A tale of two Devon rivers

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Abstract: The two rivers of central Devon, the Taw and Torridge, have a Tertiary history of development and adjustment to the geological foundation of the area. They drain the outcrops of Upper Carboniferous (Culm Measures) rocks that lie in a trough between Exmoor to the N and Dartmoor to the S. These rocks have been folded and faulted through two orogenies, and it is to their constituent sandstones and shales that many of the streams have become adjusted, but not all. The Taw, Torridge and their major tributaries have markedly discordant courses across folds and faults which merit explanation, and which may be regarded as elements of an earlier, east-draining drainage system that formerly existed at a higher level. This system may be held responsible for producing a now-dissected, Eocene to Miocene peneplain, remnants of which can be identified in the 190–290 m summits of central Devon, and for the transport of weathered, alluvial sediments to the subsiding Petrockstow and Stanley Bank basins, sited along a major structural lineament, the Stickleback Fault Zone. Anomalously, compared with other Devon and Cornish rivers, the lower parts of the Taw and Torridge rivers flow NW to Bideford Bay, probably the consequence of subsidence toward the Stanley Bank basin. The lower Torridge, though not the lower Taw, displays a fine group of ingrown meanders, most likely initiated on a flood-plain graded to a 130 m Early Pleistocene marine level.

The catchments of the rivers Torridge and Taw and their tributaries occupy most of central Devon and parts of the adjacent uplands of Exmoor and Dartmoor. Drainage density is high across the region and run-off is concentrated into the lower parts of the two rivers which flow northwest, in parallel to Bideford Bay. The catchments have evolved over a long time and have been subject to changes resulting from river capture, uplift and subsidence, folding and faulting. The drainage patterns of today retain evidence of some of these changes and it is the purpose of this paper to elucidate some of the formative stages.

The relatively low ground of central Devon is coincident with a trough of marine Upper Carboniferous rocks which lies between the Exmoor massif of continental and marine Devonian rocks to the N and the granite intrusion of Dartmoor to the S. As part of the Cornubian block, the whole region has been affected by both Variscan and Alpine orogenies, and structural control of drainage pattern is strong. Though never glaciated, the area has been periglaciated on many occasions. Over the millions of years since Miocene uplift, marine incursions have not been extensive and subaerial denudation accounts for the forms of the present land surface. Figure 1 provides the chronostratigraphic background for the region.

The geological setting

The Upper Carboniferous rocks of central Devon (also known as the Culm Measures – Thomas 1982; Leveridge and Hartley 2006; Edmonds *et al* 1975) are mostly marine sediments and have been allocated to three main units (Thomas 1988) the oldest of which is the *Crackington Formation* (Freshney *et al* 1979). This outcrops in the centre of the trough at Chumleigh where it has been raised by several broad west–east anticlinal folds, and also in a fault-bounded area at Hartland (Fig. 11). Narrow up-faulted outcrops lie NW of Chumleigh (Fig. 12b). The sediments are turbiditic sandstones, siltstones and mudstones and sporadic black shales (Freshney *et al* 1979). Succeeding the Crackington Formation in the north part of the trough, east from Bideford to the River Bray (Fig. 11) is the *Bideford Formation*, consisting of massive, cross-bedded sandstones, partly deltaic, partly turbiditic, with grey shales. Underlying most of the land surface is the youngest *Bude Formation*, made up of massive sandstones within a sequence of grey mudstones and shales (Freshney *et al* 1979). Variously shallow-water, fluviatile and deltaic, they lie within broadly synclinal zones N and S of the Crackington Formation outcrop and extend W to the coast south of Yeol Mouth.

		Ma
Quaternary	Holocene	
		0.11
	Pleistocene	
		2.6
Neogene	Pliocene	
		5.5
	Miocene	
		23
Paleogene	Oligocene	
		34
	Eocene	
		56
	Paleocene	
		66
- - - - - - - - - -		
		252
Permian		
		290
Carboniferous	Upper Carboniferous	
		327
- - - - - - - - - -		
		360
Devonian		
		420

Figure 1*. Chronostratigraphy of north Devon.*

The rapid alternation of sandstones and shales in all three Formations provides ample opportunities for ridge and valley development at a wide range of scales, but all three were also affected by N–S compressive forces during the Variscan orogeny (Freshney *et al* 1979; Selwood *et al* 1982). A myriad of periclinal folds trending largely WSW to ENE (similar to the many exposed in the western cliffs southward from Hartland Point to Bude (Figs. 2, 3) determine the grain of the country over the whole of the Upper Carboniferous outcrop. The rocks have also been extensively faulted. The dominating structure is the Sticklepath Fault Zone which trends SE to NW from Tor Bay, across east Dartmoor, through Bideford Bay and E of Lundy Island (Fig. 11) and comprises groups of dextral wrench faults that have a cumulative displacement of 7–8 km (Freshney *et al* 1979; Holloway and Chadwick 1986). Lesser-scale wrench faults, often in groups, closely spaced and parallel to the Sticklepath Fault Zone, characterize the whole Upper Carboniferous area (see British Geological Survey Sheets 308, 309, 323, 324).

This structural pattern is rendered more complex by secondary sinistral wrench faults aligned NE to SW, and by a few W–E faults such as that which brings up the Crackington Formation near Atherton (Freshney *et al* 1979). The combination of faulting with the broadly W–E lineation determined by the folding is responsible for the ubiquitous off-setting of individual shale and

***Figure 2**. Chevron folding in Crackington Formation rocks. The horizontal top is a former wave-abrasion surface at c. 85 m OD, eroded in the manner of the present one at the foot of the cliffs. View NE, SS 222 248, 17-07-1996.*

***Figure 3**. Pitching anticlinal fold on foreshore in Crackington Formation rocks. View NW, SS 222 248, 17-07-1996.*

sandstone layers, and this in turn strongly influences valley development, stream alignments and spring activity. The region was later subjected to Alpine orogenic pressures and to reactivation of many of the faults (Shearman 1967; Freshney *et al* 1979; Selwood *et al* 1982; King 2006).

