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THE MID-DORSET SWELL; A RE-ASSESSMENT

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The Mid-Dorset Swell was first described (in detail) by Dr. P.V.O. Drummond in 1970. During the 1970s it became an accepted interpretation of the facies variations seen in the mid-Cretaceous sediments of the western part of the Wessex Basin. In the 1980s geophysical surveys in the area, coupled with a greater understanding of extensional tectonics and crustal isostacy, have generated a database on the basement control of Mesozoic sedimentation. The development of sequence stratigraphy in the 1990s has provided an additional tool with which to tackle the problem. Applying all these new data to the area of mid-Dorset it is possible to question the concept of the 'swell', although there are significant problems in only using extensional faulting as the control on sedimentation.

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INTRODUCTION

The Mid-Dorset Swell was first hinted at by Hancock (in House, 1963) and Drummond (in Smith and Drummond, 1962). It was postulated, initially, as an explanation of the thinning of the Upper Greensand in north Dorset and the absence of Lower Cenomanian deposits between Shillingstone and Evershot (see Figure 1). Following the publication of the Proceedings of the Geologists' Association, Volume 81, Part 4 in December 1970 (which contained papers by Kennedy, 1970; Drummond, 1970; and Selwood *et al.,* 1970), the concept of the Mid-Dorset Swell became entrenched in the Cretaceous literature (e.g. Carter and Hart, 1977) of Devon and Dorset.

