Condensed facies of the Radstock Shelf

General introduction

The Radstock Shelf lies to the north-east of the Mendip periclines and is underlain at shallow depth by the Coal Measures. A thin sequence of arenaceous Mercia Mudstone Group facies and Penarth Group lie beneath the Lias Group strata. Middle Lias strata are absent from the Radstock Shelf and only a small remnant of Upper Lias is present in the extreme north of the area. The Lower Lias succession across most of this area is overlain directly by bioclastic limestones of the (Upper Bajocian) Upper Inferior Oolite.

The Lower Lias succession developed on the Radstock Shelf is one of the most remarkable examples of a condensed sequence anywhere in the British Jurassic System. There are considerable local variations in thickness and completeness of the succession, but even at its maximum development the entire Hettangian and Sinemurian sequence attains a thickness of less than 10 m compared with over 200 m for equivalent strata in adjacent basinal settings. The succession is highly fossiliferous, with abundant ammonites that have enabled fine subdivision of the sequence. Among the published descriptions of the Lias of the area several have been distinguished by their great contributions to our understanding of these deposits. Moore (1867a) was the first to call attention to the greatly condensed succession in the area, and Tawney (1875) confirmed the presence of most of the Lower Lias ammonite zones. Their work was summarized by Woodward (1893). In a seminal work, Tutcher and Trueman (1925) described more than 30 exposures of the Lias Group in the Radstock area, including descriptions or lists of the contained fauna. Most of the exposures were small quarries, of which all but a handful are now infilled or obscured by vegetation. They recognized the significance of the facies changes and discussed in detail the conditions of deposition of the Radstock Lias and its relationship to underlying structural controls. Their account formed the basis of almost all subsequent descriptions, notable among which was that of Arkell (1933) who summarized this earlier work. Not until the publication, more than 50 years later, of a special memoir on the Lower Jurassic rocks of the Bristol district (Donovan and Kellaway, 1984) did any new information become available. Although still reliant in part on the descriptions of Tawney (1875) and Tutcher and Trueman (1925), Donovan and Kellaway took the opportunity to re-interpret much of the biostratigraphy and the controls on deposition in this area, as well as providing more detailed lithological descriptions of the main stratigraphical units.

General description

Of the many sites described by Tutcher and Trueman (1925) most have long been infilled or overgrown. Three of the quarries in the Radstock area — Bowldish Quarry, Kilmersdon Road Quarry and Huish Colliery Quarry have been selected as GCR sites. They represent the best sites that remain accessible and demonstrate some of the lateral changes that characterize the Radstock Lias. To understand the significance of the particular succession exposed at each site requires a knowledge of the overall Lower Lias sequence in the Radstock area together with the extent and nature of lateral and vertical variations in thickness and facies for which these three sites are considered representative. The succession can be broadly divided into three stratigraphical units displaying similar facies developments; the Hettangian succession, the Sinemurian to early Lower Pliensbachian succession, and the late Lower Pliensbachian succession.

Hettangian succession

The Hettangian succession of the Radstock district comprises mostly thin-bedded and commonly bioclastic impure limestones separated by thin shales or shaly partings. In early publications they were often termed the 'Corn Grits'. In most instances Tutcher and Trueman (1925) did not describe the Hettangian succession at each site in detail, instead citing only the total thickness of limestones and shales for each zone. However, the Hettangian part of several of these sections was described by Tawney (1875). Even at its maximum development, only the Planorbis and Liasicus zones are present, typically resting on the Pre-Planorbis Beds or 'Ostrea Beds' and, in turn, underlain by the distinctive Sun Bed at the top of the Langport Member (= White Lias) of the Penarth Group. The Angulata Zone is absent on the Radstock

Shelf, the 'lower Angulata Zone' of 'hitcher and Trueman's (1925) account being equivalent to the Liasicus Zone. On parts of the Radstock Shelf to the south of Radstock the Hettangian Stage is also absent — (Figure 3.13), with Sinemurian deposits resting, directly on the Sun Bed. Thicknesses of the Hettangian deposits increase northwards towards Bath and the Avon Valley (Figure 3.13), with the development of four distinct facies units within the Blue Lias Formation (Donovan and Kellaway, 1984).

Sinemurian succession

The Sinemurian succession on the Radstock Shelf is highly condensed with several substantial hiatuses and a number of ammonite subzones absent or known only from derived material in younger strata. Tutcher and Trueman (1925) and Donovan and Kellaway (1984) recognized five distinct units within the Sinemurian succession of the Radstock Shelf (Figure 3.14). The lowest of these, the 'Bucklandi Bed', is a 0.05–0.75 m-thick fossiliferous limestone, which at Bowldish Quarry and several other sites is continuous with the topmost preserved limestone of the underlying Hettangian succession. It has yielded a rich fauna of brachiopods, bivalves and other fossils. Geographically it is restricted to an area roughly bounded by Radstock, Timsbury and Paulton. Despite its name it is of Semicostatum Zone, Sauzeanum Subzone, age, for although Getty (in Cope *et al.,* 1980a) cited the occurrence of a fragmentary *Arietites* as evidence of the presence of the Bucklandi Zone, stout-ribbed coroniceratids similar to *Arietites bucklandi* also occur in the Scipionianum Subzone and are a more probable source for this specimen. It has also yielded derived and phosphatized *Arnioceras, Agassiceras, Euagassiceras* and *Coroniceras.*

