The Edinburgh Geologist

No.28

Autumn/Winter 1995

C T Clough

THE EDINBURGH GEOLOGIST
No.28 Autumn 1994

Cover Illustration

Portrait of C T Clough (1852-1916) drawn by Miss J Mclaren from photographs.

Acknowledgments

Publication of *The Edinburgh Geologist* is supported by grants from The Peach and Horne Memorial Fund and the Sime Bequest.

Published by
The Edinburgh Geological Society

Contributions and letters to:
Dr A J Highton
c/o British Geological Survey
Murchison House
Edinburgh
EH9 3LA

ISSN 0265-7244

Price £1.50 net

Editorial

In this issue of the Edinburgh Geologist, the Society's Preseident, David Land, recalls the life and work of C T Clough. Clough remains one of the most pre-eminent field geologists to have served with the Geological Survey, and it is fitting that the most prestigious award of the Society bears his name. Having walked in his footsteps as part of the BGS re-survey programme in the Scottish Highlands, I am always in awe of the accuracy of his mapping, his eye for detail and innovative interpretation. This sentiment, I find, often cannot be extended to some of his pre-eminent Survey colleagues of that time.

The main contribution to this issue charts the history and development of the British Geological Survey's Offshore Mapping Programme. John Hull, in his acceptance of the Clough Medal on behalf of BGS, draws a poignant anology between this offshore work, and the pioneering survey of the UK landmass by Clough and his contemporaries in the latter part of the nineteenth century. Dan Evans and Martyn Stoker present insights into recent scientific and commercial advances undertaken by the Offshore Programme, now built on a foundation of international, in particular European, cooperation.

Reaction to Mike Browne's review of the *Geology of Scotland (3rd edition)* in Issue 27 has been quite interesting, with many people sharing his sentiments. Here, we present a robust reply from Professor Gordon Craig in his capacity as editor of all three editions. This presents an insight into the history of this publication and sets out a challenge to the next generation of geoscientists who's researches are taking us forward in our understanding of the geology of Scotland.

In our book reviews, Dan Evans (a man of the sea) examines the series of booklets *A Landscape Fashioned by Geology* published by Scottish Natural Heritage. Potentially these represent an exciting way forward in explaining to the public at large, how geological processes have influenced our landsacape. In these days of image conciousness in science, these publications must represent a step forward in raising the profile of the earth sciences.

Andrew Highton

Charles Thomas Clough (1852-1916)

David Land
Edinburgh

Each year the Society awards its prestigious Clough Medal to a geologist 'whose original work has materially increased the knowledge of the geology of Scotland or the north of England'. The award also perpetuates the memory of Charles Clough who, though a Yorkshireman by birth, became an adopted Scot through his long and distinguished career in the Geological Survey of Scotland. In the minds of Scottish geologists and of field geologists world-wide, Clough stands pre-eminent for the meticulous accuracy of his field mapping and for his major and original contributions to the understanding of the geology of Scotland. He worked in that heroic age of Scottish geology which is generally associated with the names of Peach and Horne, in which, without any prior knowledge but soundly based on field observations, a fundamental understanding was attained of thrusting, refolded folds, metamorphism and volcanic history.

Family and education

Charles Clough was born on 23rd December 1852 in Huddersfield, where his father, Thomas William Clough was a junior solicitor and town clerk (chief executive). His mother was Amelia Jane, daughter of James Ibeson, a surgeon. Charles was the fifth child in his family, with three brothers and two sisters.

We know nothing of his family life, except that his father was wealthy enough to send his third son Charles to Rugby School (1867-1871). From there he went to St. John's College, Cambridge where, according to his close friend Edward Greenly (1938) he was 'intended for the church', but for some reason instead he turned to geology. Maybe his professor influenced him. Maybe Huddersfield's Coal Measures, with their coal and iron mines and sandstone and shale quarries, aroused his youthful curiosity. He was awarded an exhibition in natural sciences from 1872-74, and graduated with a first in the Natural History in 1874, gaining his MA in 1878.

Career

In 1875, when he was 25 years old, Clough began his lifelong career with the Geological Survey, working first in Teesdale and northern Northumberland. In 1884 he was transferred to Scotland where he remained until his death in 1916. He was promoted to District Geologist in 1902, and was president of our Society from 1908 to 1910. The Geological Society of London awarded him the Murchison Medal in 1906; and in 1916 he was elected a fellow of the Royal Society of Edinburgh, as well as being awarded an honorary LLD by the University of St. Andrews.

Marriage

In 1881 Clough married Anna Mary Durham, the youngest daughter of Thomas Durham who was a ship owner of Shields. They had two daughters and a son who followed a medical career. Clough died in 1916 following a railway accident, but his wife survived him until 1935.

Geological Work

Bailey (1923) in his obituary of Clough, lists his geological achievements which I summarise here. In Cowal he originated the theory of refolded recumbent folds and proposed that metamorphism was controlled by both temperature and pressure, distinguishing successive steps of mineral development and relating them to periods of tectonism. In the northwest Highlands he worked with Peach and Horne and others in this classic ground. Mapping between Loch Glencoul and Loch Inchard and around Loch Maree, he separated metasedimentary schists from igneous gneisses, concluding that the former predate the latter. Also, in distinguishing folded dykes, he foreshadowed the later division of the Lewisian into Scourian and Laxfordian. In Sleat he unravelled some of the most complicated thrusting, including folded thrusts. In Easter Ross he helped with the problems of the Carn Chuinneag-Inchbae Complex. In Mull he worked out the time relations of cone sheets and gabbros; recognised a general basic to acid sequence in the intrusions; recognised pillow lavas in the central complex and played an important part in establishing the principle of differentiation by gravitational settling. In Ayrshire he showed that there was no unconformity at the base of the Barren Red Coal Measures, and helped in the recognition of the bauxitic clay. All these were original and important contributions to geological principles generally and Scottish ones in particular. In addition to the above there was a great deal of more routine mapping in the Highlands and also in the Lowlands from Ayrshire through Lanarkshire into the Lothians.

It was as a geological surveyor that Clough was pre-eminent, his detailed mapping being unrivalled for completeness and accuracy. Field surveying was almost a religion to him; but he found writing papers and memoirs more irksome and, rather like James Hutton, did not do himself justice in his writings. For example, his work in Cowal produced his most fundamentally original ideas on refolded folds and metamorphism, but the Cowal Memoir (1897) buried these in a mass of detail that it was some years before it was recognised as a classic of geological literature. Greenly remarks: 'How one longs for somebody to have arranged the Cowal memoir for him: its intellectual greatness would then have been manifest from the outset'. Bailey wrote that Clough, speaking of some inferences he (Clough) had made, said 'I wrote that but no-one seems to have noticed it'.

The high standard of Clough's mapping was gladly acknowledged by his colleagues. Ben Peach once told of a visit by some continental surveyors who looked at some of his and Horne's maps, admitting that nothing done in their country compared in quality with those they saw. But Peach generously commented 'I only wished I had been able show them some of Clough's maps'.

Character

Clough had the ability to locate himself in the wilderness with an accuracy hardly to be improved by the use of aerial photographs. On one occasion his chief, Jethro Teall, who was a petrologist, was inspecting him in the field, when Clough remarked that he had something special to show. Teall recalled this afterwards: 'we wended in and out, between bosses of gneiss, an interminable distance, where he alone could find his way like some infallible Red Indian. At last we came to a narrow pegmatite vein where he pointed out a crystal, only an inch or two across, of the rare green microcline, amazonite. "Don't hammer it" he begged, "that's all there is of it".'

Clough was short but very strong and tough. Someone remarked in Peach's hearing that Clough was a little man. Pretending to misunderstand this, Peach said 'I'll have you know that Clough is a great man'. Then he added 'He's a Hercules in miniature'.

One wet day in the Cheviots, a colleague called to see him. 'Have you seen Mr Clough?' he asked a shepherd, who replied 'Well I can't rightly say that I've actually seen him, but I did see a pair of boots and an umbrella going up the brae'.

Clough was noted for his dogged determination, undeviating rectitude and endurance. He was frugal in habits, a teetotaller and a vegetarian. This sounds a grim list, but in fact he was kind and generous, helpful, transparently sincere, full of humour and always ready for a laugh. Geikie and Greenly tell of meeting Clough one miserably wet dreich day at Kinlochewe: Clough broke into sunny laughter as he greeted them. 'Did you ever know such a man' said Geikie 'why, if sunshine is not to be had without, he always seems to bring it with him'.

He could appreciate a joke against himself. He used to localise places from the letters of words on the map. Nobody enjoyed this skit more than he did, at a Scottish Survey dinner:

Five-eighths of a mile
from the A of Argyll
There's a quarter-inch grit
with a speck of rutile.

However, he was apt to impose on others the standards he imposed on himself. For example, fossil plants were needed from the Canonbie coalfield, and Clough felt it his duty to search for them. Of course he needed a guide underground, so the mine manager found himself enduring a rather trying day, as Clough insisted on wading for hours in the water of a deserted level. A few weeks later the Survey's fossil collector Macconachie was sent alone, and called upon the manager who greeted him with 'Guid marnin Maister Macconachie, I'm verra glad to see ye, but I hope ye hanna brocht ye'r bonny wee water rat wi' ye this time'.

Accident and death

Clough died as he would have wished, on active service in the field. In 1916 he was 64 years old and but for the war may well have retired. He stayed on to help with the war effort, and in this connection he was re-examining the ground at Birkhill (southwest of Bo'ness) with a view to advising on fireclay mining there. Hurll's No 1 mine had run into an east-southeast fault, and decisions were needed as to the best way to proceed. The fireclay was exposed in the railway cutting just to the south of where Birkhill station now stands. This cutting is very narrow, just wide enough for the single line, and the banks were rather overgrown with trees and shrubs. Clough was slightly deaf and, being engrossed in his work, did not notice a train bearing down on him until it was too late. South of the cutting for a good mile, the railway descends northwards on a gradient of 1 in 60, quite steep for a railway. A north-bound train would therefore be coasting quietly downhill, and keeping a good lookout a driver may not have noticed anyone in the cutting until he was almost on top of them.

Clough suffered sever injuries to his legs. It is said that he nevertheless insisted on finishing the note he was writing, and also exonerated the driver of any blame. He was rushed by special train to Edinburgh and taken to the Royal Infirmary, but died three days later on August 27th from pneumonia (a common complication in those days), following amputation. He is buried in Lasswade churchyard.

The Memorial Plaque

The Bo'ness branch railway is now operated by the Scottish Railway Preservation Society who have a station at Birkhill a short distance to the north of the site of Clough's accident. With the co-operation of the Railway Society, our Society fixed to the station building a plaque to the honour and memory of Clough. This was unveiled in September 1993 by the President, Professor G S Boulton and Alex King, Chairman of the Railway Society (Figure 1).

Figure 1. Unveiling of the plaque to the memory of C T Clough at Bo'ness railway station by the Society's President and the Chairman of the Scottish Railway Preservation Society in September 1993

The Clough Medal

In September 1934 Clough's daughter Florrie wrote on behalf of her mother to Sir John Flett, who was then President of this Society as well as Director of the Geological Survey: 'It would please my Mother very much to do something to perpetuate Father's memory. She wishes to place £1000 in the hands of the Edinburgh Geological Society to provide an occasional award to promote the study of the Geology of Scotland and the North of England. She does not wish the award to be confined to Scotsmen.' Flett, who was a personal friend of the Clough family replied: 'I cannot tell you how pleased I feel that your mother has been so generous as to provide a sum of £1000 for administration by the Geological Society of Edinburgh to encourage research ... . All the work your father did has fully stood the test of time ..., and your mother's generosity will secure that Dr Clough's name will be perpetually connected with the advancement of the Knowledge of the science to which he devoted his whole life.'

