PERMIAN AND LOWER TRIASSIC LANDSCAPES OF THE EAST MIDLANDS

8th Presidential Address to the East Midlands Geological Society

4th February 1973

by

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Summary

The Address commences with a review of Midland Pre-Permian topography and then describes the changes thought to have occurred in the evolving scenery of the East Midlands area, from the local commencement of Permian sedimentation, the Basal Breccia, to the close of the Lower Triassic,as represented by the Pebble Bed Formation. Only brief reference is made to younger Triassic formations.

Introduction

The evidence for Palaeogeography can only be deduced from an examination of the rocks of the area. In most instances, only a part of the original facts are preserved and deductions aud surmises have to be made, based on incomplete information. The main lines of evidence which are missing from the present review are those concerned with the life of the time, for there are few fossils, either plant or animal, preserved. Fossils are used to provide environmental or ecological evidence, as well as enabling some degree of correlation of rock sequences from one locality to another to be made. Thus it must be stated at the start that, with a paucity of information for two parts of the palaeogeographical reconstrution any conclusion reached at this time on the palaeogeography must be considered tentative and hypothetical. Most papers on East Midlands Permian and Triassic palaeogeography seem to be prefaced by statements of this kind, yet there is a considerable amount of geological information available and increasingly so, which allows something more than an outline to be attempted.

The table below lists the formations of the East Midland's Permian and Triassic sequence and indicates their relationship to the underlying strata. Text-figs 1 to 6 are topographical sketches of an area centred about the present position of Derby (D), Leicester (L) and Nottingham (N) and illustrate the postulated changes. The present east and west coast-lines of England have been added to assist with reference points.

Table - Permian and Triassic Formations of the East Midlands

Upper Trias	Red marls	Glen Parva Formation
		Trent Formation
		Edwalton Formation
		Harlequin Formation
		Carlton Formation
		Radcliffe Formation
	Waterstones	Colwick Formation
	Basement Beds	Woodthorpe Formation
	- Break in the sequence -	
Lower Trias	Pebble Beds	
	Mottled Sandstone	
	- unconformity in the south and west, on Coal Measures; elsewhere conformable on -	

Table continued...

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		Red marls
		Magnesian Limestone
Upper Permian	{	Dolomitic Siltstones
		Basal Breccia
		- unconformity -
Coal Measures		

Detailed descriptions of these formations can be found in Elliott (1961) and Taylor (1965, 1966) although their main criteria are given in the following text. Geographically, this Address is principally concerned with the East Midlands but some reference will be made to adjacent areas, as indicated by the text-figs. Aspects of Lower Carboniferous palaeogeography for this area can be seen in Taylor (1971) and for the Upper Carboniferous in Elliott (1968, 1969, 1970).