Associated with the Sticklepath Fault Zone and related to these pressures are 'pull-apart' basinal features controlled by local subsidence (Fig. 11). In central Devon the most prominent example is the Petrockstow basin (Bristow 1968; Freshney, 1970; Freshney *et al* 1979) but, to the SE on the E side of Dartmoor, the Bovey basin is considerably larger. To the NW both are dwarfed by the Stanley Bank basin that lies submerged E of Lundy Island (Brooks and James 1975).

The Petrockstow basin is some 7 km long and 0.8 km wide, formed by subsidence involving reactivation of several parallel and cross faults (Fig. 4, Fig. 12a). Its deepest part approaches 760 m and is filled by complex and somewhat disturbed sequences of kaolinitic clays, silts, and sands, with some gravels and lignite, almost all derived from adjacent outcrops of Upper Carboniferous sandstones and shales (Bristow 1968; Freshney 1970; Freshney *et al* 1979; Edwards and Freshney 1982). These materials are throughout essentially fluvial, representing bedload, suspended overbank and back swamp deposits, and display cyclic, fining-upwards sedimentation. Shallow lakes may have been present at times. The uppermost 260 m or so are of Oligocene age, those below are Eocene but, presuming the basin surface was once part of the central Devon plateau, much sediment has been lost to subsequent erosion. All the Tertiary deposits accumulated under tropical and subtropical climatic conditions, Britain then lying well to the S of its present latitudinal position, and when the absence of polar ice determined a low pole-equator temperature gradient. Similar in many ways to deposits in the Bovey basin they are ascribed to the Bovey Formation. Of particular geomorphological interest is their alluvial character, which indicates that sedimentation kept pace with subsidence, and their lithology, which reveals weathering and derivation from Upper Carboniferous rocks (Bristow 1968).

Of far greater importance is the submerged Stanley Bank basin near Lundy (Fletcher 1975). This basin is about 32 km long and 17 km wide, and at least 340 m deep (Brooks and James 1975). Although it is submerged, its contained sediments are similar to those in the Petrockstow basin, are also regarded as Oligocene, and confirm subtropical and tropical environmental conditions. As discussed below, its lower elevation and submergence relative to the Petrockstow basin may have a bearing on the development of Bideford Bay and the lower courses of the Taw and Torridge rivers. Edwards and Freshney (1982) suggest a fluvial connection between the two basins during the depositional phases.

Exmoor rises above the N side of the central Carboniferous trough. A massif of marine and continental Devonian rocks, its southern edge is clearly defined east of the Mole river valley by the rise of ground along the line of the Brushford fault (Fig. 5). Near East Anstey, the latter is met by the northwest-southeast Combe Martin wrench fault (Figs. 6, 11) but its line continues westward without deviation close to the Devonian/Carboniferous junction to Barnstaple and Braunton, though no fault has been mapped. Extrapolation of this line carries it toward the Stanley Bank basin.

The Dartmoor granite pluton sharply defines the southern side of the central Devon trough and had been intruded about 300 Ma ago into Crackington Formation rocks already folded and faulted (Hawkes 1982; Gunnell 2020), producing a metamorphic aureole. Its NE corner is transected by the Sticklepath Fault Zone which dextrally displaces the granite/Crackington Formation boundary by some 2 km near Sticklepath.

***Figure 4**. Petrockstow basin, with quarry-exposed ball clays. The basin forms a topographic depression along the Sticklepath Fault Zone, drained to the Torridge by the river Mere, and its surface lies at 60–70 m OD. Higher ground at c. 140 m OD provides a minimum measure of the loss of upper parts of the basin sediments since late Oligocene time.*

The drainage network

It is against this geological background that the patterns of rivers and their tributaries may be compared, but first a brief description of them is apposite (Fig. 6).

The river Torridge rises within Hartland Forest a few kilometres from the coast at Clovelly, and close to the head of the southerly-directed river Tamar. It flows generally SE, clearly influenced by wrench faults (British Geological Survey Sheet 308), and collects the river Waldon, a long right-hand tributary, before turning E at Black Torrington to gather two large N-flowing affluents near Hatherleigh – the river Lew, and the river Okement which rises in Dartmoor. Most of these lesser streams accord closely with fault and fold alignments but, north of Hatherleigh, the Torridge contrarily crosses the Sticklepath Fault Zone, avoids entering the Petrockstow basin and turns N to enter a parallel zone of wrench faults and develop a fine stretch of ingrown meanders before reaching the sea in Bideford Bay.

The river Taw commences on the high ground of Dartmoor near Cranmore Pool and flows N parallel to other joint/fault-guided streams, first into Taw Marsh, then into a deep gorge between Belstone and Sticklepath whence it follows a course due N for 11 km to Bondleigh, crossing W–E fold alignments. Turning NE from Bondleigh, it completes two right-angled, fault-controlled bends to join with and take up the SE–NW line of a major right-bank tributary, the river Yeo, which heads close to Dartmoor (Fig. 6). Near

Figure 5. The rise to high Exmoor (c. 360 m OD) across the Brushford fault. Foreground with central Devon surface at c. 275 m on Bude Formation rocks. View N from Hares Down, SS 853 212, 05-07-1994.

