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Cover Illustration: A Geological Survey photograph (C595) taken c.1910 showing water spouting from a borehole at Old Catcraig Quarry, Dunbar. The bore starts from the bottom part of the Longcraig Upper Limestone and goes down 425 feet. The geologist is C. T. Clough.

The photograph is reproduced by kind permission of the Assistant Director, Institute of Geological Sciences, Edinburgh.

EDITORIAL COMMENT

A brief comment this time as we have, in the words of a certain television personality, a 'packed programme'. We just wish to confirm that there are no prizes for an alternative caption to the cover photograph although we might consider publishing any attempts. The photo does remind us, however, of an often neglected resource, some important aspects of which are described in this issue.

Contributions for the next issue, Spring 1983, should be in our hands by mid-January. Happy reading.

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BUILDING STONES OF EDINBURGH PROJECT

Prompted by the publication of the Glasgow Society's *Building Stones of Glasgow* booklet, the Society has decided to revive the project on the Building Stones of Edinburgh. I have accordingly been asked to undertake the supervision of the project with a view to eventually producing a publication.

I can report that, although still in the formative stage, the project is now under way. Dr Alex Mackie and myself have started to gather information and we have already enlisted the help of other interested members of the Society.

We envisage the project to take account, not only of the stones used in Edinburgh's buildings (both local and imported), but of the famous sandstone quarries, such as Craigleith, Ravelston, Hailes and Redhall, which supplied the stone. The eventual publication will differ markedly, therefore, from the Glasgow one, in that we will give emphasis to the quarries themselves. We intend, nevertheless, to include an itinerary round Edinburgh's buildings, describing the stone used.

The first step is to make a thorough bibliographic and documentary search and produce a catalogue of records relating to Edinburgh quarries and building stones. We also intend to visit as many quarries as possible and to look at the stone as it appears on Edinburgh's more important buildings.

If any members of the Society can offer information on any aspect of Edinburgh's building stones, Alex Mackie and myself would be very pleased to receive it. We can both be contacted at the meetings, and in addition I may be tracked down at Murchison House.

Richard Gillanders

WATER – A RENEWABLE RESOURCE?

I. B. Harrison[1] and M. P. Henton[2]

A presentation on behalf of the Institution of Geologists at the Fifth Joint Meeting of Geological Societies, Glasgow in September 1982. This paper is reprinted from the *British Geologist*, whose Editor we thank. Eds.

Introduction

The evolution of the British water supply industry over the past century has seen many remarkable technological advances. Dams, earthworks, treatment plants and supply networks became bigger, more sophisticated and more expensive as the demand for water from the domestic and industrial sectors increased. The time is fast approaching, if indeed it is not already here, when the question must be asked "How much is water worth? Must we continue to walk the 'bigger, brighter, better' treadmill or are there other ways to provide and protect a resource which is so crucial to a civilised society?"

The authors of this paper are hydrogeologists whose aims are to develop but yet conserve underground water with particular reference to Scotland. We hope to show in this paper how geologists can help to make our water resources truly renewable.

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Why groundwater?

Most of us are so familiar with the upland impounding reservoir or lake as a water resource that we tend to assume that water has always been supplied in this way. It hasn't of course; most of our towns and cities were located on old fortified sites which contained some form of natural water supply – sometimes a stream but usually a spring or a dug well. Very often the development of towns depended on the availability of water and the widening search for resources brought the requirement for civil engineering. In Edinburgh, for example, there are several wells in and around the Castle and each of the 'closes' in the old town had its own well. Needless to say, poor sanitation and limited resources in the aquifer necessitated the public supply of clean water from 'the countryside' – Comiston Springs – and thus began the ever increasing need to look further afield culminating with the newly completed Megget reservoir scheme.

Other cities too, found that importing water from upland gathering grounds was the only way to overcome pollution of local groundwater resources – Glasgow, Liverpool, Manchester and Birmingham come to mind in that respect. But the wheel is beginning to turn. More and more water supply authorities are recognising that the capital cost of building dams and their supply and water treatment works is beyond their means. Some of the schemes recently completed were built on assumptions of population and industrial growth which have been proved totally false.

It is in this context that we need to look at groundwater use today. Although some 30% of bulk supplies in England and Wales are from underground sources, the figure in Scotland is less than 10%. In recent years, however, water supply authorities have become more aware of the potential for 'conjunctive use' of groundwater and surfacewater during the summer when reservoir and river yields are low. Very often, rivers are used as 'pipelines' to transport groundwater from the abstraction area to a demand zone, often using existing intake equipment. Large schemes of this type have been implemented by Thames, Severn-Trent, Anglian and North-West Water Authorities in England and most of the other authorities have similar, though smaller, schemes planned or in operation. This type of groundwater use, which sometimes involves deliberate depletion of the aquifer in expectation of winter recharge, needs very careful management. Usually, the aquifer is 'modelled' by digital techniques so that predictions of aquifer response can be made for specific abstraction and meteorological conditions. The real point of all this activity is that to provide a similar quantity and quality of water from conventional resources at that time of the year would be inordinately expensive and totally unjustified.

A major groundwater scheme providing 10–20 million gallons per day would probably cost about 5% of an equivalent conventional scheme (assuming a freely yielding aquifer is available) with consequent 'knock-on' savings in loan charges. Then why doesn't everyone use groundwater? Partly because 'freely yielding' aquifers are by no means always available but also because there is a great deal of vested interest in maintaining the *status quo.* Groundwater development is quick, cheap and simple so consultants, contractors and water authority staff would all lose out. When did you last see the Queen opening a borehole?

Many authorities, especially here in Scotland, have realised that groundwater can offer solutions to some of their problems. Although we do not have aquifers on a regional scale, such as the Chalk or Triassic Sandstone in England, there are nonetheless areas where groundwater can play a major role in future supply development. These include the Dumfries, Lochmaben and Mauchline basins (Permian), Central Fife (Upper Devonian) and the Moray coast (Permian). In other areas smaller resources are well worth developing, especially for seasonal demands or for rapid industrial development.

The renewable resource?