The Palaeogeography

Geographical position of the British Isles

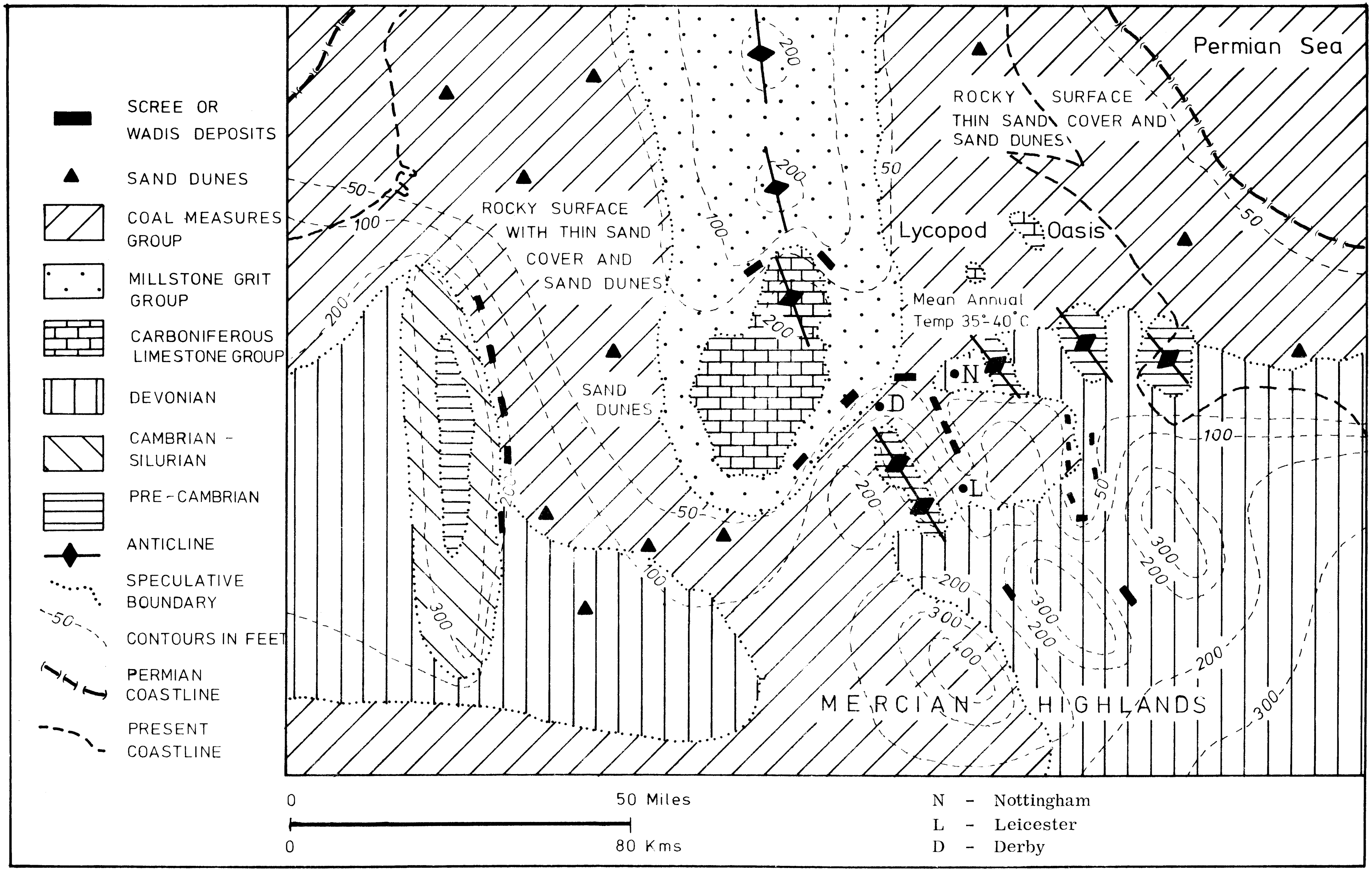
Palaeomagnetic evidence has been used by Holmes (1965) to position the British Isles between 10° and 20° north of the equator. The general movement of world continental blocks to positions familiar at the present day had not yet taken place and during the Permian and the Triassic, it is envisaged that a large continental mass, the greater part of N. America, occurred to the west of the British Isles. Even allowing for the existence of a channel of water between the two land areas, the presence of a large land mass to the west would influence the climate of the time. The orientation of sand dunes has been used to postulate dominantly easterly winds, which would also pass over land surfaces. Either condition could result in desert conditions.

The pre-Permian surface (Text-fig. 1)

Prior to the deposition of the first Upper Permian sediments, the Midlands had been involved in a period of upheaval, the Hercynian orogeny. Although the evidence for major events of this period of mountain building are to be found well to the south, it is thought that at this time an area of land, the Mercian Highlands, extending across the south Midlands from East Anglia into Wales, increased in altitude. This upland area, composed of Carboniferous Devonian, Lower Palaeozoic and Pre-Cambrian rocks, was a major source of sediment throughout the Permian and Triassic Periods. To the north of the Mercian Highlands (text-fig. 1), the old coal swamps of Derbyshire, Nottinghamshire, Staffordshire, Yorkshire and Lancashire had been uplifted, eroded, folded and left as a low lying area, with isolated hills made up of the harder rocks of the Carboniferous and Pre-Cambrian.

Since this address was delivered in February 1973, Wills (1974) has published a geological map of England and Wales prior to the deposition of Permo-Triassic rocks, which indicates the present known extent of Upper Palaeozoic strata below that of the Triassic. Text-fig. 1 indicates a more widespread occurrence of both Devonian and Upper Carboniferous rocks were later eroded during Triassic times, mainly to provide sediment for the Lower Triassic Pebble Beds. Further erosion, during the Upper Triassic has produced outcrops as indicated on Wills' maps.

Sub-aerial weathering of the Carboniferous rocks resulted in the oxidisation of their iron content and particularly in the shales and mudstones, has coloured them red, buff, yellow, green and purple, instead of the usual grey or black rocks. Break up of outcrops through weathering would produce scree deposits and sand and gravels. Except for the colour-altered rocks, a few feet of breccias and the odd sand deposit, there is very little evidence of a period of weathering which must have removed many thousands of feet of strata.



Text-fig.1. Pre-Permian Topography.

The Upper Permian Sea (Text-fig. 2)

During the Lower Permian, the sea was located outside the limits of the British Isles. At the commencement of the Zechstein (Upper Permian), a general lowering of the land surface with respect to sea level allowed the sea to sweep in, covering much of the area of the north Midlands. It is generally assumed that, as most of the Upper Permian rocks are at present to be found east of the Pennine fold axis, this formed the western limit of the sea which encroached from the east. Reference to text-fig. 2 will show that the existence of connecting waterways through the south Pennines would allow access also from the west. Rock debris lying on the land surface was redistributed in the East Midlands area to form a relatively uniform layer, the Basal Breccia. It consists of angular fragments of Carboniferous rocks of all types - sandstones, ganisters, shales, mudstones, limestones, dolomites and coal. The fragments are multicoloured and the sandy matrix is well cemented with dolomite. The sea was, in places, in direct contact with the Carboniferous Limestone and this resulted in its dolomitisation. Such dolomitised limestones and reddened interbedded shales have been seen in bore-holes in the Trent Valley and in N. Leicestershire at outcrop and it is for this reason that the southern boundary of the Upper Permian sea is here drawn well to the south of the conventional southern limit illustrated by Sherlock (1928) and Wills (1951).

