SHROPSHIRE GEOLOGY: AN OUTLINE OF THE TECTONIC HISTORY

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I. INTRODUCTION

IT IS unusual to find in an area as small as Shropshire so wide a variety of geological formations as this county possesses. Rocks of almost every epoch from the Pre-Cambrian to the Liassic contribute to its geological record. The greater part of this story is revealed in the southern of the two distinct geographical regions which comprise the county. In the northern part the terrain is relatively flat, open and low-lying: it is situated over a single comparatively simple geological structure with soft and gently tilted strata cropping out. To the south, the hills of the "Shropshire uplands" reveal rocks and geological structures of many different kinds and ages. Indeed, their striking topographical features and the related drainage pattern are in large measure due to the underlying geology, where soft rock formations alternate with, or are faulted against, hard ones.

Naturally, the most resistant and hard materials, such as the volcanic rocks, produce the most prominent hills; the softer formations are rapidly excavated into stream valleys or lowlands. The Breidden Hills, Corndon Hill, Linley and Pontesford Hills, the Caradoc Hills and the Wrekin are all steep-sided or even craggy summits, owing their existence to the presence of hard volcanic or igneous rocks. The highest points in the county, Brown Clee Hill (1,790 ft.) and Titterstone Clee Hill (1,749 ft.), are sited upon outcrops of just such material. Hard sedimentary rocks form the tor-studded ridge of the Stiperstones and the abrupt slopes of the Longmynd, while the somewhat softer Silurian limestones produce the well-known escarpments of the Wenlock Edge area. Clun Forest and the Long Mountain are uplands situated on outcrops of flaggy, hardened Silurian shale. The streams of southern Shropshire sometimes desert the lowlands of the softer outcrops and follow courses cut through the harder formations, as at Ironbridge, Craven Arms, and near Ludlow.

The explanation of these vagaries is to be found in the events of the glacial Pleistocene period, a subject beyond the scope of this paper (see Pocock and Whitehead, 1948).

The geological events which have led to the present complex pattern of outcrops in Shropshire constitute its structural or tectonic history. Weighty and important problems are posed by the distribution of the various formations, and while we may regard some of these as more or less satisfactorily solved, many await solution. Murchison, Lapworth and other pioneers in British geology worked in Shropshire, and more recently the names of Watts, Cobbold and Whittard have become closely linked with the county. In the present account we shall refer to their work, much of which bears directly upon the evolution of Shropshire's "solid" geology. Covering much of the area is a mantle of superficial or "drift" deposits—gravels, boulder clay and alluvium —largely the products of the last million years or so. We are in no way concerned with these at present, though they represent a final and all-important chapter in the story of the origin of the natural landscape. In one respect these drift deposits are a great nuisance—they obscure critical points where access to the solid rock formations would be most welcome.

The tectonic history of a region is drawn from studies of the distribution and attitude of the rock formations within the ground; of their composition, which may give some idea of their provenance or origin; and of their fossils, which may help in correlating rocks of different areas. Often there seems to be a direct relationship between the type of sediment accumulating in any region and the earth-movements taking place locally or in adjacent areas. In Shropshire this appears undoubtedly to have been the case, and a great complex dislocation, the Church Stretton Fault Zone or Church Stretton Disturbance, has exerted a profound influence, possibly since Pre-Cambrian times and certainly throughout most of the Palaeozoic era. Sediments of one type to the east of the Fault Zone are sometimes represented by rocks of quite a different character to the west.

The course of geological events in Britain has been punctuated by a number of locally quite violent earth-movements. At first sight their effects may appear suddenly, almost without warning, in the record. Closer examination of geological history, however, shows that movement of some kind is always going on and these "earth-storms", as some writers have called them, are the culminating phases of movements which are spread over great periods of geological time. We are concerned with four principal phases:

4.	Armorican	Permian Carboniferous
3.	Caledonian	Devonian Silurian
2.	Taconian	Ordovician
		Cambrian
1.	Unnamed	Pre-Cambrian (several movements including a Post-Longmyndian).

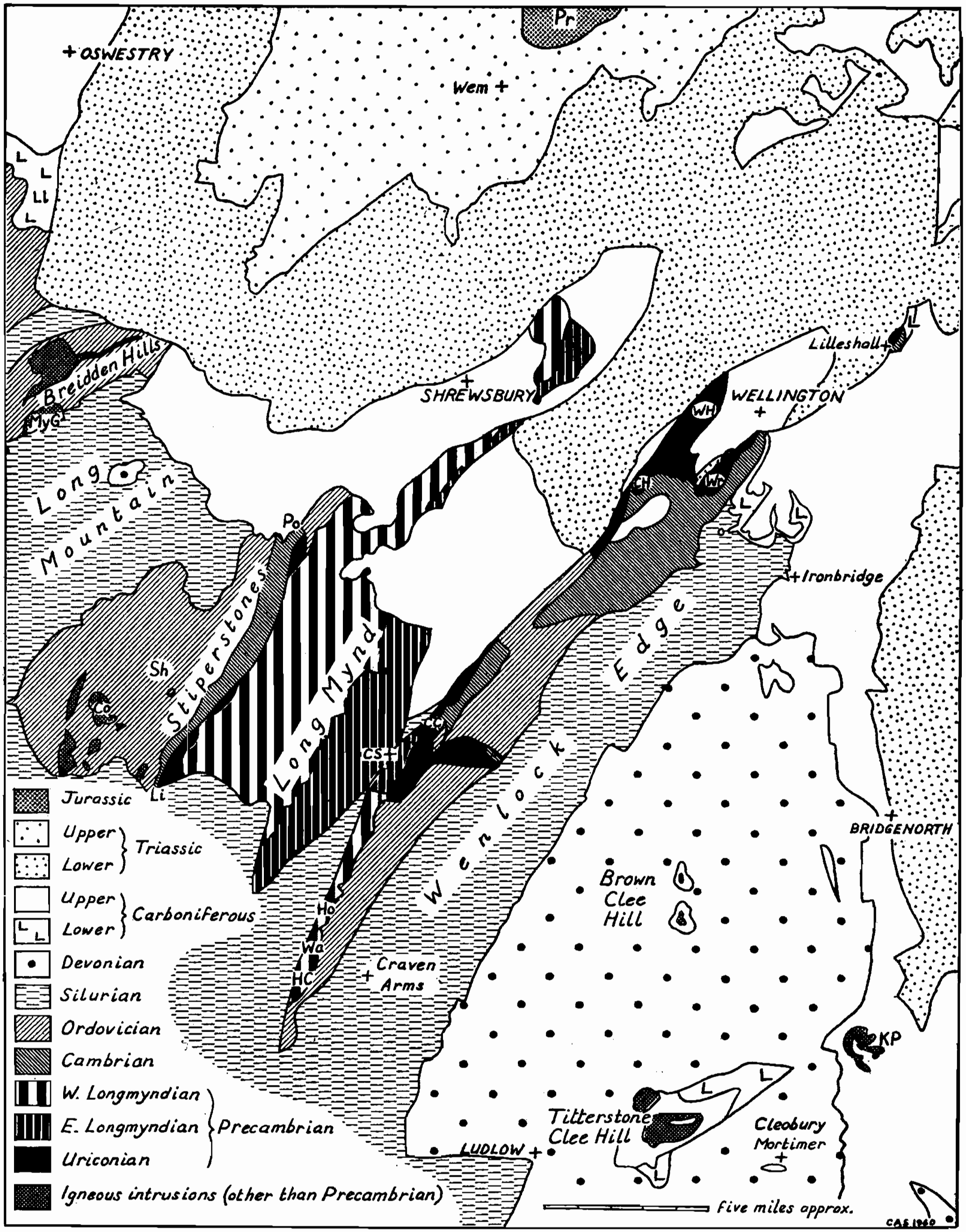

Pr
OSWESTRY
Wem
L
Ll
Breidden Hills
MyG
SHREWSBURY
Lilleshall
L
WELLINGTON
WH
Wo
CH
Long Mountain
Po
Stiperstones
Sh
Co
Long Mynd
Ironbridge
Wenlock Edge
CS
Li
Ho
Wa
HC
Craven Arms
BRIDGENORTH
Brown Clee Hill
KP
Titterstone Clee Hill
Cleobury Mortimer
LUDLOW
Five miles approx.
CAS 1960
Jurassic
Upper
Lower
Triassic
Upper
Lower
Carboniferous
Devonian
Silurian
Ordovician
Cambrian
W. Longmyndian
E. Longmyndian
Uriconian
Precambrian
Igneous intrusions (other than Precambrian)

FIG. 1.

