CONFERENCE REPORT

DEEP GEOLOGY OF EASTERN ENGLAND

A Joint General Meeting of the East Midlands Geological Society
and The Yorkshire Geological Society
University of Nottingham, Saturday 15 November, 1986, 11.00–17.00

If the success of new ventures can be measured by their popularity, then this first joint meeting between the two geological societies of the East Midlands and Yorkshire certainly resounded. On a potentially diverting bright and warm autumn Saturday, more than 250 people crammed into the Social Sciences lecture theatre on the Nottingham University campus to learn of the mysteries of the deep. They were entertained by a diverse set of contributions and by some lively discussions, and few could have left without having learnt something new.

The meeting was opened by the President of the EMGS, who pointed out that the idea of a joint meeting had arisen at least two years ago, when it became evident that many members of the YGS were moving into the East Midlands catchment area through the centralisation of the British Geological Survey at Keyworth. Several people are, of course, members of both societies and it had been intended that one of that number, the eminent local geologist Sir Peter Kent, should chair the opening session of the meeting. Sadly, as readers will be aware, Sir Peter died earlier in the year and his absence was marked before the scientific sessions by a minute's silence in his memory. In the event, the two society presidents, Dr. Ian Sutton and Dr. Dennis Smith, took the chair for the morning and afternoon sessions respectively.

Information on the subsurface geology of Eastern England has been gained in two ways: directly, from boreholes, and indirectly, through geophysical surveys. Both types of data received considerable attention in the talks presented, which opened with a general overview by Dr C.J. Evans. He began by emphasising the vast amount of new information that has accrued in recent years from numerous boreholes drilled during exploration for hydrocarbons and from various lines of geophysical investigation (here he incidentally introduced the first pun of the day when he discussed the "explosion" of seismic research). He then showed how gravity traverses revealed the Carboniferous blocks and gulfs originally mapped by Falcon and Kent and noted the presence of some anomalous "lows", particularly that around Newark, which he tentatively explained by a thick sequence of Devonian basinal sediments, but which he conceded may also be due to a granitic intrusion. The alternative interpretations of such anomalies sometimes give rise to heated controversies, as we were to discover later in the day. Dr. Evans then turned to magnetic maps, which were generally less informative, and seismic refraction maps, which revealed something of the eastern England "basement", showing Charnian velocities under much of the East Midlands and Norfolk, with velocities attributed to Ordovician sediments occurring to the South. The seismic method also reveals the presence of intrusive bodies in the basement, and the second part of the talk, presented by Mrs. J.M. Allsop, addressed the nature and history of these intrusions.

Mrs. Allsop first summarised the main groups of igneous rocks, recognising differences between an early phase and a later set, the latter with ages in the range 430–450 Ma, or sometimes considerably younger where there was probably a Hercynian overprint. Representatives of the first are found in the South Leicestershire diorites, and an example of the second is the Mountsorrel granodiorite. Both groups can be recognised by their distinctive magnetic and gravimetric signatures. A third, distinctive set of gravity anomalies is apparent around the Wash and north Norfolk, which suggests the presence of another body or set of bodies. The geophysical characteristics here are closely comparable with those of the Shap and Skiddaw granites in the Lake District and the Weardale and Wensleydale granites in the Pennines, and Mrs. Allsop consequently considered the Wash and adjoining areas to be underlain by a major early Devonian batholith.

Caledonian events were also the theme of the paper by T.C. Pharaoh, R.J. Merriman and P.C. Webb. Dr Pharaoh delivered the talk, which set out to consider the status of the East England Caledonides, for which several models have been proposed in the literature. Geochemical similarities were highlighted between many of the concealed volcanics of eastern England and exposed Caledonian igneous rocks such as the Mountsorrel granodiorite and its associates, suggesting that early Palaeozoic volcanicity was much more widespread than previously realised. The extent of metamorphism was also revealed by illite crystallinity studies and fabric evaluation; zones could be recognised proceeding from diagenetic on the Midland Platform to anchizone in the Eakring area and epizone to the East. Putative boundaries between these zones have a broad NW-SE trend,

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parallel to structures picked out geophysically, and point to the existence of an eastern England Caledonian fold belt, essentially forming a mirror image to the Welsh Caledonides on the opposite side of the Midland Platform. This pattern conforms with that originally suggested by Selwyn Turner in 1949 and bears little resemblance to subsequent plate tectonic models dominated by the closing of the Iapetus Ocean. The structures may relate to the Tornquist line recognised in northern Europe and considered by some to mark the existence of an ancient ocean in this area, closure of this being more significant for the East Midlands than closure of the Iapetus.