Sediments succeeding the Basal Breccia are somewhat variable in the southern Nottinghamshire area. West and north-west of Nottingham the main rock type is a dolomitic siltstone with plant remains. Northwards in north Nottinghamshire, grey mudstone with plant remains but with little dolomite are referred to in Geological Survey G.B. publications as the Permian Lower Marl or the Lower Permian Marl. The rocks may be oxidised, which results in buff or red colours in contrast to the grey of the unweathered rock. The plant remains are derived from forests growing on low islands, some of which are depicted on text-fig. 2. A tropical climate is indicated by the formation of dolomite. The amount of plant material preserved in the rocks decreases towards the base of the Magnesian Limestone, suggesting increased drought conditions and factors making for increased precipitation of dolomite.

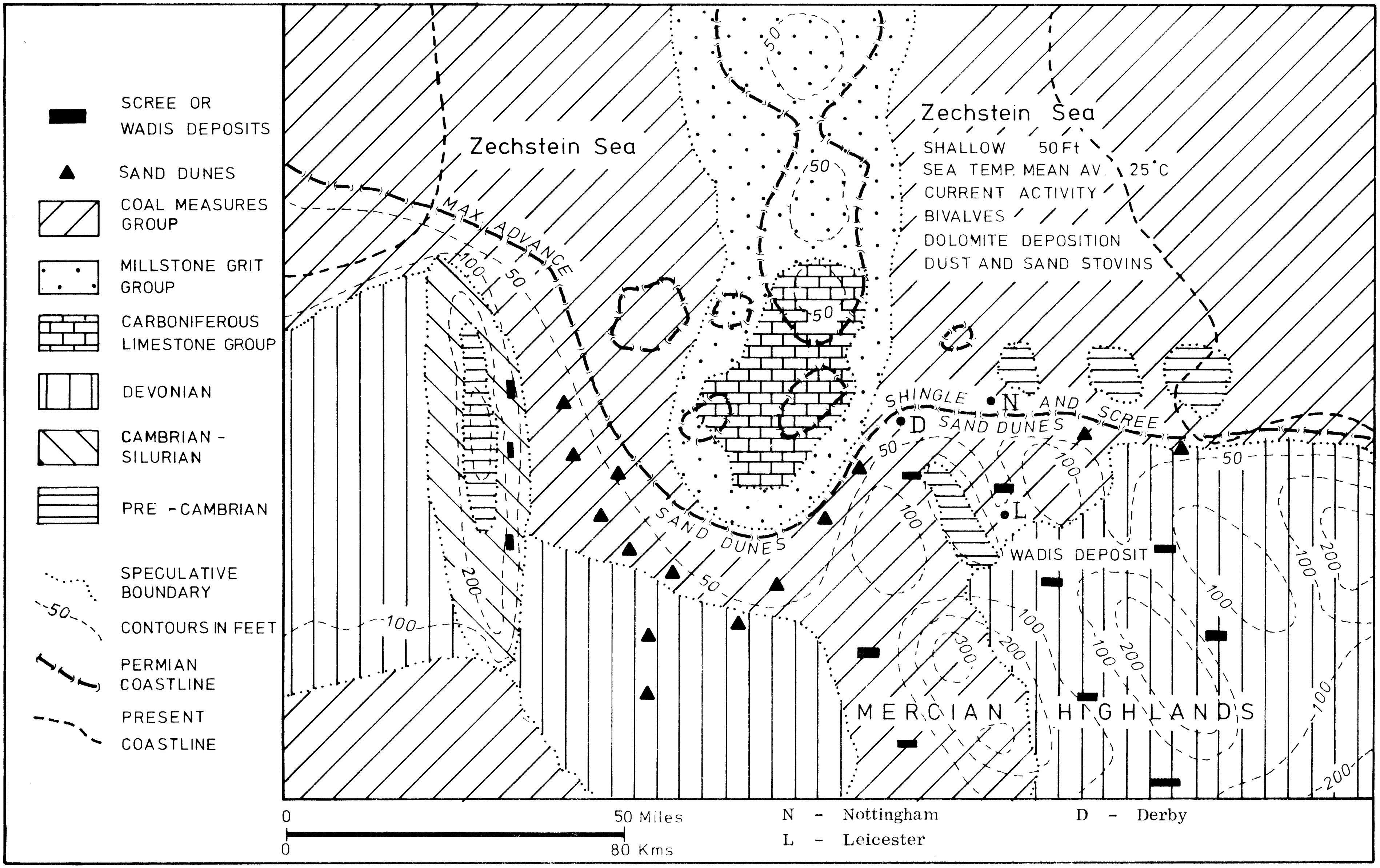
The Magnesian Limestone of the Bulwell-Linby area is coarse grained, deposited in a shallow sea, with currents oscillating the crystals allowing them to grow to a large size. To the south at Strelley, sand and small pebbles are cemented with dolomite which indicates the proximity of a local shore line. Sand may also be present in some of the Magnesian Limestone of the Mansfield area resulting in the formation of the Mansfield White and Red Dolomitic Sandstones. Although Wills (1951) shows a river introducing this sand into the Mansfield area, it could be the result of wind deposition from a nearby island into the sea. North of Mansfield, the Magnesian Limestone is fine-grained, well bedded in the lower part with reef-knolls in the upper.

