

AN AWKWARD INTERFACE: THE 'INTERMINABLE GREYWACKE' AND CULM

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In 1836 two gentleman geologists, Sedgwick and Murchison, rapidly inspected the 'Greywacke' rocks of Devonshire intending to resolve a controversy about the sequence of 'Transition' formations underlying the Carboniferous. Fresh structural interpretations and the identification of a new geological period would be presented to a scientific conference in Bristol that year where the reception would be mixed. This paper sets their observations in the context of contemporaneous knowledge while tracing a journey around the county to correct misunderstandings upheld by prominent authorities at the time.

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INTRODUCTION

In his influential Geological Manual, published in 1831, Henry de la Beche details the fossils of greywacke rocks and includes anthracite but does not distinguish the sequence of formations within the 'Grauwacke Groups'. A decade earlier, Revd William Buckland had traditionally designated these ancient rocks as 'Transition' (Table 1) and as such no sequence had yet been defined in any region. Geological maps of that time only generalised the distribution of vast tracks of undifferentiated greywacke and, because of its useful fossil record, also depicted outcrops of 'Transitional' limestone.

Below the Old Red Sandstone were these perplexing, vast arrays of highly distorted, grey sandstone, shales and slate.

Named Grauwacke by the old German miners, this intermediate group had long been separated by Werner from between the 'Primary' crystalline rocks and the succession of overlying 'Secondary' sedimentary formations. Called 'Transition' the name suggests a kind of geological limbo, the unknown where the transition from chaos and confusion heralded the orderly structures above.

At other localities the economic importance of the younger coal-bearing rocks to the Industrial Revolution had motivated detailed mapping and structural comparison with all regions that invited speculative exploration. In 1822, building on William Smith's work, Revd William Conybeare and William

Buckland 1821	Phillips/Conybeare 1822	De la Beche 1831	1830-41
Alluvium		Modern	Pliocene, Miocene, Eocene
Diluvium	London Clay	Erratic Blocks	(Lyell 1830-33)
Tertiary	Plastic Clay	Supracretaceous	
Chalk & Greensand	Chalk Greensand	Cretaceous Group	
Oolite or Jura LS	Oolitic series	Oolite Group	
NRS & Magn LS	NRS	Red SS Group	
NR Conglomerate	Magn. LS & Cong. LS		Permian (Murchison 1841)
Coal Measures	Carb. Coal Measures	Carb. Group	
LS	Carb. Grit & LS		
Old Red Sandstone	ORS	Grauwacke Group	Devonian (Murchison 1836-)
Transition LS & Grauwacke			Silurian (Murchison 1835)
			Cambrian (Sedgwick 1835)
Primary		Primitive	

Table 1. Comparison of stratigraphic sequences. Based on Rudwick (2008), Phillips Conybeare (1822) and De la Beche (1831).

Phillips had placed the coal-bearing strata in their newly named Carboniferous period. They had also defined the succession of distinctive groups of British rocks from the recent formations overlying the distinctive Chalk as far down as the Old Red Sandstone beneath the industrially important coal formations (Table 1), but no further.

THE INTERMINABLE GREYWACKE

In 1831 Revd Professor Adam Sedgwick and Roderick Impley Murchison, having previously worked together interpreting areas of Scotland and the Alps, now tackled the 'interminable greywacke' of Wales and Welsh borders. As Secretary to the Geological Society in 1831 and Foreign Secretary from 1835, De la Beche probably used the old German miner's spelling of *Grauwaacke* in deference to continental research. Sedgwick worked in North Wales classifying the stratigraphic succession of the old fossil-bearing rocks of the Berwyn Range westwards to Caernarfon. Murchison prudently started from a known reference point and traced richly fossiliferous formations underlying the Old Red Sandstone. Directed to the Wye valley by Buckland, he followed Transition beds and overlying formations northwards to the Triassic plain of Cheshire. Hence he ordered the upper Greywacke along the south Wales frontier, in Shropshire and Herefordshire. "I realised in about four months of travelling... that it was the most fruitful year of my life, for I had laid the foundation of my *Silurian System*" (Geike 1897 p.416). Murchison was thirty-nine in 1831, here describing only his seventh season of field geology.