Following these contributions on the older underground rocks of the region, attention turned for much of the remainder of the day to the cover of Carboniferous strata. First among the papers on this topic was that of K. Smith and N.J.P. Smith, presented by the former and outlining a tectonic model of Carboniferous basins in eastern England. The large, but largely confidential, data base of well logs and seismic profiles allowed the authors to develop a model of tilted blocks for the production of the Carboniferous troughs. In this hypothesis, faults were activated during late Devonian crustal extension to produce half-graben structures which received Carboniferous sedimentation. The overall development of the Carboniferous basin was related to regional subsidence, but locally sedimentation was controlled by continued activity on growth faults which persisted into the Chadian and Arundian and subsequently diminished. During the Hercynian Orogeny E-W compressive stresses effected basin inversion. The model could be related to mineralisation of the carbonate platform and used to determine the onset of oil generation, which the authors considered to have been in the late Westphalian to late Permian. In discussion, geologists from British Petroleum aired disagreements with the proposed burial history and indicated preference for an interpretation that involved a thick (at least 2 km) Mesozoic overburden and substantial Mesozoic hydrocarbon generation.

More detail of the pattern of Carboniferous sedimentation was given in the last talk of the morning, by A.E. Strank, herself now with British Petroleum. Dr Strank summarised the results of biostratigraphical studies of 128 wells through the Carboniferous sequence of eastern England. From the correlations obtained, largely through micropalaeontological (particularly foraminiferal) biozonation, palaeogeographical and isopach maps could be constructed and areas of reefs, dolomites, evaporites and palaeohighs located. A series of palaeogeographical maps through the Dinantian stages showed the development of the gulfs, of the shelf-margin reef belts and of local unconformities. In the shelf facies, these unconformities increase in magnitude eastwards, where the Dinantian was thinly developed on a belt of highs from Askern to Spital. Three-dimensional computer models of the Dinantian surface could be generated and used in the interpretation of geophysical patterns.

Lunch was followed by a temporary excursion up-column, with G.A. Kirby and P.W. Swallow's account of the structural evolution of Flamborough Head. Dr Kirby, who presented the talk, related surface shatter zones and complex structures to deep-seated structural deformation, which had been investigated by a N-S seismic reflection traverse. The seismic line crossed an E-W fault zone, extending from the Vale of Pickering to Flamborough Head and separating the Cleveland Basin from the Market Weighton axis. Within this disturbed zone, a complex of Triassic, Jurassic and Lower Cretaceous rocks is found, sandwiched between relatively undisturbed Magnesian Limestone and Chalk. This structure was interpreted as having commenced with the development of a graben in the latest Jurassic. The northern margin continued to be active as a southerly-downthrowing listric normal fault into the early Cretaceous, when it exerted significant control on the depositional thickness of the Speeton Clay. Major faulting appears to have ceased prior to the deposition of the Chalk.

The Market Weighton "axis", having been introduced by Dr Kirby, provided the focus of attention of the next two papers. The first, somewhat provocatively entitled "The Market Weighton Carboniferous Trough", was given by N.C. Arveschoug, who advanced the hypothesis that the negative gravity anomaly in this area suggested the presence of a thick sequence of sediments. His evidence was based on the resemblance of the anomaly shape to those of known sedimentary basins and the presence of oil and gas shows in boreholes similar to those found above the Gainsborough Trough and the Widmerpool Gulf. His gravity modelling, taken with seismic data, suggested a total Carboniferous sediment thickness of about 9,000 feet in the centre of the proposed basin, and he noted that the long axis of the anomaly was coincident with the NE-SW trend of faulting in the area, which would be consistent with the development of a graben. An alternative view, that a granitic intrusion was responsible for the anomaly, had been published by Bott, Robinson and Kohnstamm (1978), and M.P. Bott rose to re-assert this interpretation in the second of the two contributions. To him, the shape of the profile of the anomaly suggested a body with outwardly sloping edges (e.g. an intrusion) rather than with inwardly sloping margins (e.g. a sedimentary basin). Also, the relationships between gravity and magnetic anomalies in the Market Weighton region are similar to those found above proven granites, and "shelf areas" within the isogal pattern resemble those associated with the Wensleydale and Weardale intrusions. Professor Bott conceded that it was possible to model a sedimentary basin to account for the gravity anomaly, but calculated that it would need to be of unusual shape and would have to contain an immense thickness (at least 27,000 feet) of sediments. In the lively discussion that ensued, Mr Arveschoug pointed out that recent seismic evidence indicated thickening of Carboniferous sediments in the area and suggested that sedimentary magnetite may be contributing to the magnetic anomaly pattern. Professor Bott, however, felt that the proven thickening was insufficient to explain the gravity anomaly and noted that the magnetic patterns appear to be part of a regional phenomenon, rather than explicable by a local thickening of magnetic sediments. He admitted, however, that whereas on the Alston and Askrigg blocks the

