Geol. Bull. Univ. Peshawar, Vol. 4. 1969, *pp*, 18-23.

PALAEOGEOGRAPHY OF ENGLAND AND WALES DURING CAMBRIAN TIMES

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The Cambrian rocks of England and Wales appear in relatively small outcrops in seven isolated areas, and in most cases, as in Scandinavia, they are situated at considerable distance from one another. For this reason it is difficult to establish palaeogeographic maps of the area. The Cambrian sediments of England and Wales were deposited in different environments as can be shown by their lithological differences, and probably the sediments are derived from different sources. However, in some parts the lithological succession is remarkably similar, as for example in the Midlands during Lower Cambrian times.

The palaeogeographic conditions of Cambrian sedimentation in North and South Wales were first described by Hicks (1894) as giving rise to shallow water deposits. O.T. Jones (1938, 1955) argued in his two classic papers for the evolution of two parallel geosynclines during Cambrian and Silurian times in the British Isles; he suggested that the geosynclines were shallow during Cambrian times and that their general trend was NE to SW; Stubblefield (1956) supported this claim, but Knill (1959) proposed that there were both marginal and axial deposits during Lower and Middle Cambrian times on the basis of isopachytes. Separately, Hicks (1894), Nicholas (1915), Illing (1915), Cobbold (1927), Matley and Wilson (1946) and Groom (1902) proposed that the Cambrian rocks of St. Davids, St. Tudwals, Comley, the Harlech Dome and Malvern, respectively, were deposited under shallow water conditions. Kuenen (1953) suggested that the Rhinog Grits of the Harlech Dome are a greywacke sequence and were deposited in a deep geosyncline. Kopstein (1954) maintained that the whole of the Cambrian rocks of the Harlech Dome, except the Dolwen Grits, were deposited in a deep sea environment by turbidity currents.

The succession of the Lower Cambrian in the Llanberis Slates (Caernarvonshire) has been correlated with the Caerfai Series of South Wales by Hicks (1894) on lithological evidence. This suggests that the basal rocks in both areas were deposited in the same environment and had the same provenance. It has been shown by Farshori (1962) that the basal beds of the Caerfai Series in South Wales were accumulated on the margin of the Welsh Geosyncline, the source being somewhere to the north-west

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of Pembrokeshire (Fig. 2). There was probably the same source supplying sediments which formed the basal beds of the Llanberis Slates and from the facts given by Jones (1938) one may presume that he suggests the Lower Cambrian sediments are shallow water deposits. It was proposed by Bassett and Walton (1960) that the lower beds of the Hell's Mouth Grits were deposited on a continental slope delta, and that the currents bringing them probably flowed from the north-east. The Rhinog Grits of the Harlech Dome are considered as being the equivalent of the Hell's Mouth Grits, whose current direction was also shown to be from the north-east and east by Woodland (1939), and Matley and Wilson (1946), respectively. This does not agree with the supply direction suggested by Kopstein (1954, p. 83). Matley and Wilson showed this current direction on lithological and stratigraphical bases, the sediments' source being an area of the Precambrian complex of Anglesey. Kopstein proposed the derivation of sediments in a SSW-NNE direction on the evidence of the orientation of the longest axes of pebbles and on primary sedimentary structures. Kopstein (1954, pp. 60, 61 and 62) indicated five palaeo-current directions in three stereograms which were prepared on the orientation of the pebbles and sedimentary features in three different localities. The current directions are shown by him to be: (a) Galli-bant, SSW-NNE on the basis of the orientation of the long axes of pebbles, and (b), Llanbedr, ESE-WNW, NNE-SSW and SSE-NNW. The NNE source in (b) was partly confirmed by Knill (1959, p. 319); he states that on the eastern side of the Dolwen pericline, the Rhinog Grits were derived from the north-east. During the same period in Pembrokeshire the current direction is shown by Farshori (1962) to have been from the north-west. Therefore it can be suggested, in the light of the above evidence, that the northern strand line of the Welsh Geosyncline shifted from north-east to north-west (Wales). The trend of the isopachytes in North Wales (Jones, 1955) shows that the strand line had a north-east orientation. The Lower Cambrian rocks of Herefordshire, Warwickshire, and Shropshire are lithologically different from those of the Lower Cambrian of Wales; therefore it is suggested that the sediments deposited in the former areas came from a different source, probably somewhere south of the Welsh Geosyncline. The Wrekin Quartzite at Comley, which is fine-grained, has an unconformable relationship with the underlying Precambrian rocks. The unconformity between the quartzites and the Precambrian rocks can also be seen in the Malvern Hills and at Nuneaton. The quartzites at Comley were described by Cobbold (1927), at Nuneaton by Illing (1915), and in the Malvern Hills by Groom (1902) as being shallow water deposits. Cobbold also proposed that these Lower Cambrian quartzites were formed on a folded Precambrian surface. The thickest deposits occur at Nuneaton and in the Malvern Hills, whereas at Comley the Wrekin quartzite is relatively thin. Because of this it is proposed that during the beginning of the Lower Cambrian period, when the sea transgressed, the sea bottom at Comley was probably