Sedgwick, who was briefly accompanied by Charles Darwin, was more challenged because there was a major unconformity in North Wales below the Carboniferous Limestone and fewer fossils. Consequently, he was obliged to utilise a marker horizon well down in the Greywacke Group, distant from the Secondary rocks, as he traced the sequence of the slates and calcareous greywacke, correlating them against his Bala Limestone. Clearly he was scrutinising the lower Greywacke with a Primary basement recognised in Caernarfon and Anglesey.

A joint tour in 1834 attempted to link the two study areas. However, a correlation with Murchison's upper Greywacke would defy definition for several years, later causing bitter disputes, which were only partially resolved in 1874 when Charles Lapworth introduced the Ordovician Period.

At the 1835 Dublin meeting of the British Association for the Advancement of Science, the collaborators introduced two geological systems, the Silurian and Cambrian. The ancient masses of Greywacke Sedgwick ascribed Cambrian, from the Roman name for Wales. Murchison's Silurian System, named after a tribe of the Welsh borders who had harassed the Romans, embraced formations between the Old Red Sandstone and Greywacke (Table 2).

If correctly identified, Murchison's definition of the Silurian period had significant economic implications. The Silurian rocks contained some 'peculiar' fossils but not the abundant tropical plant species that produced coal in later Carboniferous times. Hence, Murchison argued that as the Silurian beds were formed before the appearance of the fern-like tree fossils associated with coal, then by identifying these older Silurian

beds, coal would not be present and expensive prospecting could be avoided. Of course such a bold assertion tested credibility. Already, at the 1834 meeting of the Geological Society De la Beche had produced coal plant fossils from the Greywacke of North Devon. Even though he was the authority in the field and was soon to become the government geological surveyor, Murchison contended that De la Beche was mistaken and had found plant fossils in the younger coal-bearing formations. Others thought Murchison's criticism presumptuous as he had no knowledge of the locality. Clearly a visit to Devon was imperative to resolve the matter.

So, early in July 1836 Sedgwick and Murchison travelled by overnight stagecoach from London to Bristol. They immediately continued on to Bridgwater and hence proceeded to scrutinise the older geology of Devonshire. This was to be a remarkably energetic excursion for within five weeks they would present their findings to the annual conference of the British Association for the Advancement of Science in Bristol. Their urgent intention was to resolve the ongoing controversy about the chronological sequence of the older 'Greywacke' rocks and stratigraphical position of the Culm.

Leaving Bridgwater, armed with Greenough's old (1820) geological map and De la Beche's recently published large-scale map, the gentlemen progressed on horseback or with a hired pony trap, observing the rocks in quarries, road cuttings and coastal cliffs. In their notebooks it was recorded that 'Mountain Limestone' was seen on the 5th July. Soon after, the comparative age of the Quantock Hills was considered. The Carboniferous sequence of the Mendips was behind them and probably they anticipated finding an intermediate geology in these hills before tackling the older system; but no such median was evident.

The 'Old Greywacke Rocks' were next observed in the cliffs near Minehead and they suspected the rocks at 'Linton' were even older, probably analogous with the Lower Silurian Caradoc Sandstones. Further on, the thick 'arenaceous systems' looked like 'very ancient Cambrian' rocks. On the 8th July they dined with Maj. Harding, a local amateur geologist, one of Sedgwick's correspondents who had sent samples of Devon anthracite. In his company, they studied fossils in the nearby Ilfracombe cliff sections.

Next, turning inland, en route for Barnstaple, they traversed the suite of rock strata noting that the successively younger rocks were all dipping steeply southwards. Near Barnstaple Murchison noted that they had found the base of the true Silurian System; implying perhaps that there was some doubt about the age of the strata passed to the north. Scrutinising the ground around Pilton they rejected the information provided in a recent map by De la Beche who was now surveying the South West for the Geological Survey. Murchison regarded the appearance of the rock types at Pilton as representative of the Llandeilo Flags even though he failed to find confirmative fossils. They made no mention of the tight trough structure that had forced De la Beche to infer that the Culm was a re-emerging continuation of the older rocks to the north. If Sedgwick recalled receiving a sketch of this trough from De la Beche previously, he either overlooked this detail or dismissed it as a misinterpretation (Figure 1).