Each one affected to a greater or lesser degree the geological formations in existence at that time, and the older formations have to some extent suffered with the advent of each new phase of movement. Little is known of the earth-movements of the Pre-Cambrian times, but some of them must have been intense. The Taconian and Caledonian earth-movements were more violent in Wales and other highland regions of Britain than they were in Shropshire, while the Armorican phase was felt more intensely in South-West England. Sometimes the Armorican earth-movements may be separated into distinct phases between which deposition of sediment recommenced.

The following, then, is a much-simplified account of the major events affecting the formation and deformation of the various groups of rocks which make up what is one of the classic areas of British geology. As research continues, it will no doubt become necessary to reconsider much that seems well-established today.

II. Structure

The largest single element in the structure of our province is the great fault-girt downwarp of northern Shropshire and Cheshire. At its centre in Cheshire the Palaeozoic floor beneath the red Triassic beds has subsided to 6,500 ft. or more below present sea level. Near Prees the floor is probably at about 5,000 ft. below sea level. Evidence from deep boreholes suggests that between Carboniferous and early Mesozoic times this floor sank between great faults placed similarly to those which limit the outcrop of the Triassic rocks today (Fig. 2).

Three economically important geological structures, the Oswestry, Shrewsbury and Leebotwood coalfields, emerge from beneath the western and southern edges of the Cheshire and North Shropshire Basin. Each shows an internal, largely synclinal structure acquired before the major downwarping of the Triassic-filled basin began, and their positions at the margin of the much larger unit suggests that subsidence here began well before Triassic times.

(1) *The Oswestry Coalfield*

This coalfield occurs as a small trough-like structure resting upon the eastern flank of the Denbighshire Ordovician-Silurian block. The Carboniferous strata dip generally eastwards or, in the south, northwards and to the south and west the coalfield is bounded by a "rim" of Lower Carboniferous strata running north from Llanymynech Hill. North-eastwards from here runs the western margin of the Triassic of the Cheshire and North Shropshire Basin, a fault or series of faults, on the eastern side of which the Coal Measures sink beneath the overlying Triassic rocks.

Fig. 1.

Sketch-map of the solid geology of Shropshire (outcrop boundaries only).

CC	Caer Caradoc	HC	Hopesay Common	Ll	Llanymynech Hill	Sh	Shelve
CH	Charlton Hill	Ho	Horderley	MyG	Moel-y-Golfa	Wa	Wart Hill
Co	Corndon Hill	KP	Kinlet Park	Po	Pontesford	WH	Wrockwardine Hill
CS	Church Stretton	Li	Linley	Pr	Prees	Wr	The Wrekin

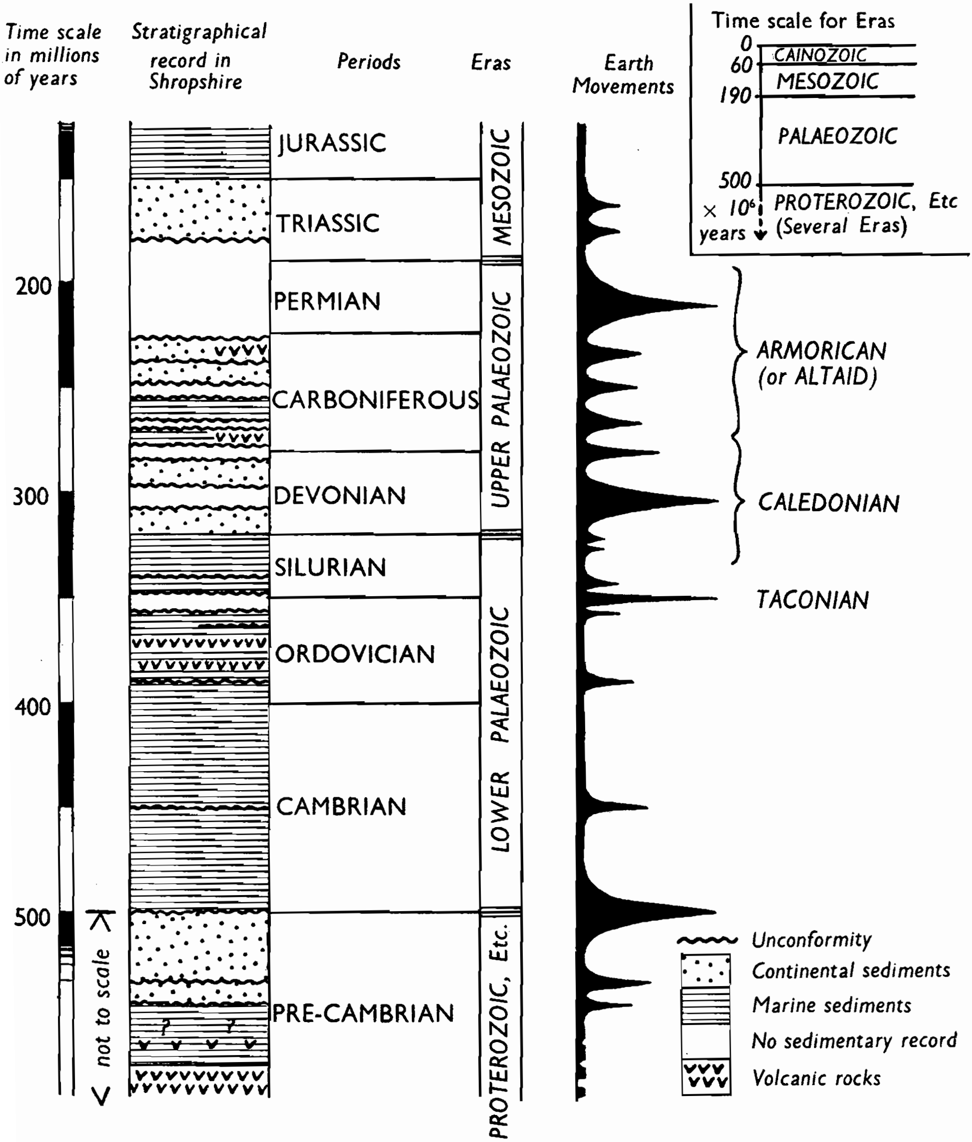


TABLE 1.

Geological time scale and phases of earth-movement in Shropshire.

(2) *The Shrewsbury Coalfield*

This belt of Upper Carboniferous rocks dipping gently northwards over an irregular basement of Lower Palaeozoic and Pre-Cambrian strata on the southern flank of the North Shropshire Basin gives a shallow zone of coal-bearing beds. Covering the Coal Measures are the Triassic strata which also dip northwards, and little is known about the northward extension of the Coal Measures at depth below the Triassic.