Donovan and Kellaway (1984) found no evidence for the presence of the Bucklandi Zone on the Radstock Shelf (Figure 3.13). The succeeding Spiriferina Bed comprises a few centimetres of grey sandy clay with abundant phosphatized nodules and fossils, notably the brachiopod *Spiriferina walcotti.* Derived ammonites of the genera *Arnioceras, Coroniceras* and *Euagassiceras* indicate a late Semicostatum Zone, Sauzeanum Subzone age. The Spiriferina Bed represents the lowest part of the Turneri Clay, which, around Radstock comprises a few centimetres to 1.2 m of blue, laminated clay. It thickens to the north. Moore (1867a) recorded 28 species of foraminifera from the Turneri Clay, which accordingly was termed by him and by Tate (1875) the Foraminifera-zone. The ammonites *Caenisites* and *Arnioceras* are present together with derived *Agassiceras* and *Euagassiceras.* The absence of *Microderoceras* and *Promicroceras* indicate that only the lower part of the Tumeri Zone, the Brooki Subzone, is represented by the Turneri Clay (Donovan and Kellaway, 1984). The 'Fumed Clay is overlain by the Obtusum Nodules. At Timsbury 0.43 m of clay was present at this level and included two nodule bands. The upper of these was considered by liacher and Trueman (1925) to correspond with the single nodule layer or limestone band that is generally present elsewhere in this laterally persistent bed. The Obtusum Nodules have yielded *Asteroceras* and *Arnioceras,* together with rarer *Promicroceras, Xipheroipheroceras* and *Cymbites,* which mostly indicate the Obtusum Subzone. Tutcher and Trueman (1925) also listed *Asteroceras stellare,* indicative of the succeeding Stellare Subzone, but without any stratigraphical or locality information for this species. The Denotatus Subzone of the Obtusum Zone, both subzones of the Oxynotum Zone and the Densinodulum Subzone at the base of the Raricostatum Zone have not been recorded in the Radstock succession. The limestone of the Obtusum Nodules is overlain by a thin greenish-brown clay, the Raricostatum Clay, which reaches a maximum recorded thickness of 0.45 m at Hodder's Quarry, Timsbury. Tutcher and Trueman (1925) noted poorly preserved *Echioceras raricostatoides* within the clay and derived *Leptechioceras macdonnelli* in a thin nodule band at the top. These indicate the presence of the Raricostatum and Macdonnelli subzones within the Raricostatum Clay, although Edmunds *et al.* (2003) found evidence only for the Raricostatum Subzone.

Lower Pliensbachian succession

Tutcher and Trueman (1925) recognized four main lithological units in the Lower Pliensbachian succession of the Radstock district. The lower three units represent a continuation of the condensed sequence seen in the Sinemurian succession. This passes up into a succession of clays with scattered nodules.

The Armatum Bed and the overlying Jamesoni Limestone appear to represent a single lithological unit, locally separated by a conspicuous bedding plane, of cream-coloured, fine-grained, bioclastic ironshot limestone. Together they attain a maximum thickness of more than 2 m, but are restricted to an area within a few kilometres of Radstock. Fossils, particularly ammonites, bivalves and brachiopods, are abundant. Echinoderm debris is abundant in thin-section although recognizable fragments are seldom evident in hand specimen. The basal part of the Armatum Bed contains abundant derived nodules and phosphatized ammonites, the latter often beautifully preserved. *Echioceras raricostatoides* is particularly common, along with various species of *Paltechioceras,* including *Paltechioceras tardecrescens* (= *P. aplanatum*). Species of *Paltechioceras* are preserved in light-grey limestone, in contrast to the dark-grey or black phosphatic limestone typical of specimens of *Echioceras.* These ammonites indicate the presence of the Raricostatum and Aplanatum subzones. Other ammonites in the lower part of the Armatum Bed include *Oxynoticeras, Gleviceras, Eoderoceras* and *Epideroceras* from the Raricostatum Zone. The higher part of the Armatum Bed contains taxa typical of the Taylori Subzone of the succeeding Jamesoni Zone, such as *Apoderoceras, Phricodoceras* and *Radstockiceras.* A single specimen of *Gagaticeras neglectum* from Rockhill Quarry [ST 6795 5540] may indicate the former presence of the Oxynotum Zone in this area (Donovan and Kellaway, 1984). Detailed investigation of a temporary section 1 km to the south-west of Radstock revealed that the Armatum Bed there could be divided into five distinct units with discrete ammonite faunas (Edmunds *et al.,* 2003). The lower two, termed the 'Gleviceras Limestone', are assignable to the Raricostatum Zone, while the upper three, termed the Apoderoceras Limestone', are of Taylor' Subzone age. However, it has not yet been ascertained whether this sequence can be recognized at any of the three GCR sites described here and, considering the rapid lateral variations seen in the Radstock Lias, it may be only very local in its extent.

