

Triassic and Jurassic environment and lithostratigraphy, Northern England

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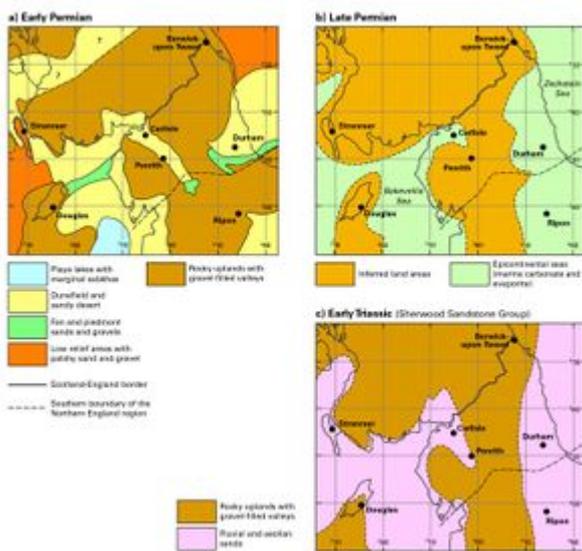
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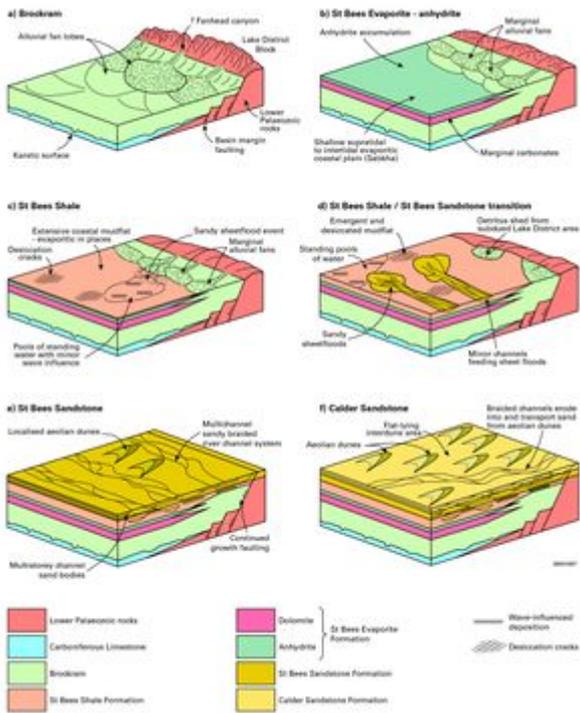
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Introduction



Distribution of depositional environments across northern England during Permian and Triassic times (after Cope et al., 1992. Atlas of Palaeogeography and Lithofacies, Geological Society of London Memoir, No. 13). P916085.



Cartoons illustrating the changes in depositional regime through Permian and Triassic times (after Akhurst et al., 1997. The geology of the west Cumbria district. BGS Memoir). P916086.



St Bees Sandstone Formation strata. (Permo-Triassic, Sherwood Sandstone Group) at St Bees Head, Cumbria. (P220633).



St Bees Sandstone Formation strata at Hole

Sike near Ousby, Cumbria [NY 6199 3452].
 Cross-bedded, red-brown sandstone overlies
 finely bedded brown and pale grey
 micaceous sandstone and siltstone.
 (P221917).

GROUP	EAST IRISH SEA AND SOLWAY FIRTH BASINS			CARLISLE BASIN	VALE OF EDEN BASIN
	OFFSHORE		ONSHORE (West Cumbria)		
JURASSIC	Liass Group	Liass Group (undivided)		Liass Group (undivided)	
	Peebles Group	Lilstock Formation		Lilstock Formation	
		Wesbury Formation		Wesbury Formation	
TRIASSIC	Marec Mudstone Group	Blue Anchor Formation		Blue Anchor Formation	
		Dunck Mudstone Formation		Stennis Shales Formation	
		Warton Muds Formation			
SHERWOOD SANDSTONE GROUP	Orebank Sandstone Formation		Orebank Sandstone Formation	Kilbinton Sandstone	Kilbinton Sandstone
	St Bees Sandstone Formation	Caldar Sandstone Member	Caldar Sandstone Formation	?	?
		Bullington Member	St Bees Sandstone Formation	St Bees Sandstone Formation	St Bees Sandstone Formation
	Bromborough Mudstone Formation		St Bees Shale Formation	Eden Shales Formation	Eden Shales Formation
St Bees Exposite Formation		St Bees Exposite Formation			
PERMIAN	Cullinart Sandstone Formation and Brockton		Brockton	Pennine Sandstone Formation and Brockton	Pennine Sandstone Formation and Brockton