The beds of dolomite are separated by thin layers of grey-green clay, commonly a few mms in thickness and rarely, up to 50 mms. Intraformational breccias can be found in the area between Bulwell and Strelley. The fragments are usually smaller than those of the Basal Breccia but they are still composed of weathered Carboniferous rocks. These fragments must have been swept into the marginal areas of the sea from the land areas by infrequent rain storms.

Fossils in these Upper Permian rocks of the East Midlands are rare. In addition to the plants mentioned above, casts and moulds of bivalves are known from the Bulwell-Linby area.

In the East Midlands, therefore, the Zechstein Sea was shallow and warm, with low lying islands, some of which developed a vegetation cover, at least for a short time after the initial incursion of the sea. Others would have fringing sand dunes. Seasonal rainfall could account for the clay partings, or the clays could be the product of an unknown volcano, as they resemble, superficially at least, the 'way-board clays' of the Lower Carboniferous. The surfaces of the dolomite are irregularly stylolitic, which suggests yet a third possibility for the origin of the clay; an insoluble residue.

The Upper Bed of the East Midland's Magnesian Limestone is often mineralised, containing galena, wulfenite, asphaltite and barite. The minerals are deposited in cavities left after



Text-fig. 2. Topography at the time of deposition of the Magnesian Limestone removal of shells, within the pore-spaces of the coarse grained dolomite and in solution cavities. The top surface may show worm borings (Elliott and Taylor 1971). There is a sharp sedimentary break above the dolomite, prior to the deposition of red marls which marks a regression of the Zechstein Sea.

The red marls (Permian) (Text-fig. 3)

Above the Magnesian Limestone, there occurs a variable sequence of red marls, fine-grained reddish-brown sandstones and grey dolomitic siltstones. In the absence of any detailed sedimentary work on this formation and without fossils, only a speculative account can be given of the palaeogeography of the time. It is considered that the Nottinghamshire area formed a salt marsh or lagoonal environment with the main body of sea water to the north and with only occasional incursions of the sea to the south at which time the dolomitic siltstone was formed. In the lagoons fine sandstones and marls were deposited and surrounding the standing water there would be sand dunes, these being the source of sand in the lagoons.

The Mottled Sandstones (Text-fig. 4)

