A Liassic palaeofault from Dorset

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(Plate 1)

Summary. Evidence is presented for Liassic (Toarcian) faulting at Watton Cliff in coastal W Dorset. This movement is inferred from the abrupt changes in thickness of the Junction Bed and contiguous strata given that the contact with the overlying shale and clay is horizontal. Further evidence for synsedimentary movement is manifested by the presence, in the palaeofault zone, of numerous calcilutite-filled fissures penetrating a coarser, more sandy matrix. These neptunian dykes and sills contain abundant ammonites of the middle to late Toarcian, presumably the time of fault movement. This onshore Jurassic palaeofault broadens the known extent of such features from Sutherland (Brora–Helmsdale Fault) and Yorkshire (Peak Fault) to include southern Britain.

1. Introduction

A considerable body of evidence attests to intra-Jurassic earth movements in the British Isles. Early work by Buckman (1901), synthesized and expanded by Arkell (1933), has latterly been supplemented by Casey (1971), Hallam (1975) and Sellwood & Jenkyns (1975); stratigraphical relationships point to movements in early, middle and late Jurassic time. However, the only clearly documented palaeofaults that embrace this time interval are the Brora–Helmsdale Fault (Kimmeridgian) in Sutherland and the more controversial early/middle Jurassic Peak Fault exposed on the Yorkshire coast (Bailey & Weir, 1932; Arkell, 1933; Hemingway, 1974). There exists, of course, abundant evidence for Jurassic faulting in the North Sea (e.g. Chesher & Bacon, 1975; Kent, 1975; Ziegler, P. A. 1975; Ziegler, W. H. 1975) and coeval tectonic activity is known from East Greenland (Surlyk *et al.* 1973).

Sellwood & Jenkyns (1975) attempted to explain the nature and sequence of Pliensbachian to Bajocian facies in Britain as a function of differential fault movements in the pre-Permian floor, a conclusion disputed by Hudson (Hudson, Sellwood & Jenkyns, 1976). We therefore feel it is of interest to document evidence for late Liassic (Toarcian) movement along a fault zone now exposed in coastal west Dorset.

The timing of this faulting is such that it correlates with opening of the central Atlantic some 180 ma BP (Pitman & Talwani, 1972; Dalrymple, Grommé & White, 1975) and with the initial ocean spreading of the Alpine–Mediterranean Tethys (Smith, 1971; Dewey *et al.* 1973). The former northern and southern continental margins of the Tethys, now exposed in the Alps, exhibit spectacular evidence of Liassic faulting (Trümpy, 1960; Plancherel & Weidman, 1972; Coadou & Beaudoin, 1973; Bernoulli & Jenkyns, 1974; Baud & Masson, 1975). The fact that similar, synchronous tectonic movements have apparently taken place in an area of so-called 'stable' northern Europe is undoubtedly significant.

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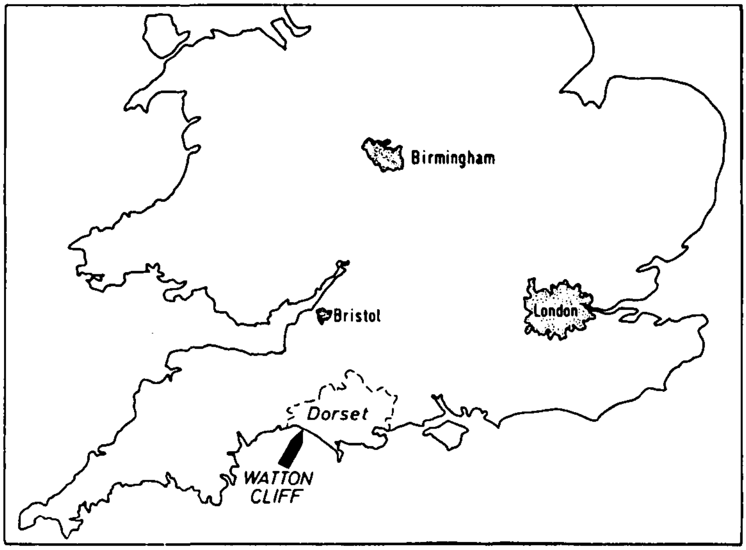

Figure 1. Location map, indicating the area studied.

