Strike slip faulting in Somerset and adjacent areas

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The presence of strike-slip faulting in Cornwall, Devon and Dorset is well established. There is now a growing body of evidence that strike-slip faults are to be found throughout Somerset as shown by faults and joint patterns. There were major dextral strike-slip movements during the Variscan Orogeny. Later movements have affected the Jurassic and Cretaceous formations and possibly Palaeogene rocks. Strike-slip faulting has implications for field mapping, the development of landforms and the quarrying industry.

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Introduction

Strike-slip faults have long been noted throughout SW England cutting the Variscan basement (Devonian and Carboniferous), granite plutons (Permian) and post-Variscan sedimentary successions. Dearman (1963) inferred that NNW-SSE trending dextral strike-slip faults in Devon and Cornwall largely originated as Variscan structures that were reactivated during mid-Tertiary shortening of the Alpine orogenic foreland. The Sticklepath-Lustleigh Fault zone and associated Tertiary pull-apart basins e.g. Bovey Basin (Edwards, 1976); Petrockstow Basin (Bristow *et al.*, 1992) are important examples of these structures. Shearman (1967) reported evidence for NNW-SSE Tertiary fault movements in north-west Exmoor. Likewise similar dextral and associated NE-SW sinistral strike-slip faults have been reported in Dorset. For example, the 20 km-long Poyntington Fault, east of Sherborne, is interpreted to have a post-Jurassic dextral offset of some 3 km. Thickness variations on either side of the fault suggest that it was active during sediment deposition (Bristow *et al.*, 1995, pp. 134-139, figure 56). The purpose of this paper is to elaborate published work and focus on further evidence of strike-slip faulting in inland Somerset (Figure 1).