From the succeeding Jamesoni Limestone a diverse ammonite fauna has been obtained (Tutcher and Trueman, 1925; Donovan and Kellaway, 1984), including the genera *Polymorphites, Platypleuroceras, Uptonia, Tropidoceras, Tragophylloceras, Lytoceras, Parinodiceras, Liparoceras* and *Derolytoceras* (Donovan and Howarth, 1982). Together these taxa indicate the presence within the Jameson' Limestone of the Polymorphus, Brevispina, Jamesoni and Masseanum subzones. The Jamesoni Limestone and Armatum Bed also contain a rich and abundant fauna of bivalves, brachiopods and gastropods, most of which were listed by Donovan and Kellaway (1984). Sellwood (1972) noted an abundance of infaunal and epifaunal suspension-feeding bivalves and trace fossils, indicating unconsolidated sediment beneath agitated, probably shallow, water. Most of the shells have been winnowed from life position but show little evidence for significant transportation. Corroded quartz grains within the Jamesoni Limestone indicate two phases of cementation.

The uppermost unit of the condensed Radstock Lias is the Valdani limestone, which rests directly upon the Jamesoni Limestone across a restricted area between Radstock and Paulton (Figure 3.13). At its maximum development, in Old Pit Quarry [ST 6840 5563], It comprised 0.7 m of coarse-grained, hard crystalline limestone, becoming more ironshot towards the base. The ammonites present within it include *Acanthopleuroceras, Beaniceras, Liparoceras, Tragophylloceras* and *Lytoceras,* together indicating the Valdani Subzone. Bivalves and brachiopods also are abundant and diverse in this unit, though more difficult to extract than in the Jamesoni Limestone.

The succeeding clay units, the Striatum Clays and Capricornus Clays of Tutcher and Trueman (1925) are nowhere exposed today but sections were recorded at Timsbury Sleight [ST 656 593] (Tutcher and Trueman, 1925) and at the Broadway Lane Claypit [ST 6670 5635] (Donovan and Kellaway, 1984). At Timsbury Sleight about 37 m of blue clays with a few thin nodule bands were present between the top of the Valdani Limestone and the unconformity with the Upper Lias above and could be assigned to the Luridum, Maculatum and Capricornus subzones. Donovan and Kellaway (1984) noted a progressive reduction southwards in the thickness of these clays. At Clandown they are about 30 m thick but they diminish rapidly south of Radstock to less than 3 m north of Upper Vobster [ST 700 490]. Much of this southward thinning can be attributed to erosion prior to deposition of the overlying Inferior Oolite. Although a conspicuous conglomeratic unit at the Broadway Lane Claypit indicates a hiatus in the Maculatum Subzone, this is minor in comparison with those in the Sinemurian Stage and cannot be considered to have contributed significantly to this thinning southwards.

General interpretation

The observations made by Tutcher and Trueman (1925) In the Radstock district enabled them to undertake a detailed bed-by-bed interpretation of the sequence of events during deposition of this condensed Lower Lias succession. Many of their conclusions remain valid today although they need to be placed in a broader regional context, as was done to some extent by Donovan and Kellaway (1984). Although each of the three GCR sites provides a unique record of the local

Lower Jurassic succession in that part of the Radstock Shelf, their greatest value is the way in which together they demonstrate the rapid lateral thickness variations, which are such a characteristic feature of the Lias succession in this area.

Hettangian succession

The Hettangian succession on the Radstock Shelf is the least distinctive of the three Lower Jurassic stages represented in the area. It lacks the distinctive facies of the Sinemurian or early Pliensbachian units, instead comprising limestones and thin shales not dissimilar to those seen elsewhere in the Blue Lias Formation. Nonetheless, the Hettangian sequence is highly attenuated, reaching no more than a few metres in thickness, and only the Planorbis and Liasicus zones are present (Figure 3.14). This reflects slow rates of subsidence and deposition across the Radstock Shelf during this period.

The Hettangian strata here are locally underlain by an exceptionally thick (about 5–6 m) development of the Langport Member (= White Lias) of the Penarth Group, which occupies a narrow east–west belt in this area. Comprising pale mudstones and calcilutitic limestones with desiccation cracks and a restricted fauna of bivalves, gastropods and ostracods, it was deposited in a shallow, occasionally emergent, marginal-marine environment. The Hettangian strata show an increasing marine influence as the early Jurassic transgression flooded across the area allowing more diverse faunas, including ammonites, to become established. Structurally, the Hettangian strata show a similar disposition to that of the White Lias (Langport Member), again thickening into an E–W-trending belt passing roughly through Radstock. This is the same general trend as many of the faults that have been mapped out in this area, and for the Mendip region as a whole (see (Figure 2.1), Chapter 2), suggesting that, In late Triassic and Hettangian times at least, minor fault-bounded basins developed within the confines of the Radstock Shelf; as has been demonstrated to the south of the Mendip Hills (Jenkyns and Senior, 1991). Although Tutcher and Trueman (1925) Identified two distinct east–west troughs, Donovan and Kellaway (1984) suggested that, on the limited data available, this was not the only interpretation possible to account for the Hettangian subcrop pattern. Thickness variations in the Planorbis and Liasicus zones, and the configuration of the Hettangian subcrop pattern beneath the Sinemurian strata (Figure 3.13), indicate an interplay between primary controls on Hettangian deposition and subsequent erosion in late or post-Hettangian times (Green, 1992). The Hettangian strata appear to have been gently folded prior to early Sinemurian planation and deposition of the Bucklandi Bed. The most severe of these minor flexures is located about Radstock itself, where a more than 7 m-thick Hettangian succession, extending up into the Liasicus Zone, thins northwards to 1 m or less in under 2 km (Donovan and Kellaway, 1984). This roughly coincides with similar thickness changes already noted in the Langport Member below and indicates a common underlying control on sedimentation and/or erosion. The relatively thin successions on basement highs, notably an extensive area to the south of Radstock, were removed by erosion whereas the thicker successions in the minor basins survived.