In the literal sense, of course, the hydrological cycle ensures that all water is a renewable resource, but groundwater is renewable on its own account in several distinct ways. Groundwater contributes the 'baseflow' of all streams. This is that portion of flow left after discounting surface run-off; the layman may imagine that all the water in a stream is recent rainfall but this is not so. Virtually every stream receives a baseflow contribution, varying from less than 5% in a poorly permeable catchment to over 80% in catchments on highly permeable aquifers such as Chalk. By abstracting groundwater we 'short circuit' the natural flow regime from recharge zone to baseflow discharge. The volume abstracted is effectively renewed by increased infiltration or decreased discharge (or both) but provided that natural recharge capabilities are not exceeded groundwater continues to be abstractable at virtually constant quality and quantity over many years.

Occasionally, abstraction consistently exceeds demand with the result that water levels and yields decrease and water quality often deteriorates. Merely reducing the pumping rate may not be a total solution if there is no other source of potable supply. In certain cases it has been possible to reinvigorate the aquifer by artificially recharging relatively poor quality water (e.g. untreated river water) and abstracting and recharging groundwater on the same site. Such a case might be a factory using groundwater for cooling or processing where there was minimal quality change.

Groundwater is also valuable because of its inherent thermal stability. This means that it can be used as a heat source for low temperature heat pumps. A heat pump is essentially a refrigerator working in reverse to produce heat by cooling a source fluid. Groundwater, even a metre or two below ground surface, maintains a remarkably constant temperature. Seasonal fluctuations of $\pm$ 2^{o}C about a mean of 10^{o}C are common. A typical heat pump, using a flow of 201/min (5 gal/min) will produce a net 5 kW of heat (as warm air at about 33^{o}C or water at 43^{o}C) for an input of about 2 kW electricity, lowering the groundwater temperature by about 3^{o}C. Heat pumps are commonplace in the USA and some European countries but are relatively scarce in the UK. They have a great potential for increasing heating efficiency but yet are pollution free and use groundwater as a renewable resource because it is unchanged chemically and so can be reinjected to the aquifer.

True geothermal energy, using groundwater at elevated temperatures from deep boreholes, has yet to be demonstrated as a viable proposition in the UK. Experiments being carried out at Southampton and in Cornwall look quite promising, but there is little evidence of geothermal energy being available on a nationwide scale. On the other hand, by injecting hot water, such as industrial power station cooling effluent, into shallow aquifers, much of the heat could be reclaimed at a later date merely by pumping the water out again. In this way, the groundwater regime can make energy renewable at minimal cost.

Groundwater pollution

If groundwater is to be exploited to the full as a valuable and renewable resource, it must be kept clean and wholesome. The difficulty with groundwater as opposed to surface water is that once it becomes contaminated it is very difficult to remove the pollutants and return the groundwater to a potable state. In the case of severe pollution, it usually ends up with the particular aquifer in question, or a specific part of it, being written off as a resource. This contrasts with, say, a river abstraction point suffering the effects of a toxic spillage or discharge upstream. The abstraction point will have to be shut down for a day or two until the pollutants have been flushed through the system but once the last traces have passed downstream abstraction can recommence. The same applies to surface water reservoirs holding water for potable supply.

On the whole groundwater can be considered slightly less susceptible to pollution than surface waters but the chief property that contributes to its vulnerability is the slow rate of movement of water through the host strata, contrary to what happens in a river or even in a reservoir where there is an element of storage, the movements of pollutants within an aquifer can be measured in terms of years, not days. It will therefore be apparent that it is imperative to protect groundwater in aquifers that are currently being used or even in those that will not be used for the foreseeable future.

Sources of pollution

There are many contaminants that can affect groundwater to differing degrees. Some arise as point sources of pollution such as chemical spillage, landfill sites or even cemeteries whilst others are of non-point origin, for example the general increase in nitrate concentrations in some UK groundwaters due to the increasing use of nitrogenous agricultural fertilisers.

A Point sources

1. Landfill sites. When waste from industrial, commercial and domestic properties is disposed of in a quarry or other type of site it is known as a landfill. The science of landfill has evolved rapidly over the last ten years and there is now a better understanding of how it works and how to achieve the objective of minimal environmental disruption. The main problem at any landfill site is the disposal of leachate, a highly polluting liquor that is the result of rainfall or other water moving through decomposing refuse and dissolving out the highly soluble organic breakdown products which for domestic refuse are chiefly carboxylic acids and ammonia. In high rainfall areas the quantities can be transported into the groundwater. A lot of research has been carried out recently into the effects of the more toxic and hazardous pollutants from landfills on groundwaters and one of the general conclusions drawn from the work is that the effects of such contaminants are generally fairly localised.

Nevertheless, if a landfill were sited within the radius of influence of a borehole abstracting potable water, then it would be quite possible for contaminants to be drawn into the abstracted water. It is important to ensure that landfills are situated away from water abstraction areas or from aquifers that might be developed in the future.

2. Chemical spillage. On any site where chemicals are handled, refined, processed or stored it is quite likely that spillages will occur, usually in small quantities over a length of time. One specific product that causes more pollution problems than is often realised

is petroleum. Sometimes slight tank leakage builds up over the years into a sizeable volume of petrol or diesel fuel. The carelessness that causes other spillage can be seen at the back of many vehicle operators' premises or on construction sites where fuel escapes and runs unhindered into the subsoil. This again can affect a potable water supply if the petroleum products are drawn into an abstraction borehole. Minute quantities of hydrocarbon products (e.g. 1 ppb of phenol) are detectable by taste in chlorinated public supply water.

3. Direct discharge of wastes to underground strata. This practice is frowned upon by many Water Authorities, River Purification Boards and the National Coal Board although some discharges do still exist in various parts of the country. Usually coal workings are the recipients of wastes such as acid pickling liquor, plating wastes and chemical industry wastes, but any underground void space could be used. The dangers are twofold. Firstly, it is difficult to predict where the wastes will migrate and several incidents have occurred where they have broken out on the surface again. Secondly, and partly related to the first point, is the possible contamination of unpolluted groundwaters which might be used for industrial or potable supply.