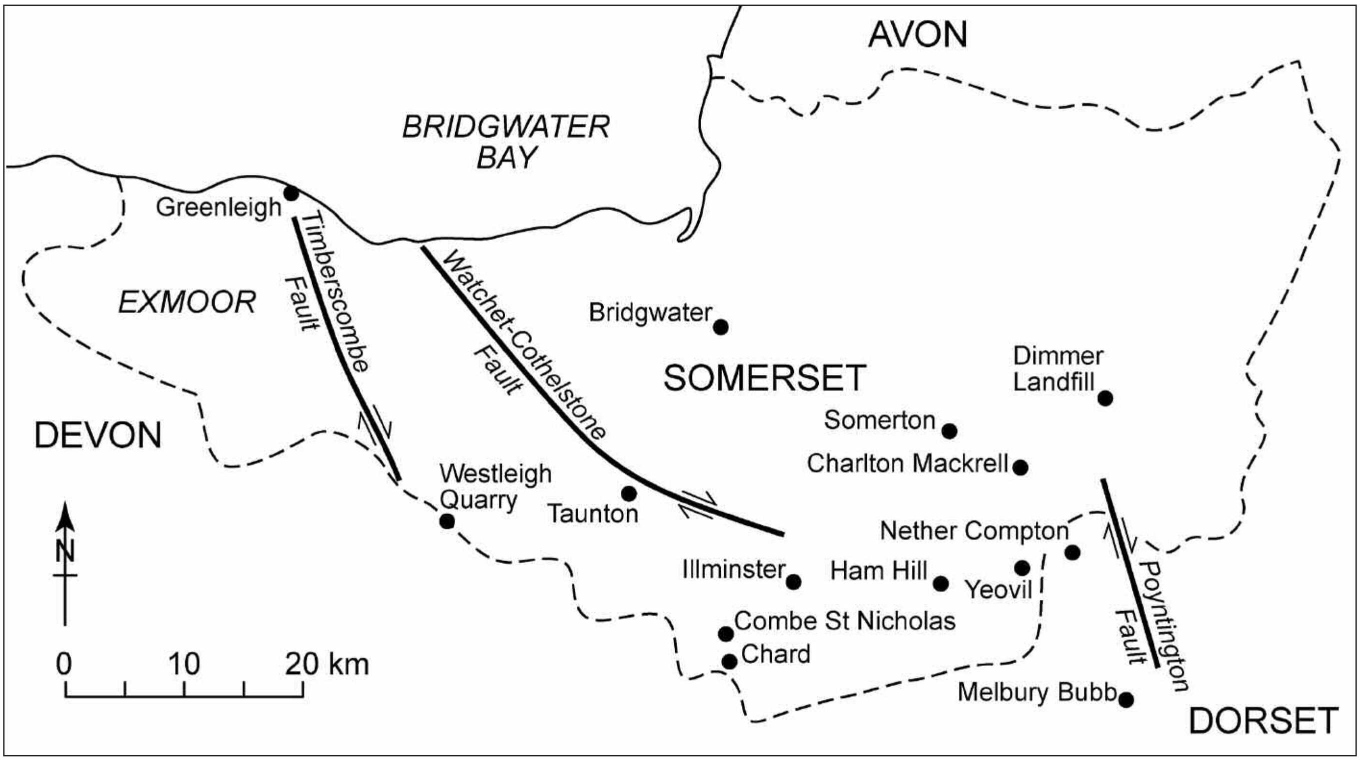

Figure 1. *Map showing the location of places referred to in the text of the paper, along with the major structures in the region.*

Summary of previous work

The Watchet-Cothelstone-Hatch Fault system which borders the south-west side of the Quantock Hills has been shown to have a dextral strike-slip displacement of some 16 km (Miliorizos and Ruffell, 1998) (Figure 1). More recently, it has been traced northward across the Bristol Channel (Miliorizos *et al.*, 2002). Whittaker (1972) reported that the Watchet Fault west of Watchet has a horizontal, post-Liassic, dextral displacement of 275 m. The parallel Timberscombe fault was described by Webby (1965). The displacement of Devonian rocks by the Watchet-Cothelstone-Hatch Fault system suggests that major NNW-SSE displacements took place during the Variscan Orogeny (Miliorizos and Ruffell, 1998). There have also been studies of structures along the Somerset coast between Blue Anchor and Hinkley Point (Kelly, 1996; Kelly *et al.*, 1998; Nemčok *et al.*, 1985), Peacock and Sanderson, 1995a, 1995b; Palmer, 1975; Peacock and Sanderson, 1999; Willemse *et al.*, 1998). These demonstrate that the inversion-related strike-slip faults were formed in lithified sediments and that they either reactivated pre-existing Variscan strike-slip faults or developed as neoformed structures (Nemčok *et al.* 1985). Recent mapping by the British Geological Survey has demonstrated that Cretaceous and Tertiary sedimentary rocks in east Somerset and Dorset are affected by NNW-SSE and associated NE-SW trending faults, developed during a phase of compressional tectonics related to the Alpine Orogeny. The E-W Mere Fault provides evidence of compressional tectonics during the Tertiary (Bristow *et al.*, 1995). Prudden (1983) described evidence for strike-slip faulting at Ham Hill in south Somerset based on slickenside striations and offset tension fractures. Drummond (1970) speculated that the NNW-SSE Parrett Valley Fault, 1 km west of Ham Hill, has a dextral displacement on the basis that the E-W Coker Fault appears to have been offset. Harvey and Stewart (1998) have discussed the Mangerton Fault in south Dorset in connection with conjugate strike-slip fault zones.

Ham Hill

Ham Hill Country Park, 6 km west of Yeovil, is an extensive area of abandoned quarry workings plus two active quarries (Figure 1). There are a number of good exposures of Ham Hill Stone, a bioclastic limestone, of Lower Jurassic age. A quarry face, at the northern end of the hill (ST 4788 1714), shows smoothed slickensides with horizontal striations and right-stepping *en-echelon* faces lined with calcite crystals; these features are interpreted as evidence for dextral movement. There are also less frequent indications of sinistral movement trending NE-SW. These features can be traced in a zone of disturbance trending NNW-SSE toward the southern end of Ham Hill. An old quarry face close to the limekiln (ST 480 165) shows a smoothed and horizontally-grooved NNW-SSE vertical face indicating dextral movement in addition to brecciation. In the area around Ham Hill, of twenty nine faces with horizontal or near horizontal slickenside striations, twelve are dextral and trend approximately NNW-SSE, whilst eight are sinistral and trend NE-SW. Prudden, (1995) interpreted these structures as conjugate shear fractures that formed as a result of N-S compression. The northern end of the quarry face (ST 4777 1716) shows a set of N-S, steeply-inclined joints in a zone 4 m wide that appear to be associated with the strike-slip structures mentioned above.