Hence, although Bowldish Quarry is the most northerly of the three GCR sites (Figure 3.13), its position on this flexure led to pre-Sinemurian removal of all but a thin remnant of Hettangian sediments (Figure 3.14). Even at Huish Colliery Quarry, more than 3 km to the southeast, a greater thickness of Hettangian strata has survived than at Bowldish Quarry, while at Kilmersdon Road Quarry, located between the two other sites, the Hettangian succession extends up through the entire Planorbis Zone and part of the Liasicus Zone.

Throughout the area the Angulata and Bucklandi zones are absent (Figure 3.13). Tutcher and Trueman (1925) did record *Epammonites isis* from the Spiriferina Bed of Bowldish Quarry, a species known to be diagnostic of the Bucklandi Subzone (Page, 1992), but no other evidence of either the Bucklandi or Angulata zones has been found among the diversity of derived ammonites in the Bucklandi Bed, suggesting absence is due to non-deposition rather than to pre-Semicostatum Zone erosion. In support of this, Hallam (1981) noted a late Hettangian regression following on from a minor deepening phase in the Liasicus Zone. Basinward from the Radstock Shelf, towards Keynsham and Bristol (Figure 3.13), this can be recognized in the transition from the Saltford Shales of the Liasicus Zone (Division B of Donovan and Kellaway, 1984) to the more limestone-dominated successions of the Angulata Zone (Division C), and Bucklandi to early Semicostatum zones (Division D). Early Bucklandi Zone shallowing is particularly clearly indicated by the condensed Calcaria Bed (Donovan and Kellaway, 1984). This late Hettangian to early Sinemurian period of regional shallowing evident in basinal successions appears to correlate closely with the stratigraphical gap between the Hettangian and Sinemurian stages on the Radstock Shelf.

Sinemurian succession

The Sinemurian succession is the most striking part of the Lower Lias succession on the Radstock Shelf. Its south-eastward pattern of thinning is thought largely to reflect original depositional controls (Green, 1992), a view supported by the remarkable persistence across much of the Radstock Shelf of all of the characteristic Sinemurian lithostratigraphical units despite their local extreme attenuation. All are well represented at Bowldish Quarry, where they total more than 1.5 m. At Kilmersdon Road Quarry ((Figure 3.13) and (Figure 3.14), 3 km to the south-east, this part of the succession is less than 0.5 m thick, yet still retains all of the characteristic lithostratigraphical units of the Sinemurian Stage in this area. At Huish Colliery Quarry, 1 km farther east, the Sinemurian succession has been removed by early Pliensbachian erosion and its former presence is represented only by derived Raricostatum Zone fossils in the base of the (Lower Pliensbachian) Armatum Bed, which here rests directly on the Planorbis Zone.

Sinemurian deposition in the Radstock district commenced in the Scipionianum Subzone, as indicated by derived *Agassiceras* in the Bucklandi Bed, and correlates closely with a widespread transgression (Hallam, 1981) marked by mudstone-dominated successions in the Wessex and Severn basins and by the early Sinemurian transgression across the London Platform (Donovan *et al.,* 1979). By latest Semicostatum Zone times this transgression had advanced to affect deposition across the entire Radstock Shelf. Hence the Bucklandi Bed is found in nearly all exposures except where it has been removed by post-Sinemurian erosion. Continued deepening of the sea led to deposition of the Turneri Clay, almost all of which was removed by erosion from the southern part of the shelf around Radstock, prior to renewed deposition in the Obtusum Zone. There is no evidence of a hiatus between the Turneri and Obtusum zones in the adjacent Severn Basin to the north and Wessex Basin to the south and hence it can be attributed at Radstock to localized tectonic movement. The Obtusum Nodules are remarkably constant in character over almost the entire area: the associated mudstones were winnowed away at most localities to leave what is essentially a remanié nodule bed. The lithology of the Obtusum Nodules — dark laminated limestone containing ammonites and fish scales — is reminiscent of similar nodules encountered in the Obtusum Zone elsewhere, notably in the Black Ven Marl Member of the Dorset coast (Lang and Spath, 1926). The latter were deposited in an anoxic benthic environment and indicate that such conditions were widespread during Obtusum Zone times and hence must reflect an underlying eustatic control.