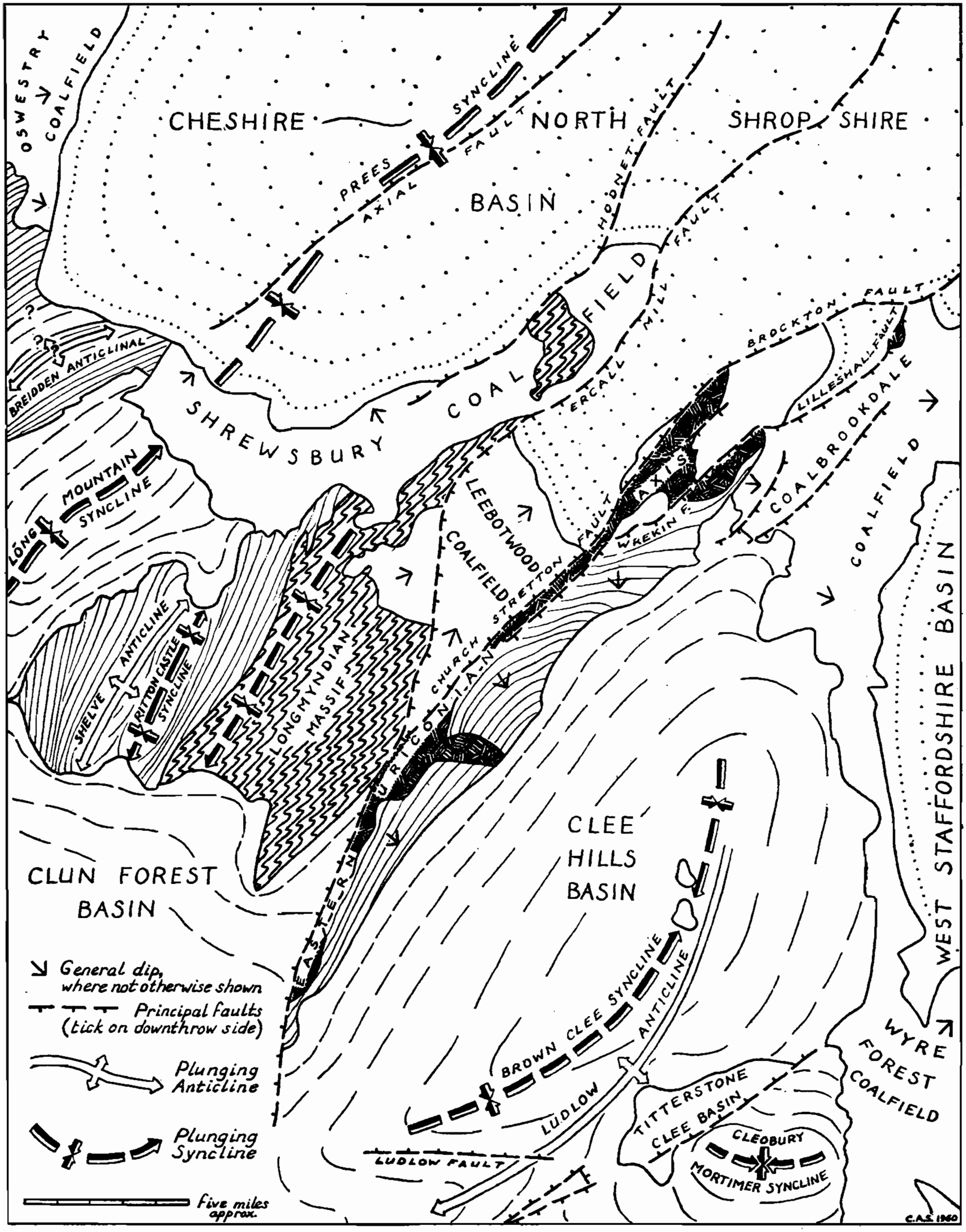
(3) *The Leebotwood Coalfield*

One of the smaller Shropshire coalfields is located in this broad down-faulted belt of Carboniferous and Triassic rocks. It is confined between the Longmyndian Massif and the Eastern Uriconian Axis (see pp. 93, 95) and is pinched away between these two blocks just north of Church Stretton. To the north the basin floor plunges northwards between the Ercall Mill fault and the Wrekin, and Triassic rocks outcrop at the surface. Longmyndian or other Pre-Cambrian rocks probably occur immediately below the Coal Measures. Within the Measures several minor flexures run more or less parallel to the edges of the coalfield but, apart from these, the beds dip gently northwards.

Our map reveals two important and conspicuous features in the geology of southern Shropshire—a number of major unconformities, and the strong N.E.-S.W. "grain" or strike of the country with its attendant faulting. The former are important clues to a long and complex history and perhaps the most obvious are those at the base of the eastern Ordovician outcrops, at the base of the Silurian, of the Coal Measures and of the Trias. Breaks between other rock formations may not be so immediately apparent but they are locally of great significance. The N.E.-S.W. (or Caledonoid) trend has probably resulted from compression of the area from the west and north and from the features of the Pre-Cambrian basement which underlies the region. The Church Stretton Disturbance, affecting rocks of many ages from Pre-Cambrian onwards, tends to divide the southern part of the country into two distinct provinces. It extends from north-east of the Wrekin, along the Church Stretton Valley southwards to beyond Brampton Bryan in N.W. Herefordshire, and may be part of a fault system extending much farther. It is possible that the rare and minor earthquakes recorded in the northern part of the Welsh Borderland were caused by slight movements in this fault system. This and other faults and planes of unconformity serve conveniently to separate on the map, as they do in the field, a number of smaller units or sub-provinces, each of which has its own distinct geological structure. These structural units are not, of course, all of the same age, nor have they all suffered the same type of earth-movement.

(4) *The Breidden "Anticlinal"*

The Breidden Hills are occupied by a relatively small asymmetrical unit of Upper Ordovician shales and volcanic rocks penetrated by an intrusive dolerite. The Ordovician beds are said to be warped about a north-east-south-west axis and the dolerite tends to accentuate the apparent anticlinal structure. Field evidence suggests, however, that the north-western limb of the anticline is no longer represented at the surface. In one of the summits,



OSWESTRY COALFIELD
CHESHIRE NORTH SHROPSHIRE BASIN
PREES AXIAL FAULT
SYNCLINE
HODNET FAULT
SHREWSBURY COALFIELD
BREIDDEN ANTICLINAL
BROCKTON FAULT
ERCALL MILL FAULT
LILLESHALL FAULT
COALBROOKDALE COALFIELD
LONG MOUNTAIN SYNCLINE
LEEBOTWOOD COALFIELD
WREKIN F.
AXIS
CHURCH STRETTON FAULT
SHELVE ANTICLINE
RITTON CASTLE SYNCLINE
LONGMYNDIAN MASSIF
EASTERN URICONIAN AXIS
WEST STAFFORDSHIRE BASIN
CLEE HILLS BASIN
CLUN FOREST BASIN
BROWN CLEE SYNCLINE
LUDLOW ANTICLINE
WYRE FOREST COALFIELD
TITTERSTONE CLEE BASIN
CLEOBURY MORTIMER SYNCLINE
LUDLOW FAULT
General dip, where not otherwise shown
Principal faults (tick on downthrow side)
Plunging Anticline
Plunging Syncline
five miles approx.
C.A.S. 1960

FIG. 2.

Moel y Golfa, an intrusion of andesite in the shales and ashes forms the hill-crest. The strata were folded before the Silurian was laid unconformably upon them.

(5) *The Long Mountain Sycline*

The Silurian shales of the Long Mountain area, lying between the abrupt mass of the Breidden Hills and the rolling Shelve country, are thrown into a broad syncline upon the axis of which is preserved a small isolated patch of Devonian strata. The earliest folding to affect this region seems to have been in pre-Coal Measures times, but to the north-east the Carboniferous and Triassic rocks also are folded along a north-eastern continuation of the Long Mountain synclinal axis in the great Prees syncline—the basin of the Shropshire-Cheshire lowland.

(6) *The Shelve Anticline and the Ritton Castle Syncline*

These two adjacent structures lie within the western Ordovician outcrop and are flanked to north, west and south by Lower Silurian beds. In all they cover about 45 square miles, the Shelve anticline occupying somewhat more than the western half of this area and exposing nearly all members of the local Ordovician sequence. The strata are in general tilted at angles up to 35 degrees, either to the east or to the west. Professor W. F. Whittard (1952) has detected several important faults, some (tear faults), breaking across the fold limbs, and others running parallel to the lines of the outcrops. The amount of horizontal movement in some of these faults amounts to many scores of yards, and most of it seems to have occurred before Llandovery times (see p. 100).

(7) *The Longmyndian Massif*

This very large unit includes all series of the Longmyndian rocks and the so-called Western Uriconian volcanics. Topographically it embraces the Longmynd and the high ground about the river East Onny and extends northwards to Pontesford Hill and (eventually) to Haughmond Hill. Its western boundary is marked by the Pontesford-Linley faults, with the Cambrian and Ordovician lying to the west; the eastern boundary is provided in part by the Ercall Mill fault and by the Church Stretton faults. To the north the Coal Measures overstep southwards on to the Longmyndian almost as far south as Church Stretton itself, while in the south Silurian beds transgress on to the margin of the massif. It is possible that the major faults on both eastern and western sides are tear faults, and the Longmyndian rocks are remarkable here for the number of small tranverse tear faults also present.

Within the western half of the Longmyndian outcrop between Church Stretton and Linley Hill a major synclinal overfold has been detected by J. H. James (1956). Geological parties from Preston Montford have been able to establish the continuation of the fold northwards.

FIG. 2.

Sketch-map of structural units in Shropshire. Selected major faults and axes of folding are shown. The Uriconian and Longmyndian units are conventionally shaded. The lines drawn on the younger units indicate the general structural "grain"—they do not represent outcrop boundaries or thickness contours.