B Non-point sources

1. Nitrate pollution. Much has been written and much research carried out into the problem of increased nitrate levels in groundwater in some parts of the UK. The reason for the concern is the undesirability of nitrate concentrations over 11.3 mg/1 (expressed as $NO_3 - N$) in drinking water for human consumption because infants and women in pregnancy are susceptible to a blood disorder known as methaemoglobinaemia. The source of the increased nitrate levels is thought to be agricultural fertilisers but the precise mechanisms that cause the effects are still the subject of intense debate. At the moment most water authorities deal with the high nitrate concentrations by judicious blending of the waters available to them from all sources.

2. Ferruginous and saline waters from mining activities. In coalfields where long term pumping has drawn down water levels substantially, cessation of mining (and hence pumping) allows the levels to rise again as "water table rebound". When groundwater comes into contact with air drawn into the old workings, its oxidation potential changes and it attacks iron sulphide minerals present in the strata. The reaction allows iron to enter solution in the ferrous state and sulphuric acid forms. If water table rebound

allows this water to be discharged via old shafts, adits, or fissured outcrops, the mine water takes up atmospheric oxygen which leads to iron precipitation as the insoluble ferric hydroxide, an unsightly orange-coloured blanket, on the stream bed and as particulate matter in fish gills or on aquatic plant life. The devastating effects of this type of pollution have become more and more apparent recently, especially in Scotland, and there appears to be very little that can be done to prevent it. These ferruginous waters can also cause a diminution in water quality if they migrate downwards to, for example, a sandstone aquifer that is being used for industrial purposes. A more unusual and interesting case is that of the Kent coalfield where saline water is pumped to the surface from the concealed Coal Measures underneath the Jurassic and Cretaceous strata. This saline water has been discharged into streams or to ponds overlying the Chalk since the turn of the century and has resulted in widespread contamination of the Chalk aquifer. In recent years direct pipelines to the sea have been built but most of the damage has been done and it will take many years to rehabilitate the aquifer.

3.Saline intrusion. Groundwater abstraction in certain coastal areas has lowered water tables to such an extent that intrusion of highly saline water has occurred. In the UK, the Thames and Mersey estuaries are particularly badly affected and there is evidence of intrusion in other areas such as Hull and Grimsby. Rehabilitation of affected aquifers is difficult and lengthy. Not only must the pumping rate be reduced – implying development of other water sources – but some form of positive recharge is sometimes necessary. In California, treated sewage water has been injected to form a 'barrier' of fresh water between the sea and inland abstraction zones. Again water is being used as a renewable resource, but one which requires careful management if it is to carry out all the roles which are demanded of it.

Conclusion

In this paper we have tried to illustrate the scope for groundwater use within the UK and the dangers that exist for pollution of this valuable resource. Conservation of groundwater resources requires effort not only on the part of existing users but also by those whose actions could unwittingly derogate the quality or quantity available for use. Water is the ultimate renewable resource but we have a duty to use it wisely not only for the benefit of present generations but also as custodians for those to come.

Acknowledgements

The views expressed in this paper are those of the authors and do not necessarily represent those of their respective employers. The paper is published with the permission of the Director, Institute of Geological Sciences (NERC) and of the River Inspector, Forth River Purification Board.

Bibliography

A bibliography on groundwater evaluation and quality, hydrogeolocical maps, heat pumps and geothermal energy is presented with this article in *British Geologist*, Vol. 8, No. 4.

Sources of literature on hydrogeological research

Hydrogeological research is published in journals such as *Groundwater, Journal of Hydrology, Water Resources Research, Water Services* and in the journals of (*inter alia*) the Geological Society, the Institution of Water Engineers and Scientists and the Institution of Civil Engineers. Short articles have also appeared in *British Geologist*, the magazine of the Institution of Geologists. The main research organisations, the Institute of Geological Sciences and the Water Research Centre, have their own research report series which provide data on recent research and development in many aspects of hydrogeology.

HYDROCARBON EXPLORATION IN THE NORTH SEA

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The history of exploration for oil and gas in the North Sea can be divided into four distinct phases, each of which was initiated by one significant oil or gas discovery. Once it has been established that hydrocarbons occur in a particular geological setting (known as a 'play' in oil company jargon) then other similar prospects are drilled. This usually leads to an initial upsurge in activity followed by a slow decline as the new idea is worked out.

Phase 1. The Southern Permian Play.

The initial interest of oil companies in the North Sea area was as a direct result of the Groningen gas field discovery in the Netherlands in