The absence of the Denotatus Subzone, the Oxynotum Zone and the Densinodulum Subzone on the Radstock Shelf is evident also in the Dorset coast succession. The Oxynotum Zone in particular appears largely confined to the thicker basinal successions of the Severn and Wessex basins (Hollingworth *et al.,* 1990), and suggests a eustatic control since it correlates with a Europe-wide shallowing event (Hallam, 1981). The succeeding Raricostatum Clay appears to represent a late Sinemurian transgression well documented on the Dorset coast, the London Platform (Donovan *et al.,* 1979), Europe and South America (Hallam, 1981). Hence it is probably also eustatic in origin. The Sinemurian–Pliensbachian boundary in the Radstock district, with its conspicuous reworking of fossils from the Raricostatum Clay, bears some similarities to the successions in Dorset and Yorkshire, which also show evidence of shallowing and reworking. In Dorset both the Macdonnelli and Aplanatum subzones are absent, removed by erosion prior to deposition of Hummocky (Bed 103 of Lang and Spath, 1926). Hummocky contains reworked and encrusted nodule fragments and echioceratid ammonites, though none from the missing two subzones. It is clearly condensed and shows many similarities with the Armatum Bed of the Radstock succession, although the latter indudes evidence for the Macdonnelli and Aplanatum subzones. It suggests that the event which caused erosion of the Raricostatum Clay, whether due to uplift or regression, was not confined to the Radstock Shelf though Hallam (1981) notes the lack of evidence for a large-scale eustatic fall at this time.

The remarkable lateral persistence of each of the distinctive lithostratigraphical units of the Sinemurian succession indicates that subsidence rates on the Radstock Shelf throughout the Sinemurian Stage were minimal but increased slowly northwards. The sometimes striking correlation of some of the lithostratigraphical units, such as the Turneri Clay or Obtusum Nodules, with periods of transgression or eustatic highstand, suggests that eustasy was a major factor influencing the nature of the Sinemurian succession on the Radstock Shelf The effects of erosion, rather than original depositional controls, increase southwards but appear largely confined to winnowing of the clay units, leaving a still more highly condensed sequence of reworked nodules and remanié fossil horizons. There seems to be no progressive loss southwards of individual lithostratigraphical units from the Sinemurian succession, analogous to that seen in the

Hettangian Stage. Instead the loss of the Sinemurian strata passing southwards appears to be sudden and complete, as exemplified in passing from Kilmersdon Road Quarry to Huish Colliery Quarry (Figure 3.14). The widespread occurrence of abundant reworked late Sinemurian fossils in the Armatum Bed testifies to a significant episode of erosion at about the Sinemurian–Pliensbachian boundary. It suggests that on the southern part of the Radstock Shelf where the Sinemurian sequence was already highly attenuated, this erosion event was sufficient to remove the Sinemurian succession in its entirety, as apparently occurred at Huish Colliery Quarry. Although the derived fauna of the Armatum Bed is largely of Raricostatum Zone age, Donovan (1958a) recorded the occurrence of derived *Promicroceras* in this unit at Upper Vobster [ST 707 497], where the Jamesoni Limestone and Armatum Bed rest directly on a planed surface of Carboniferous Limestone, indicating that erosion extended down at least to the Obtusum Zone. It may have removed the last remnants of the Hettangian succession here. Still farther south, on the Carboniferous Limestone periclines of the Mendip Hills, the Lias is absent as a discrete stratigraphical unit although the former presence of early Jurassic sediments is indicated by fissure fills of Sinemurian age (Jenkyns and Senior, 1991; Simms, 1997), as at the Cloford Quarry GCR site.

Pliensbachian succession

The massive bioclastic limestones of the Jamesoni and Valdani limestones show a strikingly different pattern to that of the underlying Sinemurian succession. Both are restricted to the Radstock Shelf, passing northwards into more typical open-water clay facies (Donovan and Kellaway, 1984), but the Valdani Limestone occupies a considerably more restricted area than the underlying Jamesoni Limestone (Figure 3.13). Unlike the Sinemurian strata, the Jamesoni Limestone continues southwards, finally disappearing only where overstepped by the (Bajocian) Inferior Oolite Group. At Upper Vobster, the Jamesoni Limestone is the sole representative of the entire Lias succession. The striking contrast between the distribution of the Sinemurian deposits and that of the basal Pliensbachian limestones indicates a significant change in depositional regime around the Sinemurian–Pliensbachian boundary. Both indicate deposition on a shallow shelf dipping gently to the north or north-west. In Sinemurian times subsidence rates across this shelf were negligible and periods of deposition, represented by the main lithostratigraphical units, correlate fairly closely with transgressions or eustatic high-stands. The southward spread of the Jamesoni Limestone, onto areas where earlier Liassic sediments were absent, suggests that subsidence of the shelf was the dominant control on deposition in early Pliensbachian times. The shallower southern parts of the shelf extending towards the Mendip periclines favoured the accumulation of clean-washed bioclastic limestones analogous to the Southerndown Member of the Hettangian Stage at the Pant y Slade to Witches Point GCR site. The region of maximum development of the basal Pliensbachian limestones roughly coincides with that where the White Lias (Langport Member) reaches its maximum thickness and Hettangian thicknesses are reduced. This suggests that a local basement high, probably associated with one of the re-activated Mendip thrusts, persisted in this region throughout late Triassic and early Jurassic times and exerted a major control on deposition. Passing northwards into deeper water these limestones gave way to mudstone facies more typical of the basal Pliensbachian succession elsewhere. The Valdani Limestone appears to represent the final episode of this shallow-shelf deposition, confined to the local basement high. Later subsidence rates were sufficient over the whole shelf for deposition of normal open-water mudstone facies, the Striatum Clays and Capricornus Clays, to occur. Nonetheless, even this part of the succession shows significant attenuation compared with correlative strata farther north (Donovan and Kellaway, 1984).