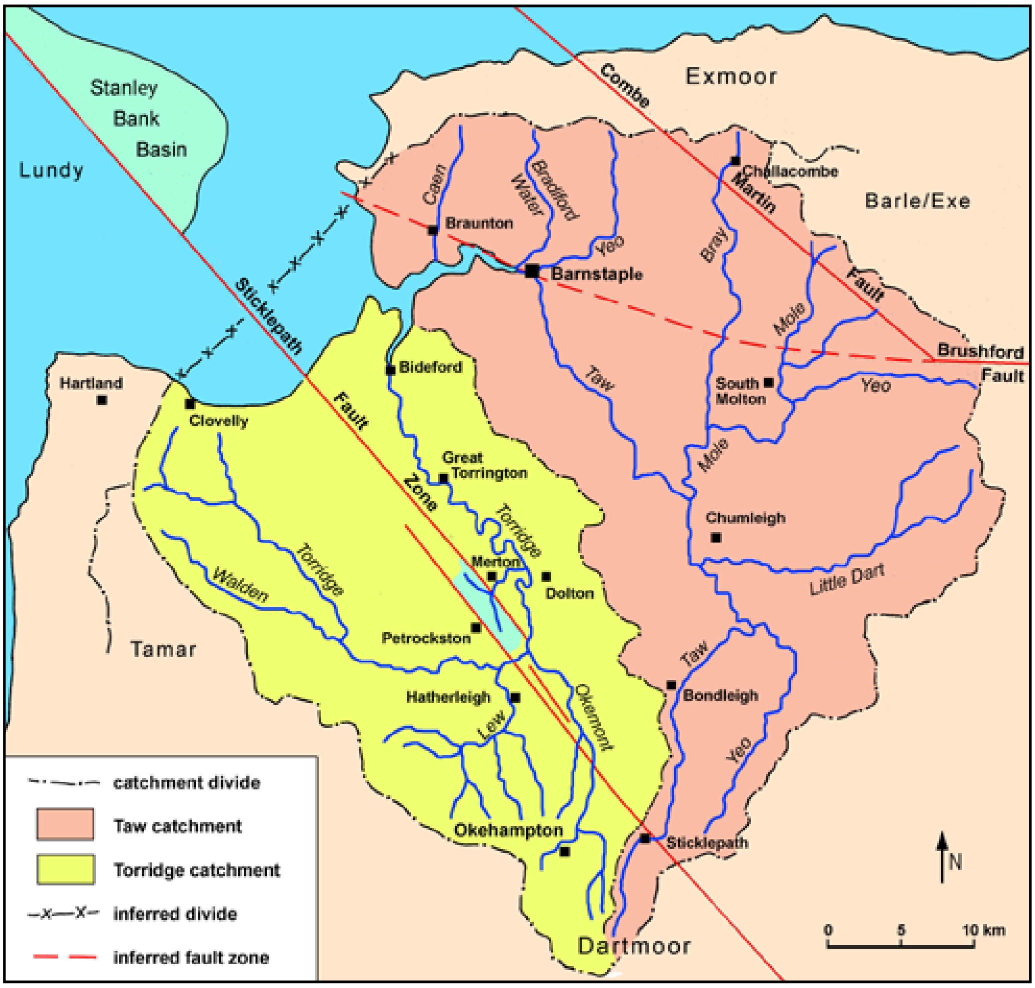

Figure 6. Catchments of the Torridge and Taw and main drainage systems.

Chumleigh the Taw gathers the long, sinuous and incised Little Dart river from the E and, 5 km N, it is joined by the S-flowing lower Mole/Bray river which rises 20 km N within Exmoor Forest around Challacombe. The upper Mole also drains part of Exmoor, being one of several feeders that originate close to the line of the Combe Martin fault. From its confluence with the Mole, the Taw occupies a flat-floored, twisting valley NW to Barnstaple, receiving many fault- and fold-guided tributaries. In its lower reaches the Taw takes more S-draining Exmoor streams – yet another river Yeo, the Bradford Water and the river Caen.

With a geological foundation of rapidly alternating shales and sandstones, compressed into large numbers of E–W folds and crazed by sets of intersecting faults, it is no surprise that the land surface, after millions of years of subaerial denudation, closely reflects these controls through its landforms and drainage patterns. Everywhere, spring action is rife, providing a groundwater component to surface runoff, and determining that valleys over time extend headwards along lines of weakness. Shales generally underlie the valleys; sandstones normally constitute the ridges, hills and spurs; and stream courses follow shale outcrops and fold and fault lines, which induce sharp bends manifest in so many elements, large and small, of the drainage patterns, as described above.

However, departures from these norms occur especially with reference to the Taw, Torridge and their major tributaries because, although in detail their courses are adjusted, they are discordant in their general directions. These anomalies provide some clues to the history of these drainage systems and can be formulated as a group of questions.

Why do Taw tributaries flow S across the strike of the Exmoor Devonian rocks and why do the Mole and Bray streams transect the Brushford fault and flow many kilometres over Upper Carboniferous rocks before joining the Taw?

Why do the rivers Yeo, upper Taw, Okement and Lew flow N from on or close to the Dartmoor granite, also crossing Upper Carboniferous rocks and, in the case of the Taw, the Sticklepath Fault Zone ?

Why does the Torridge flow S from the Hartland area, turn E to collect the rivers Lew and Okement, cross the Sticklepath Fault Zone and appear wilfully to avoid entering the Petrockstow basin?

Why does the Torridge, having collected the Okement, flow NNW to Bideford Bay, again influenced by wrench faults, and why does it develop a stretch of classic ingrown meanders?