UK NORTH SEA - MAIN FIELDS

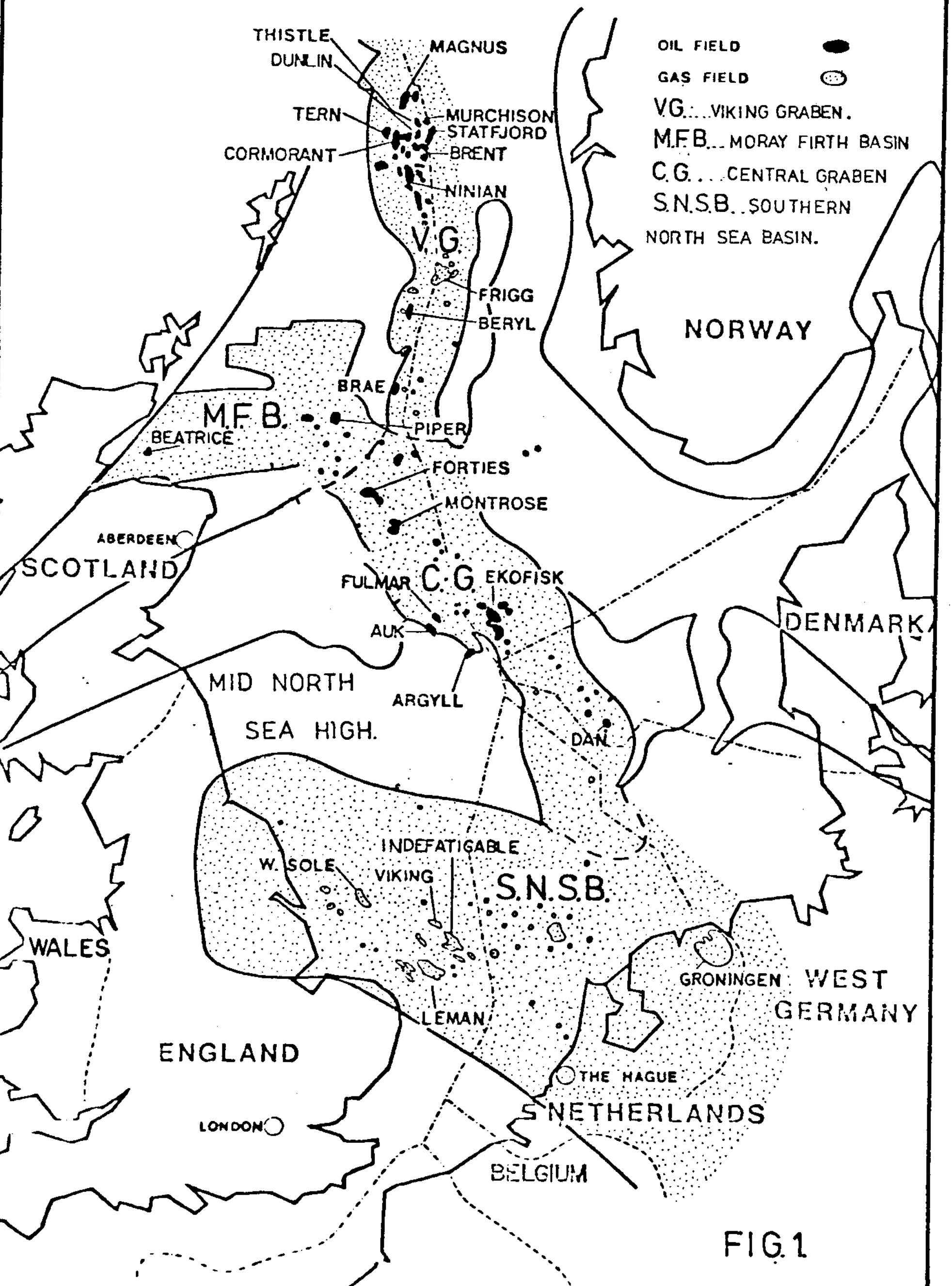

FIG.1

1959 (Fig.1). The Groningen find was huge, even by global standards and the understanding of its origin ensured that a major exploration campaign would follow in the adjacent offshore areas. The gas was generated from Upper Carboniferous Coal Measures, from where it migrated into the overlying Lower Permian (Böthegende) dune sands. The trap was provided by fault blocks beneath a cover of Upper Permian (Zechstein) evaporites (Fig.2). Consideration of the onshore geology of eastern England, the Netherlands and northern Germany suggested that the same critical combination of source, reservoir and seal would be present beneath the southern North Sea. The seismic techniques of the early sixties were sufficient to identify the major structures and by 1965 most of the UK's big offshore gas fields had been discovered. Two major problems, however, were encountered: one geological and one geophysical. The geophysical problem was caused by the variable thickness of the overlying salt. The velocity of sound in salt is, usually, significantly higher than in the surrounding sediments. The result of this on seismic sections is that reflections beneath salt swells are artificially lifted (see Fig.2). The pull up effect of salt can be calculated but not always accurately. As a result of this a number of unsuccessful boreholes were drilled on 'false highs'. The geological problem was concerned with the quality of the reservoir rocks. It was quickly established that the reservoir lithologies were contained within an east–west trending belt of dune sandstones. However, within this belt the reservoir quality was disappointing where the sandstones were thickest. Detailed analysis showed that this area of the dune belt had suffered deep burial in the Mesozoic with attendant porosity destruction by the chemical processes that go on at great depth. However, these set-backs apart the development of the southern gas play was a very successful one.

Phase 2. The northern Cretaceous and Tertiary Plays.

The southern Permian basin is separated from the northern North Sea basins by the oil barren Mid-North Sea High. The northern North Sea area differs from the southern Permian basin in that it is comprised of three intersecting fault-bound basins (Fig.1). In the southern North Sea water depths are relatively shallow allowing the use of drilling rigs which stand on the sea bed (jack-up rigs). The greater water depths of the northern North Sea necessitated the use of floating drilling rigs (semi-submersibles). These together with the more hostile conditions in the northern North Sea made exploration in this area more difficult. The discovery of the billion barrel Ekofisk field in 1969, however, was precisely what was needed to encourage exploration in this area. Located on a relatively simple anticline it proved that the sediment fill of

THE SOUTHERN NORTH SEA GAS PLAY

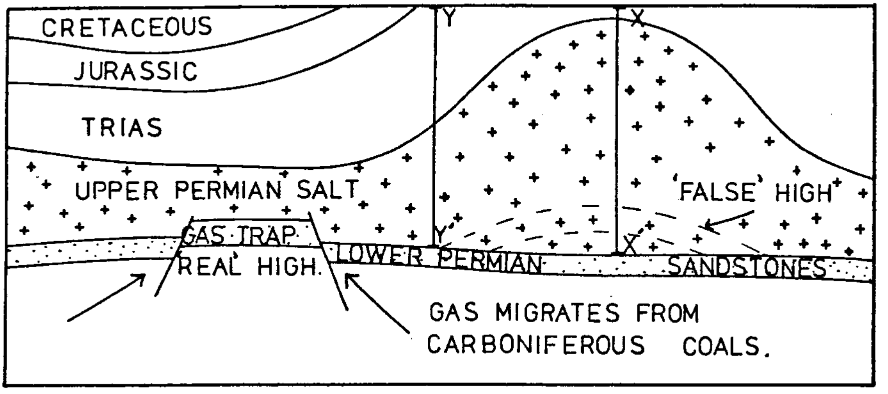

FIG 2. THE VELOCITY OF SALT IS SUBSTANTIALLY GREATER THAN THAT OF THE SURROUNDING ROCKS. CONSEQUENTLY SOUND TAKES LESS TIME TO TRAVEL BETWEEN X - X' THAN IT DOES BETWEEN Y - Y'. THIS CREATES A 'PULL UP' OR 'FALSE HIGH' ON THE SEISMIC SECTION.