SILURIAN	Upper	Ludlow Rocks
		Wenlock Limestone
SILURIAN	Lower	Caradoc Sandstones
		Llandeilo Flags
CAMBRIAN	Upper	Higher beds of Berwyns
		South Wales Slates
		Bela Limestone
	Middle	Higher mountains of Caernarvon & Merioneth
		Snowdon Beds
	Lower	Anglesey and SW Caernavon schists and gneisses
No fossils		

Table 2. Sedgwick and Murchison – Silurian and Cambrian classification of 1835. Based on Hallam (1992).

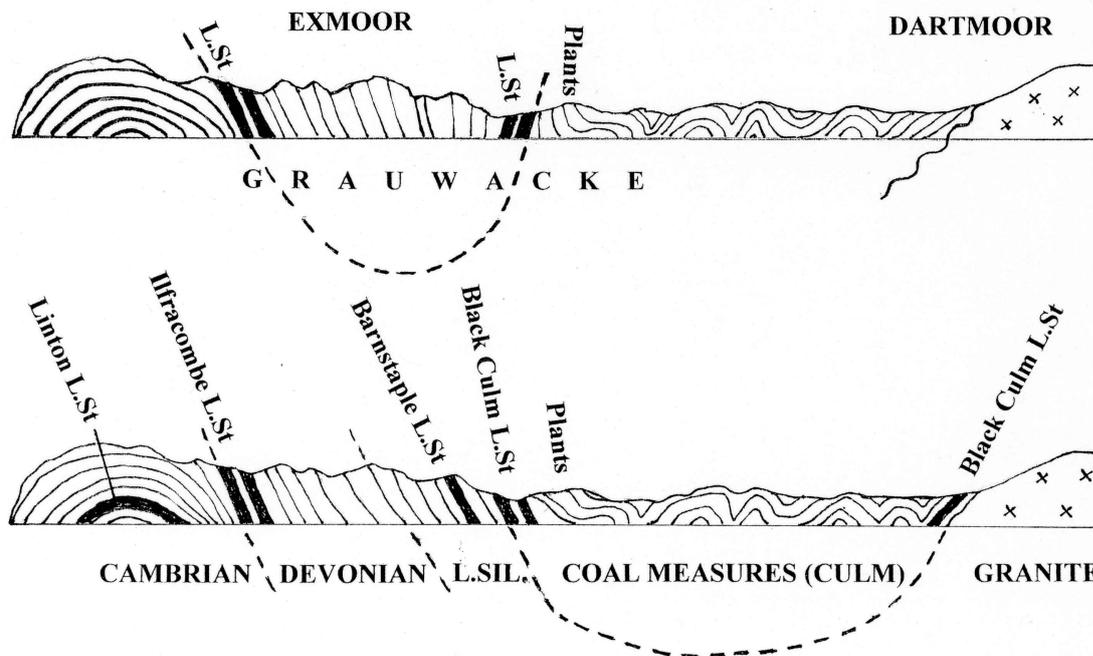


Figure 1. From De la Beche's section, N-S through north Devon, sent to Sedgwick in 1834. Below: Sedgwick and Murchison's section exhibited in Bristol August 1836. Bands of limestone are marked in black. From Rudwick (1985) p.164.

South of Barnstaple Sedgwick and Murchison judged that they had entered the area of the contentious Culm. They were sure that the strata north of Barnstaple were older (Lower Silurian) and suspected, contrary to De la Beche's claim, that the plant-bearing Culm rocks were not Transition but true Coal Measures. A major unconformity was expected, possibly obscured under the Taw Estuary. Here they made a distinction between the 'Culm Limestone' and associated shales below; and the sandstones, shales and thin seams of anthracite above. Further on, from Bideford to Clovelly, the carbonaceous series convinced them that these rocks were 'wholly unlike' anything seen in the Exmoor coastal Greywacke formations.

