tectonic setting; palaeogeography; base-level fluctuations and seismic sequences.

Reservoir Geometry of Clastic Depositional Systems; Diagnosis, Prediction and Modelling

(5 days)

The course emphasises the depositional geometries of sand bodies in settings where they are likely to have reservoir potential. Consideration of the general principles of facies analysis and reservoir modelling is followed by treatment of different environmental settings. For each major setting the course reviews:

- Definitions of “reservoir”.
- The main processes and environmental controls operating in present-day settings.
- Methods and criteria for characterising the setting from well and other data.
- The potential for predicting sandbody geometry, size and orientation.
- Approaches to quantitative modelling of reservoir continuity, emphasising determinative and stochastic approaches.
- Internal reservoir heterogeneities.
- Possible diagenetic modification of primary depositional variability.

The following environmental settings are normally covered, although this list can be tailored to particular needs:

- Fluvial and alluvial settings
- Deltas
- Shallow-marine and coastal environments
- Submarine slopes and deep-water sandstones
- Aeolian dunes and related settings
- Glacial settings

The course is intended for general and production geologists, and for reservoir engineers with a few years' experience who wish to update their sedimentological background knowledge in order to design optimum development strategies. The course can become a focus for stimulating more fruitful interaction between geologists and reservoir engineers.

The course is mainly lecture-based, drawing on a wide range of modern and ancient examples, including reservoir case studies. Some short exercises can be included.

Exploration for Sandstone Reservoirs: Depositional Systems & Basin Analysis

(5 days)

The depositional setting of potential reservoir sandstones is determined by the nature of the depositional environment, its relationship with the tectonic and palaeogeographic setting and with patterns of sea level fluctuation. This course discusses the major environments of sand deposition and the ways in which local tectonics and base level changes may enhance the reservoir potential in each case. The possibilities for stratigraphic and combination traps in the various environments and tectonic settings are emphasised. The facies relationships within each major environment are outlined as a guide to predicting likely reservoir characteristics and connectivity and hence to making risked estimates of potential reserves. The major environments considered include:

- Fluvial and alluvial settings
- Deltas
- Shallow marine and coastal environments
- Submarine slopes and deep-water sands
- Aeolian dunes and related settings
- Glacial settings

Deposition in basins of contrasting tectonic style is discussed, and relevant aspects of sequence stratigraphy and systems tracts are explored.

The course is intended for exploration geologists of some years' experience who wish to upgrade their exploration success in areas where more subtle trapping styles may be expected. The course is largely lecture-based but includes some exercises. Courses can be designed to focus particularly on those environments and settings that are perceived as being important in the area where the course is being held.

Sedimentology of Selected Depositional Environments

(Variable duration depending on topics)

Courses can be designed to suit particular regional or company requirements. They may focus on a particular suite of environments or can present an overview of all the major clastic depositional settings. In addition to the environmental discussion, each course includes a day of introduction to the basic processes of sediment deposition and to the principles of sedimentary facies analysis. For each environment, present-day examples are discussed to show how the interplay of processes controls the distribution of major sedimentary units.

Selected ancient examples are discussed to explore the extent to which the lessons of the present-day setting may be applied, and the extent to which novel interpretations and models should be considered. The interaction of the various environments with different tectonic settings is also discussed.

These courses are intended for geologists who need to upgrade their general sedimentological expertise, and should be of benefit to both exploration and production personnel.

Recent Clients

- Agip KCO
- Amerada Hess Ltd
- Anadarko Petroleum Corporation
- BG International Ltd
- BHP Billiton Petroleum Ltd
- BP Exploration
- Britannia Operator Ltd
- Buried Hill Ltd
- Burren Energy
- Cairn Energy Plc
- CanArgo Energy Corporation
- Chevron Energy Technology Co.
- ConocoPhillips (UK) Ltd
- Delta Oil Co.
- ENI S.p.A.
- ExxonMobil International Ltd.
- GDF Britain Ltd
- Heritage Oil & Gas Ltd
- INPEX Corporation
- Maersk Olie og Gas AS
- Marathon Oil Co.
- Max Petroleum Plc
- Neflex Petroleum Consultants Ltd
- Repsol YPF Exploracion
- Shell International Exploration & Production B.V.
- Statoil ASA
- Talisman Energy (UK) Ltd