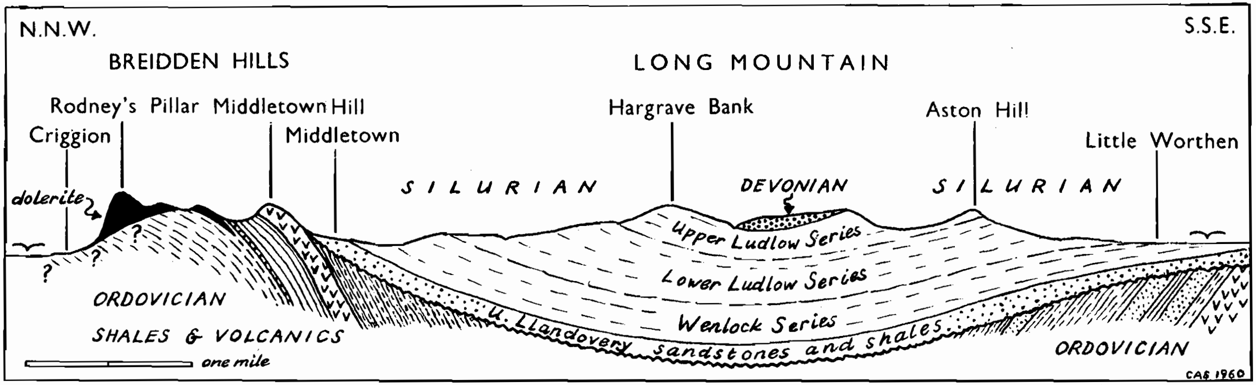


FIG. 3.

Section across the Breidden Hills and Long Mountain (after Watts). *vertical exaggeration c.x 2.*

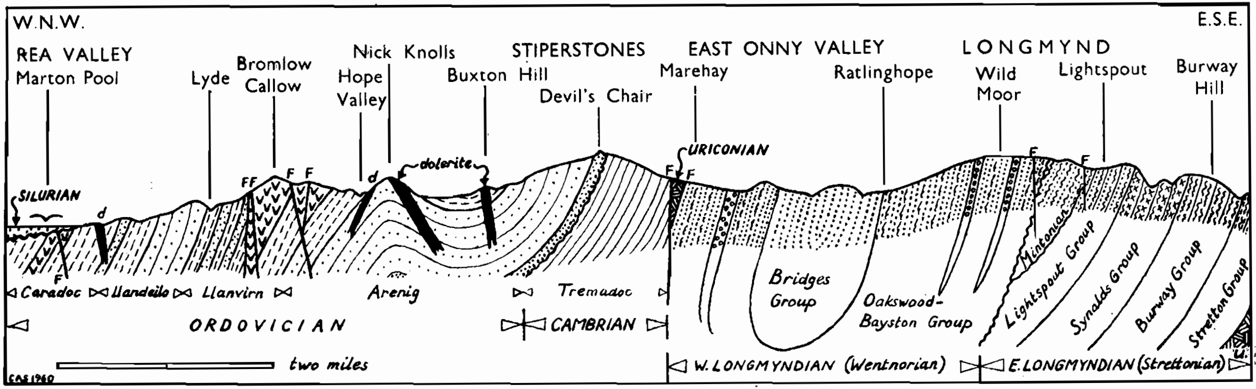


FIG. 4.

Section across the Shelve and Ritton Castle folds, and the recumbent syncline in the southern part of the Longmynd (partly after James). *vertical exaggeration c.x 3.*

(8) *The Eastern Uriconian Axis*

This name is given by the Geological Survey to the narrow belt of Uriconian and other rocks lying immediately to the east of the Church Stretton Fault and giving rise to the line of hog's-back hills on the eastern side of the Church Stretton valley. At its northern extremity it includes the Lilleshall, Wrekin, Charlton and Wrockwardine hills; towards the south it crosses the river Onny at Horderley to reach Wart Hill and Hopesay Common. The Wrekin sector of the axis is bounded to the north-west by the Church Stretton-Brockton fault, and to the south-east by the almost parallel system of Wrekin and Lilleshall faults. Farther south the Church Stretton Fault links with a complex of faults in which movement has occurred in several directions. Within the Lower Palaeozoic beds associated with the faults as at Comley near Caer Caradoc and near the Wrekin, several small tight steep folds are also developed and broken by small tranverse faults. In the Lawley-Caradoc area Dr. E. S. Cobbold (1927) distinguished three main faults, the western being a complex fracture, the middle a thrust, and the eastern probably a tear (normal) fault. Between the major dislocations occur several small fold structures with axes striking north-west, parallel to the minor tranverse faults. The amount of actual displacement caused by the faulting is difficult to assess for the movement has been discontinuous and not always in the same direction.

(9) *The Clun Forest Basin*

The Silurian rocks (capped in places by Devonian sediments) in the extreme south-western corner of the county occur as part of a large complex basin or syncline which extends into adjacent parts of Montgomeryshire and Radnorshire. The strata are grits and thick shales, hardened and often closely fractured. In general, the folding and some of the local faulting is along north-east to south-west lines, but gentle folding and faulting almost at right angles to this is also known.

(10) *The Clee Hills Basin*

Between the Eastern Uriconian Axis and the Coalbrookdale and Wyre Forest coalfields the succession is thrown into a series of gentle folds. Dips are seldom greater than 10 degrees, and in general they converge upon the higher parts of the Clee Hills. The axis of the Brown Clee Syncline runs south through Brown Clee Hill to pass just north of Ludlow where the plunge is reversed to the north. Between this structure and the Titterstone Clee Syncline, the Ludlow Anticline may be traced to link with a more complex structure south-west to Ludlow. The Titterstone Clee Syncline is not a simple downfold and appears to have been the site of intermittent downwarping in Upper Palaeozoic times. At Titterstone Clee Upper Coal Measure rocks are preserved and intruded into them is a large doleritic sill. Faults, both large and small, penetrate the Carboniferous sequence and are at least partly responsible for the delineation of the Upper Old Red Sandstone and Cornbrook Sandstone outcrops.

In the small asymmetrical shallow syncline at Cleobury Mortimer Lower Old Red Sandstone with a small outlier of Coal Measures lies about a short almost east-west axis.

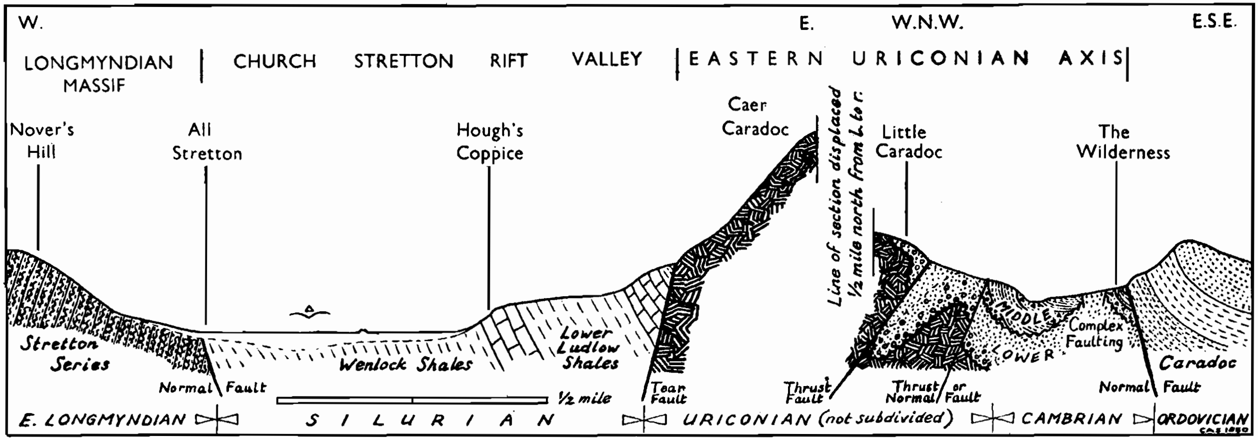


FIG. 5.