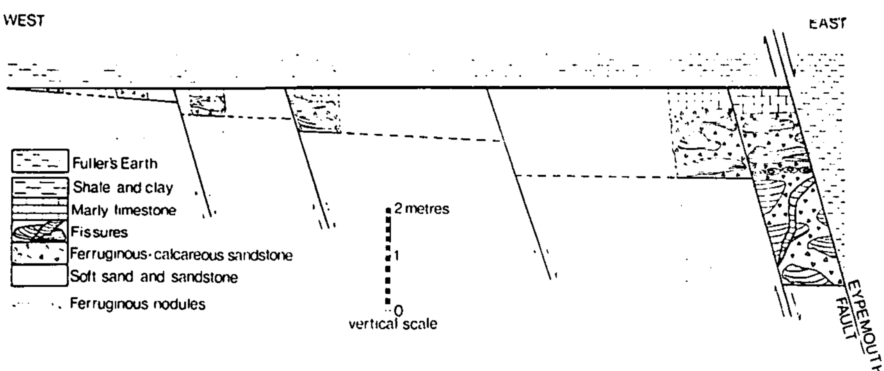

Figure. 2. Interpretative section along Watton Cliff showing the normally faulted Junction Bed overlain, above a horizontal surface, by shale and clay. Only the most easterly palaeofault can be easily recognized. Horizontal distance illustrated by section is approximately 300 m.

2. Evidence for Liassic faulting in Dorset

We infer Liassic movements from study of the variation in thickness of upper Pliensbachian and Toarcian rocks (Junction Bed and contiguous strata) at Watton Cliff (Fig. 1). This locality, previously described by Day (1893), Buckman (1922) and Jackson (1922, 1926), has been colloquially termed Fault Corner because of the structural contact of the Lias with the Middle Jurassic Fuller's Earth. The Geological Survey (Wilson, *et al.* 1958) concluded that the fault was pre-Albian but intra-Cretaceous in age. Sections along Watton Cliff to the west of the major fault – generally termed the Eypemouth Fault – are shown in Figure 2.

The evidence for synsedimentary movement is clearly shown by the abrupt jumps in thickness of the Junction Bed and the fact that its contact with the overlying shale and clay (*Dumortieria levesquei Zone*) is horizontal (Fig. 2). Additional evidence for fault movements is given by the presence of abundant sediment-filled fissures penetrating a matrix developed as a grey to reddish-brown calcareous/ferruginous quartzarenite. These fissures were seen by Jackson (1926) who interpreted them as normal, although impersistent members of the stratigraphic succession. The fissures are developed along most of the area illustrated in Figure 2, but they die away westwards; individual examples, with thicknesses commonly in tens of centimetres, may be traceable over a horizontal distance of several metres.

The majority of these fissures are subhorizontal, usually possess smooth undulating bases, and may end bluntly (Plate 1*a*); they are commonly filled with multiple intrusions of fine-grained parallel- and cross-laminated buff calcilutites and somewhat coarser milky limestones, both of which contain very sparse quartz grains. Radiaxial fibrous and blocky calcite compose the top levels of some fissures, the former presumably being a replacement fabric after a void-filling submarine cement (Kendall & Tucker, 1973). Additionaly, rare subvertical neptunian dykes cut both the fissures and the host rock (Plate 1*b*). Very small sediment- and calcite-filled cracks (diameter 0.05–0.5 mm) also occur locally, as do somewhat larger geopetal cavities. Similar complex fissuring and cavity formation have been described from the Mediterranean Jurassic (Castellarin, 1965; Wendt, 1971). It is possible that the thickness changes in the Junction Bed and associated rocks are directly related to the number of horizontal fissures that have intruded the strata.

The fills of the fissures locally contain echinoid and crinoid fragments, thin-shelled bivalves, small gastropods and ammonites, the latter providing a date for the filling of the fissures. All ammonites identified by us (*Grammoceras* spp. and *Hammatoceras insigne*) indicate a late Toarcian age (*Grammoceras thouarsense* Zone); although Jackson (1926) recorded fissures (our interpretation) containing early Toarcian faunas (*Hildoceras bifrons* and perhaps *Harpoceras falcifer* Zones). The older sandy host rock contains faunas indicative of the late Pliensbachian and early Toarcian, although some of these forms are undoubtedly reworked.

We suggest the following sequential events in the exposed fault zone;

(1) Formation of an upper Pliensbachian – lower Toarcian ferruginous quartzarenite under conditions of minimal net sedimentation leading to early submarine lithification by calcareous cement (Bathurst, 1971; Milliman, 1974).

(2) Extensional movements during middle to late Toarcian times leading to faulting and fracturing of an imperfectly lithified substructure; sculpturing of the fractures by current scour and filling with fine- and medium-grained lime mud, locally rich in fauna.

(3) A further series of tectonic movements producing vertically orientated sediment-filled fissures.

(4) Presumed deepening of water, leading to clay deposition in late Toarcian (*Dumortieria levesquei* Zone) times (cf. Sellwood & Jenkyns, 1975).

3. Conclusion

We take the above evidence to indicate that a series of Liassic palaeo-faults affected the deposition and nature of the limestone and sandstone facies in this part of Dorset. The fact that the intensity of fracturing and the degree of displacement along the Junction Bed outcrop (Fig. 2) increase towards the Eypemouth Fault itself leads us to suggest that this fracture was the main palaeofault active during this time.