Recent quarrying operations have revealed an old E-W quarry face 170 m to the west at ST 4765 1703; massive beds of Ham Hill Stone are separated by a 3 m-wide zone riven with N-S fractures. An exposure 100 m to the north shows smoothed, grooved slickensides trending 330° similar to the features mentioned above to the east.

Similar fractures, but on a larger scale, can be seen in the working quarry at the southern end of the hill at ST 4830 1612 where there is a 15 m wide zone of fractures trending N-S. The working face of the quarry has been cut back to these fractures which have facilitated stone extraction. However the fractures have reduced the size of building stone that can be extracted. Together, the exposures at Ham Hill indicate a broad NNW-SSE trending zone of dislocation; it is not possible to estimate the lateral displacement but it may not be very great.

An examination of loose, clean-cut Ham Hill Stone, to be seen in the work's yard and in new buildings, often reveals near-vertical zigzag lines that look like stylolites; they tend to be perpendicular to the bedding and are iron-stained. However, close examination of the fractures shows small calcite crystals indicating that there has been a slight lateral displacement; these may be evidence for compressional tectonics. These fractures are a source of weaknesses causing the stone to split and result in wastage for the quarry operator when processing the stone.

Yeovil area

Gore Lane, an E-W trending sunken lane in the Bridport Sands at Nether Compton east of Yeovil (ST 6000 1688), exposes a section in Bridport Sands (Upper Lias) as shown in the sketch section in Figure 2. The section is 50 m in length and shows a wide zone of disturbance, which may reflect the less competent nature of the Bridport Sands compared with more competent beds such as the limestones of the Inferior Oolite. Four faults trend 330° and two at 010°. There was no evidence of lateral movement but one of these faults was exposed further south in a cutting in the A30 where the Inferior Oolite limestones showed N-S trending, slightly oblique striations on joint faces.

There are a number of sub-parallel NNE-SSW faults near Bradford Abbas (ST 5515), shown on the British Geological Survey 1:50.000 Yeovil geological map, and a similar pattern has been mapped to the north in the Sandford Orcas area (ST 6221). The result is a pattern of narrow outcrops with one particularly good example to the east of White Post (ST 1602 2038) where there is a 100 m wide N-S outcrop of Beacon Limestone. The Poyntington Fault is 4 km to the east. Further north, a sliver of Thorncombe Sands 3 m wide, wedged between beds of younger Beacon Limestone, was observed in road excavations at Chapel Cross on the A303 (ST 6320 2630). The 1:50 000 Yeovil geological map also shows a number of NNE- and NNW-trending faults, 1 km northwest of Nether Compton (ST 5917), that are reminiscent of a conjugate system resulting from N-S compression. Temporary exposures in and around Yeovil, observed by the author over the last 40 years, have revealed numerous small faults with a northerly component.

Gulls are frequently observed in exposures in deeply dissected country in south Somerset. These are vertical gaps in the strata up to a 0.5 m in width and associated with hillside cambering. There are nine prominent gulls in the 200 m-long cutting in the Bridport Sands Formation (Upper Lias formerly Yeovil Sands) at Yeovil Junction (ST 5749 1417); the cutting trends NE-SW and transects a ridge running NNE-SSW. Eight of the gulls trend NNW-SSE and N-S whilst one was NNE-SSW. A similar situation was observed by the author when the A303 Ilminster Trunk Road Improvement was undertaken to the

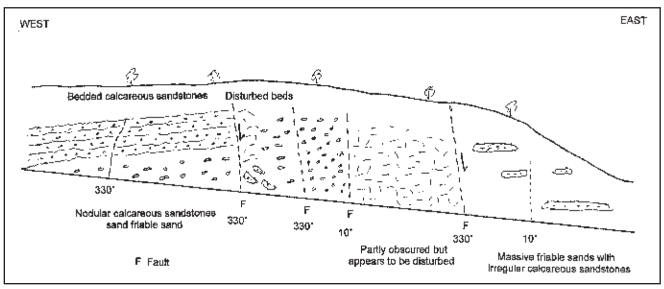

Figure 2. *Sketch section showing dislocated Bridport Sands in Gore Lane, Nether Compton, Dorset.*

north-east of Ilminster (ST 3990 1535). A cutting through the Marlstone Rock Bed Formation (Middle Lias) showed 55 gulls aligned as follows: NNW-SSE 14, NW-SE 24, WNW-ESE 17. The sides of two NW-SE gulls with striations dipping at 5° and horizontal respectively. The orientation of these gulls is evidence that many of them may have opened up along planes of weakness associated with NW-SE strike-slip faults.