THE MIDDLE JURASSIC FAULT BLOCK PLAY

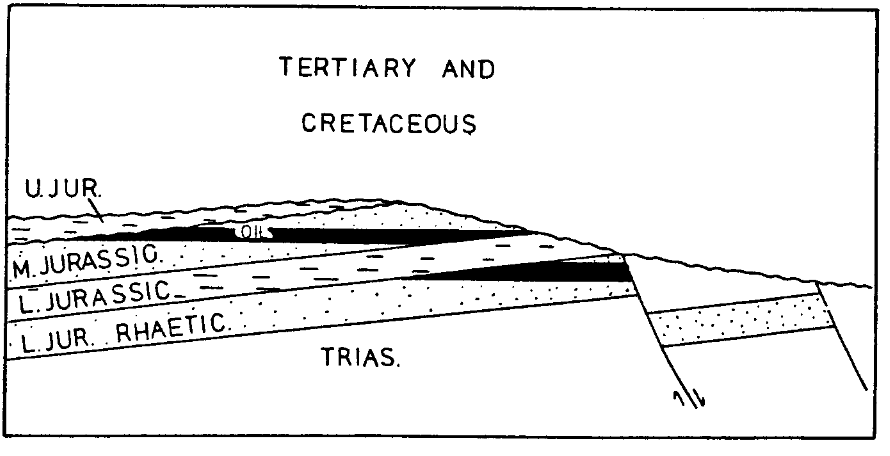

FIG 3. OIL MIGRATES FROM DEEPER PARTS OF THE GRABEN AND IS TRAPPED IN TILTED FAULT BLOCKS TRUNCATED BY A BASE CRETACEOUS UNCONFORMITY. ALTHOUGH THE MAIN RESERVOIR IS IN THE MIDDLE JURASSIC SANDSTONES, OIL MAY ALSO BE TRAPPED IN THE LOWER JURASSIC.

THIS IS THE MOST SUCCESSFUL TYPE OF PLAY IN THE NORTH SEA.

the graben was capable of generating significant quantities of oil. The following year another simple-looking high was drilled and resulted in the discovery of the giant Forties field. Structural simplicity, however, does not mean that the development of the oil accumulation itself is going to be simple. At Ekofisk the oil is produced from the Upper Cretaceous Chalk. This is most uncommon as chalk usually has very low permeabilities (ie it does not allow fluids to pass easily through it). In the Ekofisk case, however, abnormally high pressures created as the chalk was buried caused intense fracturing within the reservoir so increasing the permeability. Producing oil from reservoirs which are under high internal pressure (known as 'overpressured') is a hazardous business. This fact was catastrophically underlined by the Ekofisk 'blow out' of 1977.

The reservoir of the Forties field is comprised of a series of sand bodies interbedded with claystone. This means that some parts of the reservoir are isolated from other sections by impermeable barriers. The development of such a field is obviously more complex than that of a continuously connected sheet sand. In all, 108 wells will probably be needed to develop this field.

Phase 3. The Middle Jurasic Fault Block Play.

During the late sixties and early seventies the techniques of acquiring and processing seismic data were being revolutionised. Principally this involved the development of digital recording and processing techniques. The recording of sound waves as a series of numbers rather than in continuous wave form, allowed much greater use of computer processing. The improvement to the 'sound picture' of the earth that is displayed on seismic sections was dramatic. It meant reflections could be seen more clearly and at greater depths.

In the North Sea the improvement in seismic data was important in the recognition of prospective structures beneath the thick Tertiary/Cretaceous sequence. The discovery of the Brent field in the Viking Graben in 1971 was located on one of these sub-Cretaceous structures and opened up a major new play. The trap is created by rotated fault blocks which are truncated by a late-Jurassic unconformity (Fig.3). The reservoir rocks are Middle Jurassic sandstones, sealed by overlying Kimmeridge Clay or Lower Cretaceous claystones. The oil in these structures was mostly generated from Kimmeridge clay sequences located in offstructure areas. This proved that lateral, as well as vertical, oil migration had occurred. This Middle Jurassic fault block play has turned out to be one of the most successful in the North Sea. The extent of this play is primarily governed by the distribution of the

Middle Jurassic sandstones. These sands were deposited as part of a delta complex which occupied the northern part of the Viking Graben. An illustration of how successful this play has been is given by the dense cluster of oil fields which have been found within the Viking Graben (Fig.1).

Phase 4. Further Developments.

Since the time of the major developments referred to above, hydrocarbons have been found in all three of the northern North Sea grabens in a variety of geological settings.

In 1972 the potential of the Outer Moray Firth was proved by the discovery of the Piper Field. Structurally similar to those of the Brent province the oil in this field is located in Upper Jurassic (Oxfordian) sandstones. Stratigraphically, the oldest reservoir rocks are the Devonian sandstones of the Buchan field (discovered 1975). The discovery of the Brae field (also in 1975) was especially significant. The reservoir in this case is Upper Jurassic sandstones and conglomerates located on the downthrown side of major faults (Fig.4). This new play was quickly developed by Phillips Petroleum in their discovery of the adjacent Thelma (1976), Toni (1977) and Tiffany (1979) fields. The discovery of the Fulmar field in 1975/6 also established an Upper Jurassic sandstone play in the Central Graben. The Beatrice find in 1976 is closest yet to the Scottish coast. This was significant in proving that the Kimmeridge Clay source rocks of the Inner Moray Firth had been buried deeply enough to generate hydrocarbons.

THE BRAE TYPE PLAY

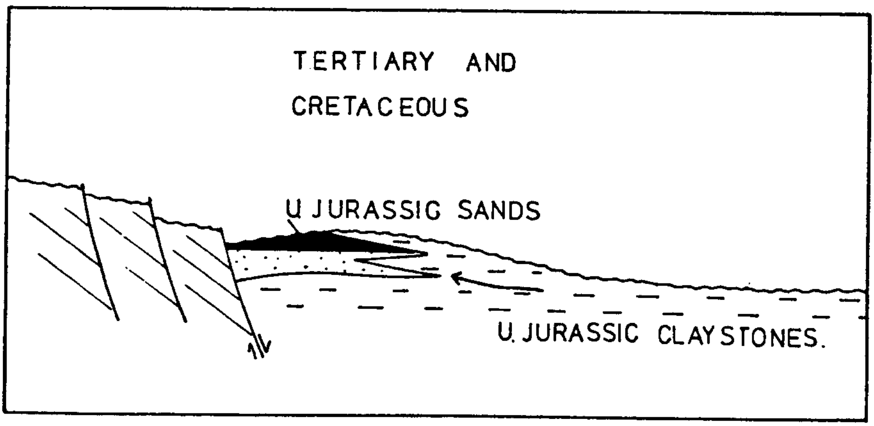

FIG 4. THIS PLAY IS UNUSUAL AS THE TRAP OCCURS ON THE DOWNTHROWN SIDE OF FAULTS. THE ROCKS ON THE UPTHROWN SIDE ARE IMPERMEABLE AND HAVE PREVENTED FURTHER UP DIP MIGRATION OF THE OIL.