The Mid-Dorset Swell is primarily used to explain:-

(i) the thinning of the Upper Greensand in north Dorset

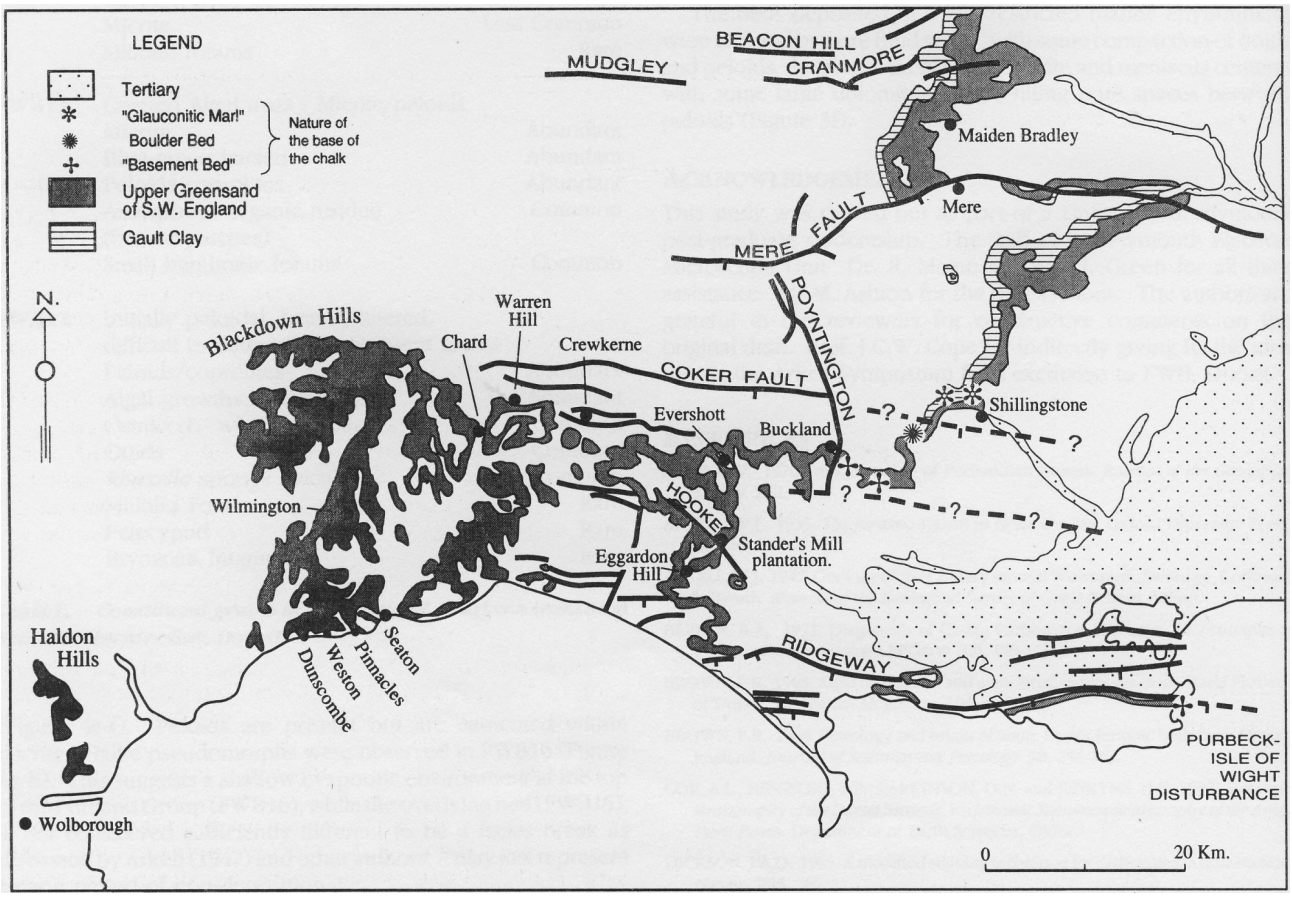

Figure 1. Geological map of Dorset, E. Devon, S. Somerset and S.W. Wiltshire. Additionally this map shows some of the major faults (based on Chadwick (1986) and Jenkyns and Senior (1991) which may have been active in the Early to mid-Cretaceous. The nature of the base of the Chalk is also indicated for a few key localities.

(ii) the location and thickness of the "Chert Beds" within the Upper Greensand succession;

(iii) the variation in thickness of the "Chalk Marl"; and

(iv) the changing nature of the "Chalk Basement Bed".

When initially described the Swell was said to extend southeastwards from Buckland (Figure 1) to the Isle of Purbeck. This thinning of the Upper Greensand across the area is quite clearly shown by earlier observations of Arkell (1947), House (1961), Phillips (1964), Ridd (1973) and McKenzie (1978), Stoneley suggested that the Jurassic to Early Cretaceous sedimentation of the area was affected by intermittent growth of deep-seated listric normal faults (trending east-west). This regime terminated in the Aptian and was later replaced by inversion, and, in the Miocene, northwards compressive movement along the former normal faults. This interpretation was very much in line with that of Kent (1978) for the Southern North Sea Basin where