a ridge of folded rocks and due to this we get thin deposits at Comley and thick beds at Nuneaton and the Malvern Hills. Presumably these quartzites were accumulated on a continental shelf south of the Welsh Geosyncline, which was trending in an ENE-WSW direction. The upper beds of the Lower Cambrian are fine-grained and muddy in England and Wales, and are composed of a greywacke sequence, muddy sandstone and shale; therefore it is suggested that the strand line moved northwards and southwards on both sides of the Welsh Geosyncline.

The change in lithology and palaeontology has been shown by Hicks and Harkness (1871) in the green pebbly sandstone at St. Davids. They yield the lowest *Paradoxides* and Hicks (1881) named them the Lower Solva Series. The contact between the Solva and the Caerfai Series is structurally conformable, though sharp, and marks a distinct change of lithology (Jones, 1940). In the author's opinion, at the close of Caerfai times an uplift occurred in South Wales, and the sea withdrew from the south and south-west and the sediments' source moved from NW to S and SE (Fig. 3). A similar regression can be shown in the Malvern Hills, where the Middle Cambrian rocks are completely absent. It has been suggested by Farshori (1962) that the Middle Purely Shales of Nuneaton and the *Paradoxides groomi* beds of Comley are equivalent to the Middle Solva Series of South Wales on faunal evidence. But in Comley the erosion of the top beds of the Lower Cambrian has been shown by Cobbold (1927): therefore it can be concluded that the sea regressed from the Comley District during the deposition of the Lower Solva Series in South Wales and the Middle Purely Shales at Nuneaton; probably the conditions were neritic and favourable to trilobites. The Welsh Geosyncline was linked with the Caledonian Eugeosyncline and a number of species migrated between Scandinavia and the British Isles (Farshori, 1962). The absence of the Solva Series in Llanberis (N. Wales) is probably due to a regression of the sea, and the northern shoreline of the Welsh Geosyncline lay just north of St. Tudwals. The Cilan Grits of St. Tudwals are equated with the Barmouth Grits of the Harlech Dome; according to Nicholas (1915) they were deposited in shallow water, probably as the marginal facies. The Barmouth Grits are thinnest in the north-east and the Gamlan Shales and Flags lie on the top of the Barmouth Grits and are thickest in the north-east. Matley and Wilson (1946) showed the source (Precambrian metamorphic) was situated to the east of the Harlech Dome during the deposition of the Barmouth Grits and Gamlan Flags and Shales. On the other hand Kuenen (1953) and Kopstein (1954) claimed, after observing the cross-laminations and studying the orientation of elongated pebbles, that the sediments were derived from the SSW.