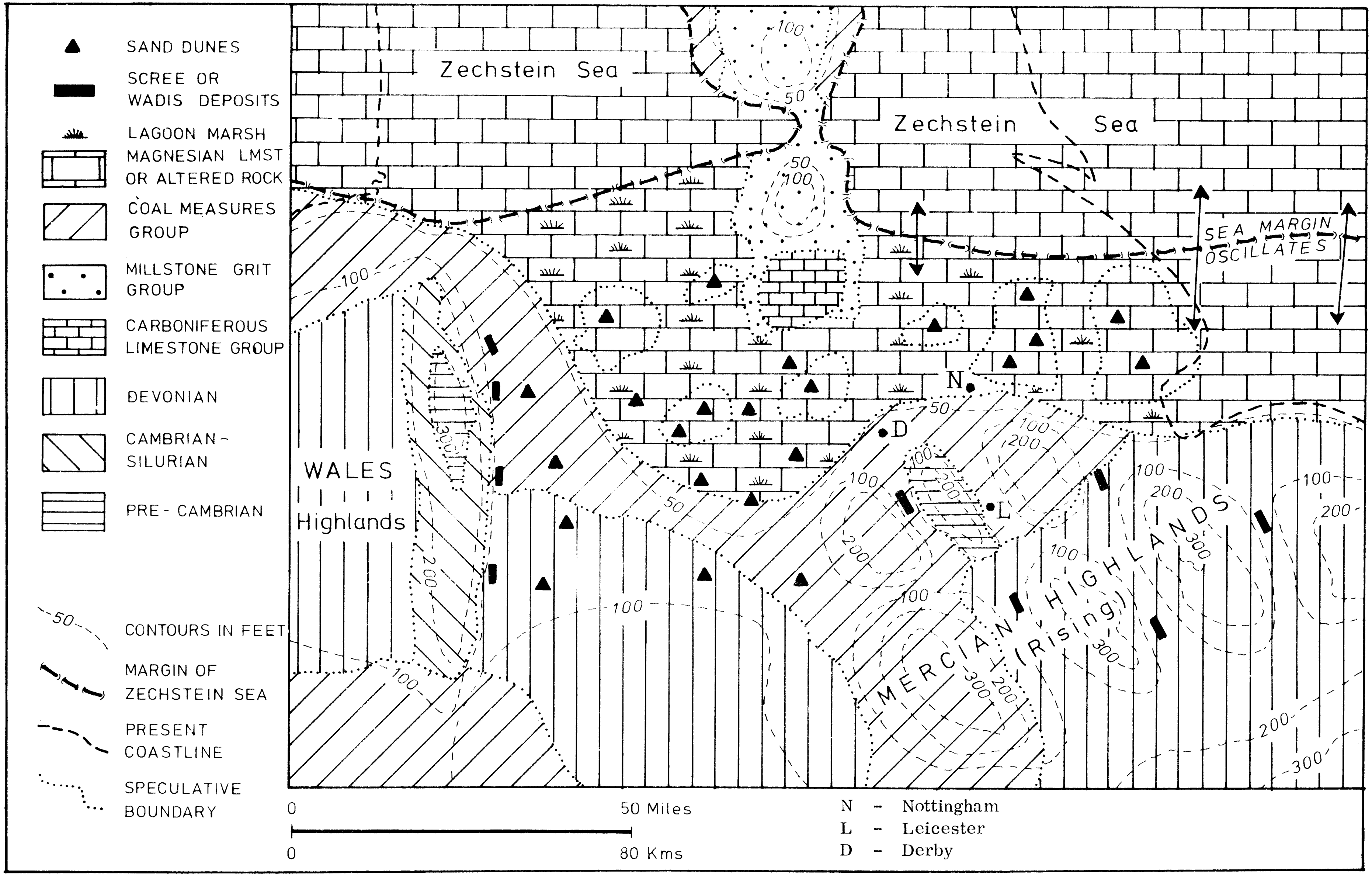
Ideally, the sandstones of the Mottled Sandstone Formation should consist of fine-grained sand with interbedded thin red marl seams, only mms. in thickness. Variation in marl content and grain size are common, with marl being more common and the sand finer at the base. In places the sandstones are mottled with green or yellow patches. The mode of deposition of this formation in the East Midlands is still uncertain. The regular alternation of marl and sand suggests two sources of origin of the sediment, the marl being deposited in lagoons with wind blown fine sand or fluviatile sand. Cross-bedding is common, with some units rarely, up to 15 feet in thickness. In the West Midlands, sand dunes are more extensive and their structures have been described from the Bridgnorth Sandstone Formation.

It can prove difficult to distinguish between marly sandstones developed within the red marl formation and those at the base of the Mottled Sandstones. It is possible that the marl in the Mottled Sandstones is the result of redeposition from eroded red marls. Confusion of these deposits has resulted in many bitter arguments, including those between Sherlock and Trechmann in their attempts to find the junction between the Permian and Triassic system of Nottinghamshire.

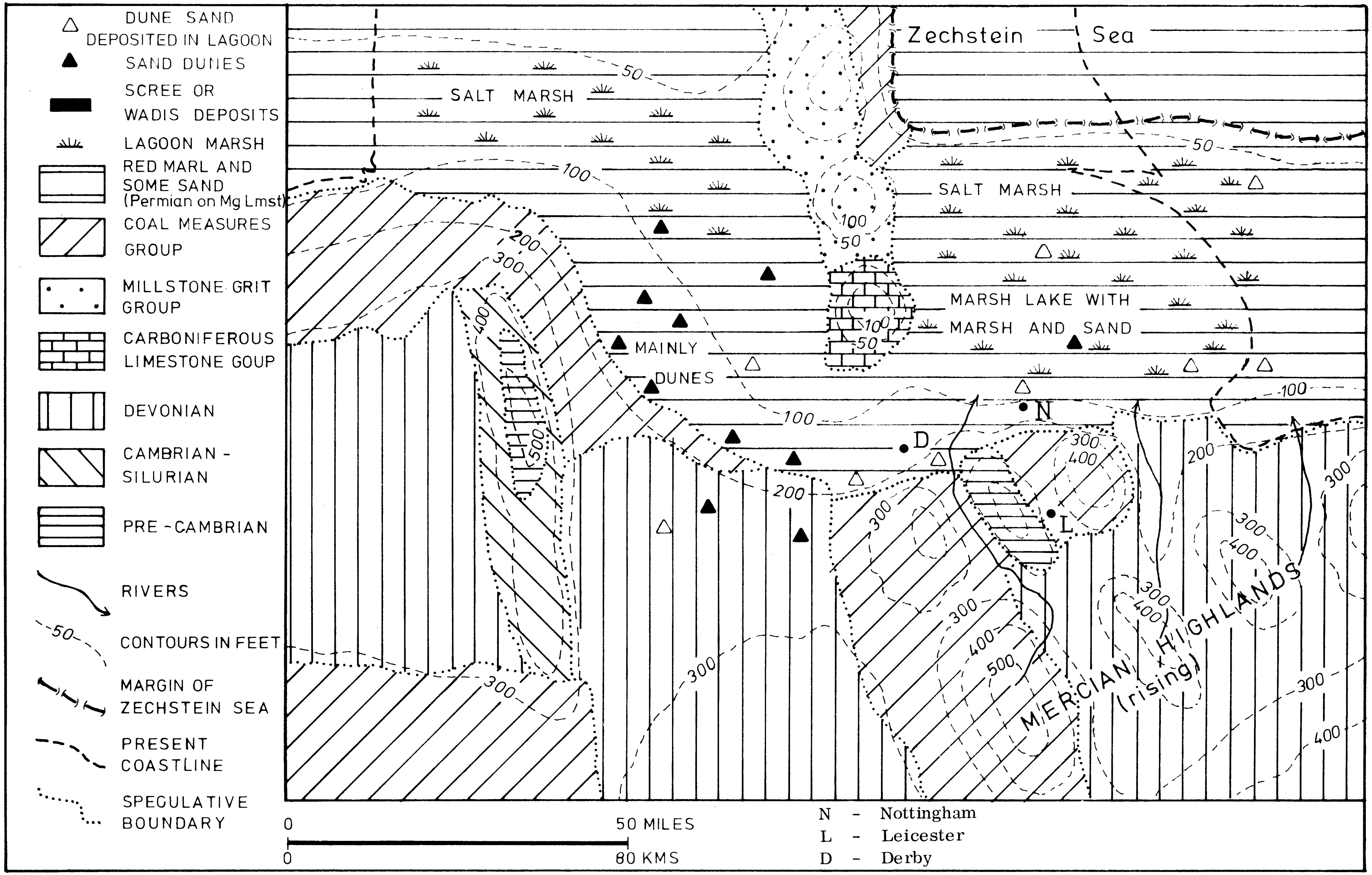
The Pebble Beds (Text-fig. 5)