Why does the Taw, after receiving the Mole/Bray tributary, proceed to Bideford Bay in a series of right-angled bends unlike the Torridge meanders?

Why do the lower courses of the two major rivers, discordant with the underlying geological lineaments, flow parallel toward Bideford Bay?

Why are the Sticklepath Fault Zone and the Petrockstow basin not followed by a major river?

Before these questions can be addressed it is necessary to consider one more geomorphological element in the region.

Planation surfaces

Considerable emphasis has been laid above on the geology of central Devon and on the character and structures of the Upper Carboniferous rocks over which the rivers and streams flow. Some of the latter rocks have been resistant enough presently to underlie areas of higher ground, but a significant geomorphological feature is the accordance within a height range of 190 to 290 m OD of higher eminences throughout the Upper Carboniferous outcrop, despite the lithological and structural diversity. Freshney *et al* (1979) note that the ridge tops in the Chumleigh district appear deceptively level, yet deny peneplanation.

Disregarding the present incised valleys and allowing for some later lowering of summits, not least during Pleistocene periglaciation, an undulating surface may be envisaged (Fig. 7) extending between the Exmoor and Dartmoor uplands, over the two catchments from the coast in the W across the Sticklepath Fault Zone and other shear zones, to the Exe catchment in the E. Despite Freshney *et al*'s comment, it is entirely feasible to interpret this surface as the end product of a long period of subaerial denudation.

***Figure** 7. Gently undulating central Devon surface, at 200–250 m OD, on Bude Formation rocks, E of Witheridge. Exmoor c. 24 km in the distance. View N, SS 815 136, 05-08-1984.*

***Figure 8**. Reskajeage cliffs, to St Agnes Head and Beacon. Erosion platform lies between 75 to 120 m OD. View NE, SW 623 431, 06-04-1982.*

Widespread planation surfaces have been recognized elsewhere in SW England. Walsh *et al* (1987, 1999) note the frequent occurrence of coastal plateaux between 50 and 150 m OD which they ascribe to a single 'Reskajeage Surface' developed across different rock types (Fig. 8). At St Agnes Beacon some 10 m of sands and silts survive on Palaeozoic rocks at 130 m OD and have been ascribed various ages from Miocene to early Pleistocene (Gunnel 2020). Numerous benches, at various heights, have been recorded along the Cornish and south Devon coasts (Fig. 13), some regarded as of marine origin (Brunsden 1964), others subsumed into the Reskajeage Surface.

Coque-Delhuille (1991) traced a 'main surface' throughout Devon and Cornwall noting that its height declines southwest from *c.* 300 to 220 m OD peripheral to Dartmoor toward the Reskajeage cliffs (Fig. 8) (due to subsidence as shown by the descent of the several granite plutons). She regarded the summits of Exmoor and Dartmoor as the product of an earlier cycle of erosion, and ascribes initiation of the lower, main Devon/Cornwall Surface to the Lower Cretaceous. Removal of later Lower Cretaceous and Chalk sediments resulted in a Paleogene surface beneath Eocene and Oligocene sediments. The latter are considered to have been largely removed during and since the Miocene, except for the basins, and this led to exhumation of parts of older surfaces to become elements of a single polygenetic Reskajeage Surface.

King (2006) has more recently reviewed the denudation history of SW England and endorses the view of Walsh *et al* (1999) that previously identified surfaces may be subsumed into the single multi-phase, sub-Paleogene Reskajeage Surface. He further considers that two main episodes of subaerial erosion in western Britain followed the Variscan orogeny — the first producing the sub-Paleogene surface and the second, initiated in the Late Oligocene/Miocene, inducing dissection of that surface and shaping of the present-day landscape.

In a wide-ranging yet comprehensive review of Dartmoor geomorphological research, Gunnell (2020) considered the concept of Dartmoor as an 'etchplain' — the product, under tropical environmental conditions, of deep hydrothermal weathering and erosion of weathered profiles, overprinted by Pleistocene periglacial regimes. Variations in lithology and structure would, however, give rise to an irregular landscape. The landscape of central Devon could concurrently have undergone similar conditions and processes, as witnessed by the subsiding basin deposits, but the summit accordance, with none of the sandstones rising higher, points here towards a dominance of subaerial fluvial planation.

For the purposes of this paper, it is apposite to regard the central Devon summit plane on Culm Measures as part of this sub-Paleogene Reskajeage Surface extending across the Taw and Torridge catchments, and it is tempting to regard the time taken for the weathering and translocation of rock materials as coeval with that taken to fill the sedimentary Petrockstow and Stanley Bank basins (Straw 1986). As noted above, these deposits are considered to be essentially alluvial, transported by slow-flowing, low gradient streams (Freshney *et al* 1979; Edwards and Freshney 1982). The present surface of the Petrockstow deposits is *c.* 60–70 m OD but an unknown thickness of upper layers has been lost through later erosion (the basin is presently drained by the River Mere to the Torridge, Fig. 12a) and bordering country rises over 140 m OD (Fig. 4). The proven surviving thickness of 760 m points to a very long period of sedimentation ascribed, based on environmental assessments (Edwards and Freshney 1982, citing C. Turner) to the Eocene and Oligocene, and this can only imply a similar period of rock weathering and transport. The only largescale, low relief feature capable of having provided the sediment is the now-dissected planation surface described above and claimed elsewhere as a peneplain of Oligocene age (Straw 1986).