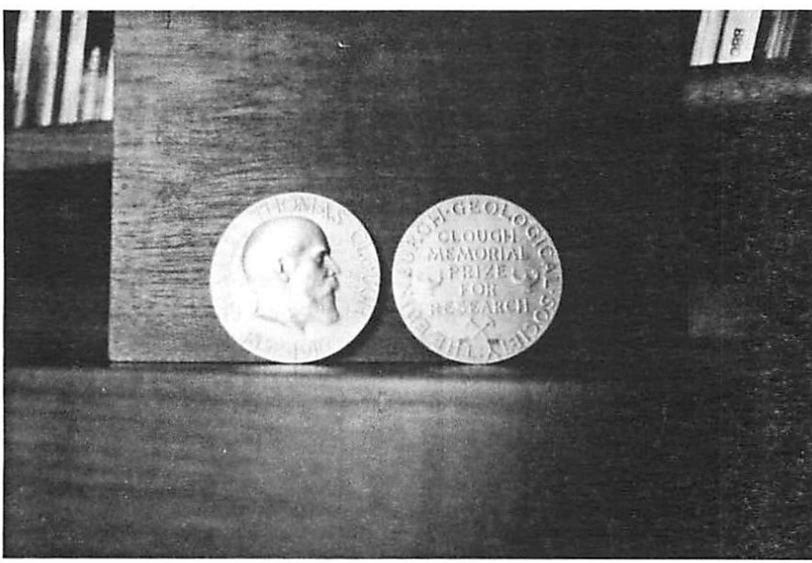

Figure 2. The Clough Medal

Discussions followed which led to the creation of the Clough Medal, which was to be awarded as described at the beginning of this article. A further wise provision was agreed that 'should it appear at some future date that the money could be more advantageously used for the advancement of the study of geology in another way, the Society is to have the power of altering the scheme to this effect'.

The medal itself (Figure 2) is of silver, 51 mm in diameter and 3 mm thick, weighing just over 2 troy ounces (65 g). A matt anodised finish is given which does not tarnish, though neither can it be brightly polished. The obverse of the medal shows a bas-relief bust of Clough facing right and encircled by the words '**Charles Thomas Clough 1852-1916**' ; while the reverse has the words '**Clough Memorial Prize for Research**' in the centre, encircled by '**The Edinburgh Geological Society**' and embellished by two lamps (of learning) and crossed geological hammers. The dies for the medal are signed 'Pilkington Jackson 1936'. Until 1990 the medals were struck by the Royal Mint; but since then they have been struck by Alex Kirkwood and son Edinburgh. Current stocks were hallmarked in Edinburgh in 1991, the marks being the sponsors marks, the lion rampant, the castle and the date letter R. Each year the recipients name and date are engraved on the rim.

In its award of the Clough Medal and of the grants towards field work from the Clough Fund, the Society continues to honour a great geologist whose accurate and elegant maps remain as his best memorial and inspiration to his own succeeding generations.

Acknowledgements
The best and most comprehensive biography of Clough is that by Greenly (1938). Other details have been gleaned from the works listed below, from the Society's archives, from Professor A L Harris, as well as from Clough's own maps and writings (which I have been pleased and privileged to use in my own geological work).

Obituaries

GREENLY, E. 1938. *A hand through time.* **2**, 498-506.

_____ 1917. C T Clough. *Proceedings of the Royal Society of Edinburgh*, session 1916-17, 12-13.

_____ 1916. C T Clough. *Geological Magazine*, **53**, 525.

BAILEY, E.B. 1923. C T Clough. *Transactions of the Edinburgh Geological Society*, **11**, 236-238.

HARKER, A. 1918. Charles Thomas Clough. *Quarterly Journal of the Geological Society of London*, **73**, 60-61.

HARRIS, A.L. 1993. Charles Thomas Clough 1852-1916. *Oxford Dictionary of National Biography.*

Geological Survey Memoirs

Clough wrote (in part or whole) or contributed to the following Geological Survey memoirs, which are listed in chronological order of publication. The first five are English. The last three made posthumous use of his maps and notes. One-inch sheet numbers are given after the abbreviated title; some are part sheets, some extend into adjoining sheets.

Memoirs of English Sheets

1887	Otterburn (Sheet 8)	1888	Cheviot (Sheet 5)
1889	Kielder (Sheet 7)	1891	Mallerstang (Sheet 40)
1895	Wooler (Sheet 3)		

Memoirs of Scottish Sheets

1897	Cowal (Sheets 29, 37)	1904	Skye (Sheets 70, 71)
1905	Mid Argyll (Sheet 37)	1907	NW Highlands (Sheets 91-92, 101-102, 107-108, 113
1910	Edinburgh (Sheet 32)	1910	East Lothian (Sheet 33)
1910	Glenelg (Sheet 71)	1911	Glasgow (Sheets 30,31)
1911	Knapdale (Sheet 28)	1911	Colonsay (Sheet 35)
1912	Ben Wyvis (Sheet 93)	1913	Fannich Mts (Sheet 92)

1916	Central Coalfield V: Airdrie (Sheet 31 part)	1916	Ben Nevis (Sheet 53)
1917	Central Coalfield II: Falkirk (Sheet 31 part)	1920	Central Coalfield VII: Rutherglen (Sheets 23/31 part)
1923	Rannoch Moor (Sheet 54)	1924	Mull (Sheets 43, 44)

Publications

Clough wrote few papers, most of his work appearing in the memoirs listed above as well as in notes in the Geological Survey *Summaries of Progress* between 1876 and 1916.

CLOUGH, C.T. 1876. The section at the High Force, Teesdale. *Quarterly Journal of the Geological Society of London*, **32**, 466-471.

GUNN, W. and CLOUGH, C.T. 1878. On the discovery of the Silurian beds in Teesdale. *Quarterly Journal of the Geological Society of London*, **34**, 27-34.

CLOUGH, C.T., MAUFE, H.B. and BAILEY, E.B. 1909. The cauldron subsidence of Glen Coe and the associated igneous phenomena. *Quarterly Journal of the Geological Society of London*, **65**, 611-676.

CLOUGH, C.T., CRAMPTON, C.B. and FLETT, J.S. 1910. The augen-gneiss and Moine sediments of Ross-shire. *Geological Magazine*, **47**, 337-345.

CLOUGH MEDAL PRESENTATION FOR 1994

The BGS Offshore Regional Mapping Programme: Its history and achievements

JOHN HULL

Mr President, I thank you, the Council and Fellows of the Society for the great honour they bestow on the Geological Survey in the award of the 1994 Clough Medal to the Offshore Regional Mapping Programme. This award goes to a dedicated team of scientists, cartographers and engineers, who's work since 1966 has produced many scientific and technical achievements. I must admit to a personal sense of pride in receiving this award on their behalf. This stems from my position as a founder member of the, then, 3-man team created by Sir Kingsley Dunham to undertake the first systematic survey of the UK Continental Shelf. Also, I am fortunate to have been around long enough to play some part in bringing this particular programme to a satisfactory conclusion.

Charles Thomas Clough, was a member of the early Geological Survey. His work, in Scotland and Northern England, during the 19th Century was a crucial to our understanding of the geology of the United Kingdom landmass. It is hoped that we of the modern Geological Survey may be seen as continuing Clough's ethos in the latter part of the 20th Century. The Survey's activities on land are now largely concerned with the revision of the early mapping in the light of modern scientific thinking. However, it is in the primary survey of the offshore areas, which constitute our continental shelf, that we are continuing the pioneering work of Clough. The objective of the offshore programme has been to further our understanding of the geology of the UK, and it is the completion of the mapping project which is recognized here tonight.

Background

In 1966/67 our knowledge of the geology of the UK was summarized on a 1:625 000 map of the landmass only. Our territorial waters extended to the 3-mile limit, but little thought or knowledge was given to what lay within or beyond these bounds. Today, the UK offshore area is over twice that onshore, and a summary of the geology of the UK has recently published as maps at the 1:1 million scale. The geology of the territorial waters claimed by the UK generally differs from the landmass, as the coastline is in part structurally controlled. Only the older basement rocks between Scotland and Ireland, have any similarity with those seen on land. From the Mesozoic upwards, the geological record is better represented offshore.

The creation of the first Continental Shelf Unit within the Geological Survey was not entirely fortuitous. Its inception coincided with the Wilson years of "White Hot Technology", a period of relatively generously funding for Civil Science. The Survey (then IGS), for example, expanded into such fields as offshore geology and industrial minerals assessment. There was also increasing commercial stimulation at this time. This followed the discovery in 1959, of large quantities of natural gas in porous sandstones at Groningen in the northern Netherlands. Questions were asked as to the extent of these rocks, and whether they occurred on the British side of the North Sea. The answer was uncertainty. There commenced a period of offshore drilling, which in December 1965 led to the discovery of gas in the UK sector by BP. Proving to be in commercial quantities, the West Sole Field was established to the east of the Humber. This marked the start of production in the UKCS, which continues to this day. At this time, barrages across the Wash, Severn and Mersey estuaries, were being considered. This influenced the choice of the first area to be surveyed, namely Morecambe Bay and the East Irish Sea.

The Offshore Programme in BGS

From a modest beginning the level of BGS activity increased quickly. In 1976 the Continental Shelf and Marine Geophysics Units amalgamated to form the Continental Shelf Division. At its peak, this group consisted of 100 people and a budget of £50 million. Funding initially came from the Civil Science Budget, but latterly the Department of Energy (now part of the DTI) became the main contributor. The D of E provided unstinting support, particularly in the face of threatened Treasury cut-backs.

The UKCS is divided into map areas defined by 1 degree of latitude and 2 degrees of longitude. Each map sheet takes its name from either a bathometrical/ morphological feature or that of a famous geologist. Although the latter includes former Directors of the Survey, sadly Clough's name is not amongst them. The limits of the reconnaissance survey were from the low water mark to the 200m isobath. 70 sheets (or part sheet) have been surveyed, and a total of 336 geological and geophysical maps produced at 1:250 000 scale. Each sheet area is covered by 5 map types, namely: Solid Geology, Quaternary Geology, Seabed Sediments, Gravity (Bouguer anomaly, or Free-Air anomaly in waters deeper than 200m), and Magnetic (mostly based on commercial aeromagnetic surveys). These maps and their associated databases are complimented by 1:1 million scale summary maps of the seabed sediments and solid geology, with the Quaternary soon to appear. A set of 10 offshore regional reports were planned. Five of these have been published to date, with the remainder to be released within the next year.

The databases which underpin the maps and reports are extensive. They consist of some 200,000 line kilometres of seismic data, 250 000 sample/shallow core sites (down to 5 or 6m) and over 500 cored boreholes. Innumerable mechanical, geochemical, mineralogical and biostratigraphical analyses have been made. Comprehensive bathometric and sidescan sonar databases have been compiled that have utilised existing Royal Navy data. These BGS databases are in the public domain and available to anybody who cares access them.

Survey Methods

In the initial stages of the programme, it was decided to start from the 'known' land geology and work outwards. Consequently, the offshore survey was viewed as an extension of the existing onshore 6-inch mapping programme with the traditional field men like Peach, Horne and Clough becoming BGS divers. Given the area involved, the water depths and the time-scale, this methodology was obviously not practicable in the longer term. Nevertheless, a BGS diving team is maintained and has provided support to such diverse projects as submarine archaeology, and collection of seabed samples during an investigation into potential metalliferous placer deposits off Rum.

In general, earlier *ad hoc* geophysical work by BGS and other University projects had been undertaken from NERC Research Ships and/or Hydrographic Office ships of the Royal Navy. These ships are fine for their purpose, but generally better suited to geophysical rather than geological surveys. However, for the long periods of use required by the survey programme, BGS has chartered vessels from the private sector. This has necessitated developing an in-house engineering expertise in modifying ships for specialised surveys. This eventually led to long-term periods of hire, e.g. 5 years for such ships as the *Whitethorn* and *Wimpey Sealab* (renamed *Pholas*). Important advantages were gained from this practice, with continuity and stability facilitating the development of new equipment.

In the earliest days of the programme, the sampling equipment used reflected that available to the offshore site investigation industry, e.g. shipek grabs, gravity corers, Alpine vibrocorers and commercial rockdrills. The purpose of most commercial surveys is to obtain material for engineering tests. However, the Survey's main requirement is to collect samples for detailed scientific examination. Consequently, innovative engineering developments were required across a range of activities. An early product was CONSUB, a remotely operated submersible, developed in a joint venture with British Aerospace. This replaced the shallow-water diving geologist. It had the advantage of allowing one to get close to outcrop in water depths up to 600m, sample it, and see what you were doing! Although the vehicle worked well, its use in UK waters was limited due to restricted outcrop and handling requirements. It was eventually superseded by other more flexible and more widely applicable techniques. Nevertheless, its development in the seventies was "state of the art". As US Admiral Alan Shepherd (commander of Apollo 14) remarked on a visit to Murchison House, the technology employed in building CONSUB was comparable to that of the moonshots of the day. A second version continued to be used commercially up to the late 1980s.