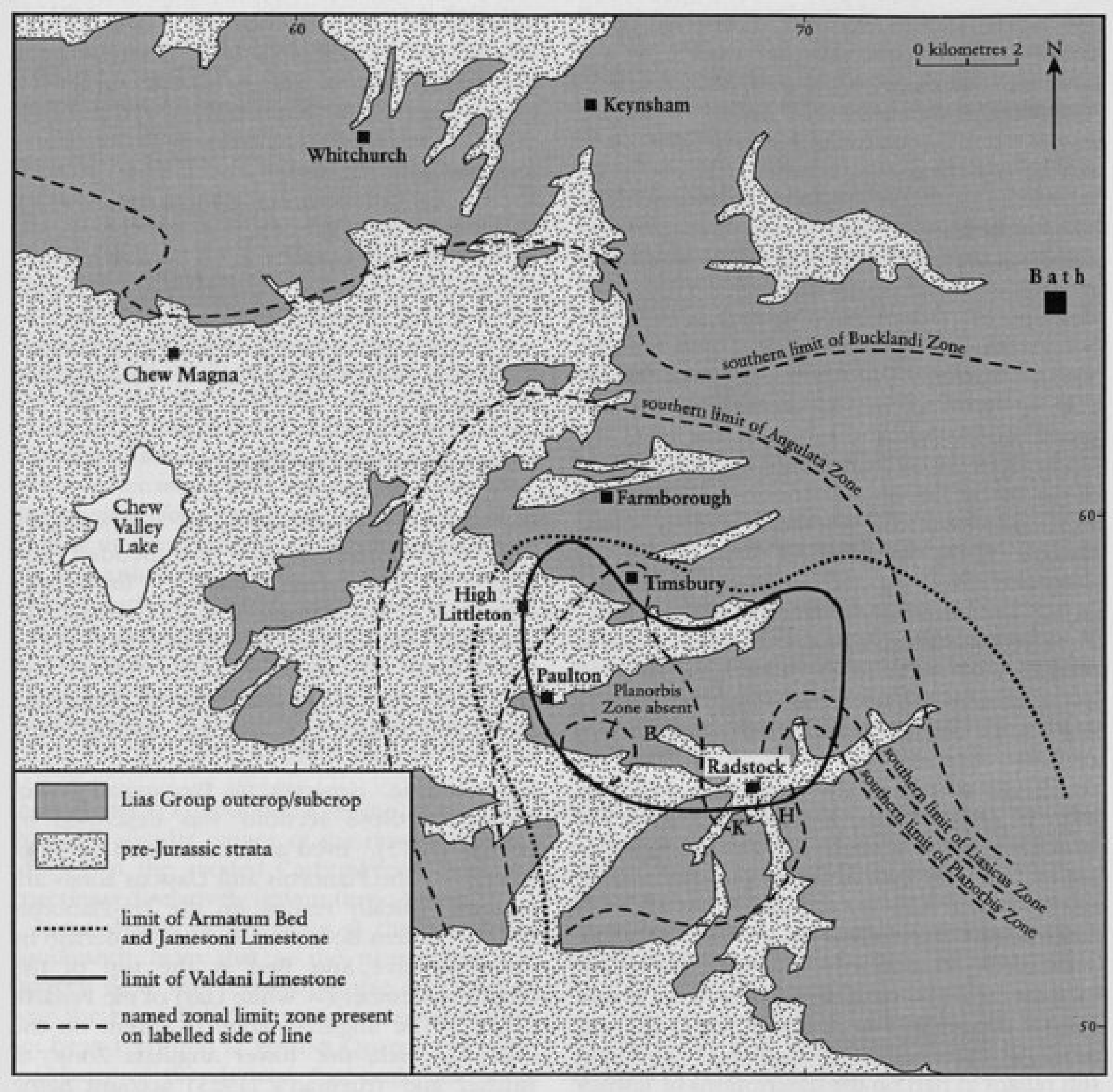
The persistence of condensed deposits through the Jamesoni Zone contrasts with the 20 m-thick mudstone succession which comprises much of the Belemnite Marl Member on the Dorset coast. Similar thick mudstone-dominated successions occur in the Severn Basin (Cope *et al.*, 1980a) and on the Yorkshire coast (Hesselbo and Jenkyns, 1995) suggesting that the highly condensed nature of the Radstock Shelf succession is due to local tectonic controls. The succeeding Valdani Limestone encompasses the Masseanum and Valdani subzones, and may also be attributed largely to local tectonic control. On both the Yorkshire and Dorset coasts, the Ibex Zone successions are greatly reduced in comparison with those of the Jameson Zone, suggesting that there might also be some eustatic influence.

Above the Valdani Limestone there is an abrupt change to a much thicker, mudstone-dominated succession on the Radstock Shell; not dissimilar to that encountered in more basinal settings. The Davoei Zone and uppermost Ibex Zone, represented by the 'Striatus and Capricornus Clays', together exceed the entire thickness of the condensed Lower Lias sequence suggesting that the local tectonic controls on sedimentation were greatly reduced during the later interval. This appears to have been a temporary feature: at most localities the remainder of the Lower Jurassic succession was removed by erosion prior to deposition of Upper Inferior Oolite (Upper Bajocian) limestones.