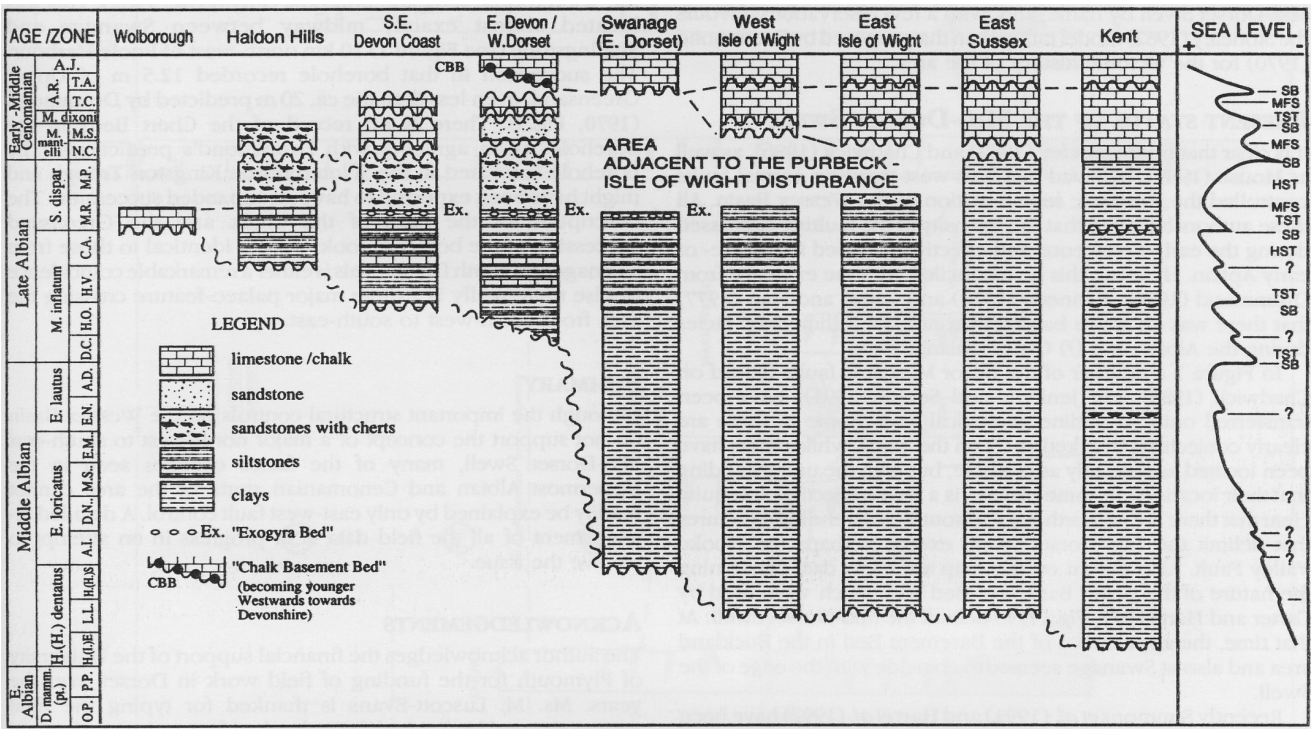

Figure 2. Sequence stratigraphy of the mid-Cretaceous succession in S.W. England developed from Hart et al. (1992)

Drummond (1970, Fig.3). Kennedy (1970, Fig.20) shows a cross-section of this most convincing structure. Drummond (and Kennedy) thought of the Mid-Dorset Swell as an active feature in the Late Albian, but with further movements (uplift?) in the Early and Mid-Cenomanian and also in the latest Cenomanian. While accepting that the major, present-day structures, are trending east-west, Drummond's isopachyte maps clearly show north-west to south-east orientations. He presented convincing evidence to support his concept of a series of north-west to south-east trending uplifted periclines in mid-Dorset. Drummond was influenced by the recently published (Webby, 1965a,b) data from the Quantock Hills in north Devon and west Somerset and the sub-surface data of Kent (1949). The Mid-Dorset Swell was, therefore, regarded as having been produced by uplift along those north-west to south-east trending transcurrent faults. The present author (Hart, 1973; Carter and Hart, 1977) was quite happy to go along with that interpretation.

Work in the Isle of Wight and the Hampshire Basin (Daley and Edwards, 1971; Edwards and Freshney, 1987; Flint, 1982) certainly supports the concept of Cenozoic sedimentation being controlled by north-west to south-east trending basement control.

EXTENSIONAL TECTONICS

With the discovery of the Wytch Farm oil-field and a developing appreciation of its sub-surface geology (Colter and Havard, 1981; Hinde, 1980) there began a total re-assessment of the structural development of the Wessex Basin. Stoneley (1982) was one of the first to produce an interpretation of the area, concentrating especially on the Purbeck - Isle of Wight Disturbance. Influenced by the the earlier phase of faulting also ended in the Aptian. The detailed cross-sections of the South Dorset area given by Stoneley (1982, Figs 3,4) all show the importance of these intra-Cretaceous faults, all of which terminate at the base of the Upper Cretaceous. It should be noted that both Drummond (1970) and House (1989, p.11) have different views on the age of the faulting (intra-Cenomanian and pre-Albian respectively).

In the discussion of Stoneley's paper (1982, pp.553-554) Drummond was clearly dismissive of this tensional-compressional model. Drummond (again invoking Webby, 1965a,b) clearly regards the north-west to south-east trend as the more important lineament and (quoting Drummond, 1970, Fig.9) wants all the north-west to south-east trends on his map as the surface expression of dextral shears in the basement.

Extensional tectonics were again on the agenda in the mid-1980's following the acquisition of deep seismic reflection profiles from on-shore (Whittaker and Chadwick, 1984) and offshore (Brewer *et al.,* 1983). The publication of the Atlas of Onshore Sedimentary Basins in England and Wales (Whittaker, 1985) again shows how east-west normal faults have controlled the sedimentary basins in southern England. Chadwick (1986), summarising much of the on-shore data, presents a map (Fig.4a) showing the Variscan basement of southern England, and clearly shows a major north-west to south-east wrench fault crossing Somerset and Dorset. Allied to this are a number of major east-west trending thrusts which, during the Permian-Cretaceous interval (Fig.4b) became associated with numerous, east-west trending, normal faults. Chadwick (1986) eloquently develops a polyphase extensional model for the Wessex Basin using both crustal, and perhaps, lithospheric extension. Using outcrop (e.g. Jenkyns and

Senior, 1977) and seismic data, Chadwick identified a number of episodes of syn-depositional normal faulting. These intervals ofenhanced fault activity are seen in the Permo-Triassic, early Jurassic, late Jurassic and early Cretaceous. Chadwick identifies the mid-late Cretaceous as time of fault quiescence when the rate of general subsidence increased, burying underlying faulted sequences. Although he acknowledged the presence of facies variations within the mid-Cretaceous succession, it is quite noticeable Chadwick (1986, pp.483-484) does not mention the Mid-Dorset Swell by name, and, with a few reservations, favours the Stoneley (1982) model rather than that proposed by Drummond (1970) for the tectonic history of the area.