Engineering Developments

Engineering developments for the offshore programme are many, and a few of the more significant are highlighted below.

In geophysical surveying 6 pieces of seismic apparatus are towed from the stern of the ship and together with ship-mounted equipment, operate simultaneously. To avoid interference between the seismic sources, a control system was designed to regulate the firing sequence of up to 5 seismic devices. Delay times for the firing of each instrument were calculated to minimise interference between sound sources and receivers, and thus optimise the record quality. Of the array of devices deployed, the Deep-tow Boomer (a BGS development of a Canadian Huntec boomer) allows operation in water depths down to 1000m. Penetration is of the order of 150 milliseconds (= up to approximately 200m), with a resolution of 1 metre. Using this device channels cut in Weichselian glacial deposits could be discriminated from later in fills of late-Glacial and Holocene sediments.

In the early years of the Programme, seismic activity in the UK was monitored by a number of onshore stations grouped into local networks, e.g. the LOWNET system around Edinburgh. Seismometers in this network regularly detected earth tremors thought to originate in the North Sea. In co-operation with the Norwegians, the network was expanded into coastal areas. However, to obtain better coverage, and higher resolution data, a system was designed for deployment on the seabed. Two seismometer arrays were built and deployed in the North Sea adjacent to the Beryl and Statfjord platforms, respectively. The innovation of the design was in the method of deployment, and the communication packages. A buoy was hardwired to a seabed seismometer and data transmitted to a recording station on an adjacent oil platform. This was transferred to shore every 7 days for analysis. Earthquakes with magnitudes up to almost 6ML (ML = magnitude scale = Richter Scale) are known in the North Sea, e.g. Dogger Bank Earthquake in 1931, but 4.8ML was the largest recorded when these systems were in operation in the 1980s.

To calibrate the geophysical data samples and cores of the sea-bed sediments and rock are required. Commercial off-the-shelf equipment was not designed specifically for geological purposes, this has led to the to the design new tools. For example, the 'Vibrocorer' can obtain an 83mm (c. 3.3 inches) core of unconsolidated sediment, stony clays and soft rock to a depth of 6m in waters up to 1800m of water, although it is capable of operating down to 2000m. The 'Rockdrill' uses a similar 3.5 tonnes frame to the vibrocorer. However, its power source is a self-contained electro-hydraulic system, with a base-mounted swivel which drives a hexagonal outer barrel. The power and retraction units, together with a microprocessor control system, are located within the frame on the seabed. The drill can recover core up to 5m, and is operational to a depth of 2000 metres. The limiting factor for operation is not usually the rig, but an umbilical which joins it to the ship and provides power, computer control, communication and the hoist functions. For deeper drilling and coring in deep water a conventional wireline system is used on board a dynamically positioned commercial drilling ship. Although techniques are similar to commercial based drilling, in-house designed drill bits provide more complete core recovery. The form and composition of the bits chosen depends largely on the nature of the geology being drilled, but is a balance between cutting ability, wear and cost.

Our sampling and drilling tools have achieved international recognition. The UN, for example, purchased a vibrocorer for the Chinese Second Marine Brigade in Guangzhou, with BGS building and commissioning the equipment on site. Our developments have also been utilised by the International Ocean Drilling Programme (ODP). This led to secondment of personnel to Texas A & M to assist in the development of a new prototype vibro-percussive drill. While BGS geologists have also participated in engineering cruises to test the principles of drilling in abyssal plain environments. BGS engineers and computer programmers are currently collaborating with the German Survey (BGR) and others, on a project being funded by the EC MAST II programme, to develop a

30-m hammer corer. This will be capable, ultimately, of operating in water depths in excess of 4,500 metres of water. The relevance of the deeper drilling capabilities to hydrocarbon resources and safety issues is particularly recognized by Norway. Together with the Nansen Arctic Drilling Programme, they continue to retain BGS staff as consultants for some of their offshore projects.

Other areas of collaboration have come in the field of geochemical surveys. Together with the Harwell Laboratory of the Atomic Energy Research Establishment, BGS has been responsible for the development of a number of gamma-ray spectrometers for marine surveying. One instrument, the **EEL**, measures both the natural radioactive constituents of rocks and sediments, and radionuclides resulting from artificial sources. From this, distribution maps of natural gamma-ray emitters, e.g. thorium, uranium and potassium, have been compiled. By incorporating a neutron source, the probe can also be used in exploration for metalliferous deposits, e.g. placers, chromium-rich crusts and manganese nodules. A prototype instrument was used in the mapping of manganese nodules on the floor of Loch Fyne. In the North Sea the distribution titanium, a significant detrital mineral, reflects that of sandy sediments. Conversely high concentrations off the west of Scotland mostly coincide with the outcrop of igneous rocks. Geochemical analyses have been made of seabed sediments, and 1:250,000 scale maps produced to complement the seabed maps.

Scientific Studies

Much data has been derived using the surveying techniques described above. This routine surveying and monitoring has been mainly used to generate maps, but some fascinating science has also come to light. For example, the 7 known Tertiary igneous centres of onshore Scotland and the Islands have been supplemented by the discovery of 12 additional offshore complexes, and there may be more. Two of the better known offshore complexes, the Erlend (in the north-east Faeroe-Shetland Basin) and Darwin (in the north Rockall Trough), were identified from gravity anomalies. Modelling over the central Erland (60mgal) anomaly indicated the presence of a gabbroic pluton beneath the lava pile. Subsequent seismic reflection surveys identified a vent. The flanking volcanic parts of the complex have been penetrated by three wells. One well (209/3-1) penetrated about 1000m of MORB-type tholeiitic basaltic and peraluminous dacitic lavas. The Darwin complex also consists of a gabbroic pluton overlain by a similar suite and thickness of extrusive rocls.

Significant advances have come in the field of Quaternary stratigraphy. For example, on the northwest Hebridean margin a borehole was drilled, about

140km west of Lewis, to investigate the link between shelf/slope sequences and the northeast Atlantic deep-sea record. Results were not quite what was expected. The borehole proved a 103.3m succession of Plio-Pleistocene sands and muds overlying Middle to Upper Miocene glauconitic sands and Upper Oligocene carbonate-rich muds. The sediments provide an excellent record of the transition from pre-glacial to glacial conditions in the mid-latitude NE Atlantic Ocean. However, Holocene sediments are poorly represented, and a large number of unconformities were encountered in the sequence. Palaeontological work, together with the magnetostratigraphy and palaeo-environmental analysis, suggested that climatic conditions in the late Oligocene, mid to late Miocene and the early Pliocene were warmer than the present. Climatic deterioration in the late Pliocene continued, in a fluctuating manner until the early mid-Pleistocene when full glacial conditions were established in Anglian times (c. 440,000 years BP).

Interest in the evolving history of the North Sea basin and its fill has led to many BGS-led collaborative projects involving five other Geological Surveys (Denmark, Schleswig-Holstein, Lower Saxony, Netherlands and Belgium) and many universities. From the many studies, one in particular involved BGS staff and researchers from the Grant Institute. Early mapping had identified an unexpectedly thick Quaternary sequence (c. 800m), implying a still active depositional basin. The research project examined the evolution of a series of pro-grading deltas in the southern North Sea. It was found that these deltas formed initially in late Tertiary times, from rivers draining westwards from the Baltic and eastward from the proto-Thames and other British rivers. By the early Pleistocene, however, the main source of sediment derived from central European river systems (e.g. Rhine, Elbe), with the UK and European deltas coalescing by Middle Pleistocene times. This was followed by a northward migration of the delta front, which then infilled the whole of the southern North Sea. By modern standards the delta would now rank as the second or third largest delta in the world with a plain extending over 600km east-west and 700km north-south. The delta system was overwhelmed by the Elsterian (Anglian) glaciation, with large sub-glacial channels incised into the delta top. Similar thick, complex sequences of Quaternary sediments occur in the Irish and North Celtic Seas. These also show evidence of later glacial channelling. The incised channels occur at several levels and are of differing ages. The origins of these channels, as a consequence of sub-glacial and periglacial processes, remains contentious.

Despite the thickness of the offshore Quaternary sequences, Holocene sediments are poorly represented. Nevertheless, the Flandrian transgression commenced 10 000 years ago and its progress is well documented. For example, the Irish Sea at 10 000 years BP was open to the north-west, but cut off from the Celtic Sea. By 8000 years BP the southern barrier was breached, with the western coastline as we know it today being formed between 5 and 2000 years ago. Penecontemporaneously, the North Sea was open to the north from the earliest Flandrian times. With time, the transgression moved southwards until the Straits of Dover were breached and the British Isles formed.

Palaeontology has played a full part in the study of the geology offshore. As a consequence of sampling techniques, complete macrofaunal sequences are generally not recovered. Hence research has largely concentrated on microfauna and flora. The former, including foraminifera (amoeba with calcareous shells) and ostracods ("water fleas"), occur in rocks from Cambrian times to the present day. These may have biostratigraphical significance, e.g. Ostracods from the early Cretaceous of the southern North Sea and foraminifera from the Neogene (*Bulimina alazanensis* and *Nonionella turgida*). Microfloras include calcareous Nanoplankton (microscopic algae), e.g. the coccoliths of Jurassic and Cretaceous sediments; and more importantly palynomorphs (organic walled microfossils), e.g. dinoflagellate cysts such as the Upper Jurassic cyst *Gonyaulacysta jurrassica*. Zonal schemes have been erected from their study which facilitate correlation, and give clues to the depositional environment. Thermal maturity may also be assessed from colour differences, the darker the colour, the higher the thermal "rank".

The study of microfossil systems enable us to errect refined biostratigraphical and chronostratigraphical correlations. Such high resolution schemes have proven invaluable in examining the Cenozoic and Upper Mesozoic sequences offshore. Research into dinoflagellates has led to the first detailed high-resolution biostratigraphy of the late Pleistocene and Holocene which links the sequences in the North Sea, Rockall Trough, Faeroe-Shetland Channel and the Hebridean Shelf/Slope with the North East Atlantic. From this work, a link has been established between cyst climatostratigraphies and isotope data in DSDP holes.

Tephrachronology (the study of the petrography and provenance of volcanic ash falls) has been important in a constructing high-resolution stratigraphies. However, unlike Iceland, New Zealand or even East Africa, this method has conventionally not been considered applicable to the UK Quaternary, although historic ash falls have been reported in Scandinavia and even a few in northern Britain. In 1986 both acid and basic volcanic shards were found in BGS vibrocore samples from the Witch Ground Formation in the central North Sea. This ash deposit was the first to be recorded in the UK Quaternary sequence, and forms part of an extensive fall originating in Iceland during the Loch Lomond Stadial. The fall-out from this eruption extends from eastern Canada to onshore Norway, and has been dated at 10 600 BP by reference to lake sediments radiocarbon dates in Norway. The presence of this ash band in the offshore sequence to the west of Scotland has triggered a search for onshore deposit in Scotland principally led by researchers from Edinburgh University. A second ash of early Holocene age (9000 years BP) has been sSubsequently found in many offshore cores. These tephra horizons are invaluable chronostratigraphical markers, and have the potential to tie down environmental changes offshore and allow correlation with onshore sequences.

Natural Hazards

Some of the interesting scientific discoveries also provide insights into potential natural hazards. There is much evidence west and north of Scotland of sediment instability, mostly in the form of debris flows (or slide). One such slide (Miller) has displaced 50 km^3 of sediment, which is a much greater volume than one would find on land. However, by offshore standards it is not large. Off the western seaboard of mid-Norway, near Storrega, are several massive slides components of which have moved material in excess of 1500 km3 (see the following article). The impact of such areas of instability on any seabed engineering projects are obvious but may also affect the adjacent land areas. Movement on one slide in the Storrega area was large enough to generate a series of tidal (tsunami) waves, which affected much of north-west European coastal area. In eastern Scotland this event is represented by a transgressive marine sand, which tapers landwards in peats and Carse Clays from sites from the Firth of Forth northwards to Wick. Dates from the enclosing peats suggest this event occured at c. 7000 years BP. The cause of instability of sediment piles is thought to be linked either to earthquake seismicity, the sublimation of gas hydrates, or a combination of both. Although the risk of slides forming of the magnitude of the Storegga structure is small, it is not impossible within the lifetime of most coastal engineering developments.