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EXPLANATION OF PLATE

Plate 1 (*a*). Smoothly sculptured, bluntly terminating fissure filled with calcilutite penetrating a coarser quartzose calcareous matrix locally containing ammonites. Vertical section. Fallen block, Watton Cliff. Diameter of coin = 1.7 cm.

Plate 1 (*b*). Neptunian dykes, composed of fine-grained calcareous sediment locally containing gastropods, Foraminifera, crinoid and echinoid fragments, and thin-shelled bivalves plus successive generations of radiaxial fibrous calcite and later equant rhombohedral spar. Matrix rock is quartz-bearing fine-grained limestone with some ferruginous intraclasts. Vertical section. Fallen block, Watton Cliff.

Geol. Mag. Vol. **114**, 1977, Jenkyns & Senior, Plate 1, facing page 52.

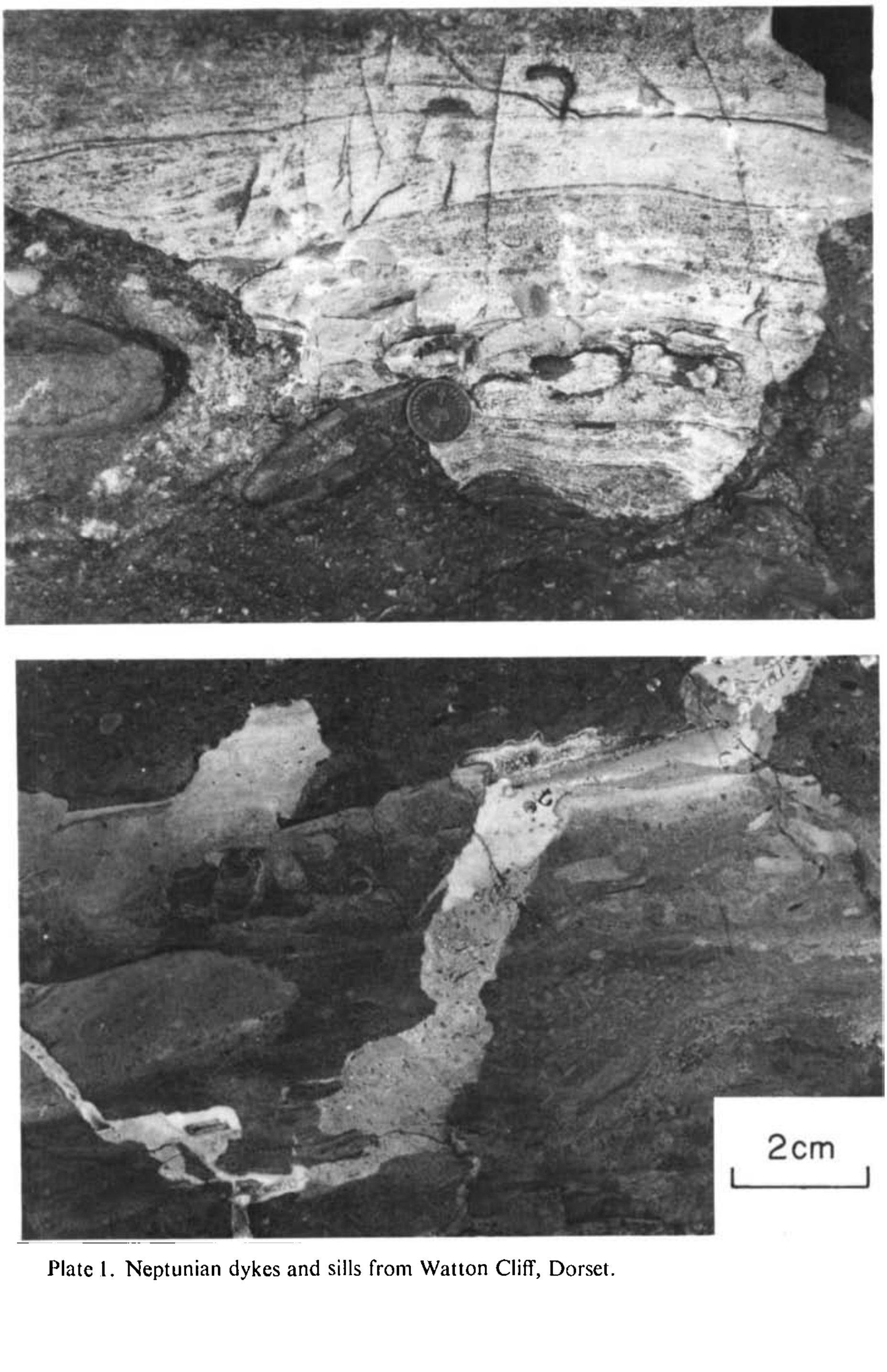

Plate 1. Neptunian dykes and sills from Watton Cliff, Dorset.