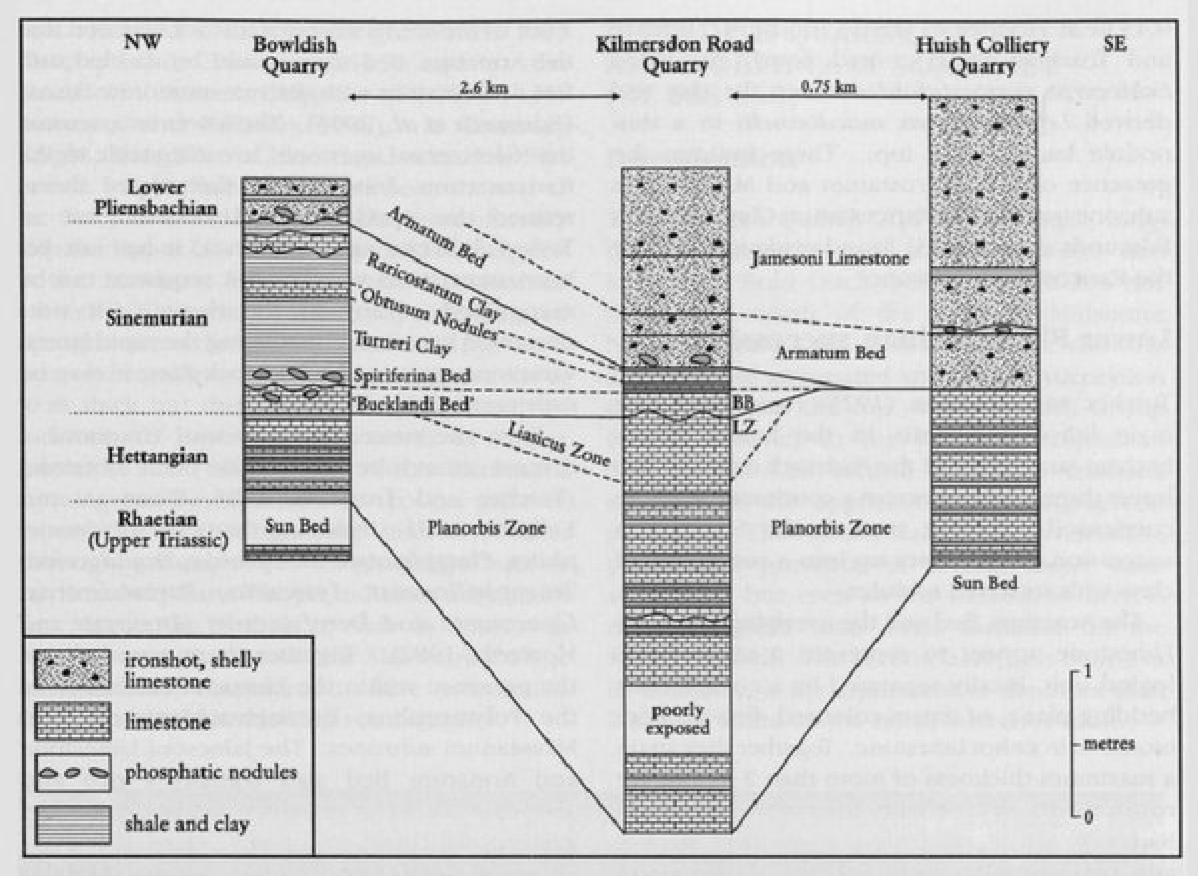
General conclusions

The three GCR sites at Bowldish Quarry, Kilmersdon Road Quarry and Huish Colliery Quarry exemplify the various factors, including subsidence rates, eustasy and erosion, which together determined the nature of the preserved succession on the Radstock Shelf in Hettangian to Lower Pliensbachian times. Although there was a southward depositional attenuation of the Hettangian succession, pre-Sinemurian tectonic flexuring and subsequent erosion exerted a greater influence on the distribution of individual Hettangian strata across the Radstock Shelf. Bowldish Quarry, located on the largest of these flexures, experienced greater pre-Sinemurian erosion than the successions at Kilmersdon Road Quarry or Huish Colliery Quarry farther south. The main lithostratigraphical units of the succeeding Sinemurian sequence show a remarkable continuity between Bowldish Quarry and Kilmersdon Road Quarry despite a more than three-fold attenuation, suggesting considerable stability of the Radstock Shelf during this interval, with depositional and erosional episodes largely under eustatic control. The Jamesoni and Valdani limestones of the basal Pliensbachian succession mark a striking contrast to patterns of sedimentation during the Sinemurian Stage. They reach their maximum development on local highs, extending south onto progressively older rocks ultimately to rest directly on the Palaeozoic basement, and pass northwards into thicker basinal clay facies. They appear to represent a high-energy, shallow-water marginal facies that developed during the initial stage of a general subsidence of the Radstock Shelf and which culminated in the resumption of normal open-water mudstone deposition across the entire shelf.

