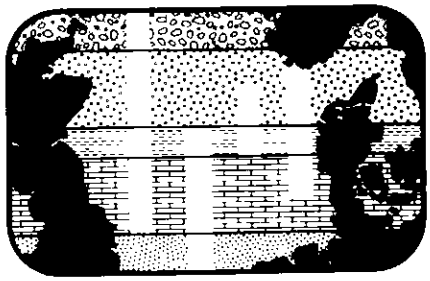
Conference Reports



Geology of the North Sea

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In 1974, the curtains of confidentially parted and the broad outlines of the geology of the North Sea were revealed at the now famous "Bloomsbury Conference". The proceedings were quickly published and immediately became the standard reference for the petroleum geology of the continental shelf of North-West Europe.

Once again, the same theme was adopted and from March 4th to 6th, 1980, 1050 delegates crowded into the lecture theatre at the Royal Lancaster Hotel in London to hear the second installment. While the drama and impact of the first conference could obviously not be repeated, much new data was presented and the suite of papers gave listeners a clear impression of the geological setting, some of the exploration and production problems, and the approaches employed to resolve them.

The writer has had no first-hand experience working in the North-West Europe area and so found some papers interesting which, no doubt, retailed material that was boringly familiar to local explorationists. Rather than give a paper by paper review, this discussion will focus on some of the conference highlights and emphasize those likely to be of interest to Canadian readers. Names in brackets refer to the authors of papers presented and indicate the source of the information or concepts discussed.

The North Sea appears to represent an unsuccessful attempt at sea-floor spreading. Exactly when the crust received this prompting is unclear. There are widespread indications that northern Europe ws affected by Permian extensional tectonics (Zeigler, Dixon), and it is clear that, by Jurassic time, the Viking Graben and its western arm, the Moray Firth basin, had begun to subside (Zeigler). SW-NE Caledonian and E-W Hercynian trends influenced break-up as is testified by the jagged margin of en échelon faults that characterise the northern sector of the Viking Graben and the NE-trending faults in the Moray Firth Basin (Threlfall, Johnson and Dingwall). It appears likely that the Great Glen Fault system underwent sinistral movement in post-Jurassic time, and that it splayed into a fan of shear zones which were finally dissipated in small offsets cutting the western margin of the Viking Graben (Threlfall). Esso believed that widespread strike-slip faulting is present in the Moray Firth Basin, and showed a seismic profile through an upthrust lozenge-shaped wedge reminiscent of Southern Californian wrench-fault structures.

In Jurassic time, there was relatively little vulcanism along the North Sea rifts compared to the vast effusions of lava that have erupted along the similarly-scaled East African rift system (Threlfall). Nevertheless, significant axial crustal thinning has occurred according to the gravity data (Donato and Tully), so that, locally, the Moho is as shallow as 20 kms. No clear picture of the paleothermal evolution or the current heat flow picture was presented although Oxburgh and Andrews-Speed discussed their preliminary assessment of heat flow in the southwestern North Sea based on data from 117 released wells. In that area, the present day heat flow appears to increase towards the axis of the Viking Graben.

North Sea rifting has had extremely fortunate consequences for hydrocarbon entrapment. Middle and Upper Jurassic sand-rich fans cluster along the Viking Graben and within the Moray Firth Basin (Eynon, Hancock and Fisher). These clastic deposits are largely marine and often, locally, very coarse-grained. At Magnus, they are interpreted as turbidites (De'Ath and Schuyleman), at Piper they are believed to be shallow marine deposits (Maher) and, for the Brae area, a depositional model was proposed which involved subaerial coalescing fans prograding out from coast-line fault scarps (Harms and others).

Typically, the jurassic oil fields lie atop horst blocks, which have been tilted and eroded so as to bring the reservoir sands into contact with the overlying Upper Jurassic oil-generating Kimmeridge Clay. Interestingly, kerogen type varies laterally within the Kimmeridge Clay. Over the Viking Graben the sequence is sapropelic and oil-prone, whereas over the adjacent shelf areas, it is herbaceous and would generate waxy oils and gas on maturation (Barnard and Copper). This whole configuration is of great interest when one considers possible prospective situations on the Labrador and Baffin Bay shelves, which also represent passive margins of former rifts. So far, no sapropelic oil-prone source rocks have been reported there, but such sequences could be present and abut clastics generated during early rifting.

Apart from the fractured Chalk reservoirs at Ekofish and Dan (Burton), the other main oil-bearing sequences are Paleocene sandstones. At Forties and Frigg, the reservoirs are interpreted in terms of lobate, partially overlapping turbidite fans fed from the west (Carman and Young, Héritier and others). The Forties oil field now has 58 wells drilled on it, and the Frigg gas field is close behind with 48. As a result, individual turbidite fans can now be defined via log correlation plus production history and the data permit realistic mapping of subfacies. Variable provenance of individual

fans is suggested by sandstone mineralogy (Knox and others).