Although a sharp junction may be seen in some localities, the change from the Mottled Sandstones to the Pebble Beds is often gradational. A significant increase in grain size, often accompanied with a lightening in the red colour of the sandstone precedes the introduction of pebbles. The colour change in the Nottingham and Sandiacre areas is more dramatic, the Pebble Beds being buff coloured. The dominant colour, in the East Midlands as in the West Midlands, is red. Marl is present, frequently in the form of mud clasts and more rarely, in seams of variable length. The pebbles are composed mainly of quartzites and are well rounded with diameters commonly up to 6 inches. At any locality, cross-bedding structures can readily be seen, indicating deltaic deposition.

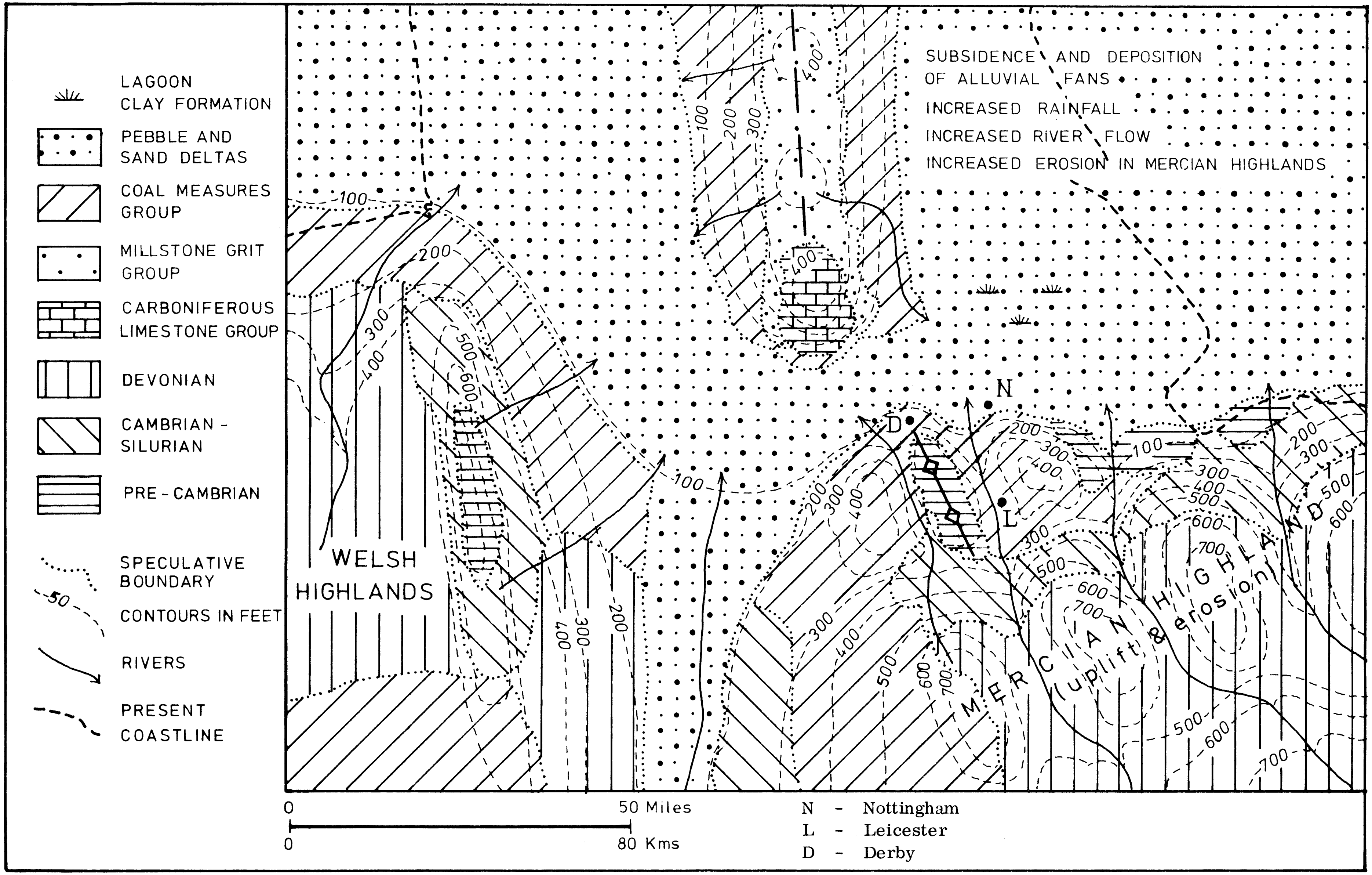
These characteristics suggest a high energy environment and a re-elevation of the Mercian Highlands is postulated to provide steeper gradients for erosion, higher rainfall, greater run-off, larger water volumes in the rivers and ultimately a thick series of deposits in deltas. The river must have been intermittent or seasonal, for allowance must be made for the deposition of layers of marl which although rarely extensive at present, were more widespread initially; later erosion by the current depositing the coarse pebbly sand preserved now only as mud clasts in the overlying pebble bed. The Blidworth Clay seam, 3 feet in thickness, is the most widespread clay-seam known. The ill-sorted nature of the Pebble Beds implies erosion of pre-existing Devonian sandstones and congomerates and Upper Carboniferous sandstones for the bulk of the deposit, followed by rapid deposition in the deltas possibly as flash flood deposits. Most of this material could be derived from the