Prior to the establishment of the BGS seismic network, the UK was generally considered to be tectonically stable. Consequently, in the early days all areas in the North Sea were considered to be of equal at risk, albeit low, and the probability of an event uncertain. In reallity this was not the real situation, as witnessed by the data collected from the North Sea in the 1980s. This showed that seismicity was highest in the vicinity of the Storegga Slide and the Norwegian Trench. Seismically unstable areas in UK waters were found within the Viking, Central and other North Sea grabens, but with relatively stable areas in between. Additionally, to the northwest of the UK, passive margin earthquakes occur at or near the "shelf break" where they may initiate many of the observed debris flows and slides.

Other natural hazards include the shallow gas deposits commonly present in North Sea sediments. Much of the gas is methane which has leaked from petrogenic reservoirs at depth and is held, usually at relatively low pressure, in a number of horizons. There is some seepage of gas from the seabed into the water column, which may ultimately contribute as a greenhouse gas to the atmosphere. Evidence for seepage is found in many areas of the North Sea, often seen as pockmarks in areas of seabed composed of soft silty clay. These pockmarks are commonly only a few metres deep and some tens of metres across, but can be up to 20 metres deep and hundreds of metres across. Some reprocessed, high-resolution seismic records can identify sediment that has been disturbed by the escaping gas, and then settled back into the hole created by the outburst. Gas is a potential hazard and catastrophic escapes have been known to damage oil rigs and platforms, or cause ships to lose buoyancy. Consequently, gas surveys are carried out before any wells are drilled on the UKCS. Shallow gas is also a resource, and potential economic reserves have been identified within a few hundred metres of seabed.

Other Discoveries

The mapping programme has been successful in delimiting the plateau and basin structure of the UKCS, including grabens and tilted fault blocks in the North Sea. The Great Glen fault and other major Caledonian faults have been shown to be still active up to the Tertiary, when they acted as normal faults. Jurassic sediments have been identified in the Moray Firth, Irish Sea, and along the Hebridean margin, where previously only older rocks were thought to exist. While Tertiary sediments were proved for the first time in Cardigan Bay and the Minch, and subsequently elsewhere offshore.

Only some of the achievements of the programme are alluded to above, but they and others are detailed in the numerous professional papers, reports, memoirs, maps and databases produced by my colleagues (some examples are included in the appended Bibliography). Together they present the current knowledge of the, and mark the conclusion of the primary offshore geological survey.

The future
Offshore we are now at the point reached by the Land Survey at the end of the last century. While the reconnaissance is over, many areas of the UKCS are not mapped in detail and the primary surveys of the deeper water and coastal areas remain to be completed. However, in the remaining years of this decade and into the next century much more work remains to be done, before our understanding of the offshore geology of the UK matches that onshore. The creation of a Coastal Geology Group of research specifically tasked to establish databases for the coastal zone compatible with, and complementary to, those onshore and farther offshore. This Group has won the right, and funding, to manage the earth science component of the NERC Land-Ocean Interaction Study. In particular it will undertake process research and the high-resolution studies of the Holocene to underpin the work of other scientific disciplines.

In the deeper water areas, geophysical surveys have already been completed in the north Rockall Trough and these will be calibrated with sampling and coring programmes. It is hoped that this work (jointly funded by a consortium of oil companies and the Science Budget) will be extended to the remaining parts of UK Designated Waters. Concurrent with these new primary surveys, a programme of revision surveys will be undertaken, and new maps produced, in the Shelf areas. Soon to be published is a new composite solid geology map of the East Irish Sea, which records the significant advances in the geological understanding of the region since the first compilations some 20 years ago.

There are also many challenges facing the Global Geophysicists which include the re-establishment of the North Sea network and creation of a network west of Britain. This will lead to the refinement of methods of hazard assessment (in particular the prediction of earthquakes). Also envisaged are refined models of the earth's geomagnetic field and their application to the requirements of the oil industry for ever more precise navigation (for 3D seismic surveys) and for the deep directional drilling of wells. Improved forecasting of external magnetic storms, will help to minimise their impact on activities, particularly in the field of electronics, where magnetic fields play a part.

In conclusion, I must acknowledge the assistance of my colleagues in the preparation of this address, you for your attention and especially, the Society for honouring the Survey with the award of the "Clough Medal". I promise that it will be found a resting place in one of the more public areas of Murchison House, where it may be seen by both BGS staff and visitors alike.

Selected Bibliography

ABRAHAM, D.A., & RITCHIE, J.D. 1991. The Darwin Complex, a Tertiary igneous centre in the Northern Rockall Trough. *Scottish Journal of Geology*, **27**, 113-125.

ANDREWS, I.J. & 6 others. 1990. The Geology of the Moray Firth. *United Kingdom offshore regional report*. London: HMSO for the British Geological Survey.

CAMERON, T.D.J., STOKER, M.S., & LONG, D. 1987. The history of Quaternary sedimentation in the UK sector of the North Sea Basin. *Journal of the Geological Society of London*, **144**, 43-58.

COOK, P.J.C., FANIN, N.G.T., & HULL, J.H. 1992. The physical exploitation of the shallow seas. *In*: HSU, K. & THIEDE, J. (eds) *Use and Misuse of the Seafloor*. J Wiley & Sons Ltd, Chichester.

EVANS, D., ABRAHAM, D.A. & HITCHEN, K. 1989. The Geikie igneous centre, west of Lewis: its structure and influence on Tertiary geology. *Scottish Journal of Geology*, **25**, 339-352.

FANIN, N.G.T. 1979. The use of regional geological surveys in the North Sea and adjacent areas in the recognitiona of offshore hazards. *In*: ARDUS, D.A. *Offshore Site Investigations. Procceding of the Underwater Technology Syposium, London*. Graham and Trotman, London, 5-21.

GATLIFF, R.W., HITCHEN, K., RITCHIE, J.D. and SMYTHE, D.K. 1984. Internal structure of the Erlend Tertiary volcanic complex, north of Shetland, revealed by seismic relflection. *Journal of the Geological Society of London*, **141**, 555-562.

GRAHAM, D.K., HARLAND, R., GREGORY, D.M., LONG, D. & MORTON, A.C. 1990. The biostratigraphy and chronostratigraphy of BGS borehole 78/4, North Minch. *Scottish Journal of Geology*, **26**, 65-75.

HARLAND, R. 1988. Quaternary dinoflagellate cyst biostratigraphy of the North Sea. *Palaeontology*, **31**, 877-903.

LONG, D., LABAN, C., STREIF, H., CAMERON, T.D.J. & SCHTTENHELM, R.T.E. 1988. The sedimentary record of climatic variation in the southern North Sea. *Philosophical Transactions of the Royal Society*, **B318**, 523-537.

LONG, D., DAWSON, A.G. & SMITH, D.E. 1989. Tsunami risk in northwestern Europe: a Holocene example. *Terra Nova*, **1**, 532-537.

PEACOCK, J.D., AUSTIN, W.E.N., SELBY, I., GRAHAM, D.K., HARLAND, R. & WILKINSON, I.P. 1992. Late Devensian and Flandrian palaeoenvironmental changes on the Scottish Continental Shelf west of the Outer Hebrides. *Journal of Quaternary Science*, **7**, 145-161.

STOKER, M.S. and eight others. 1994. A record of late Cenozoic stratigraphy, sedimentation and climate change from the Hebrides Slope, NE Atlantic Ocean. *Journal of the Geological Society of London*, **151**, 235-249.

WINGFIELD, R.T.R. 1990. The origin of major incisions within Peistocene deposits of the North Sea. *Marine Geology*, **91**, 31-52.

The BGS deep-tow boomer meets the Storegga Slide

Dan Evans
Marine Geology and Operations Group, British Geological Survey, Edinburgh

The Storegga Slide, located in the North Atlantic off Norway, is recognised as a large bathometric depression with a steep headwall. It is one of the worlds largest submarine slides (Bugge, 1983), and is thought that a total of 5600 cubic kilometres of sediment has been displaced from an area not much smaller than the mainland of Scotland (Figure 1). For such a world-class feature, surprisingly little research work has been carried out into the detail of its configuration and history; publications are confined to a few papers of which Tom Brugge of IKU in Norway is the lead author following his reconnaissance Ph.D study of the feature, and further work by the Institute of Oceanographic Sciences and Bergen University.

Bugge *et al.* (1987) considered that the displacement occurred during three slide events. Slide 1 was originally dated between 30 000 and 50 000 years ago, but there is now evidence that it took place later than first thought, perhaps nearer 25 000 years ago (T Bugge pers. comm.). Slide 2 occurred about 7 000 years ago, and Slide 3 soon after.

At a number of localities near to the eastern coast of Scotland, a sand deposit up to 5 metres above see level has also been dated at around 7 000 years in age. It has been proposed by Long *et al.* (1989) that this sand is a tsunami deposit, leading to the suggestion that the tsunami was the result of sediment displacement associated with Slide 2. Similarly dated tsunami deposits are also found in western Norway.

BGS are currently involved in an EC funded Mast II project called ENAM - European North Atlantic Margin. This project aims to study sediment processes, pathways and fluxes along the European continental margin. A particularly important part of this study is an investigation into mass movement, so that the Storegga Slide has naturally become the focal point for research. In October-November 1993 a team of BGS staff took part in a studies aboard the German research vessel *Meteor* in order to collect profiles with the BGS Deep-Tow Boomer (DTB).

The DTB is able to collect profiles with a vertical resolution of 1 metre, with a penetration of up to 200 metres in water depths of up to 1500 metres. As its name suggests, the boomer fish is towed a long way below the sea surface,

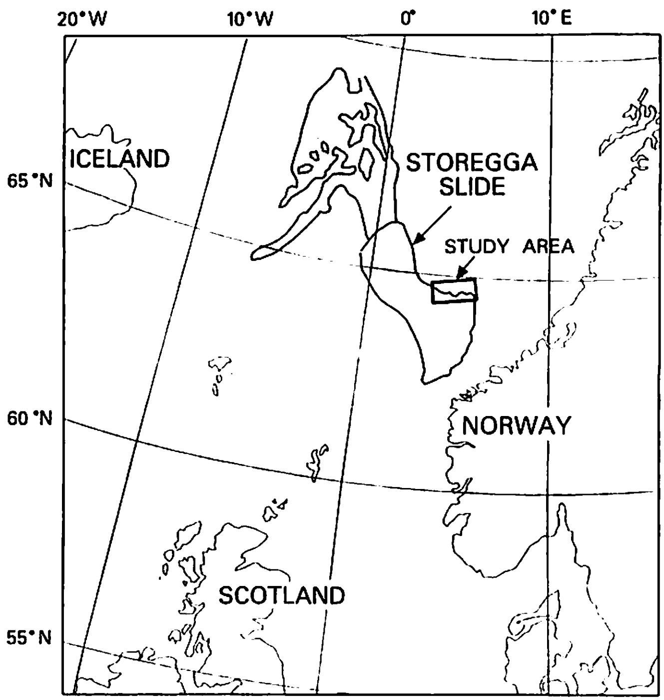

Figure 1. Location of the Storegga Slide

usually about two thirds of the way down the water column. To enable it to 'fly'at such depths a long length of cable is required , and the fish may be towed more than a kilometre behind the ship. This piece of equipment is ideally suited to studying the sedimentary deposits in and around the Storegga Slide. However, as the Slide extends into water depths in excess of 3 000 metres, only its upper reaches were studied.

The BGS team travelled to Trondheim to join the *Meteor*, which had on its previous leg sailed from Edinburgh, were the equipment had been mobilised for another project involving the DTB. The ship had sailed via the Barents Sea where it had experienced particularly severe weather conditions in a hurricane, the ship rolling 40 degrees in both directions. It was therefore with some trepidation that we sailed on the 28 October into the late autumn North Atlantic!

Fortunately the weather was generally remarkably good during the Storegga survey (although we did run for shelter on a couple of occasions). Good profiles were collected from an area on the northern flank of the Slide. The relatively small area covered by the survey only serves to emphasise the size of the slide.

The sediments adjacent to the northern edge of Slide 1 form a sequence of sea-bed parallel reflectors, although more massive debris-flow units were recorded in the shallower depths. Locally, the regular pattern of the reflectors is broken by faults, graben, and a variety of fluid escape structures, which probably indicate the presence of gas in the sediments (Figure 2).

Profiles across the Slide 1 scarp (Figure 3) show the great change in the seismic character of the disturbed sediments. They become jumbled, massive and form an irregular sea-bed, and produce strongly hyperbolic reflectors. Figure 3 also shows an almost intact slumped block immediately below the scarp. Using the DTB records an the ship's swath-bathometry system, the trace of the scarp has been mapped in detail and shown to be quite sinuous.