The Somerton area

The photograph in Figure 3 was taken during the dry summer of 1975 and shows a prominent lineament trending NNW-SSE near Charlton Mackrell (ST 5329) to the east of Somerton (Leech, 1978). An exposure in a quarry face, observed by the author, provided a section across the lineation (ST 5360 2930) showing a double fault, 1 m of disturbed Blue Lias limestones, and horizontal striations trending 310° on one of the faults faces. The Blue Lias at Charlton Mackrell has predominantly shallow well drained soils; as the fault zone contained more moisture-holding soil it consequently showed up as darker lines on the photograph. Figure 3 also shows a dense pattern of lines trending NNW-SSE which are parallel to the line of the fault; exposures in an adjacent quarry floor confirmed that these lines reflected a dense pattern of joints.

A zone some 10 m wide of N-S closely-spaced joints was observed by the author at the eastern end of a recently opened quarry working Blue Lias limestones at Ashen Cross (ST 496 274), 4 km WSW of Charlton Mackrell. The British Geological Survey 1:50 000 Glastonbury geological map shows a NNW-SSE fault 700 m to the east of this exposure.

Figure 3. *Aerial view of lineaments at Charlton Mackrell, Somerset, facing north-west. (Leech, 1978, White, J, West Air photography, Weston-super-Mare, OAP BL 1551/9/10; BL 1552/1).*

Castle Cary area

Closely-spaced N-S joints in the Charmouth Mudstone Formation (Lower Lias) were observed by the author at the Wyvern Waste Disposal Site east of Castle Cary (ST 6160 3110) in a landfill cell. These joints, together with the presence of intermittent beds of limestones, necessitated the installation of a grout curtain to contain any potential leakage.

Chard area

Steeply-inclined parallel joints trending NNE-SSW in the Lower Chalk were observed by the author in a gas pipeline trench north of Combe St Nicholas (ST 3012 1215) for a distance of 120 m along the trench and close to a NNW-SSE fault shown on the British Geological Survey 1:50 000 Wellington geological map. An old photograph of Snowdon Hill Quarry, west of Chard (ST 303 092) in Jukes-Brown (1903), shows similar, steeply inclined N-S multiple joints in the Upper Greensand that appear to be associated with the same fault.

Westleigh and Exmoor

David Roche Geo Consulting (2004) reviewed the geology in Westleigh Quarry 9 km to the southwest of Wellington (ST 06 17). Five faults with a NW trend were mapped; two of the faults have dextral strike-slip displacements. They are described thus: 'Faults recorded in the quarry face can occur as fault zones up to around 15 m across rather than as discrete features. Such fault zones are heavily stained red and are calcite lined and/or clay filled with abundant fault debris. Fault breccias occur within the fault zones and within the axial zone' (David Roche Geo Consulting, 2004).

N-S joints can be seen in many of the old quarries on Exmoor and are especially well-displayed in the Devonian Hangman Sandstone Formation at Greenaleigh (ST 952 481) west of Minehead. At Greenaleigh pervasive vertical fractures weaken the cliff face and lead to toppling and cliff retreat.

Dorset

A faulted inlier of Upper Greensand and Chalk to the south of Yeovil at Melbury Bubb in Dorset (ST 5906), shown on British Geological Survey 1:50 000 Yeovil geological map, is bounded by faults with a northerly trend and these may be associated with strike-slip movements. Evidence of lateral displacement in the Cornbrash and Forest Marble was also observed by the author in temporary road exposures on the A37 at Closworth (ST 570 104) 4 km to the north of the inlier).