Sedgwick and Murchison arrived in Bude on the 16th July where their paths crossed that of the irrepresible Revd. David Williams, rector of Bleadon in Somerset. Both probably felt this provincial amateur could be ignored but he would voice awkward conjecture and present specimens that continued to challenge the hierarchy. Williams now listed similarities relating the rock, both south and north of Barnstaple, with those of Wales and Brittany. Hence Williams concurred with De la Beche, convinced that all the north Devon strata were equally older than the Carboniferous. Sedgwick and Murchison were sure that Williams and De la Beche were wrong. The Culm, south of Barnstaple, was uppermost, hence younger, and strata to the north of Barnstaple much older. Furthermore, Sedgwick and Murchison both suspected that the Greywacke further south, in South Devon and Cornwall, was a continuation of the formation of Exmoor. Central Devon was therefore a huge trough containing the younger sandstone and by tracing the southern boundary they would confirm this hypothesis.

Continuing along the coast, Sedgwick and Murchison observed the 'extraordinary troughs and saddles' that obscured the expected change in dip at the southern edge of their putative syncline. The reappearance of the older Greywacke was the only indication of the anticipated southern boundary. Where an unconformity was sought Murchison had to admit 'a gradual passage'; precisely the gradual transition that De la Beche had claimed. They continued to observe the coastal exposures regarded as Cambrian at Tintagel and inland past Launceston. At South Petherwin they found limestone that reminded Sedgwick of the limestone at Combe Martin and at Coniston in Cumbria.

Sedgwick and Murchison met Revd Richard Hennah in Plymouth (18th July) and viewed his collection of fossils which, when loaned to Lonsdale, would become one of the principal sources for determining the relative geological age of the Devon limestone. The 'old chloritic system of ancient rock' was next inspected at Bolt Head (21st July) and they viewed the limestone near Torquay. To confirm their provisional interpretations, they passed through Newton Abbot, Exeter, Tiverton, and so back to the northern boundary. In the locality of Bampton and Holcombe Rogus, black Culm limestone was again seen to overlie Silurian rock, the whole sequence dipping to the south. The expected unconformity or, at least, a sharp juxtaposition was not evident and Murchison had to accept that whilst the Culm was clearly overlying the older Transition rocks, it was conformable with the Upper Silurian and possibly equivalent to formations of the Old Red Sandstone.

This troublesome interface required further attention. They travelled westwards along the line of this obscure boundary but then south to the northern edge of Dartmoor at Okehampton probably to reconsider the southern boundary. By 28th July, despite failing to find an unconformable boundary, they were now more certain that the Culm was Carboniferous in age and formed in a basin occupying central Devon; and that it rested on Lower Silurian strata on the north side and Cambrian on the south.

From Dartmoor they returned to Barnstaple and went on to Ilfracombe via the coast. Here Murchison records (29th July) 'a glorious day of discovery' along the cliffs of Baggy and Morte points that clearly display Lower Silurian and Cambrian sequences. From Ilfracombe, they crossed to Swansea and travelled westward into Pembrokeshire to study the Culm rocks at Tenby, checking a correlation with the Culm of Devon. They then returned to Devon to compare the appearance of the Culm there, before Murchison left for Bristol to prepare the conference. Sedgwick traversed Exmoor and revisited the Culm limestone in the Bampton area (18-19th August) before also taking the stagecoach for Bristol.

In little more than five weeks, having covered some three hundred miles, Sedgwick and Murchison had prepared sufficient evidence for the Bristol conference. Their illustrated presentation on the second day included Murchison's notation of the rock assembly of the Exmoor landmass. This is the first

occasion in which Murchison tentatively labelled the central ridge of grey sandstone as 'Devonian'. The relative age of which is confused with, and intercalated between, the Cambrian and Silurian periods. It required several more years of comparative research, including the crucial fossil record formed by William Lonsdale, and another generation of geologists, to accept the significance of this classification.

Sedgwick and Murchison had provided a fresh interpretation of the geology of Devonshire; they had connected the older rock of Exmoor with those of south Devon and Cornwall, and established that they lie beneath the Carboniferous Culm strata. They also demonstrated the anomaly of coal-forming plants in the Old Greywacke. Subsequently, they explored the Devonian geology of the Rhineland and Harz to demonstrate correlation abroad. Murchison also went on to make a geological survey of the Russian empire and named the Permian. After the Bristol conference Sedgwick returned to mid Devon intending to unravel the 'pre-Silurian' strata south of the Culm trough. With Robert Austin, Sedgwick located the base of the Culm and collected limestone fossils that would support a comparative chronology of the area.