A particularly interesting discovery made using the DTB profiles was that there was evidence for slides that substantially predate Slide 1 of Bugge *et al.* (1987). Unfortunately we have very little idea of the ages of these older structures, but that they probably date back as far as the Pleistocene, and possibly into the Neogene. As another part of the ENAM project, workers from the University of Bergen have also identified pre-Slide 1 slide structures on the southern flank of the Storegga Slide in the North Sea Fan.

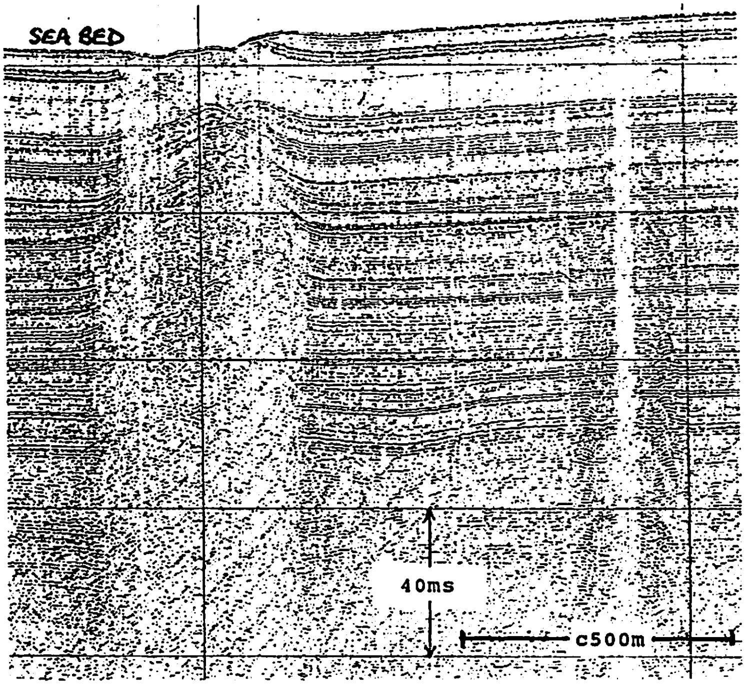

Figure 2. Seismic reflection profile from the Storegga Slide. Disruption of the layering indicating fluid escape structures due to degassing from the sediment.

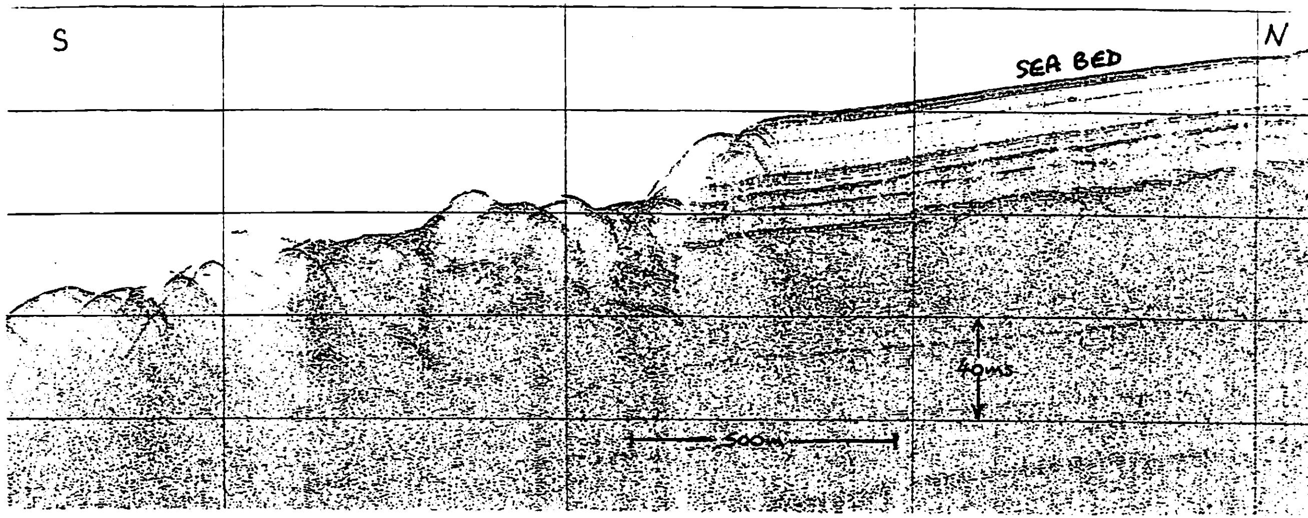

Figure 3. Seismic reflection profile of Slide 1 within the Storegga Slide complex showing the jumbled nature of the sediment pile.

It is clear that the Storegga area has been a major zone of instability for a long time, and is likely to remain so in the future. The triggers for slide propagation were probably earthquakes, for this region is the most seismically active part of the UK-Norway area, and the northern flank of the Storegga Slide lies along the line of the Jan Mayen Fracture Zone. The presence of gas may have facilitated movement, and the high sedimentation rate was probably an important factor for the slides on the North Sea Fan to the south of the Slide.

Following the Storegga survey, the *Meteor* sailed north to the East Greenland margin, allowing us a distant view of Jan Mayen. After experiencing our own brief hurricane with a maximum wind speed of 93 knots, we sailed for Kiel and berthed on the 26 November in a Christmas card winter scene to be welcomed with a gluwhein party. This was a pleasant end to the successful Storegga DTB survey which provided excellent data and valuable new insights into the nature and history of the slide area.

References

BUGGE, T. 1983. Submarine slides on the Norwegian continental margin, with special emphasis on the Storegga area. *Publikas jon Institut for Kontinentalsokke Lundersookelser*, **110**, 152.

BUGGE, T. and seven others. 1987. A giant three-stage submarine slide off Norway. *Geo-marine Letters*, **7**, 191-198.

LONG, D., SMITH, D.E. & DAWSON, A.G. 1989. A Holocene tsunami deposit in eastern Scotland. *Journal of Quaternary Science*, **4**, 61-66.

BGS and Industry: a collaborative approach to understanding the marine geology of the continental margin west of Scotland

Martyn S Stoker
Marine Geology and Operations Group, British Geological Survey, Edinburgh

The continental margin off western Scotland is an area of complex bathometry flanking the oceanic Iceland Basin. Morphologically it can be divided into an inner margin consisting of the Hebrides Shelf and an outer margin of the Rockall Trough. This area, known collectively as the Rockall Continental Margin, represents one of the last unexplored frontier regions in the United Kingdom waters where possibly significant hydrocarbon reserves remain undiscovered.

In 1992, the British Geological Survey Marine Geology and Operations Group completed the first phase of its reconnaissance geological and geophysical mapping programme of the continental shelf around the UK (Figure 1). This survey represents the most complete of is kind undertaken anywhere in the world, and was largely funded by the Department of Energy (now incorporated into the Department of Trade and Industry). Although the reconnaissance survey includes the Hebrides Shelf and adjacent slope, it does include the whole of the UK offshore area; the Rockall Trough and Plateau have yet to be systematically surveyed.

From an industry perspective, hydrocarbon exploration of the Rockall Continental Margin involves a number of problems. These include a largely unknown geology, deep water, inclement weather conditions for exploration, and lack of supporting infrastructure on the west coast. This all contributes to high exploration costs, which have largely suppressed activity in the area. This situation is now beginning to change due, in part, to several BGS initiatives undertaken in collaboration with industry since the mid-1980's.

In 1985, 1988 and 1990 the BGS established Oil Company consortia for shallow drilling, mainly on the Hebrides Shelf. The main objective of these drilling ventures was to gather stratigraphical and lithological information from a number of Late Palaeozoic and Mesozoic basins on the Hebrides Shelf. This information was integrated with the reconnaissance survey data to develop the regional geological framework as it is currently known (Stoker *et al.*, 1993). Significantly from a hydrocarbon viewpoint, several of the boreholes proved organic-rich shales of mid-Jurassic and Ryazanian age, which, if present at depth in the adjacent Rockall Trough, may have generated large amounts of hydrocarbons (Hitchen and Stoker, 1993). These borehole data have helped encourage several

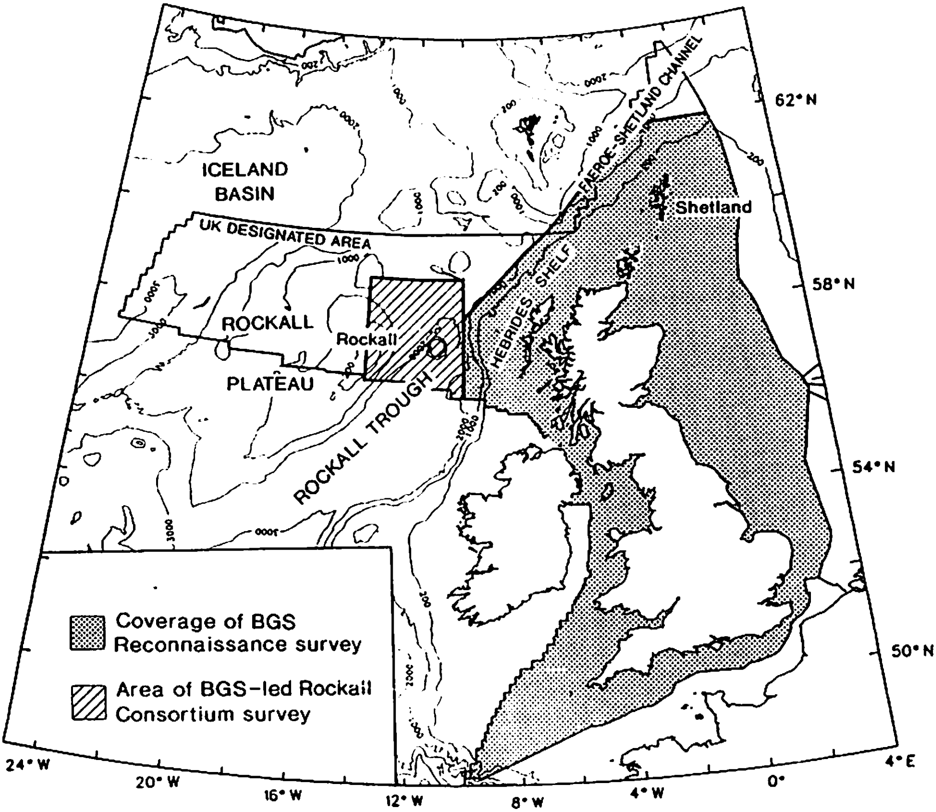

Figure 1. The area of map coverage on the UK Continental Shelf and Rockall Consortium survey project.

oil companies to undertake deep drilling on the Hebrides Shelf and adjacent slope, although the results remain confidential.

In 1992, another BGS initiative commenced; the three-year Rockall Continental Margin Project, funded by the BGS and eight oil companies. This is managed by the BGS, which chairs a steering committee; the main objective is a regional geological and hydrocarbon appraisal of the Rockall Trough and adjacent banks. Additionally, several transects will provide regional geological cross-sections traversing the entire continental margin and extending into the adjacent ocean basin.

A geophysical grid of shallow-reflection seismic, gravity, magnetic and bathometry data was collected over the entire survey area (Figure 1) by the BGS in summer 1992. In summer 1993, a detailed grid of multi-channel deep-reflection seismic data was acquired from the south-western part of the area, together with very deep-reflection seismic along the transects which image the entire crust. In late spring/early summer 1994, in excess of 200 gravity cores, Rock drill cores and vibrocores were collected by the BGS for geological and organic geochemical data. In late summer/early autumn 1994, several planned borehole sites were drilled penetrating up to 250 metres sub-seabed.

All of these data will have been acquired, interpreted and presented to the collaborating oil companies by the BGS within the three-year programme. This will remain confidential for several years. However, this information will ultimately constitute the basis for maps, which form the most important end product of the survey. It is hoped to extend the survey to include other parts of the frontier area around Rockall as part of the BGS remit to acquire reconnaissance geological knowledge of the UK offshore are. This will form the initial reference source for all potential users. At a time when the 17th Licensing Round for exploration, due to be awarded during 1995, will include the area around Rockall, the BGS is not only participating, but actively instigating exploration activities in this frontier region. Additionally, safety in offshore exploration is a prime concern for the recently established Western Frontier Association (WFA); a forum instigated by the BGS on behalf of the oil industry to consider ways of reducing risk for individuals working offshore. Funded jointly by the BGS and industry, possible research topics include regional appraisals of slope stability and other geohazard phenomena, such as gas hydrates, on the continental margin to the west of Scotland. This work would be undertaken by the BGS on behalf of the WFA. The creative use of the BGS database emphasises its importance to industry, providing an invaluable resource in the exploration of the continental margin.