Section across the Church Stretton Rift Valley and the Eastern Uriconian Axis, the latter schematic (after Cobbold). *vertical exaggeration c.x 2.*

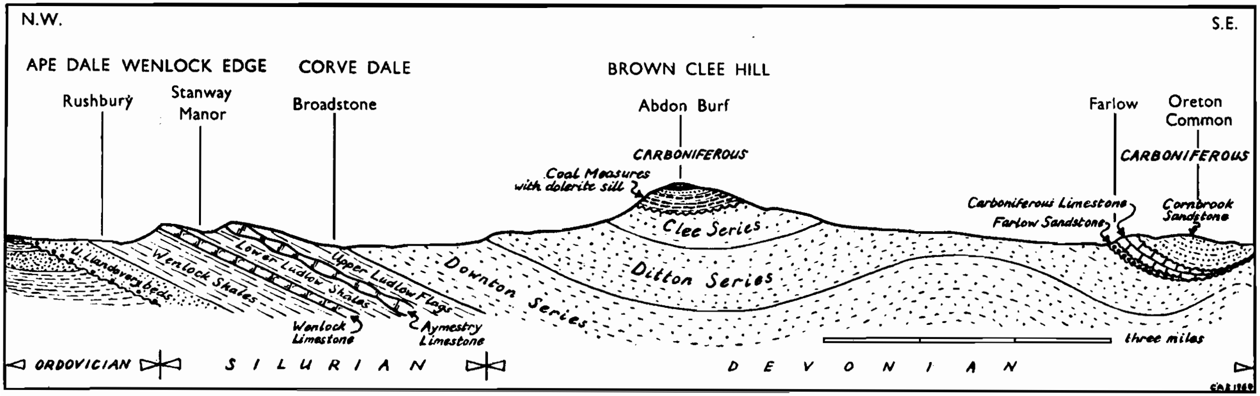


FIG. 6.

Section across the Wenlock Edge and Clee Hills basin. *vertical exaggeration c.x 3.*

(11) *The Coalbrookdale and Wyre Forest Coalfields*

The strata in these shallow coalfield basins in the extreme east of our region rest upon rocks of various ages and dip generally and gently eastwards. While the north-western boundary of the Coalbrookdale Coalfield and the eastern boundary of the Wyre Forest Coalfield is faulted, their western boundaries are marked by the normal emergence of the pre-Coal Measures basement. Within the coalfields there is considerable faulting locally, usually in directions approaching north-south or north-east to south-west. Gentle warping of the Measures into domes and troughs also occurs along similar lines.

III. Palaeogeographical stages

(1) *The Pre-Cambrian*

Subdivision of the Pre-Cambrian rocks is based upon lithological and general structural considerations and it results in three major categories being recognized. Perhaps the oldest is that of the Rushton Schists and Primrose Hill Gneisses, then come the Uriconian igneous rocks and, uppermost, the immensely thick Longmyndian sediments. The schists and gneisses are metamorphic rocks outcropping over only a few acres near the Wrekin. Exactly how they fit into the picture is not certain, but they underlie the Cambrian and appear to have suffered more alteration and crushing than the other Pre-Cambrian formations. The Geological Survey has, however, suggested that they are possibly metamorphosed representatives of the Uriconian and Longmyndian. On structural grounds we have little evidence either way.

A great thickness of Uriconian volcanic and associated intrusive rocks crops out in the line of hills forming the Eastern Uriconian axis, and also the less prominent Pontesford and Linley Hills on the western side of the Longmyndian massif. Geological structures within the Uriconian rocks are difficult to unravel but they certainly involve folding, faulting and the intrusion of large and small igneous bodies in Pre-Cambrian times. Near Church Stretton the volcanics grade upwards into the Longmyndian, which Dr. J. H. James (1956) has now grouped as follows:

WENTORIAN STAGE Coarse red and purple beds		
	Bridges Group	2,000-3,000 ft.
	Oakswood Group and Bayston Group	3,500-6,300 ft.
	——— unconformity ———	
MINTONIAN STAGE Purple and green beds		
	Portway Group	1,600-3,800 ft.
	——— unconformity ———	
STRETTONIAN STAGE Grey or greenish, generally fine-grained beds		
	Lightspout Group	2,100-2,800 ft.
	Synalds Group	2,000-2,800 ft.
	Burway Group	2,200-2,400 ft.
	Stretton Shales	approx. 3,400 ft.
	URICONIAN	

Though their outcrops are separated by several miles, there is no real reason to suppose that the eastern and western Uriconian rocks are not part of the same formation. The Strettonian beds follow on the eastern Uriconian outcrop with no pronounced break, but between the three major divisions of the Longmyndian are two important unconformities. The Portway Group transgresses gradually across the Lightspout Group and is not so crushed or compacted as the Strettonian, indicating that the extra deformation in the latter is probably of pre-Mintonian date. A stronger unconformity locally cuts out the Mintonian below the Wentnorian. The Oakswood Group seems to be overturned and to the east it can be correlated with the Bayston Group which is not inverted. This succession seems to involve a sequence of events which begins with the fading of Uriconian volcanic or igneous activity. Predominantly muddy water-laid sediments, derived in part at least from the weathering of Uriconian rocks, then accumulated. Their enormous thickness implies the depression of the crust to a considerable degree, but the process was halted and reversed for an interval before the Mintonian beds were laid down. It seems likely that fairly vigorous erosion and rapid deposition followed and that the cycle was repeated prior to the formation of the Wentorian strata. The Wentorian is composed of coarse red sediments typically produced by the rapid erosion of an area newly elevated to some appreciable relief. James (1956) interprets the structure of the Longmyndian rocks between Church Stretton and Linley as comprising a major inverted or recumbent syncline. This involves considerable movement and the dip of the Strettonian has been reversed since the Portway and higher groups were laid down. The syncline plunges to the south below a cover of Silurian deposits and was presumably formed in later Pre-Cambrian times by east-west pressure. The many small tranverse faults located in the Longmyndian beds may have first appeared shortly after the folding or may have been produced much later. In any event, their general size and orientation corresponds well with those faults in the early Palaeozoic rocks nearby and they may similarly have been produced in Taconian or Caledonian times.

(2) *Cambrian to Upper Ordovician*

The earliest fossiliferous rocks, the Cambrian System, rest with a sharp unconformity upon the Pre-Cambrian. Charles Lapworth (1888) established the presence of the Lower Cambrian series at Comley, near Church Stretton, and showed that the Uriconian and Longmyndian must be of Pre-Cambrian date. The sub-Cambrian break indicates an extensive period during which the Pre-Cambrian rocks were folded, faulted and later suffered sub-aerial denudation down to an almost plane surface. It was during this period, perhaps, that the first movement occurred along what was to become the Church Stretton Disturbance. Cambrian times opened with the rapid spread of the shallow sea over this and a much larger region. Fairly gentle subsidence occupied early Cambrian times, but prior to the deposition of the Middle Cambrian rocks at Comley on the Eastern Uriconian Axis the newly formed sediments were subjected to folding and erosion so that a minor unconformity results. Digging trenches beyond the natural exposures, Dr. E. S. Cobbold (1927) established a Cambrian sequence of distinctive bands with characteristic fossils. The order in which they occur suggests that bands present elsewhere are missing at Comley, perhaps because sea currents and crustal movement in Middle Cambrian times prevented deposition in this neighbourhood. In the shales generally included within the Upper Cambrian this same feature is noted again.

The Tremadoc Series (now regarded as Ordovician, but shown as Cambrian in Figures 1 and 4), bluish grey shales and dark micaceous flags, follows directly on the Upper Cambrian shales and shows a continuation of deposition in quiet, perhaps deep, water. Subsidence of the sea floor appears to have been uniform and extensive; there is little or no sign of the coming uplift that was to affect this area and much of Wales and the Midlands at the end of Tremadoc times. The uplift itself and the erosion and subsidence which followed it all took place prior to the unconformable emplacement of the Arenig and later formations upon the older beds.

To the west of the Church Stretton fault zone and the Longmynd an almost full sequence of Ordovician rocks, laid originally in fairly deep water, is present. East of the Longmynd, however, the Arenig, Llanvirn, and Llandeilo series are missing. The sequence in the Shelve country shows that, apart from the deposition of the white sands of the Stiperstones Quartzite in Arenig times, predominantly muddy sediments accumulated. Volcanic outbursts occurred, though on a much smaller scale than in Wales, where subsidence of the sea floor was also greater. The association of the more intense type of volcanic activity with those parts of the crust subsiding rapidly during Ordovician times is well shown on North Wales; at Shelve both subsidence and vulcanicity were on a moderate scale. Marine conditions did not reach eastwards to the Caradoc area until late Ordovician times, when sandy sediments were spread over the eroded edges of the Pre-Cambrian and Cambrian rocks. Wills (1958) has suggested that the western margin of the relatively immobile and stable region known as the Midland Block was marked by the Church Stretton Disturbance, and may have defined the eastern limit of the Ordovician sea until Caradoc times, when perhaps fault movement was felt and the narrow coastal plain became submerged. Here then, in the vicinity of Church Stretton there is again evidence of a probable structural or tectonic control over Palaeozoic geography and sedimentation.