White (1923) recorded an example of shear-cleavage and slickensides from a Chalk pit west of Blandford Forum in Dorset (ST 8302 0619) and is worth recalling: 'Near the eastern end of the pit, which is about 15 feet deep, the Chalk is traversed by a fault which appears to strike NE and hade at a high angle NW. The fault is only marked by a streak of marly stuff, and on the dirty, sloped face of the pit it would be likely to escape notice, were it not for the pronounced shear-cleavage and slickensides developed in the Chalk on the hanging side, for a distance of several yards from the fracture, and for the crushed condition of some of the flints'. The British Geological Survey 1:50 000 Shaftesbury geological map shows that the pit is close to the NNW-SSE trending Winterbourne Fault and may be a complementary splay (Bristow *et al*, 1995).

Possible relationships between structures and landforms

The dislocations described above have clearly disturbed and fractured the rock in many areas of Somerset. The fractures have weakened the rock and facilitated the transmission of ground water. The location of springs, and hence excess groundwater when permafrost thawed, may in part have been determined by these fracture zones in the bedrock. This in turn may have led to hillslope recession as a result of periglacial mass wasting acting on steep slopes. For example, in south

Somerset eleven steep-sided, blunt-ended coombes, on the south-east side of Ham Hill (ST 4915), are cut back into the Bridport Sands. Most have a north-westerly or north-easterly trend which may be related to zones of more densely fractured rock although the lack of exposures makes it difficult to demonstrate that there is a relationship. This observation may well have more general application for understanding the pattern of valleys as, for example, the coombes in the Chalk country of Dorset.

VARISCAN THRUST PLANES

Donato (1988) summarised vibroseis seismic data acquired by Gaol Petroleum plc in the vicinity of the Somerton Anticline, Somerset (Figure 4). Two important reflectors are shown: one south of the Polden Hills dipping SSW and a second, from Chadwick *et al*. (1983), south of the Mere Fault dipping SSE. These are interpreted as Variscan thrust planes. Many of the features recorded above are located between the two thrust planes including the Poyntington Fault. Donato remarks that 'dislocation would be inevitable in the area between the two thrusts, both during their initiation and subsequent reactivation, and faults such as the Biddle and Poyntington Faults may well have originated in this way.'

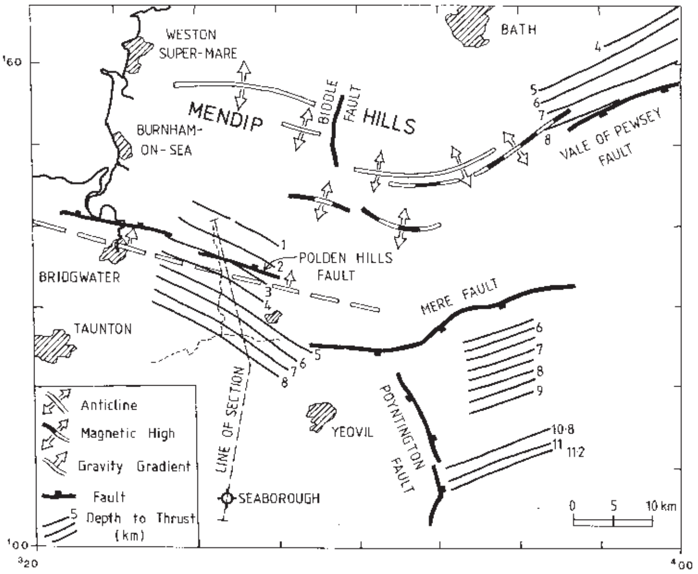

Figure 4. *Map of postulated thrusts south of the Polden Hills and the Mere Fault in relation to the Poyntington Fault. (From Donato, 1988).*

CONCLUSIONS

There is evidence for strike-slip faults in South West England, including Somerset, associated with N-S compression. NNW-SSE and associated NE-SW shear fractures are present along with associated N-S trending joints. Deformation may vary from brittle fracture in the limestones and to more ductile deformation in weaker mudstones and sandstones. There is evidence for considerable strike-slip movements during the Variscan Orogeny. Later horizontal and vertical movements may have been guided, in part, by the reactivation of these pre-existing lines of weakness. The faulting has affected the pattern of outcrops and the effects need to be kept in mind when mapping. Fractures have weakened the rock and facilitated both its removal by denudational processes and the movement of ground water; both may have influenced the location of valley development. Gulls have opened up along lines of weakness. There are also been important implications for the quarrying industry.

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