Future Developments

The largest oil and gas fields have now been found. Smaller accumulations await discovery but this is partly dependent upon the economics of development. For this reason the recent rise in gas prices has renewed interest in the smaller structures of the southern gas basin. Improved seismic processing techniques may also reveal some of the more subtle types of trap. In particular the stratigraphic trap (ie those due to a lithological change rather than a structural feature) may become more sought after. Better drilling technology is permitting wells to be drilled deeper. In areas such as the Central Graben these deep prospects may reveal significant gas discoveries. So although we are scraping the bottom of the barrel, it may take some time to complete the process.

NECKER ON ARRAN

A translation by Lizzie Davenport

Louis Albert Necker visited Arran in May 1807 at the age of 21. The visit is described in Part II of his *Voyage en Écosse et aux Îles Hebrides* published in 1821; the following translation is a paraphrase and summary of chapters 1 and 2 of this account.

Necker says disingenuously that he has heard both sides in the Wernerian – Huttonian debate speak highly of Arran as a place which contains a large number of different formations, widely dispersed in other localities but here brought together in a small area as if they had been placed there to be studied. But even matters of fact and observation seem to be contested by partisans in the great debate, and he has decided to study the formations impartially without aligning himself to any intellectual system until he has verified every observation on which it is based.

6 May Necker and his companion Mr S** arrive in Saltcoats to take ship for Arran (Ardrossan is only under construction though it looks unlikely that the jetty will withstand the huge waves driven off the Irish sea from the south). Unfortunately they are penned up for three days by a strong west wind. Not a place to write home about, Saltcoats has salt and soap factories with steam powered machinery. Mr C. a local mine master shows them something of the geology of the area round Ardrossan – red sandstone beds striking from E to W and dipping about 30^{o} to the north, cut by dykes of basalt or greenstone which are frequently weathered out leaving regular channels which look like man-made canals. Necker is puzzled by circular white blotches in the sandstone which look as if they have formed round a nucleus of shiny black material – could this be due, he wonders to ferric oxide reverting to the metallic state?

9 May The wind allows them to depart but no sooner are they out from land than they are becalmed – for seven hours they work the oars, let the sails out at the slightest puff of wind. Saltcoats remains as large as ever and they make no progress. They look at the view. Suddenly the sea changes and lashes them furiously for their murmurings against it when calm. They reach Arran too quickly for comfort and drop anchor under Brodick castle and have to go ashore in a small open boat. The father of one of their fellow passengers is waiting on the shore: he is the factor of the Duke of Hamilton and invites them to dinner in the Castle.

Caledonia at her sternest and wildest is Necker's impression of Arran, barren, desolate and rocky. The only sign of human contact is some wretched hovels scattered on the edge of the shore, thatched and virtually indistinguishable from the heather they squat on. Necker looks round anxiously for Brodick, where they are supposed to have come ashore – this is it. If this is the metropolis, he asks himself, what is the rest of it like? Things improve when they reach the local inn.

10 May The Sabbath – no rocks today as it would be sacrilege in any part of Scotland to be seen with a hammer in one's hand. So off to Church at Lamlash with Mr Lamont, their host of the previous evening. Today they can see all of Goatfield, the highest summit in Arran. They turn off through the hills, up a winding valley, over terrain of peat and heather. There are tiny sheep with half their wool hanging off and very small cows with no horns. Then they see Lamlash – a much pleasanter prospect than Brodick, with its island in the middle of the bay – spiky rocks of columnar basalt with caves which have been compared with those of Staffa, and St Molios hermit house. Lamlash village is a row of decent stone built houses, unlike Brodick, with slate roofs. The Church is full, and they hear two sermons, one in English and one in Gaelic. Necker is moved by the simplicity of the service and the devotion of the congregation.

11 May Traverse of the area between Brodick and Lamlash bays, over densely growing heather, to Corygillis. They climb Dundou, which ends in a cone of regularly shaped prisms, and these are not of basalt. Dundou takes its name, says Necker, from the dark coloured vegetation at its summit; a neighbouring hill, Dunfion, smooth hill, is named from the smooth turf at the summit. The view is tremendous – Brodick Bay, bristling with sharply rising mountain peaks and granite ridges, and Lamlash with its gentle slopes and cultivated fields. In the north, Bute and Combray rise from the bosom of the waves. The geology is as good as the view – thick beds of handsome pitchstone, a superb tone of green, shining like glass or enamel and reflecting the sun like polished metal. More eroded dykes like those at Saltcoats but much more spectacular, some are half a mile long and sixty foot high. They see lots of birds, herons, gulls, oyster catchers which are not in the least afraid of them. Necker and S** nearly come to grief in the River Brodick – strong currents, waist high water, and quicksands, which they only find out about when they get to the other side – future travellers be warned, says Necker; avoid sands at the mouths of rivers unless you have a local guide.

12 May Rain – so the departure for Glen Cloy is delayed. They get lost on the outskirts of Brodick and end up in Glen Sherrig; the climb up between the two valleys gives them a superb view of breakers booming and foaming on the shore. Glen Cloy must be the most desolate and empty of all the gulleys in Arran: on either side, high broken slopes covered with heather; rocky naked summits; peat bogs under the heather; the only sounds the moaning of wind and rushing torrents; the only sign of life an occasional grouse. Necker is gripped by angst – the sky is overcast, his sense of desolation feels like physical pain, though this may be due to the extreme cold and damp which penetrates their very marrow. But on the way down, they see some interesting geology and admire the small country house at Kilmichael.