References

HITCHEN, K and STOKER, M S. 1993. Mesozoic rocks from the Hebrides Shelf and implications for hydrocarbon prospectivity in the northern Rockall Trough. *Marine and Petroleum Geology*, **10**, 246-254.

STOKER, M S, HITCHEN, K and GRAHAM, C. 1993 *United Kingdom offshore regional report: the geology of the Hebrides and West Shetland shelves, and adjacent deep-water areas.* London: HMSO for the British Geological Survey.

Strange Earth 15: The up Escalator of Papua New Guinea

Bill Baird

Geologists working in Scotland are familiar with the raised beaches and wave-cut platforms around our coasts. These products of varying sea-levels and isostatic readjustment can be clearly seen in many areas including good examples around the Moray Firth and the coast of Argyll. At intervals of between 5 and 30 metres above the present sea-level these preserved landforms normally represent three main periods of formation, sometimes with several lesser features in between.

Raised beaches and wave-cut platforms are therefore are features that we have either visited for ourselves, seen in pictures, or have read about. What can we make of the multiple raised beaches of Huon Peninsula, New Guinea? Not just three step-like terraces in the landscape, but a positive staircase of former shorelines. Here, at least twenty raised marine terraces have been identified. These features were produced during periods when riding sea-levels temporarily overtook the continual uplift which occurs this part of New Guinea. The oldest of these terraces is dated at 300 000 years BP and stands at 150 metres above the present sea-level.

A combination of circumstances has created this staircase of terraces on the coast of New Guinea: firstly, a consistently rising coastline due to the collision of the Australasian and Asian plates; and secondly, variations in sea-level during the Pleistocene ice age. Occasional periods of apparent equilibrium, when uplift and rising sea-level were matched, are marked by the formation of the coral reefs. These have been subsequently exposed as treads on the 'up escalator' as synchronisation was lost.

Further reading

Ice Ages. CHORLTON, W and the Editors of Time-Life Books. Time-Life Books.

CHAPPELL, J and SHACKLETON, N J. 1986. Oxygen isotopes and sea level. *Nature*, **324**, 137-140.

Report on the Edinburgh Geological Society's
JAMES WRIGHT MEMORIAL LECTURE, 4TH MARCH 1992

Geology and Environment
Elements for a strategy on the basis of the French example

presented by

Dr. Gerard Sustrac
Bureau de Recherches Géologiques et Minières (BRGM), France.

Dr. Sustrac was welcomed and introduced by the President of the Edinburgh Geological Society, Prof. Geoffery Boulton FRS. Members from both the Edinburgh and Glasgow Geological Societies made up the audience of 130. A vote of thanks was given by Dr. Stuart Monro who expressed his pleasure that such a dynamic and 'catalytic' figure as Dr. Sustrac had been invited to expound his views and relate his experiences to the Geological Societies of Edinburgh and Glasgow.

Dr. Sustrac began his presentation by explaining that he was Assistant Director of Research at the Bureau de Recherches Géologiques et Minières which is the equivalent of the British Geological Survey.

Introduction

The topic of environmental geology is a relative newcomer to the geological community in France. Furthermore, the field of earth science conservation is much less well developed than in the UK. However, a general awareness of the topic of 'Geology and Environment' is occurring and, following various conferences on environmental topics, a conference on 'Geology and the confinement of toxic wastes' is to be held in June 1993. The Geological Society of France is also promoting meeting, concerning these topics.

Incentives to develop the field of environmental policy in France has come from many sources. Pressure has been applied from environmental associations (about 1500 are officially listed). In the aftermath of industrial disasters (Seveso and dioxin) the question of risk assessment for industrial sites from natural catastrophes, such as landslides (as at Valtellina) or seismic damage, has been raised. In the case of the Valtellina landslide it has led to the creation of the Geological Survey of Lombardia. Worsening tendencies, such as increasing contamination by agricultural pollutants (e.g. nitrates and pesticides), is another problem influenced by geological processes. The recent gathering in strength of the 'Green' movement has added a political facet to the necessity of environmental geological knowledge. The national scale of environmental problems was illustrated by a map of France showing the degree of damage by drought in western France.

The French situation

Political control of environmental matters in France has changed many times since the creation of the Department of the Environment in 1971. In the period 1986-1988 the Ministry for the Environment was included in a mixed portfolio with the Ministry of Public Works. Since 1988 there has been a separate post of Minister for the Environment.

Co-ordination of national environmental policies is complicated by internal political boundaries based on four scales of division. Firstly, France is divided along watershed boundaries into 6 river basin authorities which control payments for abstraction and pollution of water (Figure 1). These authorities are the responsibility of the Ministry of the Environment. The French general administration is sub-divided as follows; there are a total of 26 regional departments (Figure 2), 95 counties and 36,760 communes. Six of the 26 regional departments have created their own environmental agencies. For the most part, responsibility for environmental matters (land use, planning, waste, sewage, natural hazards, noise, permits) falls at the lowest political division and is within the jurisdiction of the 36,000+ communes.

National regulations within France stipulating acceptable environmental standards concern, in particular, drinking water and sewage sludge disposal to the soil. These are derived directly from EC regulations. Concerning soil pollution, standards defined by other EC and non-EC countries may be applied. It is, however, difficult to establish a generalised guideline. Acceptable levels of pollutants in the soil will depend as to whether the soil is to be returned to its primary state or for a particular future land use. A significant number of communes have completed plans of risk exposure to help in regulating the environment. Since the Natural Environment Plan was set up communes and counties have also started environment plans with the support of the Ministry of the Environment. However, such environmental problems are not constrained by administrative boundaries and so collaboration is vital! Co-financing of projects over national and international bodies will help to overcome these difficulties.

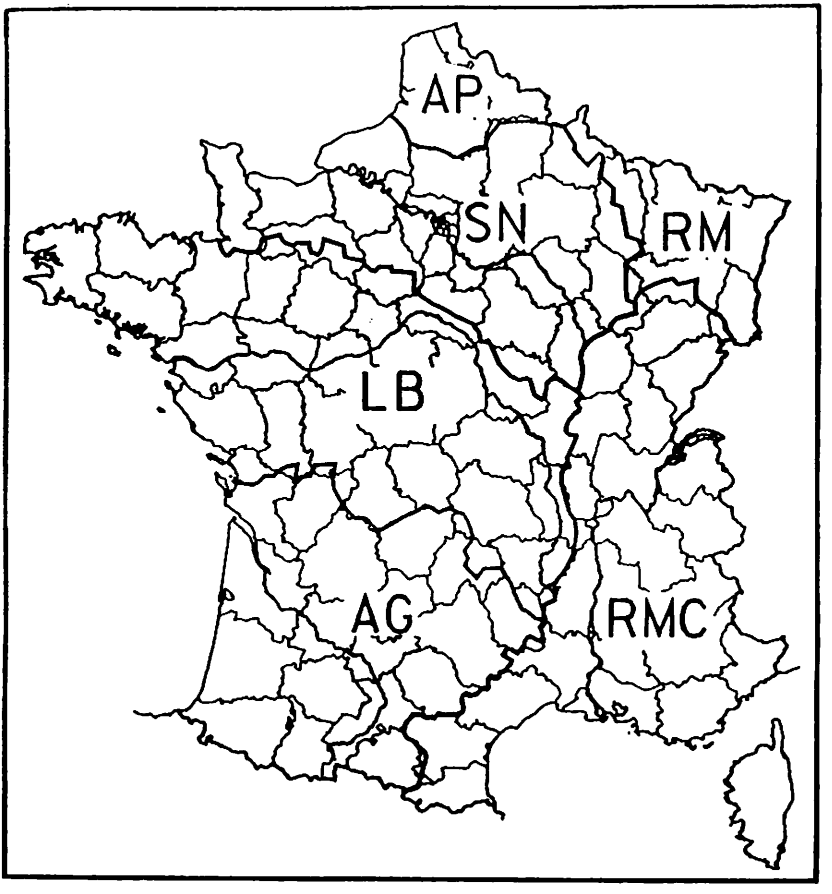

Figure 1. The river basin authorities of France

AP	Artois-Picardie
SN	Sine-Normandie
RM	Rhine-Meuse
LB	Loire-Gretagne
AG	Adour-Garonne
RMC	Rhone-Mediterrane-Corse

The study of geology in French universities differs from the UK in that although geology is taught in many centres, geological research is confined to a smaller number of specialised centres. University courses fall into three cycles. The first cycle is a two year course and the second cycle a two year course with three options. Research for higher degrees forms the third cycle completed, on average, in three years. There appears to be a healthy number of diplomas issued for graduation in environmental subjects. However, scrutiny of the statistics reveals much lower numbers of graduates have studied hydrology and waste management than ecological topics. Four co-ordinating centres have been selected to specialise in environmental research. Discussion between these groups ensures that no overlap of research interests occurs.

A list of advised 'eco-professions' has been established by the Ministry for the Environment. This includes soil scientists, hydrogeologists, hydrologists and ecotoxicologists. Earth scientists form key positions but within multidisciplinary teams. Bridges with other disciplines are of fundamental importance.

Environmental actions

Actions concerning the environment were considered under four headings; understanding the processes, monitoring, data collection and land management.

In order to understand environmental geological processes a series of experimental sites have been promoted at various periods of time, to assess natural hazards such as landslides and soil erosion. For example, studies have found that areas of high relief suffer significant soil erosion by landslides and torrential flow. However, significant soil erosion also exists in areas of low relief along 'marked' channels. There has been no co-ordination of the sites of measurement nor compilation of common results. Each site or group of sites is managed by separate institutes but the effects emerge in the form of joint policies. Other experimental sites are water-related, with studies of pollution problems (e.g. nitrates, pesticides and farm slurries), general systems and geopurification (changes in soil by input of sewage disposal to fields). One of the outstanding projects is at river catchment scale concerns basin studies, while regional studies cover 100's km^2. The River Seine basin model incorporates data from many sources, e.g. biology, hydrodynamics, temperature and water release from dams.

Programmes of environmental monitoring need to be developed and adequate co-ordination promoted. Patterns of groundwater and surface water quality can then be established. France is fortunate to have many old observatories in the form of

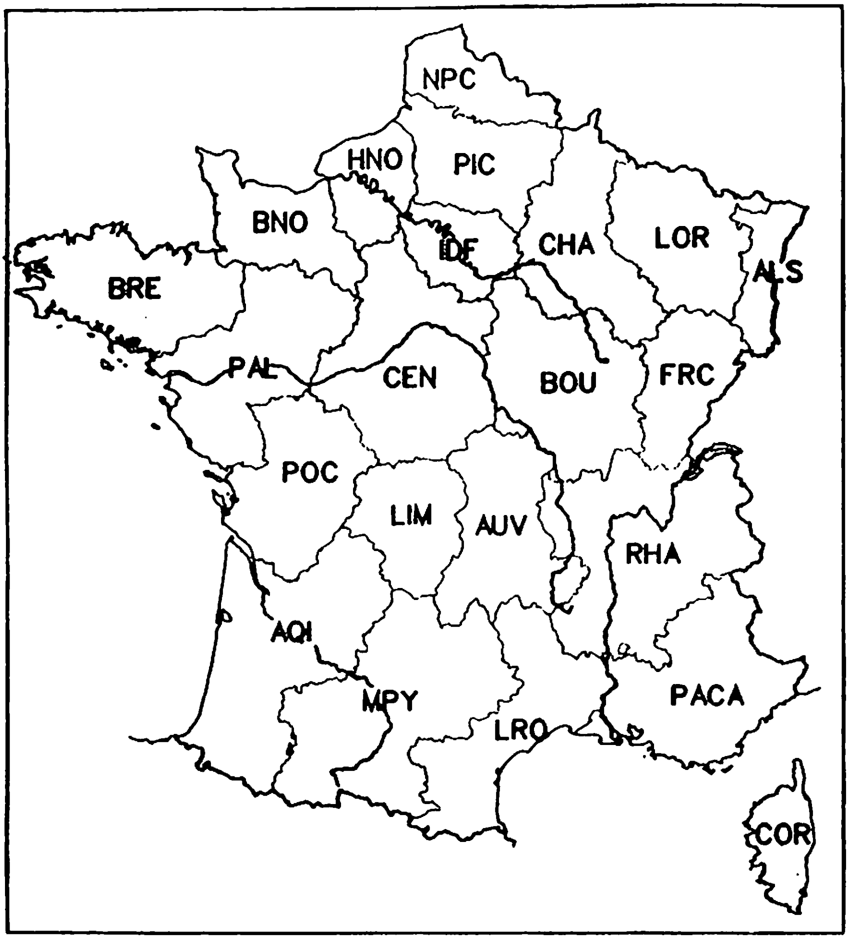

Figure 2. Regional Departments of France

water gauging stations. There are surface water gauges at 2,363 localities and surface water quality is measured at 1,443 points. Groundwater quality is assessed at 35 400 localities by the National Groundwater Quality Observatory and the watertable is measured at 3030 stations. In France 75% of electricity is generated by nuclear power at more than 20 sites. There are also a number of nuclear research sites. Careful internal and external radiological control of these sites, the general environment and food chain products has been established. France is establishing a National Teleray Network to monitor air-born nuclear pollution at one site per county. Air monitoring, the results of which are time and place dependant, includes air quality in cities (29 stations), background monitoring and also Euro site monitoring (13 stations). Networks for the long-term monitoring of forest ecosystems, soils and marine waters also exist.