PRESENT STATUS OF THE MID-DORSET SWELL

It is clear that both Stoneley (1982) and Chadwick (1986), as well as House (1989), believed that east-west-trending normal faults controlled the Mesozoic sedimentation of the Wessex Basin. All these authors believed that the intensity of the faulting decreased during the early Cretaceous and effectively ceased in the pre- or early Aptian. How can this be reconciled with the evidence from Drummond (1970), Kennedy (1970) and Carter and Hart (1977) that there was an active basement control of sedimentary facies during the Albian and (?) Cenomanian?

In Figure 1 a number of the major Mesozoic faults (based on Chadwick (1986) and Jenkyns and Senior (1991)) have been transferred onto an outline geological map. Some of these are clearly conjectural (marked as (?) on the map), while others have been located as precisely as possible, but with the understanding that their location - in some places - is a little subjective. It is quite clear that there are no north-west to south-east trending structures that delimit the Mid-Dorset Swell, except perhaps the Hooke Valley Fault. Also shown on this map are a few data concerning the nature of the Chalk Basement Bed and which were used by Carter and Hart (1977, Fig.14) to delimit the Mid-Dorset Swell. At that time, the appearance of the Basement Bed in the Buckland area and also at Swanage seemed to coincide with the edge of the Swell.

Recently Simmons *et al.* (1991) and Hart *et al.* (1992) have been developing a sequence stratigraphy for the area under discussion. As a conceptual model sequence stratigraphy can bring out relationships not discovered by general stratigraphical correlations. In this case, however, the mid-Cretaceous succession of the Dorset coast (Figure 2) cannot be resolved by this approach although work is still in progress. Despite the Middle-Upper Albian successions being largely comparable across the area there remains a major hiatus near to the Albian/Cenomanian boundary in the Isle of Wight and Purbeck. This stratigraphic hiatus shows up both in the microbiostratigraphy (Carter and Hart, 1977 and in the nature of the indigenous and reworked ammoniate faunas (Kennedy, 1969, 1970). The base of the Chalk is markedly diachronous across southern England with each successive sequence boundary marking an erosion surface and/or phosphatised fossil horizon. In the area of the Mid-Dorset Swell (Swanage) the base of the Chalk lies in the mid-Cenomanian. In West Dorset the position of the Chalk Basement Bed (Figure 2) shows another transgressive event in the mid-Late Cenomanian. Part of this transition from an Early-Late Cenomanian age for the base of the Chalk is shown in Figure 3, which is based on an area between Devizes (Wiltshire) and Buckland Newton (central Dorset). As can be seen in Figure 1, major east-west faults are crossed near Mere and Okeford Fitzpaine but in neither case is there a change in facies or thickness in the local area. The Mere Fault has a major downthrow to the south and the contact between the Lower Cenomanian and the Kimmeridge Clay was well-exposed during construction work for the Zeals bypass (A303). The extension of the Coker Fault eastwards would also be expected to have a downthrow to the south but, again, there is no apparent change in facies or thickness of strata that goes against the regional trend (Figure 3).

On the Purbeck coastline many of the available successions are along the line of the Purbeck disturbance and one cannot see what is happening to the north and south of that area.

SUCCESSIONS ON THE MID-DORSET SWELL

The key successions in North Dorset and Purbeck are dose to major east-west faults, with few data from the area between them. Drummond (1970) in constructing his isopachyte maps had to extrapolate between these areas and in the case of the Chert Beds (Fig.4A) could have drawn isopachytes with a more east-west orientation in the area around Mere. One key succession not available to Drummond (1970) or Kennedy (1970) is that in the Winterborne Kingston borehole (Rhys *et al.,* 1982). This was located almost exactly midway between Swanage and Shillingstone (see Figure 1) 10 km north-west of Poole Harbour. The succession in that borehole recorded 12.5 m of Upper Greensand, even less than the ca. 20 m predicted by Drummond (1970, Fig.3). There is no record of the Chert Beds in the borehole; again agreeing with Drummond's predictions. The borehole is located in the Winterbourne Kingston Trough and might have been expected to have an expanded succession. The description of the base of the Chalk and the Greensand succession of the borehole looks almost identical to those from Swanage and North Dorset. This is either a remarkable coincidence or else there really is a quite major palaeo-feature crossing the area from north-west to south-east.

SUMMARY

Although the important structural controls on the Wessex Basin do not support the concept of a major north-west to south-east Mid-Dorset Swell, many of the facies changes seen in the Uppermost Albian and Cenomanian strata of the area cannot readily be explained by only east-west fault control. A detailed reassessment of all the field data is in progress in an attempt to resolve the issue.