13 May Still dark and overcast so they don't climb Goatfield but go to the north of the island, taking the coast road. They see some seals and one of them looks like a bulldog, says Necker, though he can only see its head poking out of the water. They pass wretched houses which belong to poor crofters trying to eke out a living on unpromising soil, but there are some well built houses at Currie – the property of the well-to-do in Ayrshire, who come to Arran for sea bathing and fresh air. Currie is the port for a flourishing limestone industry. They soon leave this pleasant terrain for Glen Sannock, a gloomy place, and see the Cock of Arran (it is supposed to look like a Cock, says Necker) which is a landmark for shipping in the area. The mountains are harsh, severe, the whole place inspires horror mixed with awe. The place is covered with heather, like everywhere else in Arran, though it has some stunted birch trees. Glen Sannock divides into three as you go inland, and there are the usual wretched hamlets at the entrance to each glen. They follow the King's Road up the middle glen and by sunset the sky has cleared: there is a superb view from the ridge, Cantyre, Jura, the Hebrides and Loch Ranza. They intend to spend the night at the inn at Loch Ranza and have been warned about the innkeeper. The man is a character, with a taste for geology acquired goodness knows where; he is a versifier, a musician, a composer no less, and still finds time to work the farm and the fishing. The outside of the house looks promising – the inside is a disaster, dirty and chaotic. Their room turns out to be bedroom and public bar, huge holes in the floor, half the windows broken, icy draughts in every corner. Here sits the host, Mr Cowie, busily downing a bottle of whisky with the local doctor. They had met the doctor at Brodick, and he had told Cowie about them: the latter leaps to his feet, radiating enthusiasm and asks to see the rock

specimens; and launches into a geological dissertation without thinking of even offering fire or food. The house is devoid of comforts – someone would have to go a good distance for peat. An old woman tries to treat them with the courtesy guests deserve – and goes through an incredible performance coming and going on the stairs, talking away, and bringing them nothing. The noise is appalling; no amount of effort can get them anything they want; and finally they resort to asking Cowie to show them what is of geological interest in the area. He says he has to mend his plough first. Finally they set off . . . Though night is on the way when they get back there is still no sign of creature comforts, not even food. Though they do see Cowie casting his line in the loch – he catches some flounders for supper. They then hear their host tuning his fiddle; he is obviously a cultivated man and they ask for a recital; he hastily obliges with as many Scotch tunes, merry and sad, as they can take. He plays with spirit but is nonchalant about hitting the right note. Soon he insists that they see some highland dancing and calls his daughters in (they aren't bad looking though barefoot like most women in Arran). They start to dance with their brother and the guide, who shows great dexterity and great natural grace; Necker can't say the same of the other participants, though Cowie insists that his daughters have had lessons. Necker and Mr S** ply Cowie with whisky, and he scratches on his fiddle, stamps his foot, shouts and makes a horrible din. The noise is eventually more than they can stand and they quit the company. The mattresses laid out for them are appalling – only someone who had just passed this evening as they have could sleep on them.

14 May Snow on the tops of the mountains – they decide to visit Tornideon. Cowie insists in coming along and they are treated to a fusillade of verses before they have scarcely left the house – the mountains, the rocks, nature are the subjects. His germinal talent, says Necker, will need cultivaltion to come to anything. They examine veins of granite in the rocks, and Cowie gives his views on the Wernerian–Huttonian controversy. It is raining and they have seven hours' walk to the next inn. There is no hope of shelter as the locals think they are the Customs and Excise, and flee before them barring their doors. They stumble onto a cache of forty jars of whisky in a cave with old blunderbusses tacked outside. More difficulties with rivers – the Irsa water and the Machry water: you have to jump from granite block to granite block and these are covered with rushing water and Mr S** falls in. Then a treacherous bog and at last they reach Shiskin, where there is a reasonable inn in

in a hunting lodge of the Duke of Hamilton. They are soaked – with the rain and the constant falling into bogs and rivers – and dog-tired. But in Shiskin there is a famous piper and Necker wants to hear the instrument on its home ground – the Highlands. So the guide is sent to bring this Orpheus of the North, a long thin man who sits himself down in a corner, bagpipe under his arm. He waits for the signal, they give it, he blows into the bag and sounds come out which would deafen the most intrepid afficionado of this appalling instrument: he is tuning up. Then they have pibrochs, laments, reels – everyone in the inn rushes in. The pipe makes such a noise that you can't hear yourself talk; you can't even hear a poor drunk who is battering the door in and wants to join the party. The wild dancing, the virtuoso performance of our guide, the piper's long face as he sits in the corner – grotesque!

15 May The piper of Shiskin insists on leading them to the King's Cave. He marches in front playing martial music, bringing everyone out of their hovels to see what is going on. They reach Drumodoon and admire the promontory, a long range of prismatic columnar rock of considerable height. The King's Cave is one of a series in sandstone rocks hollowed out by the sea – the biggest contains crudely worked sculptures, a cross, a praying figure, which Necker thinks relate to St Molios rather than Fingal as the locals believe. They go back to Shiskin and make their way eastwards to Brodick. Necker comments on the Druid circles and Alpine topography, but he has hurt his foot; walking is slow; Glen Sherrig is long nasty and slippery; they have to cross the River Brodick again . . .

16 May Necker stays in his room as his leg is now very sore, and puts the specimens in order. Mr S** goes to Glen Rosa.

17 May Only one day to go. But it is Sunday and they must not show signs of activity; so they box up the minerals. Necker feels that they cannot leave Arran without scaling Goatfield, so they set off at four o'clock next morning. The quickest way is to go north through the grounds of Brodick Castle. Soon they have passed the vegetation line and are traversing the rocky plateau. The summit is a bare, arid pyramid of granite – a painful climb says Necker. And they cannot see anything at the top as it is cloudbound. There is an icy snell wind and they are about to make their descent when the mist suddenly clears. They can see Brodick and Lamlash bays, Glen Rosa, Glen Sannock, Bute, Combray, Ayrshire, Renfrewshire, the Irish Sea, Ailsa Craig; the vista to the west is hidden by cloud but they can see the mountains of Argyleshire to the north and Loch Fyne.

As Necker says, it is very rare to see everything, for clouds in Arran will always rob the spectator of some part of the view.