The important questions raised by data collection are which data and in what form? In BRGM earth science bibliographical data are tabled as GEODE within the Pascal database. This database is one part of an exact sciences and technology and applied sciences database set which includes information on biological, pollution and natural hazards. Within BRGM a flexible access (GeoloGIS) to all individual databases (e.g. subsoil data, geochemical inventory, computerised geological maps) is being developed (Figure 3). Combination of data from various sources is enabled using the internal SYNERGIS system within BRGM.

BRGM is currently completing a programme of 1:50 000 geological maps. More than 800 of the 1100 sheets have been finished and the rate of completion is 30 maps per year. 160 of the already completed maps have been computerised. The intention is that all maps are to be computerised. The maps are prepared as high quality engravings, then scanned and new data subsequently added. This replaced digitising on a tablet as past experience has shown this method generated slight discrepancies. The choice of scales for map production attempts to limit the discrepancy between the scientists that produce the maps and the map users.

One example of land management is the establishment of county or commune environmental plans. Such plans, which are undertaken on a voluntary basis only, have been drawn up by 14 of the 95 counties and 200 of the 36,760 communes. Amongst other actions developed are seismic zoning and microzoning and radioactive waste disposal site location studies. There are already two sites for surface storage (La Hague and Aube). An additional four sites for deep buried storage are being considered. Each of the four sites has

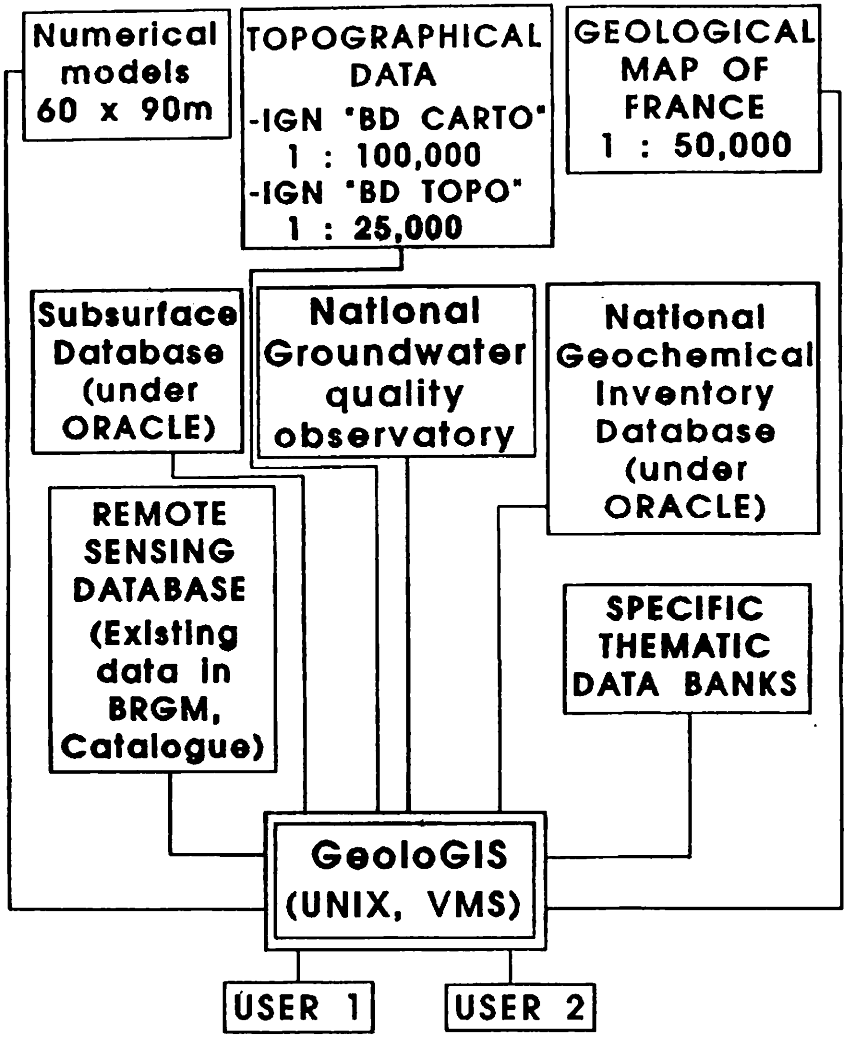

Figure 3. Geographic Information Systems (GIS) planned for BRGM

been chosen to investigate specific regional geological settings, within salt deposits, schist, granite and clay.

Perspective for the future

Dr. Sustrac highlighted aspects with future importance for environmental geology:

1. A legal basis for environmental concerns. For example, the establishment of environmental standards, the regulation of such standards and the distribution of authority to enforce regulation.
Adequate research and development work should establish thematic priorities and analytical tools within an institutional and multicompetance approach.

2. Environmentmental geologists should be active in the role of eco-advisers, eco-engineers and eco-geologists.

3. Environmental geologists should be engaging in dialogue with decision makers on all levels. For example, a new book synthesises European environmental geology (WEGS) by a series of case studies.

4. International co-operation is a necessity if the problems involving environmental geology are to be successfully tackled.

Maxine Akhurst and Mike Browne

Book Reviews:

A LANDSCAPE FASHIONED BY GEOLOGY
A review of three booklets: Edinburgh, Skye and Cairngorm

'A landscape fashioned by geology' seems a curious title for this series; it is an unusual use of the word geology, and carries an underlying implication that geology is a significant force only in areas covered by this series. Be that as it may, the booklets are visually attractive packages with fine cover photographs, and the use of high quality materials ensures that this impression persists through to the back covers.

In assessing the booklets one must ask for whom they are designed. I have been asked to review them on the basis that, as a marine geologist, I am largely ignorant about the areas of these classical areas! Unfortunately there is a grain of truth in this assumption.

From the introductory remarks in each booklet, I shall assume that the anticipated readership comprises walker, climbers, tourists and other members of the general public with outdoor interests. It must therefore be assumed that the typical reader has a low level of geological knowledge, but is looking to broaden their outlook. Therefore, if the booklet is to succeed it must first hold the initial interest, and the develop it. So, how do these three volumes fare?

Edinburgh

Of the three, this booklet perhaps makes the greatest effort to introduce geology to the beginner or learner. I believe it succeeds admirably, and indeed it is an interesting presentation for any level of geological ability. The geological development of the area is clearly presented, and the resulting distribution of rocks neatly related to the present-day topography. There is a lot of fascinating reference to the rich, geologically related history of the Edinburgh area. Residents of the city, in particular, will relate to the sections on Man's use of the land.

Some photographs are disappointingly small, although this is partly compensated by other fine illustrations. I would also have preferred the points of interest along the by-pass, to be related to the map; still it is a great idea (although perhaps not in the view of road safety experts?). I found this a very pleasing production, as I am sure would our typical reader.

Cairngorm

The subject matter of this booklet differs from the other two; the geological description of the area is confined to the Cairngorm Granite, and the description of its nature and emplacement takes only one page. The remainder of the volume largely describes the geomorphological evolution of the Cairngorms, most of which is glacial and post glacial. The scope of the booklet is therefore more limited, and perhaps for this reason it in places becomes rather detailed in its approach, and includes too much justification of the subject. The non-geologist (or should I say non-geomorphologist) would find it heavy going in parts; I found the Periglacial section particularly hard to follow. Nevertheless, our typical reader will hopefully be able to browse through the booklet and pick up many of the interesting facets. The quality of the production is excellent, with consistently fine photographs and diagrams; I particularly liked the panoramic aerial photograph and accompanying sketch of Braeriach and Cairn Toul.

Skye

Now I do know something of the geology of Skye, because I am one of those referred to in the introduction that received field mapping training on the island. Although the opening text on geological history could have been broken down a little, it is a description of the geology that I would think could be readily absorbed by all. Later sections are shorter, more punchy, and cover a wide range of topics.

As a marine geologist I would however quibble that Skye might have been placed in the wider geological context of the adjacent submarine geology. After all, most of Skye is underlain by strata which truly belong to the offshore Mesozoic sequences that occur all around the coast of Scotland, and only rarely impinge on its coastal regions; it is only the protective cover of the basalt that has ensured their occurrence above the sea level. Also the distinctive shape of Northern Skye is entirely controlled by the extent of the basalts.

The photographic and diagrammatic content is impressive, and I am confident that this booklet will appeal to its intended readership and help generate and broaden interest in the geology of the island. Climbers will particularly appreciate knowing the geological reasons for the occurrence of potentially slippery rocks among the normal gripping surface of the Cuillin.

This series is to be welcomed, and will undoubtedly help foster geology in a wider community. Hopefully there will be more volumes in the series; Scotland abounds with classic areas that are crying out to be included, and dare I say that some of them are at least partly offshore. Edinburgh and Skye represent excellent value for money at £1.50, and despite my reservations, £2.00 for the more recently published Cairngorm remains a good buy.
Dan Evans

Optical Mineralogy. Principles and Practice.
Gribble, C D & Hall, A J. 1992.

303pp. London: UCL Press. Price £50.00 (hardback), £17.95 (softback).

Optical Mineralogy represents an updated version of Gribble and Hall's ***Practical Introduction to Optical Mineralogy***, and is aimed at the middle of an increasing range of textbooks which describe the modern approaches to the microscopic study of rocks and minerals. It is designed to be used as a student laboratory textbook, serving as a quick reference to the properties of minerals under the microscope. Chapter One provides the reader with an introduction to the study of minerals using both transmitted and reflected light, with the theory being left until Chapter Four and Five, respectively. The meat of the book covers in a relatively systematic fashion both the silicate and non-silicate minerals. The silicate minerals (Chapter Two), include the main rock forming minerals with a few oddities thrown in. The minerals are presented in broadly alphabetical order, but closely related minerals (such as pyroxenes and amphiboles) are grouped together. The clear subheadings allow the optical properties of the various mineral species too be located quickly, making the book very user-friendly. The optical properties of the non-silicate minerals and their identification in reflected light are covered in Chapter Three, which includes examples from all the major mineral groups and not just the non-opaques. The summary tables of refractive indices and optical properties of both rock-forming and ore minerals, as well as the Michel-Levy chart on the back cover are all useful additions to any laboratory text. The only minor criticisms I have are that some of the figures are poorly reproduced (for example 3.16 and 3.17) and the incorrect page headings (pp 71-77) within Chapter Two.

Overall, I am certain that this textbook will make a welcome addition to any undergraduate student teaching lab.
Emrys Phillips

Geology of Scotland (3rd edition): a review by M A E Brown
A reply by Gordon Craig (editor of Geology of Scotland, editions 1 to 3)

M A E Browne's bilious review of the ***Geology of Scotland* (3rd edition)** in Volume 27 of The Edinburgh Geologist (pp.32-34), tells the reader something of the book - and reviewer. He has a point about the poor quality of the production but is not in a position to explain how that happened, and he is less than fair in his criticism of the science. The Quaternary chapter is singled out as having some of the best and the worst plates. The plates in that chapter were magnificent and included spectacular aerial photographs in colour, but editorial control was lost in the final stages of production. Browne wanted environmental topics, I did not. He thinks that the Mesozoic chapters are dated, but they were revised by two efficient authors who handed in their TSS on time. He looks back with nostalgia to the good old days of J B Sissons and T N George, and so do I; but science and life move on!