Presumably a trough-shaped subsidence took place during Upper and Middle Menevian times in South Wales, with an ENE-WSW trend and embraced the Harlech Dome region. The Menevian succession in South Wales can be easily correlated with

the equivalent beds in North Wales and the Midlands on palaeontological evidence. The beds yield many Lower Menevian fossils, i.e. *Paradoxides hicksi* zone of South Wales, accumulated on a slope in a quiet open sea far from the source area. They show lenticular bedding with numerous slump structures, together with abundant fossils. The source was probably in the north-east of Pembrokeshire (Fig. 4). The evidence also indicates that the sea bottom was sinking gradually in this part of Wales, and regression was taking place in the Midlands and the St. Tudwals district. The black mudstones and shales of the St. Davids Middle Menevian contain thin bands of graded greywackes. These beds show some lithological resemblance to the Clogau Shales, which were deposited in a deep restricted sea, occasionally disturbed by turbidity currents. In North Wales at St. Tudwals only, the *P. hicksi* zone (i.e. upper beds of Caered Sandstone and Flags and Nant-Pig Mudstone) is exposed and the erosion of the top of these beds has been shown by Nicholas (1915). The *P. davidis* zone is absent, probably due to emergence of the sea bed at that time, and the *Bellingsella* zone of Comley is represented by conglomerates of local sediments which are about 1½ feet thick. With the presence of a high percentage of black mudstone pellets in the Middle and Upper Menevian Beds of St. Davids, it may be presumed that there was erosion in the St. Tudwals area during the deposition of the greywacke sequence (Upper Menevian) in South Wales. In Menevian times deep sea conditions were shown by Kopstein to have existed in the Harlech Dome with the deposition of the Cefn Coch Flags and the Clogau Shales with greywackes. It is suggested by Matley and Wilson (1946) that the Cefn Coch Grits are thickest in the north-east and compare with the south-west in the Harlech Dome district. Therefore, the source was situated somewhere to the north-east of the Harlech area (Fig. 5). It is shown that the Menevian deposits of Comley and Nuneaton are of shallow water origin; therefore it can be presumed that the Wales Geosyncline was trending NE-SW during Middle and Upper Menevian times, with the deepest part lying between the Harlech Dome and the St. Davids area. The Lower and Middle Menevian Beds of South Wales yield a rich trilobite fauna and many of them show affinities with Scandinavia and Nuneaton. The thickest deposits of the Menevian Series in England and Wales are found in South Wales; they are about 750 ft. in thickness in comparison with 90 ft. at Nuneaton and 400 ft. at Comley. At Nuneaton glauconite is present in the upper beds of this zone. Phosphatic and glauconitic (nodular) deposits four feet in thickness lie on the top of the beds, but the *Bellingsella* zone of Comley is completely absent. Illing (1915) described them as being of shallow water environment rather than deep sea origin. In Shropshire the equivalent beds of the Menevian occur in three disconnected areas, but their thickness does not exceed 400 ft. including the unfossiliferous Hill House Shale, and they contain breccias, flags, shales and grits together with thin gritty limestone beds referred to the *P. forchammeri* zone of Scandinavia (Cobbold, 1921).

In comparision with other areas, the Upper Menevian is 100 ft. thick at St. Davids, equivalent to the *Bellingsella* zone of Comley whose thickness does not exeed 5 ft. The lithology and thickness of the *Bellingsella* zone beds show epi-continental conditions of deposition. Therefore it can be presumed that at the close of Menevian times the strand line passed somewhere near Comley and Nuneaton, in the south of the geosyncline. The current direction in the St. Davids area is shown by Farshori (1962) to have been from north to south, which disagrees with Kopstein's proposition, who suggested that the source of the Clogau Shales lay south-west of the Harlech Dome. There is no evidence of current direction in the Clogau Shales because the beds are poorly exposed.