None of the many basins surrounding the British Isles yet rivals the North Seas as a hydrocarbon province and current indications are that most of them never will, but some interesting accumulations and leads have been discovered. To date, the most spectacular is the 3 to 4 billion barrel deposit of low gravity, possibly biodegraded oil encountered in an Old Red Sandstone clastic wedge onlapping basement atop a faulted horst at the western edge of the West Shetland Basin (Ridd). The field lies in 600 feet of water, is relatively shallow, and covers a large geographic area. Flow rates are sluggish and judged to be sub-economic under all presently conceivable production scenarios. Clearly, this field represents a huge challenge and opportunity, as well as exemplifying a type of accumulation which might be present on Canadian continental shelves.

The Morecambe gas field in the northern Irish Sea offshore of Liverpool and Manchester could hardly be better located. The structure is basically a faulted anticline, 44 square miles in area and contains approximately three trillion cubic feet of gas in Triassic sandstones similar to those found onshore in the Cheshire Basin (Ebbern).

According to Colter and Havard, the main Triassic sandstone reservoir at the Wytch Farm oilfield in Southeast England was found by geochmistry. In 1973, oil was found in the Jurassic Bridport Sand in an E-W trending anticline, which is downfaulted to the south. Adjacent shales were immature according to geochemical criteria and could not have sourced the oil. However, if the Alpine fold to the South is "flattened" and pre-Miocene relationships are restored, there appears to be an adequate hydrocarbon kitchen immediately to the south, where the down-faulted Jurassic sequence is much thicker and has been buried deeper. If these sediments sourced the oil, and if the Triassic Sherwood Sand was developed at Wytch Farm in a trapping configuration as the seismic profiles implied, it was suggested that it also might be oil-bearing. This reasoning led to the drilling of the best British onshore well tested to date. Unfortunately, obtaining permission to drill follow-up wells in the beautiful countryside of southern England is no picnic. Nevertheless, despite ever-increasing reluctance, the environmental lobby in Dorset is gradually permitting the field to be developed!

No hydrocarbons have yet been found in the Western Approaches, and the reasons for the lack of success would appear to be similar to those which have caused large areas of the Grand Banks to be barren. The Mesozoic and Tertiary sequences in these formerly adjacent areas are very similar. The Kimmeridge Clay is absent but Lower Jurassic shales are potential source rocks. In the adjacent Celtic Sea, Aptian-Albian coastal sands, which are approximately correlative with the Grand Banks Eider Unit, contain approximately one trillion cubic feet of gas in the Kinsale Head field, 33 miles off the coast of southeast Ireland. The reservoir beds are relatively shallow and are folded into an elongate anticline which exhibits 47 square miles of closure. Production commenced in 1978.

It was apparent from several papers that palinofacies studies are being used quite widely to aid recognition of sedimentary environments on the N.W. Europe continental shelf (Parry and others; Owen, Hancock and Fisher). It was, however, difficult to determine how definitive these studies were in their own right, or whether they just offered additional excuses for placing rocks in pigeonholes established by other criteria.

Peter Vail gave a most stimulating interpretation of North Sea seismic stratigraphy in terms of Exxon's well-known eustatic time scale and presented an updated version of the Jurassic sea-level curve. Although many authors referred to this approach, the U.K. North Sea explorers did not appear to have applied it over the whole Mesozoic section. On the other hand, the geology of the Norwegian continental shelves to the North, where no wells have yet been drilled, was interpreted with strong emphasis on unconformity bounded sequences (Ronnevik, Jorgensen and Navrestad).

This conference gathered together speakers from industry, universities and national geological surveys and noteworthy highlights were the data compilations presented by the British Institute of Geological Sciences. Using information derived from wells drilled more than five years ago and now "released", Survey geologists presented a series of regional seismic structure maps of the North Sea (Day and others), a subcrop map of the Mid-Mesozoic unconformity (Fyfe and others), Paleocene isopach maps (Knox and others) and maps illustrating post-Carboniferous igneous activity (Dixon and others). All these maps were most stimulating documents, but unfortunately, detailed inferences could not be drawn from them. Like many of their G.S.C. counterparts, no indication of control was given, and it is to be hoped that clear documentation of the nature and extent of the data bases will not be omitted from the final published versions. All in all, though, this was a most worthwhile conference at which a great deal of valuable information was presented. The Proceedings Volume, to be edited by L. V. Illing, should be first-rate.

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