It is of more than passing interest that, in W Exmoor, the summits of Devonian rocks also reach an average height of *c.* 275 m OD, and that the rivers Mole/Bray, Yeo and other streams pass, or formerly passed, onto Upper Carboniferous rocks (Fig. 11; Straw 1995). W Exmoor may therefore also have been planed in Eocene/Oligocene time, but what of high Exmoor, east of the Combe Martin fault?

Balchin (1952) recognized a flight of 'marine' flats in Exmoor, but such a claim can now be discounted, for he did not appreciate the impact of periglaciation on Exmoor's land form, nor the control of lithology. Rather, the overriding feature of the summit areas (Fig. 10) is the declination from NW–SE within a height range of 500 to 350 m OD (Straw 1995).

Coque-Delhuille (1991) regarded Exmoor as an upland existing during formation of the Devon/Cornwall surface, preserving relics of an older higher surface. The steep bounding N, S and E slopes were interpreted as fault-line scarps and general uplift as Miocene in age.

The defining boundaries of high Exmoor are controlled by major, essentially Variscan, structures — the Combe Martin and Brushford faults in the W and S, the Mere fault or its equivalent off the N coast, and a group of N–S faults in the E between Minehead and the Quantocks. Reactivation of these in the mid-Tertiary is generally accepted (Shearman 1967; Lloyd *et al* 1973; Palmer 1975; Edwards and Williams 1985). Upward movement is inward so that high Exmoor has not only been blocked out as a horst but has also been raised relative to central Devon and W Exmoor (Fig. 9; Straw 1995). This allows a claim that the gently inclined summit surface of high Exmoor (Fig. 10) is an elevated portion of the widespread sub-Paleogene peneplane and not an older surface, and that its uplift was of the order of 150 to 200 m.

Drainage evolution

In its final stages, the central Devon peneplane necessarily had a drainage system presumably, after millions of years of development, well-adjusted to structural features. Wooldridge (1954) attempted a reconstruction (following Jones 1930) of the upper Torridge and streams draining S off Exmoor as surviving feeders of an axial river system draining E. He supported this by identifying a primary divide, still extant on Exmoor (Figs. 6, 11), and formerly lying close to the NW coasts of Devon and Cornwall. For the present purpose however the NW–SE divide between the Torridge and Tamar catchments, which extends to Dartmoor, is more relevant (Fig. 6). This model is strengthened if the streams flowing off or near to Dartmoor, such as the rivers Lew and Okement, upper Taw and Yeo, are considered, like the Exmoor streams, as incised antecedent tributaries to the axial river (Fig 11).

Freshney *et al* (1979) also envisaged early river courses, carrying the Torridge across the Sticklepath Fault Zone just SE of the Petrockstow basin and eastwards to join a combined 'reversed' lower Taw and Mole/Bray rivers, before passing SE to enter the Exe catchment. There is no reason for an antecedent river to have followed precisely the line of the present lower Taw, but the several W Exmoor streams do indicate convergence toward a river broadly along that line (Fig. 11). Freshney *et al* (1979) do not depict a 'reversed' Torridge river, but the area N and NE of the basin must have been drained and it is very likely that a river flowing SE would have existed (Fig. 11), perhaps even joining the proto Taw, no doubt influenced by wrench faults. They do however support the existence at some time of a southward-flowing river in the Petrockstow basin and make a case for the upper Torridge turning eastward near Shebbear to enter the NW end of the basin, and deposit sands and gravels of five identified terraces, but this would have been a Pleistocene feature. Freshney (1970) and Edwards and Freshney (1982) suggest a river flowing northward in the basin opposite to the general southeasterly drainage considered above, noting the general fining of basin sediments in that direction, and Freshney *et al* (1979) describe an axial zone within those sediments containing channel and coarser deposits. Such a river might have been the river Okement which closely follows the Sticklepath Fault Zone on leaving Dartmoor but there is no trace of a

Figure 9*. The rise to high Exmoor from W Exmoor across the line of the Combe Martin fault. View NE from Little Bray Cross (SS 662 379) (317 m OD) toward Challacombe Common (c. 480 m OD). 05-09-1994.*

former high-level river between the basin and the coast west of Bideford, so where did the water go? It can also be observed that if a river, whether flowing N or S, were ever established along the basin, there had to be good reasons for it to abandon such a well-adjusted course, and glaciation cannot be one of them. Tectonic movements might have been responsible but cannot be demonstrated. The Okement remains close to the Sticklepath Fault Zone so why did not a basin river? The present river Mere cannot have played any part. It rises about 4 km W of the basin, and is currently dissecting Pleistocene terrace gravels, receives tributaries and then leaves the basin via a short fault-controlled valley to join the lower Torridge.

These uncertainties do not arise if there never was a through river; absence is easier to explain than removal, because an alternative scenario can be offered.

It can be assumed that the upper Torridge kept its antecedent course round the S end of the basin and across the Sticklepath Fault Zone to the point where it was captured much later by the lower Torridge. As with the Torridge today, the high-level river would have received the antecedent Lew and Okement near this S end (Figs. 6, 11). During the Eocene and Oligocene, with rivers of low gradient, this confluence area could have been inundated periodically by floodwaters, and these floods could have extended NW on many occasions transporting sediments to different parts of the basin

Figure 10. *High Exmoor west of Simonsbath, from Emmett's Grange to Dure Down (479 m OD). View NE, SS 752 369, 03-02-1994.*