Text-fig. 3. Topography during deposition of the Nottinghamshire red marl (Permian)



Text-fig. 4. Topography at the time of deposition of the Bridgnorth Dune Sandstone (W. Midlands) and the Mottled Sandstones (E. Midlands).



Text-fig. 5. Pebble-Bed Topography

Mercian Highlands in the south and from renewed erosion of local Namurian and Westphalian coarse sandstones. The local origin of much of the Pebble Beds is supplemented by material brought into the West Midlands by a large river flowing northwards, as advocated by Wills (1951), which is thought to be responsible for providing certain exotic pebbles from the south of England and from north France. Maximum concentrations of pebbles are to be found in localities close to the Mercian Highlands with a decrease in both size and concentration to the north. The sea margin was well to the north of the Midlands during the deposition of the Pebble Beds. Unfortunately there is no clear indication of vegetation existing on land surfaces, neither is there any record of animals.

Subsequent changes of topography in the Upper Trias

Eventually a further change in climate and relief is indicated by the occurrence of sediments in the west Midlands not unlike the Mottled Sandstones already described from the east of the area; but in the East Midlands, there is a well marked break in sedimentation at the top of the Pebble Bed Formation with the formation of an erosion surface often well cemented with calcite. Subsequent sediments consist of buff sandstones and red marls or grey-green and red marls, possibly underlain by a conglomerate. There is then the widespread development of fine-red micaceous sandstones and interbedded red marl (Colwick Formation); eventually the argillaceous sediments predominate, with the deposition of the Upper Triassic red marls. This gradual fining of the sediments must be accompanied by a general lowering of relief, decrease in rainfall, encroachment of the sea and the formation of evaporite deposits.