(3) *Upper Ordovician to Upper Silurian*

Between the Ordovician and Silurian rocks occurs an unconformity of great significance. In Shropshire neither the latest Ordovician nor the earliest Silurian times are represented. Deposits of Upper Llandovery age appear as

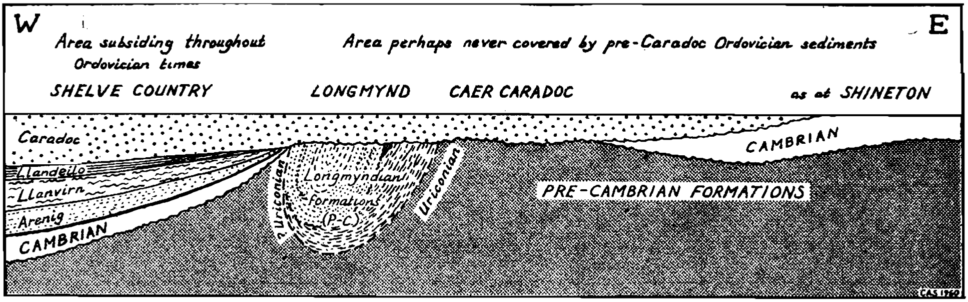


FIG. 7.
Generalized section to show the relationships of the Ordovician rocks in Shropshire.

the oldest of the Silurian, smothering a highly irregular coastland topography carved in the Pre-Cambrian to Ordovician rocks. The interval between the Caradoc and the Llandovery Series witnessed the widespread earth-movements known as the *Taconian* Orogeny. During this phase the Ordovician rocks of the Shelve and Breidden areas were thrown into their present folds and the area of the Longmynd assumed something resembling its present relief with faults perhaps forming its eastern limit in the Church Stretton region.

Fault movement, especially the tear-faulting known on a broad scale in the Shelve district, in the Longmynd, near Pontesford and at the Wrekin, probably dates from these times. Small basic igneous intrusions known in the Longmyndian, Cambrian and Ordovician rocks may possibly have been emplaced during these movements. Contemporaneous with these was general uplift of the whole area to such an extent that marine sedimentation was halted and a complex land surface of appreciable relief developed. Upper Llandovery times then saw the gradual resubmergence of this land surface and also of the old stable Midland Block. Professor Whittard (1932) has described the origin of the Shropshire Llandovery strata around the Longmynd as sediments derived from the local existing rocks and laid down in

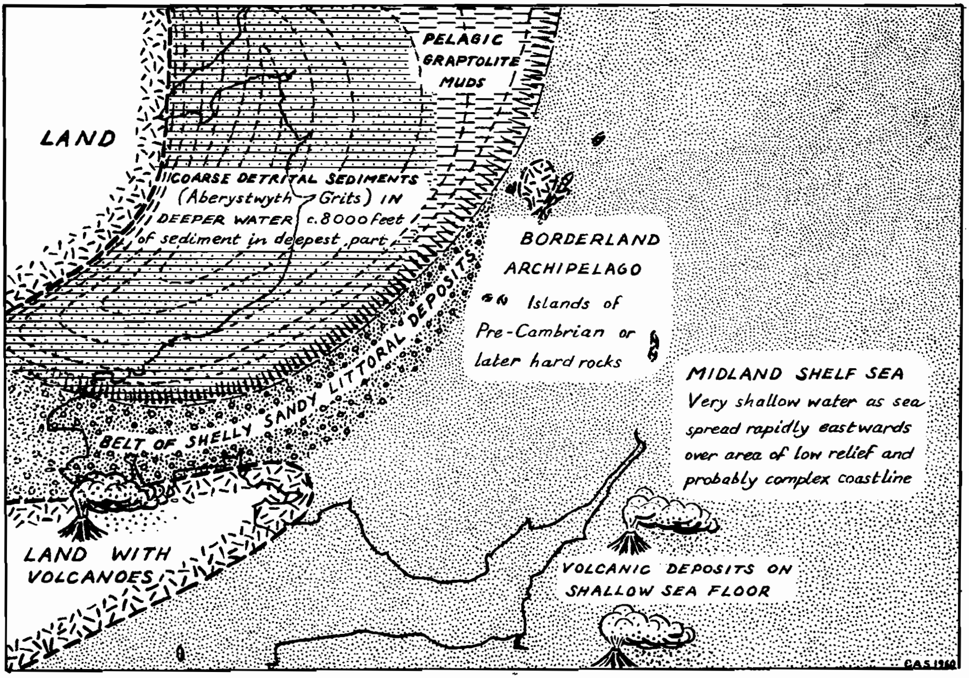


FIG. 8.

Sketch-map of early Silurian geography (after Wills).

the littoral zone around the indented and receding coastline. As relative sea level rose so the Llandovery sands and shingles spread over greater areas of the ancient surface. During this time the Church Stretton fault belt seems to have remained dormant, for Llandovery rocks on either side of it are of much the same appearance.

Wenlock times, however, brought about a completely different state of affairs. To the east of the Church Stretton Disturbance is the classic sequence of shales and limestone with its abundant coral and shelly faunas; to the west occur grey shales with graptolites. Between the Upper Llandovery and the Wenlock there is a locally distinct if not conspicuous unconformity, indicating a temporary uplift of the sea floor above current or tide level. This type of hiatus, involving little or no angular discordance in the succession, appears several times in the Silurian rocks of the Welsh Borderland.

In the Long Mountain some 1,500 ft. of monotonous grey graptolitic shaly Wenlock strata are evidence of long-continued, undisturbed quiet deposition, distant from (coastal) sources of coarse clastic sediment. At Wenlock Edge, however, the shales are different and the Wenlock Limestone caps the sequence. These rocks, reaching about 900 ft. in thickness, are of shallow water type and may be traced eastwards into the Midlands. Shelly fossils are abundant and the limestone contains reef-like masses ("crogballs", "ball-stones") of the primitive lime-secreting organisms known as stromatoporoids, and of bryozoa, corals and other benthonic fossils. The reef-like structures appear to have grown up on a relatively flat and uniform sea floor in the shallow clear water near the edge of the stable Midland Block. To their immediate west lay the fault-controlled and possibly current-swept slope into deeper waters. In the vicinity of the Church Stretton faults, near Horderley, the shelly Wenlockian gives way to an intermediate type, with both shelly and graptolitic features.

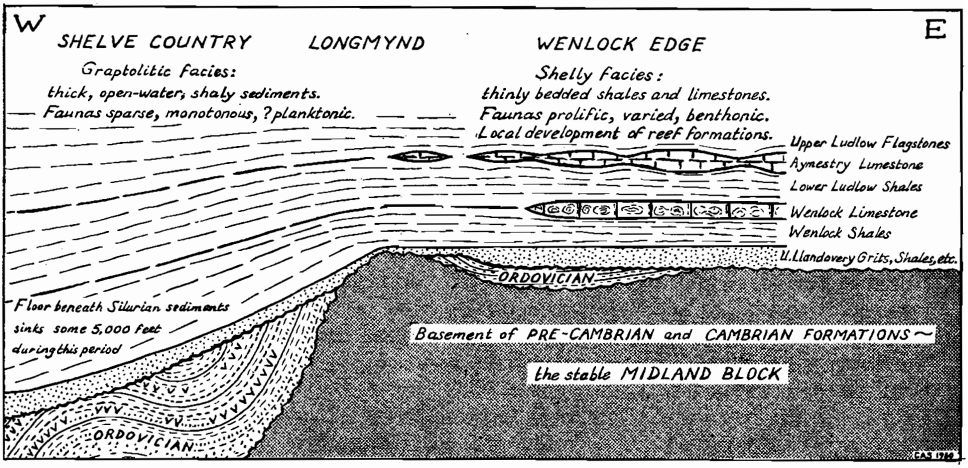


FIG. 9.

Generalized section to show distribution of formations across the Church Stretton Disturbance towards the end of Silurian times.

Only a short distance farther west but still on the eastern side of the Longmynd the true graptolitic facies is reached. Thus subsidence of the sea floor to the west of the Church Stretton faults again seems to have been a controlling factor in the production of these contrasting but adjacent and coeval deposits.