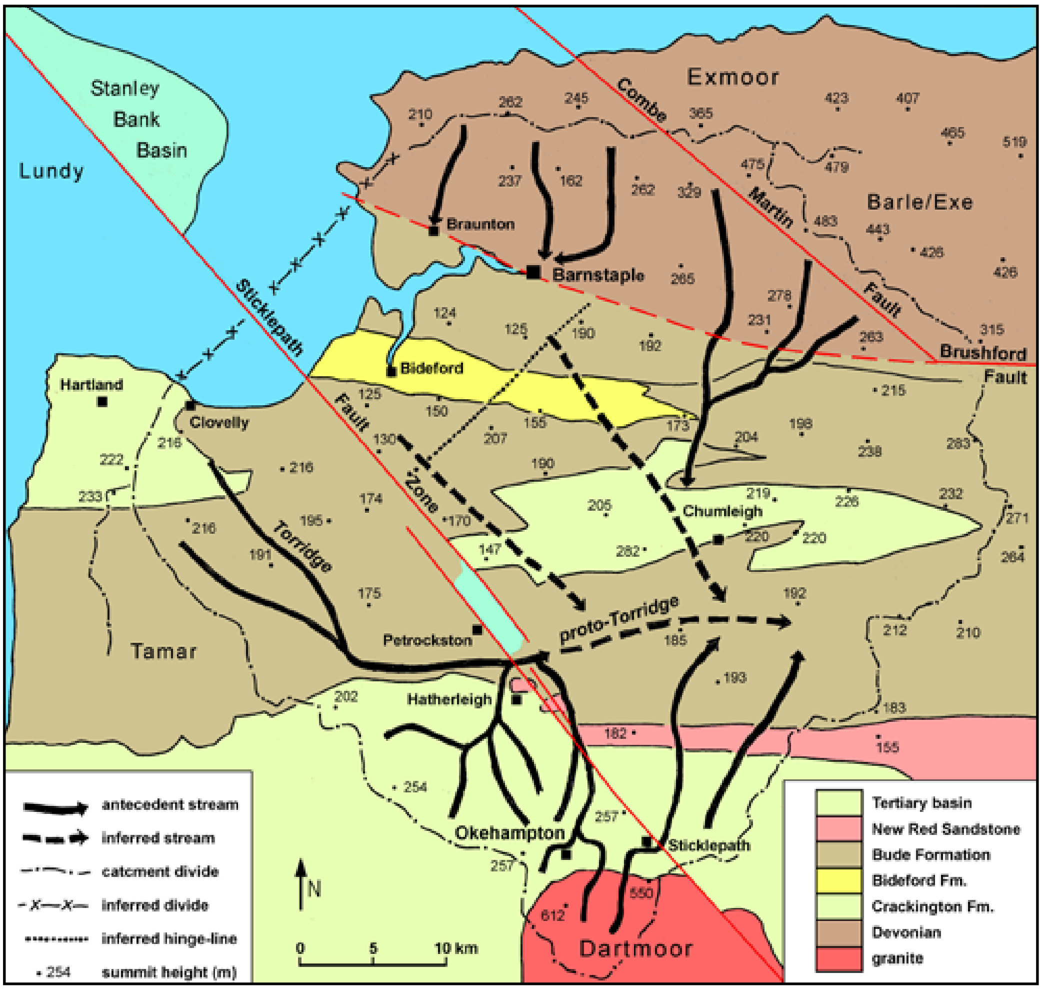

Figure 11. *Catchment and elements of proto-Torridge system showing discordant antecedent streams and inferred early courses. Faults taken from British Geological Survey Sheet 309.*

as determined by tectonic conditions. Characteristics of the basin deposits, regarded as largely fluvial by Freshney (1970), Freshney *et al* (1979) and Edwards and Freshney (1982), such as cyclic sedimentation, fining northward of deposits, wide range of lithologies and variety of depositional features including braided channels, levees and lakes, could be associated with recurrent flood situations just as well as with rivers. Inflowing waters could create the axial channels and coarse sediments noted by Freshney et al (1979), distributaries could produce braided channels and levees, and excess waters could form temporary lakes. All deposits would have been influenced by differential subsidence; repeated flooding might account for their cyclic nature, and long, dry inter-flood conditions would permit soil formation and vegetation covers. Between floods a small stream may have drained back to the Torridge.

Late Miocene uplift would have terminated these long-continued situations and headward recession of the lower Torridge would eventually allow the lower Mere, also fault-guided, to recede into the basin, subsume its drainage and commence incision of the younger terrace gravels. These relate to colder Pleistocene climates and could have been introduced to the basin by many small tributaries including the upper Mere, and be redistributed by thaw-related floods still generated in the Torridge confluence area.

An initial question remains. Why do the rivers Taw and Torridge presently drain NW? For an answer, we must look further afield.

It has been claimed above that an axial proto-Torridge receiving tributaries from N and S (Fig. 11) drained a subaerial surface of low relief. General Miocene uplift-induced rejuvenation and incision has confirmed the courses of many parts of the early system, but the axial river east of Hatherleigh and the Sticklepath Fault Zone has not survived later denudation.