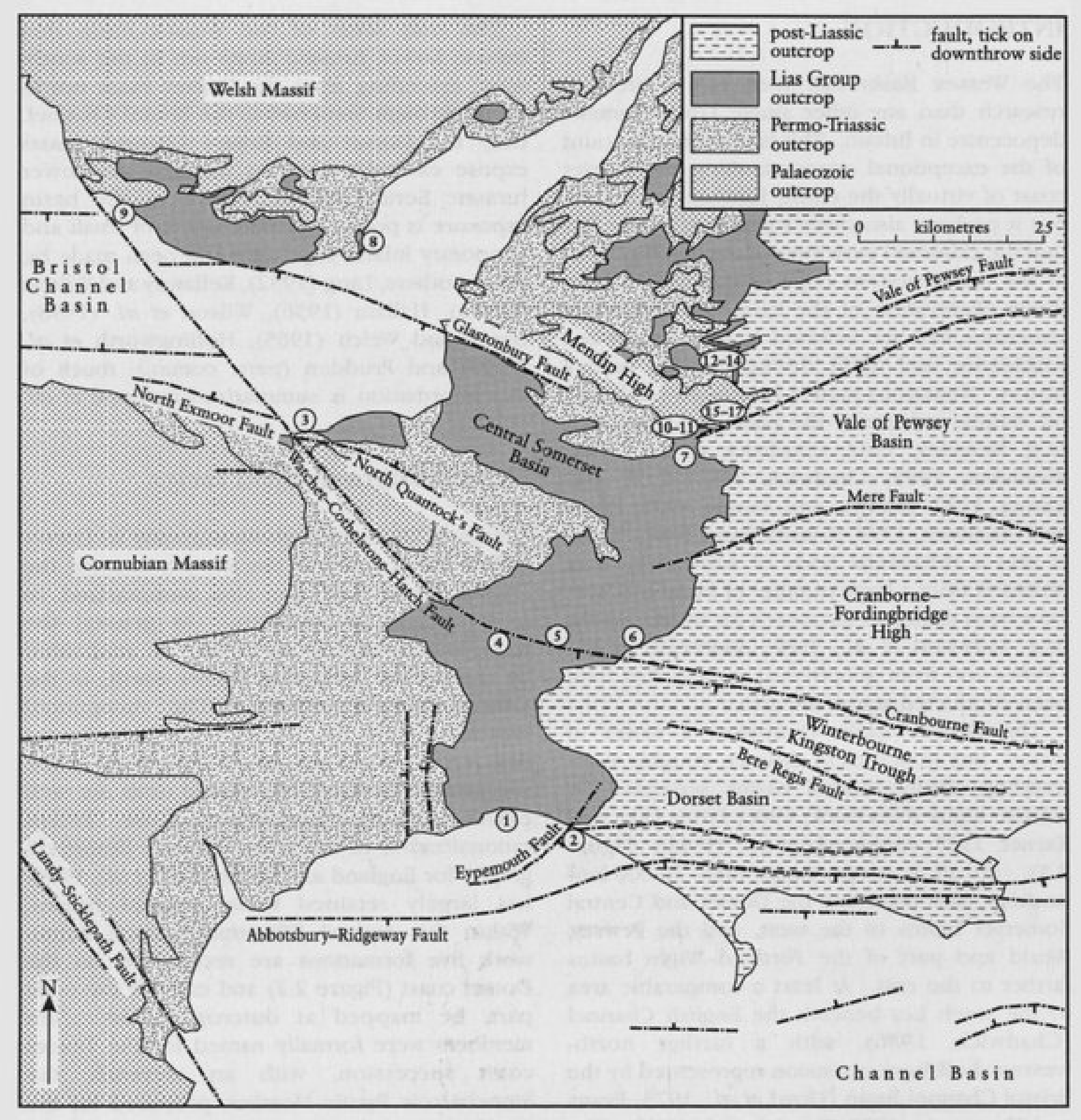
References



(Figure 3.13) Sketch map showing the southern limits of the Planorbis to Bucklandi zones in the Radstock district and the distribution of the Armatum Bed, Jamesoni Limestone and Valdani Limestone. The letters B, K and H correspond to the approximate locations of the three GCR sites of Bowidish Quarry; Kilmersdon Road Quarry and Huish Colliery Quarry. After Donovan and Kellaway (1984).



(Figure 3.14) Lithostratigraphy and correlation of the Radstock GCR sites After Donovan and Kellaway (1984).



(Figure 2.1) The major structural elements and sub-basins of the Wessex Basin and its margins. Numbers correspond to the locations of the GCR sites: 1— Pinhay Bay to Fault Corner and East Cliff; 2 — Cliff Hill Road Section; 3 — Blue Anchor—Lilstock Coast; 4 — Hurcott Lane Cutting; 5 — Babylon Hill; 6 — Ham Hill; 7 — Maes Down; 8 — Lavernock to St Mary's Well Bay; 9 — Pant y Slade to Witches Point; 10 — Viaduct Quarry; 11 — Hobbs Quarry; 12 — Bowldish Quarry; 13 — Kilmersdon Road Quarry; 14 — Huish Colliery Quarry; 15 — Cloford Quarry; 16 — Holwell Quarry; 17 — Leighton Road Cutting. After Lake and Karner (1987).