De la Beche was unprepared for the repudiation of his interpretation of the Culm at the Bristol conference. He probably felt that, whilst making observations freely available from his own work in the South West, Sedgwick and Murchison's covert exploration of his survey territory was ungentlemanly. Certainly Sedgwick and Murchison had only been able to make such a rapid and focussed inspection of Devon with the aid of De la Beche's detailed map and informative sketches. Even so, De la Beche gracefully accepted the findings presented that year.

Their methods were certainly distinctly different. Sedgwick came to Devon bringing a conceptual stratigraphic structure to explain the geology of the area. De la Beche was a pragmatist interpreting observations in the field. Not surprisingly the dichotomy of abstract notions versus observable facts had catalysed debate for many years, giving substance to the

reductive science of geology. It is perhaps prescient therefore, that in 1834 De la Beche had sent Sedgwick and Greenough a drawing depicting himself pointing to a splendidly prominent nose and saying, "This gentlemen, is my nose." In the same scene Geological Society gentlemen each observe the nose through strong, tinted glasses and exclaim, "My dear fellow! – your account of yourself generally may be very well, but as we have classed you, before we saw you, among the men without noses, you cannot possibly have a nose" (Figure 2).

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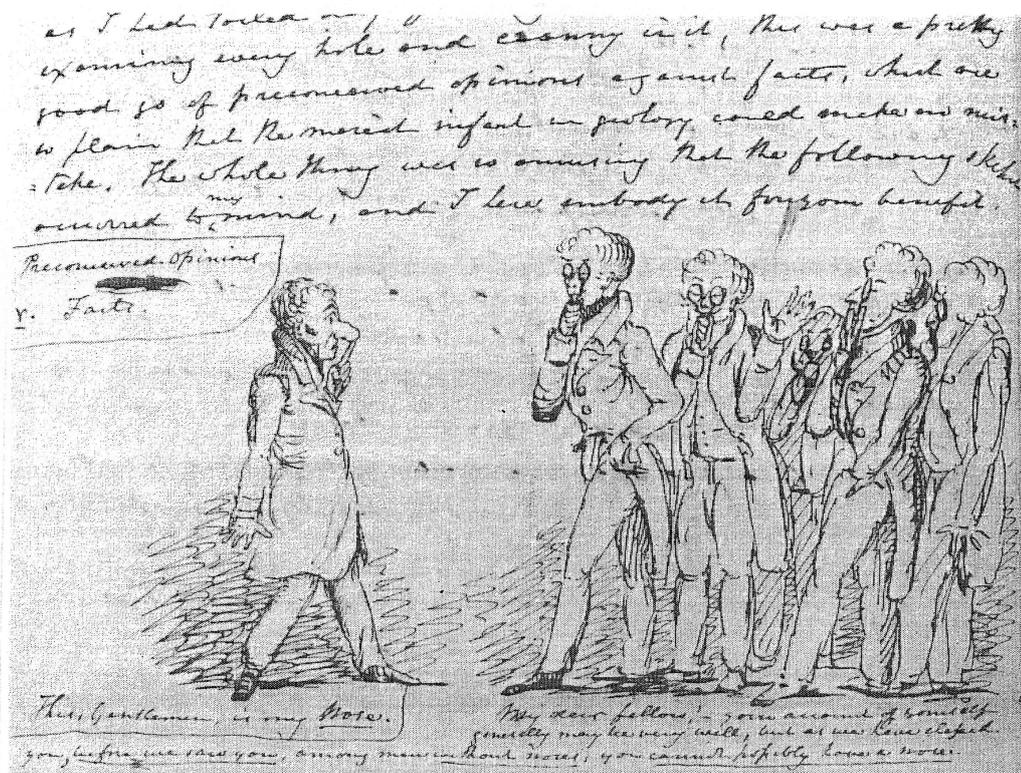


Figure 2. Drawing sent in 1834 by De la Beche to Sedgwick and Greenough depicting himself pointing to a splendidly prominent nose and saying, "This gentlemen, is my nose." In the same scene Geological Society gentlemen each observe the nose through strong, tinted glasses and exclaim, "My dear fellow! – your account of yourself generally may be very well, but as we have classed you, before we saw you, among the men without noses, you cannot possibly have a nose".