Reference has been made to Miocene uplift of high Exmoor (Straw 1995) and disruption of the Oligocene peneplane. As a tectonic event, it cannot be separated from the history of the Bristol Channel, which is complex. Following the Variscan orogeny it was a land area and then underwent subsidence through mid-Triassic (Audley-Charles 1992) and Jurassic times (Cope 2006) with the accumulation of several thousands of metres of sediments. Briefly land again, it was submerged beneath Chalk seas to emerge in the early Paleogene and become peneplained contemporaneously with central Devon and Exmoor. During the Miocene, by contrast with high Exmoor, the Bristol Channel suffered renewed subsidence which may well have affected the Stanley Bank area. It was noted above that the E–W southern boundary structure of W Exmoor curves NW towards the basin and the Sticklepath Fault Zone (Figs. 6, 11). It is plausible therefore to suggest that Miocene subsidence of the Stanley Bank area extended also into the Bideford Bay area, creating a gap in the former divide and providing a new gradient toward the basin on which new streams could arise. Noting the generally lower summit heights in the Bideford area (Fig. 11) a hinge-line might be inferred somewhat eastward of Bideford (Fig. 11). The new streams, by exploiting faults and other lines of weakness within constraining wrench fault zones, then extended headward southeast from the basin until one intercepted the axial river and became the present lower Torridge and a second, the present lower Taw, captured its present Mole/Bray tributary. These events and general dissection of the peneplain have had some 15 Ma of later Miocene, Pliocene and Pleistocene time to work out, allowing close adjustment over the Upper Carboniferous tract, of valley, ridge and stream alignments to folds and faults as described above but, at the same time, leaving no trace of the axial river east of the Okement confluence.

A final question. Why does the Torridge, and not the Taw, display a stretch of ingrown meanders (Fig. 12a)?

The courses of both rivers are controlled generally by wrench faults, but progressive headward erosion along these zones meant adjustment to cross faults and folds and, in the case of the lower Taw, formation of the many sharp curves that should not be taken for meanders (Fig. 12b). With the Torridge, however, a later event seems to have created conditions for authentic meander development to modify fault control.

The best-developed Torridge meanders occur downstream from Dolton to Great Torrington and Landcross over a distance of *c.* 16 km and display a series of tight curves along the wrench fault zone (Fig. 12a). The initial meanders must have formed on a low gradient surface, probably a wide floodplain, like those of the Taw on the present flood-plain south of its junction with the Mole/Bray, before becoming incised into that surface. Their pattern has been inevitably modified somewhat as downcutting has proceeded, with undercutting of bends, and creation of 'slip-off' slopes to produce the ingrown meanders of today. Two 'cut-offs' can be identified.

The larger 'cut-off' occurs E of Merton (Fig. 12a), its floor at 65–75 m OD, some 20–30 m above the present Torridge floodplain. Most of the floor is underlain by alluvial deposits allocated by Freshney *et al* (1979) to Torridge Terrace 6. In its southern part some of these have been removed by the river Mere which, curiously, flows 'upstream' in the 'cut-off' to reach the Torridge. A likely explanation for this is that the Mere, issuing from the Petrockstow basin, built up sufficient sediment where it entered the 'cut-off' loop to create a new gradient and divert itself eastward. Such a process is known as avulsion.

The smaller and older 'cut-off' survives on the S side of Great Torrington (Fig. 12a), its floor at 85–95 m OD. It too contains some alluvial sediments, but both ends

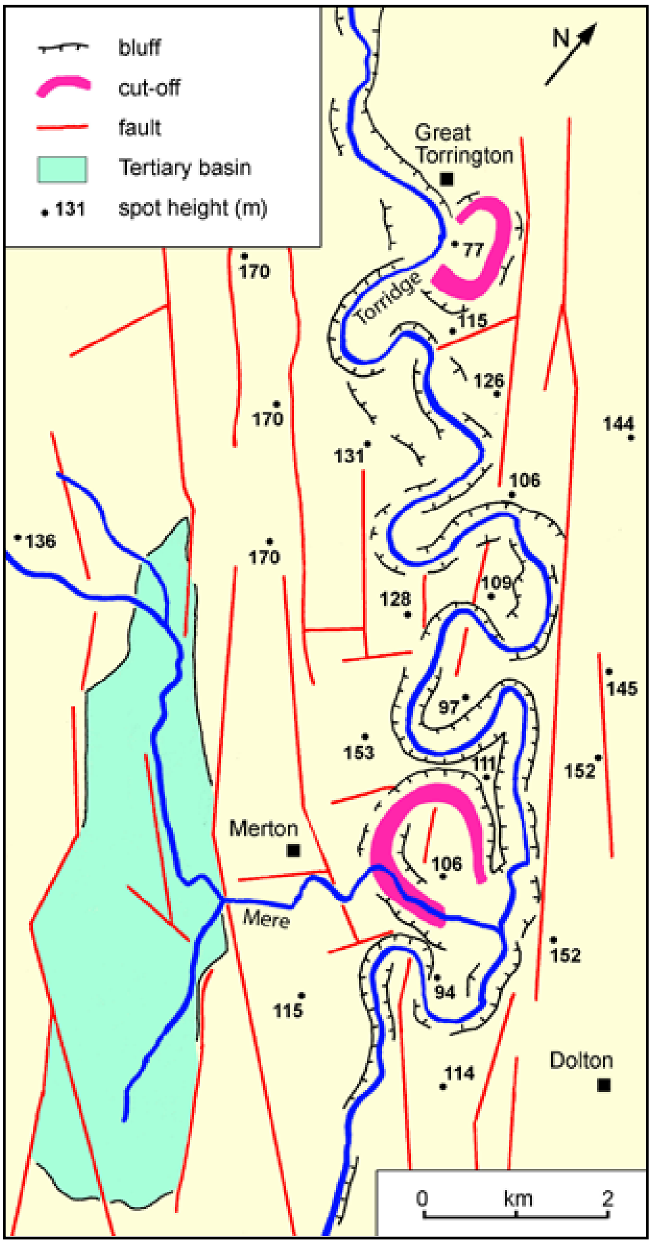

***Figure 12a**. Ingrown meanders of the river Torridge below Dolton, and the Petrockstow basin (infilled with Tertiary deposits).*