CARBONIFEROUS ROCKS

Lithostratigraphical subdivision of the Permian, Triassic and Jurassic rocks of north-west England. P916115.

In northern England, sedimentation continued into Triassic times, primarily on the sites of the former, but still subsiding, Permian basins. The Pennines remained an upland area, although somewhat more subdued than previously, separating deposition in the west from that in the east (P916085)c.

North-west England

West of the Pennines, the late Permian to early Triassic interval saw a transition from a mainly marine to a continental environment; the nature of the sediment deposited changed accordingly. A large and extensive fluvial channel system — the Budleighensis River — flowed northward, carrying significant amounts of sediment derived from a distal, southerly source in the mountains of Armorica. This dominant source was supplemented, to varying degrees, by sediment eroded more locally from high ground in the Southern Uplands of Scotland and the English Lake District. The uniform, fine-grained, micaceous, reddish-brown sandstones of the St Bees Sandstone Formation, the lowermost unit of the Sherwood Sandstone Group, were deposited by this river system (P916086)d. The formation extends over much of onshore west Cumbria and the Carlisle and Vale of Eden basins, and is exposed spectacularly in the cliffs around St Bees Head, Cumbria (P220633) and (P221917).

The base of the St Bees Sandstone Formation is usually taken at the first major sandstone bed above the thinly bedded sandstones and siltstones of the upper Eden Shales and equivalents, although the transition is almost certainly diachronous. The Permian-Triassic boundary occurs within the lower part of the formation (P916115). Siltstone and claystone beds are prevalent towards the base and a wide range of sedimentary structures, including parallel lamination, planar-and trough-cross-bedding, and convoluted bedding, is present. Throughout early Triassic times, the Budleighensis river system evolved and matured. Lithology and sedimentary structures towards the base of the

formation are indicative of unconfined sheet-flood events that pass upwards into single storey channels with over-bank flood deposits. These in turn give way to large multistorey, stacked channel complexes. The very top of the formation contains increasing amounts of fine-grained sediment, mudstone interbeds and aeolian grains.

Following deposition of the St Bees Sandstone, the extensive, high-energy river system waned and was largely abandoned. The Budleighensis River had been diverted, probably by tectonic movements, to flow eastwards of its former course, across the English Midlands and into the North Sea, depositing its sediment as the 'Bunter Sandstone' of eastern England. Consequently, desert conditions prevailed and aeolian dune fields extended over much of north-west England, driven and supplied with sediment by winds from the east and northeast (P916086)e. Large-scale draas developed, separated from each other by flat, damp interdune areas of limited lateral extent. These aeolian deposits, with their well-rounded grains, formed the dark reddish-brown, fine- to coarse-grained sandstone in the lower part of the Calder Sandstone Formation. Onshore, this formation crops out widely across west Cumbria. It overlies the St Bees Sandstone with a sharp disconformity suggesting that the change in depositional environment was abrupt and was possibly followed by a short period of nondeposition. By late Calder Sandstone times, fluvial conditions had been re-established across north-west England (P916086)f and several fluvial sandstone units occur in the upper part of the formation. The medium- to coarse-grained sandstone lithologies of these units suggest a local clastic supply, with the abundance of well-rounded grains suggesting the reworking of aeolian dunes; the orientation of sedimentary structures indicates a source region to the east-north-east.

In the offshore areas of the East Irish Sea and Solway Firth basins, and around the Isle of Man, the equivalent succession to the combined onshore St Bees and Calder Sandstone formations is all assigned to the St Bees Sandstone Formation. The offshore formation has two members: the lower fluvial sandstone of the Rottington Sandstone Member is the lateral equivalent of the onshore St Bees Sandstone, whilst the upper, aeolian sandstone of the Calder Sandstone Member is the lateral equivalent of the onshore Calder Sandstone Formation (P916115).