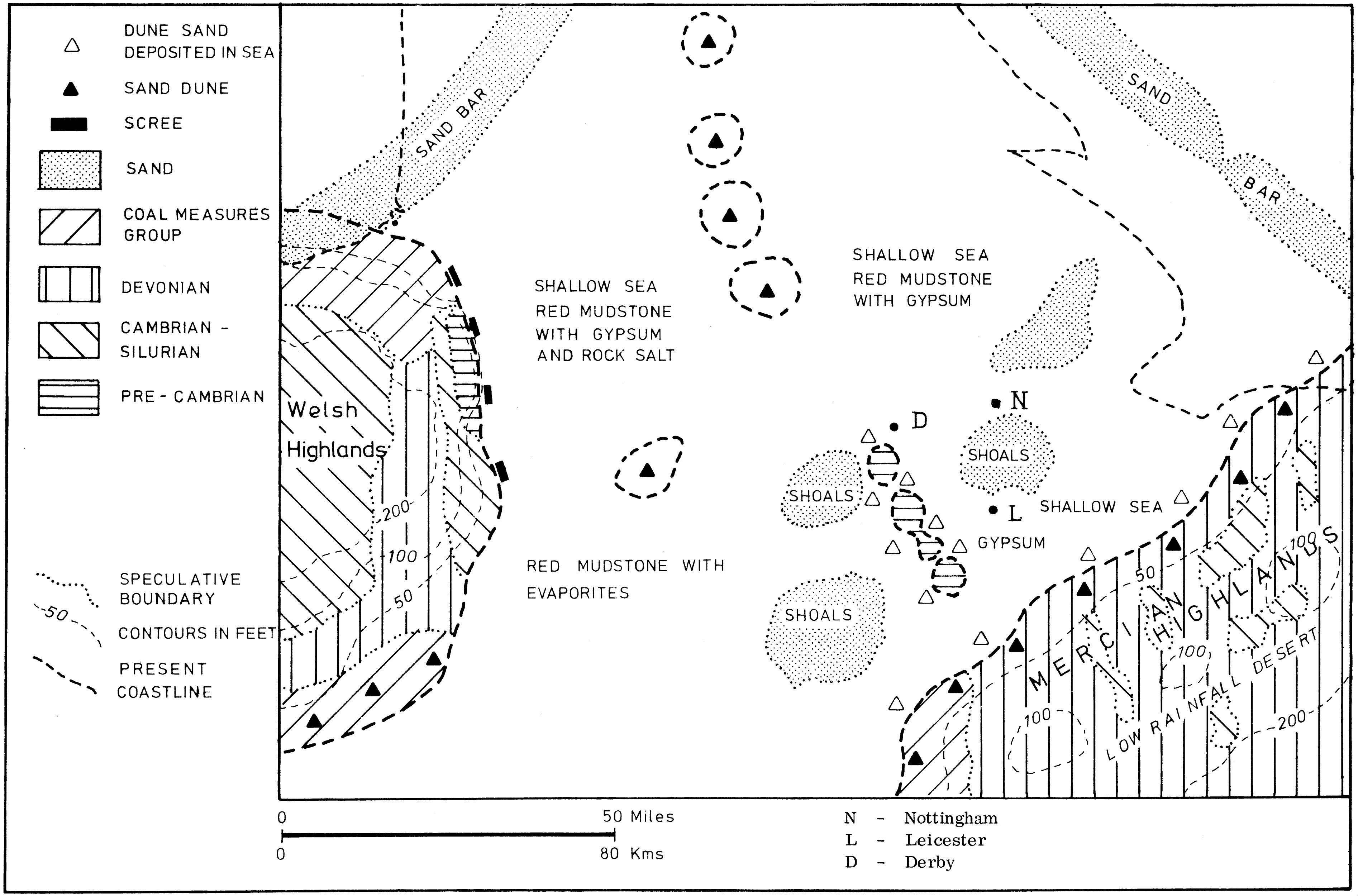
Unfortunately, in this address, there is not sufficient time to give the details of the necessary palaeogeographical changes, although for further information, text-fig. 6 on the Upper Triassic red marl has been included. The greater areal distribution of these marls, including gypsum beds in Leicestershire, means that much of the central area of the Mercian Highlands was inundated by the sea. A comparison of text-fig. 6 with text-fig. 1, indicates that there has been considerable erosion of Upper Palaeozoic rocks from the northern and western areas of the Mercian Highlands and the consequent exposure of older Lower Palaeozoic and Pre-Cambrian rocks. The isopachyte map of the Keuper Marl (Red Marls and Tea Green Marls) by Kent (1968 fig. 26, p. 143) shows the position of the remnants of the Highlands in the East Anglian area and it is assumed that a similar area occurs in Central Wales. The formation of littoral deposits, conglomerates, breccias and sandstones, in lithology not unlike sediments previously formed, has led to much confusion but the Upper Triassic sediments tend to revert to a typical facies a short distance away from the shore-lines.

Conclusions

An attempt has been made to detail topographical changes that took place during the Upper Permian and Lower Trias of the East Midlands. Earth movements are postulated to have elevated the Mercian Highlands, particularly during the deposition of the Pebble Bed Formation. The maximum period of low relief would be at the end of the Triassic Period. Compared with many periods of the geological column, rocks of Permian and Triassic age have not been studied intensively from the sedimentary point of view and in view of the general lack of fossils, detailed work on the sediments is more likely to improve palaeogeographical knowledge of the time than the study of any other aspect of the geology.

Acknowledgements

Over the past few years, much interesting information has been obtained in the East Midlands from numerous temporary exposures, by their very nature only available for examination for a short interval of time. I would like to acknowledge with thanks the engineers and surveyors who have kept me informed of their excavations and to the Members of the East Midlands Geological Society who have reported such excavations and in some cases sent me notes on them. Continuation of this vital service will be much appreciated.



Text-fig. 6. Red-marl (Upper Trias) Topography.

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