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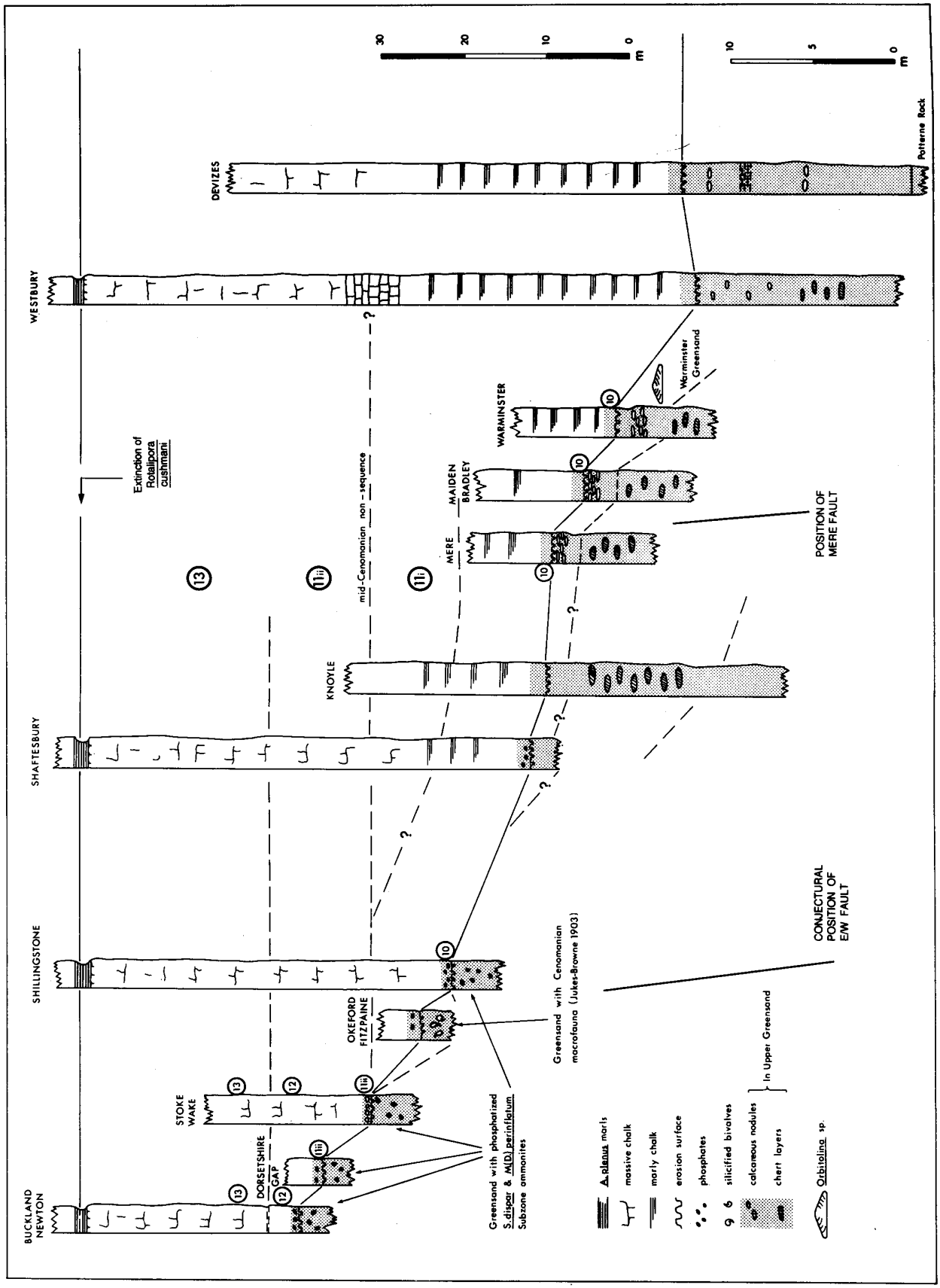

Figure 3. Correlation of the uppermost Albian and Cenomanian in S.W. Wiltshire and N.Dorset. The base of the chalk becomes younger towards the S.W, changing from foraminiferal zone (Carter and Hart, 1977) 10 to almost zone 13. Between Shillingstone and Stoke Wake the nature of the Chalk Basement Bed changes (see Figure 1) from a "normal" Glauconitic Marl to a Boulder Bed and eventually a Phosphatised Conglomerate.

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