The fluvial influx in late Calder Sandstone times was short-lived and soon desert conditions prevailed once more; aeolian dunes were common with damp areas or interdune ponds between them. Siltstone, medium-grained and planar-laminated sandstone, and coarse-grained and cross-laminated sandstone were all deposited in this environment and together form the Ormskirk Sandstone Formation. Offshore, the formation is known from the East Irish Sea and Solway Firth Basins and the Isle of Man area, with an onshore outcrop in west Cumbria. The base of the formation is marked by a discontinuity coincident with a major break in sedimentation throughout most of north-west Europe.

In the Carlisle and Vale of Eden basins, the St Bees Sandstone is overlain by strata referred to the Kirklington Sandstone Formation. This unit is broadly equivalent to the Calder and Ormskirk formations which have been recognised locally at outcrop and can be identified in the Silloth No. 1 Borehole and on seismic reflection profiles. The lower part of the Kirklington Formation is of mixed fluvial and aeolian origin and is equivalent to the Calder Sandstone, though is generally much finer-grained than that lithology in west Cumbria. The upper part of the Kirklington Formation is for the most part lithologically similar to the aeolian lithofacies of the Ormskirk Sandstone.

The St Bees Sandstone, Calder Sandstone and Ormskirk Sandstone formations, together with their lateral equivalents, form the Sherwood Sandstone Group (P916115).

By mid Triassic times, coastal and shallow marine conditions had returned to north-west England with the restoration of the Bakevellia Sea during a major transgression. Marine and evaporitic

conditions existed over the East Irish Sea Basin and Isle of Man area, with playa lakes and coastal, low-relief mudflats extending to the east into the Carlisle Basin. The strata deposited in these environments form the Mercia Mudstone Group and comprise mudstone, halite and minor amounts of dolostone, dolomitic mudstone and anhydrite. Strata of the Mercia Mudstone Group are not recognised in onshore west Cumbria, but are preserved beneath Quaternary cover in the south of the Furness District as an extension of the East Irish sea succession.

The Mercia Mudstone Group strata are best preserved in the north of the East Irish Sea Basin and the Isle of Man area where six formations are recognised ([P916115](#)). The Leyland Formation consists of a basal evaporite deposited in coastal sabkhas at the beginning of the transgression, followed by mudstone interbedded with widely varying proportions of halite. The variations in the succession are thought to result from its deposition in a wide range of spatially restricted environments including small lakes, evaporitic brine pools and salt flats, and restricted shallow marine areas. The range of environments arose partly as a result of topographical variations caused by significant syndepositional faulting contemporaneous with the marine transgression. The overlying Preesall Halite, Dowbridge Mudstone, Warton Halite and Elswick Mudstone formations all have similar lithological characteristics and were deposited in coastal marine conditions, although thickness variations of halite in the later formations suggest a general decrease in marine influence by these times. The youngest strata of the Mercia Mudstone Group in the East Irish Sea Basin and around the Isle of Man are grey-green dolomitic mudstones of the Blue Anchor Formation.

In the Carlisle Basin, the Mercia Mudstone Group is largely restricted to the central areas. At outcrop, the succession is very poorly exposed and all strata are assigned to the Stanwix Shales Formation ([P916115](#)). However, cored boreholes have proved the presence of the Blue Anchor Formation, whilst the other formations of the East Irish Sea succession can be identified from the geophysical log patterns of the Silloth No. 1 Borehole. The Stanwix Shales Formation's strata are predominantly reddish brown, locally grey-green mudstones that accumulated on broad playas and in coastal sabkhas or shallow water bodies. Some thin beds of very fine-grained sandstone, and beds of halite and nodular gypsum-anhydrite are present, and indicate deposition in saline lakes and evaporitic mudflats when enhanced subsidence elevated sea level and introduced a greater marine influence.