The Upper Cambrian rocks of England and Wales are known as the Lingula Flags. Belt (1867) divided the Upper Lingula Flags of Hicks and Salter (1866) in the Harlech Dome area into three groups, naming them, from bottom to top, the Meantwrog, Ffestiniog and Dolgelly. Fossils in the Lingula Flags differ considerably from the underlying Middle Cambrian in many parts of the British Isles (i.e. St. Tudwals, the Harlech Dome, south of Llanberis, Shropshire, Warwickshire, Malvern, and St. Davids); therefore, it is evident that a marine transgression took place at the close of Menevian times and once again the sea transgressed to the north of Caernarvonshire and south of the Welsh Geosyncline up to somewhere in Herefordshire. The Lingula Flags also differ considerably in lithology from the underlying Middle Cambrian rocks. The thickest deposits are found in the Harlech Dome area, where they were deposited in a deep geosyncline as a greywacke sequence (Kopstein, 1954), and their sediments are derived from the south-west. In South Wales the author also found the same source direction (Fig. 6) and the lower beds of the Lingula Flags were deposited in a deep geosyncline, the rest of the Lingula Flags being certainly deposited on a slope (with numerous kinds of slump structures) whose main slope was rising gradually, during the deposition of the Lingula Flags in the St. Davids area. The depositional conditions of the Ffestiniog Beds are shown by Nicholas (1915) in St. Tudwals to be shallow water, probably on the shelf. In the author's opinion the geosyncline was trending in a NNE - SSW direction during the deposition of the Upper Lingula Flags, whose marginal facies was at St. Tudwals and whose shelf facies was at Comley and Nuneaton. The St. Davids area itself was situated on the slope of the geosyncline whose deepest part was in the Harlech Dome, with the current running in a SSW - NNE direction.

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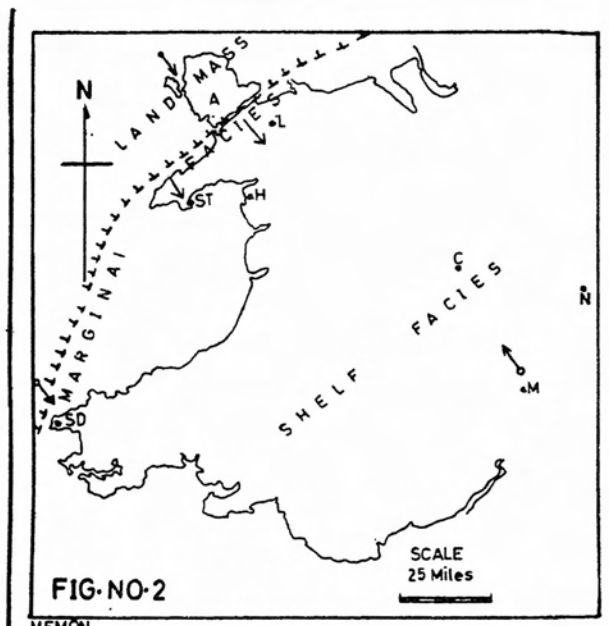
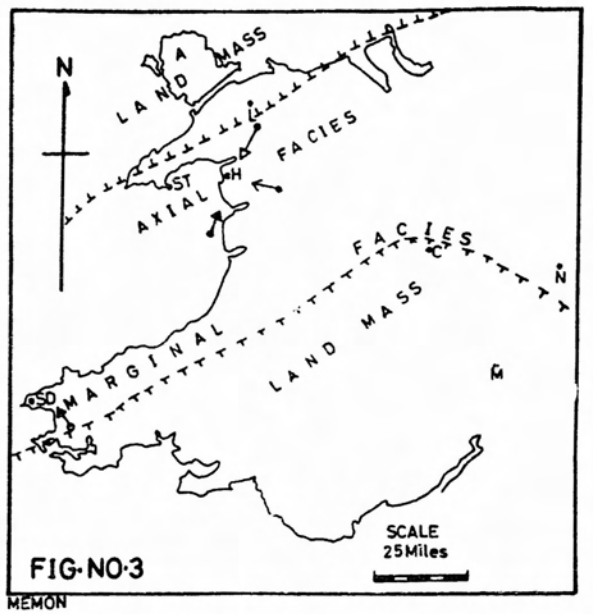
PALAEOGRAPHIC MAPS OF THE CAMBRIAN ROCKS IN ENGLAND AND WALES