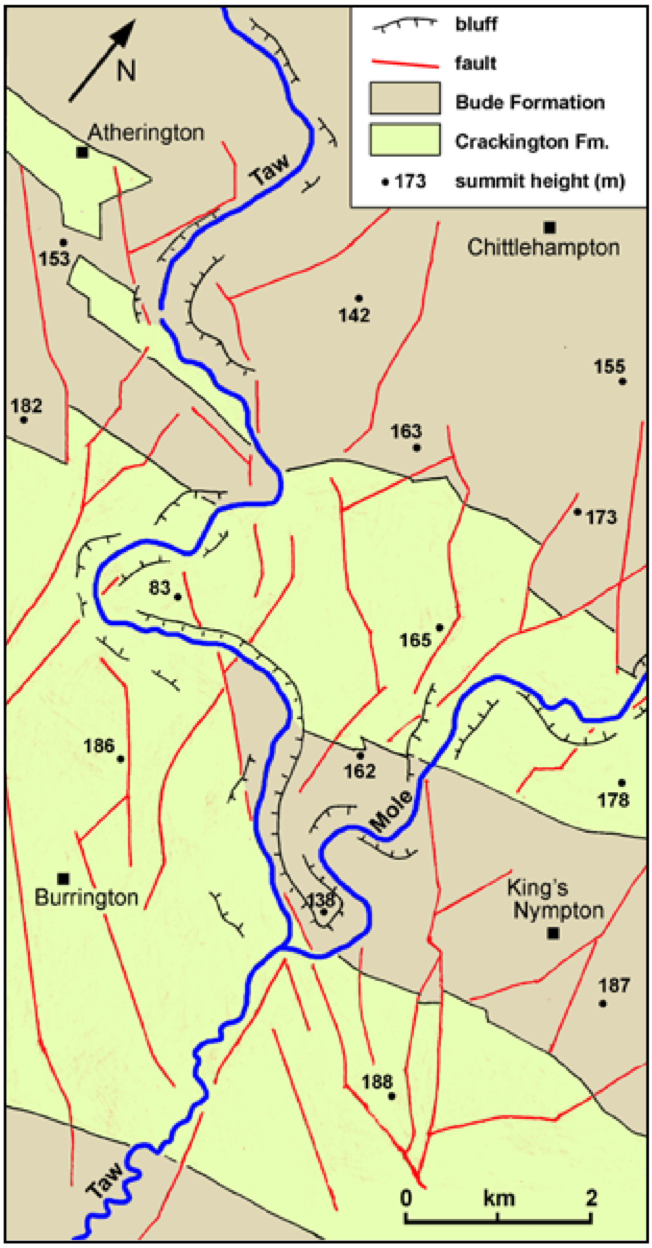

***Figure 12b**. Fault-guided course of the river Taw below its confluence with the Mole/Bray river, and its discordance with the Crackington Formation outcrop.*

of the loop have been further incised. Along the whole stretch, the loci of the meanders frequently accord with wrench faults. The height of the initial meander surface can be ascertained from the elevations of the spurs and eminences surviving between the meanders. Currently these lie between 94 and 131 m OD (Fig. 12a) and, allowing for some lowering, indicate a former valley-floor no higher than *c.* 130 m OD, probably graded to a contemporary sea-level (Straw 1986). Maritime features at similar heights occur frequently along the south and northwest coasts of Devon and Cornwall, as at Zennor (Fig. 13) and the South Hams (Brunsden 1964; Gunnell 2020) and are generally regarded as of early Pleistocene age. Similar, but less compact meanders may be observed along the lower Tamar and lower Tavy rivers, north of Plymouth, also associated with 130 m planation features.

Throughout the stretch of meanders, patches of fluvial materials survive at various heights on narrow benches beneath former river cliffs. Fragments of up to 8 terraces are identified by Freshney *et al* (1979) related to stages of Pleistocene downcutting below the initial 130 m floodplain.

By contrast, the Taw seems to have undergone no similar base-levelling and floodplain development at the 130 m level, and it is difficult to explain why not. The curves along its course are strongly fault-controlled as would be expected with headward recession (Fig. 12b) and are not incised meanders. Pleistocene incision is however witnessed by terraces bordering the floodplain.

Figure 13. *130 m platform cut into Land's End granite; degraded cliff with tors and head. View WSW, SW 472 392, 29-05-1996.*

Conclusion

It was observed at the beginning of this paper that the two catchments of the Torridge and Taw include much of the outcrop of Upper Carboniferous rocks, and it has been shown that together they constitute the former catchment of an integrated E-draining axial river. The bounding divides of this ancient catchment survive in Exmoor and S of Hartland, but not across Bideford Bay, and some elements of the axial drainage system are now represented by the antecedent S-flowing streams off Exmoor, the upper Torridge and the north-flowing streams off Dartmoor and its vicinity. These elements can be detected despite the substantial adjustment of the present land surface to lithology, folds and faults. The remarkable accordance of summit heights has been explained in terms of a formerly planed surface, the near-end product of Eocene and Oligocene denudation, on which the ancient drainage existed and from which sediments were derived to accumulate in the subsiding basins.

The disruption of this landscape was achieved by a series of events that commenced with Miocene subsidence of the Stanley Bank/Bideford Bay area. This eliminated the old divide across the Bay and produced a northwest-descending gradient which encouraged the initiation of two new streams and their headward erosion along parallel wrench fault zones but, fortuitously, not along the Sticklepath Fault Zone. The singularity of these events would seem to be confirmed by the situation where all other major rivers of the Southwest (the Exe, Tamar, Lynher, Fowey) drain south. Granted, the river Teign in east Dartmoor has an enigmatic relationship with the Bovey basin and the SFZ, but that is a tale for another day.

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