Up until late Triassic times, north-west England had lain on a northward- and later westward-inclined palaeoslope. In late Triassic times, tectonic movement re-orientated this slope to a southward inclination and allowed transgression of the sea from the south via a new 'south-west passage' that lay along the course of the present-day St George's Channel. Upper Triassic strata in north-west England were formed from the sediments deposited during this transgression and in the ensuing shallow-water, marine environment. The Penarth Group rests disconformably on the Mercia Mudstone and is subdivided into two formations. The marine Westbury Formation is present in the Irish Sea and around the Isle of Man where it consists of dark grey to black, pyritic, non-calcareous mudstone indicative of shallow marine deposition. In the Carlisle Basin, boreholes in the Great Orton area have proved the Westbury Formation, resting unconformably on the Blue Anchor Formation (Mercia Mudstone Group), with a similar lithology. The succeeding Lilstock Formation consists of thinly bedded, grey, argillaceous and calcareous siltstone and sandy limestone. It is present in the Irish Sea and around the Isle of Man, and has been proved onshore in boreholes in the Carlisle Basin. Mudcracks, gutter casts and dewatering structures present in borehole core indicate that it was deposited during a progressive shallowing of the marine environment to a subtidal and lagoonal setting.

The lagoonal and subtidal environments of Lilstock Formation times ended when marine conditions returned to north-west England towards the end of the Triassic Period; thereafter the water progressively deepened into Jurassic times. The only preserved strata from this interval exist in a

small outlier within the centre of the Carlisle Basin. There, Lias Group strata are almost entirely covered by superficial deposits with only very limited exposure in stream sections. The full extent of the outlier is therefore conjectural but has been recently revised based on additional evidence from new boreholes in the Great Orton area. At present, rocks from the lower part of the Lias Group are believed to be present over an area of approximately 70 km² to the west and north-west of Great Orton, and to be faulted against Mercia Mudstone Group strata to the north, south and west. This lowest part of the Lias Group straddles the Triassic–Jurassic boundary. The Upper Triassic strata are grey, moderately calcareous mudstones that are commonly silty and interbedded with thin calcareous siltstones. Towards the base of the Lias Group, a few thin beds of limestone and cross-bedded sandstone are present along with shell accumulations that may represent storm surge deposits within the shallow, Late Triassic sea. The base of the Jurassic system is taken at the lowest occurrence of the ammonite *Psiloceras planorbis*. The lowermost Jurassic Lias Group strata are very similar to the Upper Triassic mudstones except for the presence of this species. No limestone is present and the succession indicates a progressive deepening of marine conditions throughout early Jurassic times. Younger Jurassic strata are not preserved in north-west England.

North-east England

To the east of the Pennines, the filling of the Zechstein Basin in late Permian times substantially reduced areas of permanent open water and allowed coastal to continental, arid conditions to be re-established by early Triassic times. The Budleighensis River brought vast amounts of sediment from the high ground of Armorica to the south-west. The soft, fine-grained, thickly bedded, dull red sandstones and subordinate red mudstones and siltstones of the Bunter Sandstone are the sediments deposited in this environment; their boundary with the underlying Permian to earliest Triassic Roxby Formation is transitional and diachronous. The Bunter sandstones represents the lowermost Sherwood Sandstone Group strata preserved within north-east England and are present beneath superficial cover south of the West Hartlepool Fault. Surface exposures can be found only on the foreshore at Seaton Carew, and in the intertidal zone at nearby Long Scar where abundant cross-beds, ripple marks and desiccation cracks attest to a shallow-water, coastal origin. From time to time, swamps and peat bogs appear to have become established on the coastal plain. Evidence for this comes from carbonaceous lenses within the Bunter Sandstone at Hartlepool, coupled with widespread, irregular lenses of pale green colour and some more extensive zones of grey to yellow colouration, the likely result of localised chemical reduction of the red sands. In the Stockton area, to the south of the Seaton Carew Fault, the Sherwood Sandstone Group is known from borehole records to be overlain locally by strata of the Mercia Mudstone Group (known traditionally in north-east England as the Keuper Marl), but the mudstone is nowhere exposed. Strata of younger Triassic age or of Jurassic age are not preserved in north-east England.

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