FIG·NO·2

MEMON

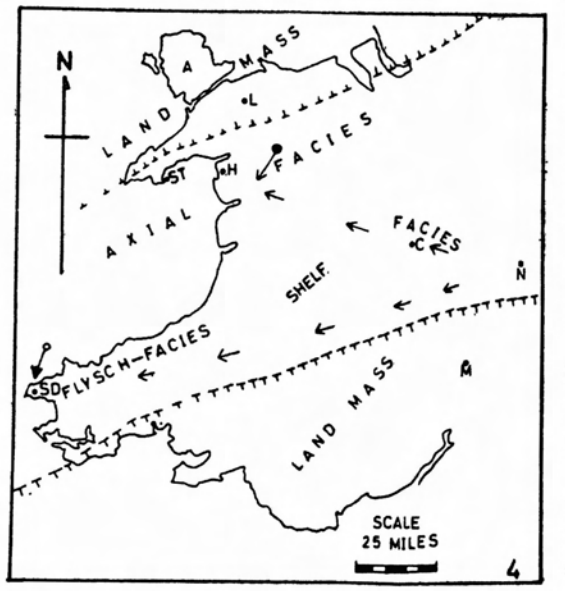
Beginning of Lower Cambrian.



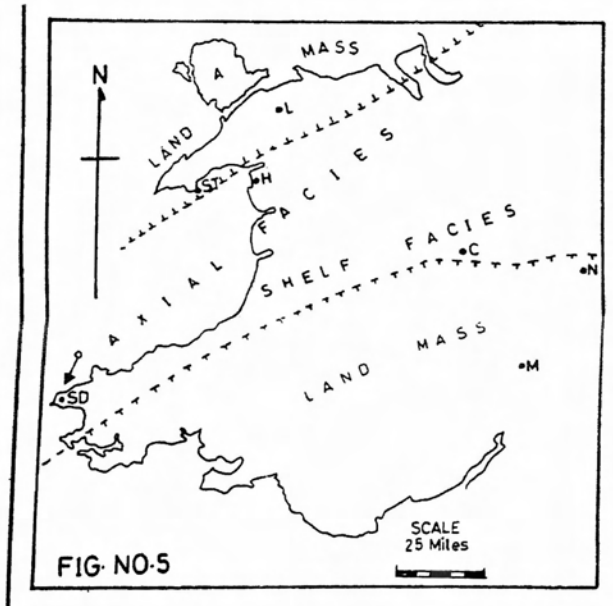
FIG·NO·3

MEMON

During the Lower Part of Middle Cambrian.

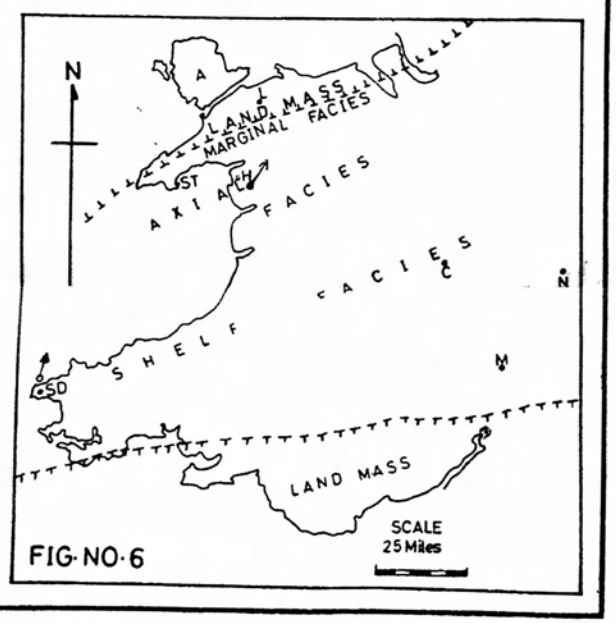


Arrows showing the route of migration of faunas during the Lower Menevian times.



FIG·NO·5

During the Upper Menevian times.



FIG·NO·6

During the Lingula Flags time.

Direction of derivation shown by Kopstein.

Direction of derivation shown by Knill.

Direction of derivation shown by Matley & Wilson.

Direction of derivation shown by Woodland.

Direction of derivation shown by Author.

A = Angelsay C = Comley; H = Harlech Dome,

L = Llanberis; M = Malvern; N = Nuneaton;

SD = St. Davids; ST = St. Tudwals

Approx. Strand Line.

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