Ludlovian times saw the continuation of the same general conditions—shallow water and generally shelly faunas in calcareous sediments to the east, graptolitic open-sea faunas in muds to the west. The Aymestry Limestone brachiopod "shell-banks", seemingly confined to a narrow belt running almost parallel to the Church Stretton line, were perhaps sorted and swept by currents at the edge of the stable block.

Recent work on the shelly Ludlow rocks of the Welsh Borderland (Lawson, 1956) shows that there are a number of levels at which current activity and perhaps gentle warping or upward movement of the sea floor prevented sediment from settling locally. This is especially so in the Upper Ludlow series where there is a distinct swing from true marine sediments towards deltaic beds. Movements beginning in Wales and elsewhere were soon to bring about a rapid and spectacular geographical change. As the Ludlovian epoch draws to a close, the influx of silty sediment and quickening of deposition begins. By the opening of the Devonian period, banks of deltaic mud and sand from new source areas make their appearance in the Borderlands region.

(4) *Lower Devonian to Upper Carboniferous*

Later Palaeozoic events are recorded by a number of comparatively thin and extremely varied unconformable rock units occurring largely in the northern and eastern parts of our county. The lowest of these units, however, follows conformably upon the Ludlow and extends to the Clee Series of Breconian age. With the Ludlow Bone Bed at the base of the Downtonian there is evidence of widespread shallow conditions and a general pause in sedimentation, so far unknown west of Church Stretton. In the Downton Series non-marine red beds follow the drab sandy deposits of the Downton Castle Sandstone and Temeside Beds—a short-lived, possibly brackish water delta. Downtonian and Dittonian deposits appear to be alluvial and fluviatile, spread as sheets across a large sub-aerial delta. Subsidence in the eastern part of the county was enough to allow 1,200 ft. or so of the marly Downton Series to accumulate. In the Clun Forest a thickness of 2,000 ft. of Downtonian beds is suspected, showing perhaps that subsidence in the west was still more pronounced than in the Clee Hills area to the east. It continued through Dittonian and Breconian times at perhaps a slightly faster pace and 2,000 ft. or more of coarser detritus entered the area. It is difficult to estimate how extensive this was, but to the west of it the ground was rising with the onset of the later Caledonian earth-movements in Wales. Rapid sub-aerial denudation perhaps under semi-arid conditions immediately began, producing the debris which was ultimately swept into the Shropshire lowland. During earliest Devonian times the earth-movements may only have affected regions distant from Shropshire, but the uplands "front" advanced slowly eastwards so that by Breconian times pebbles derived from the Wenlock Limestone and the Uriconian-Ordovician rocks of the Church Stretton—Wenlock area were incorporated in the deposits. There is evidence that to the north-east of the Midland Block also the ground was perhaps rising and contributing a flow of sediment into the Shropshire area.

Finally, the whole of the Lower Old Red Sandstone basin appears to have been involved in the uplift and to have suffered gentle folding. There is no trace of the Middle Old Red Sandstone and it is possible that in Middle Devonian times there was little or no deposition. Elevation and erosion continued almost until the end of the Devonian period when the Farlow Sandstones appeared. This break in the sedimentary record corresponds to a phase of vigorous and important movements over large areas of Britain. Again it comes within the sequence of events referred to the *Caledonian* orogeny. It may be that the Brown Clee and Titterstone Clee synclines and the Ludlow anticline acquired much of their present form during this period. Strongly marked fault disturbances in Herefordshire and Radnorshire, and many local small faults in the Dittonian strata, possibly date from this time. To the west of the Church Stretton Disturbance the Silurian beds are thrown into a series of folds which increase in intensity westwards. In the fault zone itself the Silurian beds appear to be crushed and sheared between the more resistant formations.

The coarse gritty or conglomeratic Farlovian beds, reaching a thickness of at least 400 ft., were deposited from strongly flowing streams. Unconformably overlain by Lower Carboniferous beds, they seem to represent only a small span of late Devonian time. Apart from a thin basal sandstone or conglomerate the Lowest Carboniferous occurs near Clee Hill as limestones directly related to the great Carboniferous Limestone series in South Wales and the Mendip areas. Again, only a small fraction of the record is represented; the thin limestones are unconformably overlain by the Cornbrook Sandstone which is now regarded as of Middle Carboniferous age. The shallow clear or sandy sea of the Lower Carboniferous period entered the southern part of our region from the south, probably with great rapidity since the later Devonian erosion had reduced the ground to a very low level. An axis of uplift now known to have existed during Lower Carboniferous times in south-east Wales may well have also affected the Clee Hills area: the Cornbrook Sandstone could have been deposited on the eastern flank of an elongate anticlinal (?land) area extending northwards from Usk in Monmouthshire.

In the Wellington and Oswestry areas, beds high in the Carboniferous Limestone sequence that stretches to the Pennine regions and into North Wales rest directly upon folded Silurian and older strata. The unconformity shows that the land surface of the day was here tilted to the north, so we see that two Lower Carboniferous marine invasions of the area took place at different times and from different directions. It is not known whether the areas affected ever overlapped.

Little is known of the Middle Carboniferous movements in the Midlands and Borderland, except that they maintained a barrier, perhaps discontinuous at times, separating the sedimentary basins that were developing to both the north and the south. The Cefn-y-fedw Sandstone in the north-west and the Cornbrook Sandstone at Clee Hill are both representatives of the Middle Carboniferous, but seem to have been deposited in quite separate deltaic regions on opposite sides of the barrier just mentioned.

Witness of Upper Carboniferous events are the Coal Measures of the coalfields. They constitute a complex group of sediments of variable thickness, resting upon a floor of rocks from Pre-Cambrian to Namurian (Cornbrook Sandstone at Titterstone Clee Hill) in age. The Measures show cyclic repetition of the different rock types within the group. Laterally the individual cycles vary greatly from one place to another and indicate that subsidence was far from uniform. In coal seams, largely made of vegetable debris, we have a record of swamp environment; bands with marine fossils are also known and indicate a sudden invasion of the swamps by the sea. Three such marine bands are known in Coalbrookdale, and although one is continued into the Wyre Forest, they do not occur in the Clee Hill nor in the Shrewsbury fields. Throughout Upper Carboniferous times the area of deposition expanded southward, so that in this direction progressively younger members of the Measures rest unconformably upon the floor below. In Shropshire only the Middle ("Productive" or "Sweet") and Upper (or "Barren") Coal Measures are present, and they are separated by an unconformity and an interval of time occupied by the so-called *Malvernian* earth-movements.

The Middle Coal Measures may have had a much greater outcrop area prior to the formation of the "Barren" Measures, but their extent was undoubtedly limited by high ground rising in the Eastern Uriconian Axis and stretching as far west as the Breidden Hills. The Upper Coal Measures cropping out in the Shrewsbury, Coalbrookdale, and Wyre Forest fields, rest upon the Middle Coal Measures with considerable angular discordance. In Coalbrookdale the Middle Coal Measures had been folded, faulted, eroded and in one part of the coalfield even completely removed before Upper Coal Measure times. The Upper Coal Measures of the Shrewsbury fields show a gradual return to continental (red-bed) sedimentation though there are coals in the lower parts. Throughout the group pebbles and flakes of Longmyndian and other locally derived material are to be found and at the top of the sequence the Alberbury Breccia is made up of Carboniferous Limestone and red or purple sandstone fragments (Mercer, 1959). Denudation of a Carboniferous Limestone outcrop in the Llanymynech area seems probable. Similar conglomerates south of Shrewsbury, and near Kidderminster, may have been gravel fans formed during the uplift of the ground to the south and west. Through Upper Carboniferous times two types of earth movement, often going on side by side, seem to be indicated in Shropshire. The first is the expansion of the areas of sedimentation by local subsidence and denudation; the second is periodic uplift with local folding and faulting, a process which brought deposition to a halt at the close of the Carboniferous period.