Carboniferous sediments thinned towards the granite anomaly at Market Weighton the Carboniferous thickened over the anomaly. Following contributions from the audience, some kind of compromise seems to have been agreed, with the suggestion that a granite and a sedimentary basin may both be present. Subsequent discussion concentrated on possible mechanisms by which a Carboniferous basin might be developed over a Caledonian granite.

The next speaker, Dr H. Williams, returned to boreholes for his evidence of subsurface geology and described recent drilling for coal and oil in the area of the South Derbyshire, Leicestershire and Warwickshire coalfields. There is a marked contrast between the relatively simple structure of the Leicestershire coalfield, which overlies a Charnian basement, and the considerably more complex fields of South Derbyshire and Warwickshire, where the Coal Measures are above various Palaeozoic rocks. It is possible that the latter two coalfields are connected at depth to the west of the Netherseal fault, an important NNW-SSE trending structure which appears to have become re-activated in Westphalian times, with a downthrow of 600 m to the west allowing development of a much thicker sedimentary sequence on that side. The borehole data also revealed a thinning of the Carboniferous sediment pile along the southern margin of the Widmerpool Gulf and showed overlap of successive strata onto the Wales-Brabant Massif. Dr Williams considered that Westphalian lacustrine deposits within the gulf may be good source rocks for oil, especially to the west of the Netherseal fault.

Borehole data also formed the basis of the next lecture, this time from the intensively-researched area bounded by Nottingham, Newark and Grantham. These holes have revealed the presence of widespread intrusive and extrusive basic igneous rocks within the Coal Measures, forming a continuous sequence in the east (up to 300 m or more in the Vale of Belvoir) and interdigitated with sediments in the west. Mr J.D. Raine analysed this distribution and recognised several centres that were active throughout Westphalian A times, apparently controlled by movements on faults which originated in the Namurian. Correlation of ash bands across the region suggests a predominant NW trend to the ashfall. In discussion, it was suggested that the highly deformed nature of some sediments in contact with the intrusives indicates that these sediments were soft when the lava flowed across them.

The final talk of the day was a late addition to the programme by Mr S. Klemperer, who took us deeper than any of the previous contributors by outlining some recent work under the BIRPS (British Institutions Reflection Profiling Syndicate) programme. A deep NW-SE seismic line off North-East England has indicated crustal thicknesses between 28 and 32 km and separated an area of complex signature to the north from one of much more simple structure. It may be that the demarcation line is the location of the Iapetus suture, which here appears to have a northerly dip. If extrapolated across country, the suture would cross the Lake District, which is at odds with the surface geology; it may be that there is some subsurface cut-off or deflection of the line. It will certainly be interesting to see what further revelations deep seismic exploration has in store for us!

All in all, a successful and interesting day. A few impressions remain with your reporters. One is that, obviously, borehole data are rather more secure than geophysical data, which can reveal much but cannot reveal all; of the stories told at this meeting it is those based on direct study of the rocks that are most likely to endure. Another feeling is one of frustration at confidential data. This problem was highlighted in the "News and Comment" column in the edition of "Geology Today" current at the time of the meeting, and there is no easy solution. But how can an outsider, or even an insider, assess the conclusions of a lecturer who effectively says "I have a lot of confidential borehole and seismic data that prove this to be the truth", or those of a member of the audience who counters "Well, I have a lot of confidential data that prove you are wrong"? Science somehow does not seem to be advanced by these exchanges.

Science is advanced, though, by well-organised and well-attended meetings. It is to be hoped that, after the success of this first joint jamboree, the EMGS and YGS will not leave it too long before arranging a sequel.

R.J. Aldridge and C. Bagshaw