Further reading:

Necker, L. A.: 'Minéralogie de l'Île d'Arran' in *Voyage en Écosse et aux Îles Hébrides*, Part II, chapter 4, Paris 1821.

Necker, L. A.: Documents sur les Dykes de Trap d'une partie de L'Île d' Arran in *Transactions of the Royal Society of Edinburgh*, XIV, 1844.

Eyles, V. A.: Louis Albert Necker and his Geological Map of Scotland in *Transactions of the Edinburgh Geological Society*, XIV, part II, 93–127.

Forbes, J. D.: Biographical Account of Professor Louis Albert Necker of Geneva, Honorary Member of the Royal Society of Edinburgh in *Proceedings of the Royal Society of Edinburgh*, V, 1866, 53–76.

And now, especially for those with more recent memories of Arran Mrs Muriel Hogarth presents . . .

ODE TO THE LONG EXCURSIONS

With apologies to MacGonagall

In Edin's Geological Society
One group has gained notoriety.
These are the yins that go for a week
Geological knowledge for to seek.
Mony tak' the week's excursion,
And they don't all come frae the House of Murchison.
Some come frae Museum and University Hall
And some come that ken naething at a'.
So they mak' a motley band,
The envy and pride o' fair Scotland.

They mak' a study o' maps and plans,
And stravaig aboot in wee red vans
They ettle tae be awa' to the hills
To look at rocks, outcrops and sills,
And fissures, cracks and dips and strikes
Anticlines, synclines, moraines and dykes.
Basalt, granite, felspar, whin
Fegs! They ken them, ilka yin!
And ye'll aft see queerly clad apparitions
Hammering awa' in awkward positions!

Ithers tie labels like Christmas tassels
On all yon canty, couthy fossils,
So that the ignorant may ken full right
A Brachiopod frae a Trilobite!
Whiles daft gomerils follow behind
And gawk and gape at these learned minds!

To go in two groups they arena blate,
Yin the Hard lot, the ither Sedate.
The Hard make for the peaks and bens,
The Sedate keep to paths and glens.
The Hard sprauchle on for hours and hours;
The Sedate stop tae admire the flowers.
What are they dots on the far horizon?
That's the Hard lot — it's not surprisin'
While the Sedate stot on their winsome way
Lucky to do a mile a day!

Not for the group thae posh hotels
Wi' schrieching plumbing and reekin' smells,
Faur better in a self-catering house
Arranged by Hogarth and his spouse.
Mountains o' food have arrived in kists
Shairly enough to feed thae geologists.
Ilka yin hae studied Mrs Beeton
So that their food is unco guid for eatin'.
Chicken, chops and mince and stews
Trifles, fruit, all sorts of brews.
Soup and cheese and mony a bean
This constitutes Geological Haute Cuisine!
Then at night in the local pub
They discuss a' their rocks and grub.

Noo anither excursion has come to an end
We hope we've all more geology learned
We hope our leaders are not too wabbit
They've aye been sae gleg and never crabbit.
Rum, Assynt, Mull and Skye
Islay and noo Arran forbye.
And whaur to next's the burning question
We're looking to you for any suggestion.*
I hope you a' feel none the worse
For listening to this little verse.

Lang hae ye listened tae this magnum opus
So here's my toast, and that's tae — US!

*The Billet says the long excursion in '83 is Ardnamurchan. Eds.

IMPRESSIONS OF A GEOLOGICAL JAMBOREE IN GLASGOW

The Fifth Meeting of the Geological Societies of the British Isles was recently held in the friendly city of Glasgow. Although by no means all of the societies participated, nevertheless nearly 700 geologists attended over the three-day period, 23rd–25th September. The symposia were held in the Boyd Orr Building (Glasgow's answer to Edinburgh's Appleton Tower) and the adjacent Geology Department of the University. These were followed by some excursions to exotic places like Girvan, while one was quite mysterious (to see 'Carboniferous facies').

Previous meetings with a roughly three-year interval have been in Sheffield, Swansea and Manchester while the very first coincided with the Centenary Celebrations of the Great Institute of Geology in Edinburgh in 1971. The pattern has evolved of individual societies and organisations arranging their own programme of speakers, each to a set theme. Some of the Geological Society of London's specialist groups also arranged sessions, and it was good to see the participation of the professional body, the Institution of Geologists, with a session on Geology and Conservation.

The result can only be described as highly variable, both in the chosen themes and the quality of the individual presentations. With some 150 talks being given in three days, with up to six being presented at any one time, there was an almost bewildering array for the seeker after knowledge to choose from. Anyone with a wide-ranging interest in what is nowadays referred to as the Earth Sciences stood a pretty good chance of ending up on the Saturday night with a severe bout of mental indigestion and I am not at all sure that the final advertised (geological) film show would have provided the necessary antidote. Indeed, it would be interesting to know if anyone actually survived the course – there are, after all, other things to do in Glasgow on a Saturday night (getting back to Edinburgh is one of them).

As one might have expected, the sessions devoted to aspects of Petroleum Geology seemed to attract the largest, well-suited audiences and there were, indeed, some good presentations with the high standard of of illustrations that we have come to expect gratefully from oil company personnel. Arguably the most stimulating symposium, however, was that mounted by the Metamorphic Studies Group on the role of fluids in metamorphism. At the other end of the scale, the Yorkshire Society's session on the Northumberland Trough did not seem to exactly set the world on fire, while the palaeontologists appeared to get a meagre diet. The presentation of one well-known, North American contributor seemed to me to consist of palaeoverbiage – the best thing the speaker said, right at the end, was 'I guess it's time I shut up'.

There were a number of quite interesting exhibits from which, I find, one can always learn quite a lot. In a sense, however, they suffered from being tucked away in the Geology Department laboratories (where most people did not go) or crammed into the available space by the coats and hats and umbrellas on the ground floor of the Boyd Orr Building (apparently no one ever told the architect that the wind and rain usually comes from the west in this part of Scotland). It was worth taking the lift to the 9th floor to see the Nature Conservancy's stand as well as to admire the view of the surrounding countryside when the sun finally did make it.

For many of the participants, it they were honest, I expect that the highlight of the meeting was to see the inside of the magnificent City Chambers at the Thursday evening reception – especially that wonderful marbled staircase.

Norman E. Butcher