But perhaps the reviewer's comments have served a useful purpose. They have encouraged me to look at my old files so that I can explain how these texts came into existence, and reveal, some of the pitfalls that faced me as the editor.

The idea for the 1st edition of the ***Geology of Scotland*** arose in 1961. Most of the contributors were academic, museum and Survey geologists in their thirties. Douglas Grant, then the Managing Director of Oliver and Boyd, agreed that his company would publish the book. Ernie Inkster and his colleagues in the Geological Survey drew the diagrams, including sizing all the lettering and cutting and pasting the words typeset by the printer on the prepared line drawings. The book was published in the Autumn of 1965, with a print run of 3000 copies. The reviews were kind, apart from one comment that it looked more like a tourist guide than a text book, but I could live with that. The print size was generous and paper quality high, but some of the diagrams were too large (lack of editorial control!). A further 1000 copies were reprinted with minor amendments in 1970.

Douglas Grant advised me in 1979 that another edition could now be launched under the imprint of Scottish Academic Press, of which he was Managing Director. The book obviously needed to be re-written and new authors found. Bob Lucas of the Geological Survey handled the production of the new diagrams, and the use of a smaller font-size helped to keep the longer text within economical bounds. The second edition was published in 1983, with the print run of 3000 consisting of 1000 copies in hardback and 2000 in softback. Once again it had taken four years from inception of the project to final publication.

By 1986, the second edition was nearly sold out. Sadly with deaths and illness I had to find ten new authors for the planned third edition. The page proofs and index were completed in August 1990, and I went off to the USA secure in the knowledge that the book would be published in the autumn - but I was wrong.

On my return, I found that Scottish Academic Press was in dispute with the printer. A rescue operation was mounted in early 1991 by the Geological Society of London, who offered to pay some £22,000 to the Scottish Academic Press which would enable the Society to become joint publishers of the 3rd edition. The Society further agreed to pay the remaining costs for paper, print and Binding. The Society noted that it would become the owner of the book if Scottish Academic Press ceased to trade. Some £37,000 was offered on the same conditions for ***The Geology of England and Wales***. Shortly afterwards Scottish Academic Press went into receivership. The 3rd edition (3500 copies in both soft and hardback) was published in the autumn of 1991 with the Geological Society as sole owner and publisher. The book has now covered its costs and is a profit earner for the general good of geology in the UK. The poor quality of the production is explained by the fact that the printers who had set the text had supplied the final printers with Xerox copies only (not the originals) of the diagrams, photographs and text. I suppose a drowning man should only be too grateful to be rescued regardless of the state of his clothes!

I t will be apparent that even with the best will in the world, it takes 4-5 years to publish a major textbook; especially one where every chapter has to be in a required order. No doubt floppy discs and desk top publishing will accelerate the speed of production, but who puts the bomb under the last contributor? Authors who deliver their texts on time are criticised by reviewers for being out of date: those who are late cause premature ageing of the editor and publisher.

So I offer a challenge. We will need a brand new edition of the ***Geology of Scotland*** the year 2000. I have been its editor for 30 years, a sentence I do not wish to repeat, and I guess the same goes for most of the present authors. A 4th edition will require a virile new team, old enough to show competence but young enough to be innocent about the pitfalls of life. Ideally they should have a clean bill of health and a life expectancy of at least another 30 years. Applications to be editor should **not** be sent to me, but might be addressed to the Geological Society of London.

On reflection an even better plan might be for the editors of the Scottish Journal of Geology to come to an arrangement with the Geological Society of London. Now is not too soon for an agreed plan of campaign for the ***Geology of Scotland 2000***.

I shall expect a complementary copy - in hard back of course. Perhaps M A E Browne's review has merit after all!!

Proceedings of the
EDINBURGH
GEOLOGICAL SOCIETY

158th Session
1991-92

No. 22 **September 1995**

INTRODUCTION

This, the twenty second issue of the *Proceedings*, covers the 158th Session 1991-92 of the *Society*.

MEMBERSHIP

Total membership at 30 September 1992 was 552, which represents a decline of sixteen from the 1991 figure of 568 members. The membership comprises as follows:

Honorary Fellows	8 (9)	Senior Fellows	12
Corresponding	8 (8)	Family Fellows	34
Life Fellows	26 (27)	Glasgow	12
Ordinary Fellows	445 (458)	Junior	7 (6)

Twenty Ordinary Fellows were elected, while 40 resigned, deceased or were removed.

PUBLICATIONS

Three parts of the *Scottish Journal of Geology*, Volume 27 part 2 and Volume 28 parts 1 and 2, were published during this session for the Edinburgh and Glasgow Geological Societies by the Geological Society Publishing House, Bath. Issue 26 of the *Edinburgh Geologist* was published in late 1991.

The geological guide book **Scottish Borders Geology** was *in press* at the year end. Its authors are mostly Society fellows and it is being published by Scottish Academic Press with assistance from the Society.

CLOUGH and MYKURA FUNDS

The Clough Medal was awarded to Dr M J Gallagher of the British Geological Society for his work on mineral exploration in Scotland.

LECTURE MEETINGS

The following open meetings were held during the session:

9 October 1991
Shallow geophysical investigation
Dr J S W Penn, Kingston Polytechnic
23 October 1991
Shear zone tectonics
Dr W Gibbons, University of Wales, Cardiff
6 November
Deep crustal geology
Dr A Whittaker, British Gelogical Survey, Nottingham
20 November
The communication of geology
The Presidential address was followed by the Annual General Meeting of the Society
Dr W D I Rolfe, National Museum of Scotland
4 December
James Hutton and his world
Professor D B McIntyre, Perthshire
15 January 1992
The Granites of Caledonia
Dr W E Stephens, University of St Andrews
29 January
Metalliferous sources and resources in a fragment of the North Atlantic Region
Dr M J Gallager, British Gelogical Survey, Edinburgh
On this occasion Dr Gallagher was presented with the Clough Medal
19 February
Fellow's evening
4 March
Geology and environment: elements for a strategy on the basis of the French Example
This presentation was given as the James Wright Memorial Lecture
18 March
The rocks we climb on
Mr G S Johnstone, Edinburgh

RECORD OF FIELD EXCURSIONS

25 April	Tweedsmuir Dr J D Floyd
9 May	Glen Orchy Dr P W G Tanner and Dr P Thomas
16-23 May	Skye Mr A A McMillan, Mr W J Baird and Mr S M Ross
30 May	Glen Tilt Professor D B McIntyre
31 May	Glencoe Dr G Durant and Dr D McGarvie
6 June	Roseneath Dr P W G Tanner
10 June	Pentland Hills Dr K R Gill
20 June	Schiehallion Dr P Nell
23 June	Binny Craig Mr A D McAdam
5 September	Jedburgh and Melrose Mr A D McAdam and Mr I T Bunyan
3 October	Whitberry Point Dr R F Cheeney and Mr A A McMillan

COUNCIL

Following nominations at the AGM on the 20 November, the elected members of Council for the session were:

President	Professor G S Boulton
Vice-presidents	Mr D H Land and Dr E N K Clarkson
Secretary	Dr R F Cheeney
Treasurer	Dr D Gould
Assistant Secretary	Dr C G Smith
Membership Secretary	Mr J W Merritt
Excursion Secretary	Mr J K Oakley
Meeting Secretary	Mr J A Fairhurst
Librarian	Dr W B Heptonstall
Publications Sales Officer	Mrs C M Taylor
Edinburgh Geologist and Proceedings Editor	Mr C A Auton
Ordinary Members	Mr R D Gillies, Dr A J Highton, Miss A H Hope, Miss H McHaffie, Mr A G Sutherland and Dr J R Underhill
SWT representative, co-opted	Mr M C Smith

Office-bearers not on Council

Trustees	Professor G Y Craig, FRSE, Dr C D Waterston, FRSE and Dr P McL D Duff, FRSE
Scientific editors	Dr B C Lintern, Dr D Stephenson and Dr R F Cheeney
Auditor	Mrs M McLeod

GENERAL NOTES

Dr Douglas Grant As a token of appreciation for his forty years service to the Society as editor and in many other ways, Dr Grant was presented with the scroll of Honorary Fellowship and was given a clock set in Strathpeffer gneiss.

Edinburgh Science Festival The walks of Holyrood Park were repeated and attracted over eighty participants.

RIGS Norman Butcher and Michael Smith continued to represent the Society on the RIGS working group.

SUMMARY OF ACCOUNTS

Presented below are a summary of the Society's audited accounts for the year ending 30 September 1992.
Notes: The Society owns the following items that are not considered to be realisable assets: a silver snuff box and silver cup presented to Alexander Rose, a specimen cabinet and chair made by Alexander Rose, library of geological books, archive held in the library of the University of Edinburgh and a Hutton manuscript held by the National Museum of Scotland

Report of the Auditor to the members of the Edinburgh Geological Society

I have audited the Accounts in accordance with approved auditing standards. Information supplied by individual Council members has been accepted as correct where independant conformation could not be obtained. The valuation of the Investments is by the Bank of Scotland.

In my opinion, the accounts which have been prepared under the historical convention, give a true and fair view of the state of the Society's affairs at 30 September 1992 and of the net revenue for the year ended on that date

M McLeod C.A.
74 Colinton Road
Edinburgh EH14 1AT
17 November 1993

The full listings of the Society's Accounts are available and open for inspection through the Treasurer.

Statement of Balances at 30 September 1992

	1992		1991	
	£	£	£	£
Fixed Assets				
Investment at market value		61,593		59,767
Current Assets				
Stock of publications	4,619		6,323	
Other stocks	448		503	
Debtors	521		289	
Taxation recoverable	1202		230	
Bank accounts	2,633		5,589	
	9,422		12,934	
Less:				
Creditors due within one year				
Sundry	1,126		582	
Loan (Necker Map)	-		700	
	1,126		1,381	
Net current assets		8,296		11,553
Net assets		69,889		71,320
Representing:				
Funds		69,889		71320

Revenue accounts for the year ending 30 September 1992

	General	*Publ's*	*Clough*	*Mykura*	*Total* 1992	*Total* 1991
INCOME						
Income for investments	2,598	2,072	462	306	5,438	5,465
Bank interest	187	149	33	22	391	1,199
Subscriptions	5,678	-	-	-	5,678	6,069
Tax recoverable on Deeds of covnenant	440	-	-	-	440	423
Sundry	16	-	-	-	16	-
Profit (loss) on sale of publications	-	(1,114)	-	-	(1,114)	419
	8,919	1,107	495	328	10,849	13,575
EXPENDITURE						
Lectures	1043	-	-	-	1,043	1,024
Excursions (net)	881	-	-	-	881	640
Audit fee and expenses	500	-	-	-	500	500
Billets	1,855	-	-	-	1,855	1,580
Bank charges	436	-	-	-	436	432
Stationary, postage, etc...	228	5	-	-	233	370
Insurance	200	-	-	-	200	108
Reception	59	-	-	-	59	63
Scottish Journal of Geology Vol. 27	-	3,577	-	-	3,577	-
Medal and Award	-	-	63	-	63	137
Celebrity lecture	259	-	-	-	259	-
Edinburgh Geologist	84	510	-	-	594	1,292
Additions to library	-	-	-	-	-	179
Leaflet guides	-	-	-	-	-	75
Borders Guide	-	700	-	-	700	345
Grants made	-	-	-	120	120	450
	5545	4792	63	120	10,520	7095
Surplus (defecit) for year	3374	(3,685)	432	208	329	6,480

Erratum

A printing error on page 42 of the previous issue (No. 27) of the Edinburgh Geologist led to some names being omitted.

The six ordinary members of Council should read: Dr P M Dryburgh, Mr R D Gillies, Mrs A F Mykura, Mr H Wright, Dr C G Smith and Dr J Underhill.
Thte trustees were Professor G Y Craig FRSE, Mr DC Craig FRSE, and Dr C D Waterston FRSE.
The scientific editors of the Scottish Journal of Geology were Dr B C Lintern, Dr J D Peacock and Dr D Stephenson.

The Edinburgh Geologist
No. 28 Autumn/Winter 1995

Contents | **Page**

ISSN 0265-7244