(5) *Permian, Mesozoic and Later Events*

The Triassic deposits of the northern half of Shropshire, in common with many of the Permo-Triassic formations elsewhere, rest upon an irregular "buried landscape" surface of Carboniferous and other rocks. Permian time was occupied by upheaval and sub-aerial denudation and, at the beginning of the Triassic period, the land surface of northern Shropshire and Cheshire began to subside steadily and strongly. This later region seems to have developed

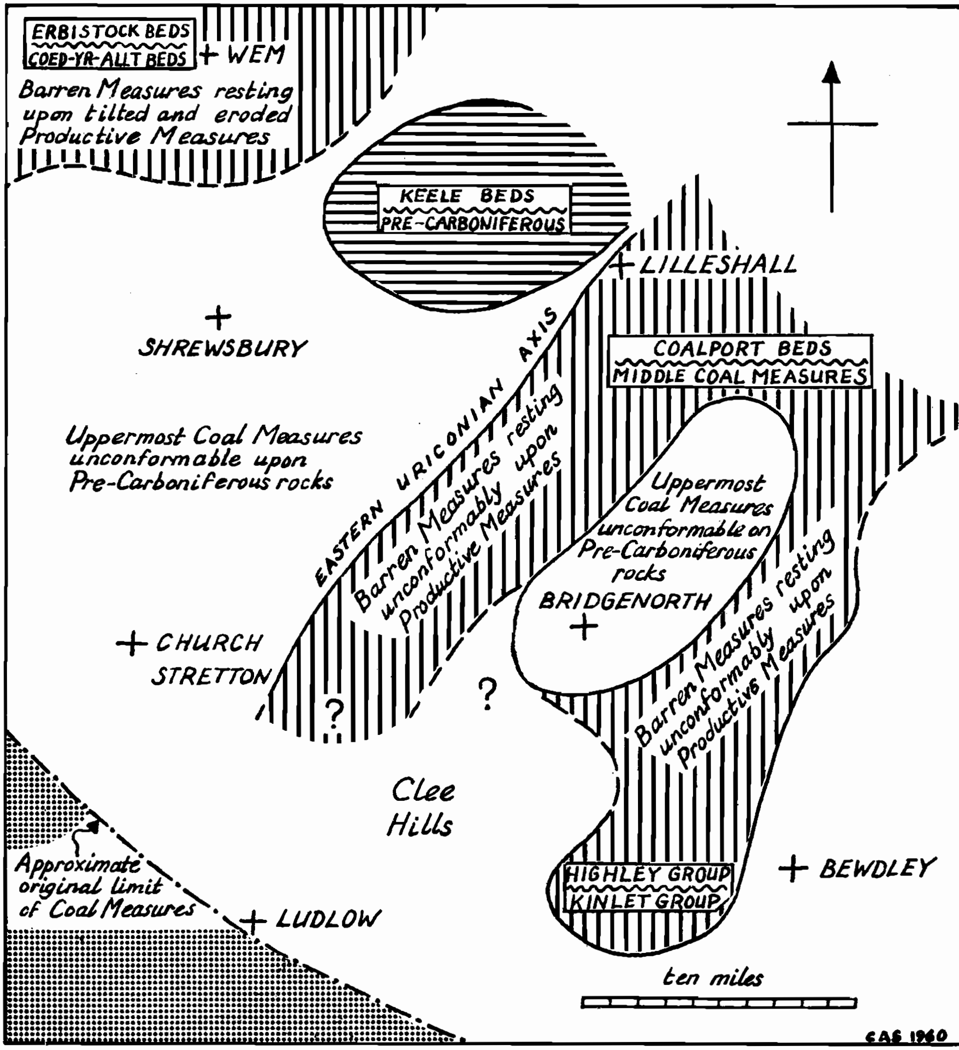


FIG. 10.
Sketch-map of the local palaeogeography and tectonics of the Coal Measures (after Wills).

throughout Permo-Triassic times as a fault-girt basin in which accumulated a great thickness of continental beds—one of the most impressive "intermontane basins" known in Britain. The southern margin of deposition in this basin reached northern Shropshire in Bunter times and about a thousand feet of Bunter sandstones and pebble beds lie to the north of the coalfields. The significance of the break below these deposits cannot be overstressed; the movements then taking place probably imparted to our geological map the greater part of the structural outline seen today. There was folding of the Coal Measures on a broad scale, but faulting most likely played the dominant role. The displacement of the Leebotwood Coalfield southward along the Church Stretton fault and the faulted boundaries of the other coalfields were produced at this time. The Clee Hill synclines experienced further movement: the coalfields there and the Measures at Cleobury Mortimer are warped and faulted along axes largely coincident with those in the Old Red Sandstone below. Sheets and dykes of dolerite known in the Coal Measures at the Clee Hills, Kinlet Park and elsewhere were most likely intruded during the later stages of the movements.

It has been thought unlikely that the Triassic deposits ever extended very far beyond their present limits, but possibly the plateau-like summit of the Longmynd was produced by plantation during the arid Permo-Triassic period and was to some extent covered by the later Triassic formations. There is, however, little real evidence to support this suggestion.

Of the post-Triassic history of Shropshire little can be said. Only with the advent of the Pleistocene period do sediments, albeit of a superficial kind, contribute again to the record. What further Mesozoic strata were ever present above the thin deposit of Liassic clays that occurs north-east of Wem is unknown. The Liassic rocks indicate a period of marine activity, but how far it extended over Shropshire is unknown. Higher parts of the Jurassic and Cretaceous systems may have spread across this part of the country but they have left no trace of their presence. In Tertiary times folding affected large parts of southern England, but the Palaeozoic regions of the British Isles remained comparatively rigid and stable. The Church Stretton dislocation may from time to time have been merely the site of small fault movements. There are, it is true, faults affecting the Triassic outcrops and several of the large faults affecting the Palaeozoic systems continue into the Triassic. They are of the normal tensional type and no great movement is involved. Their exact date remains a mystery and they may perhaps have developed slowly and periodically during Mesozoic or Tertiary times when the Palaeozoic floor of southern England was involved in flexuring on an extensive scale. Nothing comparable with the tectonic events of the Palaeozoic era took place during the Mesozoic and later times.

One final earth-movement may be mentioned, though it is not of the kind that has produced much of the present structure of Shropshire. It is the gentle rise relative to sea level of much of Britain following the disappearance of the Pleistocene glaciers. No structural deformation is involved, but the resulting steepening of stream gradients and the deepening of river valleys, such as that of the Severn below Ironbridge, has certainly had a most profound effect in the Welsh Borderland.

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Appendix

Geological formations occurring in Shropshire

Note: This appendix does not include every named bed in the geological succession in Shropshire: only those most commonly encountered in the literature are listed. Where important modifications to the nomenclature have been suggested recently the reference is given below: most of the Palaeozoic formations are listed in Professor Whittard's paper "A Geology of South Shropshire" (1952).

JURASSIC	*Liassic*	Clays
TRIASSIC	*Keuper*	Marl
		Sandstones (Bromsgrove Sandstone of Midlands)
	Bunter	Upper Mottled Sandstone
		Pebble Beds
		Lower Mottled Sandstone
		Bridgnorth or Dune Sandstone
CARBONIFEROUS	*Coal Measures*	
	Upper:	Erbistock Group (including Alberbury Breccia): Enville Beds: Keele Beds.
		Coed-yr-Allt or Newcastle-under-Lyme Beds or Halesowen Group: Coalport Beds. Ruabon or Etruria Marl

	Middle:	Productive Measures
	?Middle Carboniferous	Cornbrook Sandstone
	Carboniferous Limestone	Limestones, basalt-lava, Lydbrook Sandstone
DEVONIAN	*Upper Old Red Sandstone*	Farlow Sandstone Series (1)
	Lower Old Red Sandstone	Clee Series (2)
		Ditton Series (3)
		Downton Series: Red Downton Formation, Grey Downton Formation
SILURIAN	Ludlow Series	Upper Ludlow Shales (or Flags) (4)
		Aymestry Limestone
		Lower Ludlow Shales
	Wenlock Series	Wenlock Limestone
		Wenlock Shales
	Llandovery or (Valentian) Series	Hughley Shales
		Pentamerus Beds
		Kenley Grit or Arenaceous Beds
ORDOVICIAN	Caradoc Series (5)	
	Llandeilo Series	
	Llanvirn Series	
	Arenig Series	
	Tremadoc Series: Habberley Shales: Shineton Shales	
CAMBRIAN	Upper: Black and Grey "Orusia" Shales	
	Middle: Upper Comley Series	
	Lower: Lower Comley Series	
	Wrekin Quartzite	
PRE-CAMBRIAN	Wentnorian:	Bridges Group
		Oakswood-Bayston Group (6)
	Mintonian:	Portway Group
	Strettonian:	Lightspout Group
		Synalds Group
		Burway Group
		Stretton Shales
	Uriconian	(Volcanic) Series
	Rushton Schists and Primrose Hill Gneisses	

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