Pinhay Bay, Devon

[SY 320 908]

Introduction

Pinhay Bay, near Lyme Regis, exposes a sequence of Triassic and Jurassic rocks including the Cotham and Langport members of the Lilstock Formation (Penarth Group) and the overlying Pre-*planorbis* and Hettangian beds of the Blue Lias. The site offers the best single exposure for the Langport Member in a thick development and shows diverse evidence of sedimentology and tectonic modification. The Langport Member is a regionally important unit, that is better-developed here than in sites farther north.

Pinhay Bay has not been extensively studied. Richardson (1906) includes a very brief mention of the site, as do Jukes-Brown (1902), Woodward and Young (1906), Woodward and Ussher (1906), Lang (1924), Sellwood *et al.* (1970), House (1989), Hesselbo and Jenkyns (1995) and Wignall (2001). Hallam (1960) wrote the classic account of the Pinhay Bay Langport Member.

Description

Pinhay Bay is also known as 'Pinney Bay' (Woodward and Ussher, 1906; Lang, 1924). The section is approximately 2.5 km west of Lyme Regis; it forms part of the Axmouth to Lyme Regis Undercliffs National Nature Reserve, and is included in the Dorset and East Devon Coast World Heritage Site, established December 2001. The cliffs and foreshore at Pinhay Bay are easily accessible, but are occasionally obscured by landslides and slumps.

Sedimentology

The cliffs and foreshore at Pinhay Bay expose beds of Late Triassic and Early Jurassic age. At the western end, the Blue Lias is brought into contact with the older Penarth Group by a fault (House, 1989). The following section is taken from Hallam (1960, pp. 48–9), with additional information from Richardson (1906, pp. 407–8), Hamilton (1961), Ager and Smith (1965, p.12), and House (1989):

	Thickness (m)
Lias Group: Blue Lias:	
Alternations of thin limestones and calcareous shales.	
Including the Pre-*planorbis* Beds (lowest 2.5 m)	
Penarth Group	
Lilstock Formation: Langport Member:	
'Sun Bed': limestone, locally a conglomerate with limestone pebbles in a manly matrix; thickens locally	0.05
Thin limestones with slightly irregular surfaces and partings of brown marl; some are rubbly or have perforated upper surfaces	0.41
Limestone, locally with an irregular upper surface: occurs only in east; replaced westwards by several thin limestones	0.25
Thin, rubbly limestones with irregular marl partings; shelly band near top	0.23
Shelly marl with lenses of limestone	0.02
Limestone, locally porcellanous, with eroded top	0.11
Main Slump Bed	1.37
Porcellanous limestone	0.05

Thin, rubbly limestones with irregular marl partings and pockets of small bivalves	0.86
Limestone with irregular base	0.20
Limestone, locally with a rubbly top, containing numerous subangular fragments of porcellanous limestone; minor slump structures	1.37
Thin limestones	0.51
Limestone with minor slump structures and locally a porcellanous top	0.58
Thin limestone locally becoming porcellanous and rubbly, with slightly irregular surfaces and partings of marl up to 0.01 m thick; rare pockets of small bivalves	1.83
Lilstock Formation: Cotham Member:	
Including the Cotham Marble, the '*Estheria* Bed', and black shales *Westbury Formation:*	1.5
'*Contorta*' Shales	5.0

The Langport Member limestones seen at Pinhay Bay (Figure 4.26) and (Figure 4.27) are chemically very pure and, when viewed in thin section, are seen to be composed almost entirely of interlocking calcite crystals. Rarer minerals and clasts include pyrite and detrital quartz. The limestones occur in two forms, the first pale yellowish-cream in colour, the second grey, porcellanous, and with a characteristic hard, smooth surface and porcellanous. The yellowish-cream limestone is commonly bounded on the upper and lower surfaces by the porcellanous type. Only the yellowish-cream facies shows any evidence of deformation (Hallam, 1960).

The rubbly limestone (Figure 4.27)b and (Figure 4.28)b, better described as an intraformational conglomerate, is characterized by angular and subangular pebbles that occur in layers, pockets, or lenses (Hallam, 1960). Primary sedimentary structures are common in many of the limestone beds and include evidence of subaerial exposure, such as polygonal cracks on the upper surface of the 'Sun Bed'; in places flakes of sediment created by the cracking have produced a conglomeratic horizon (Hallam, 1960).

Slump structures are especially well-developed in the 'Slump Bed' (Figure 4.27)c–e, (Figure 4.28)a that is approximately 1.4 m thick and is characterized by large blocks of limestone and small pieces of the porcellanous limestone in a limestone matrix. The blocks include slump balls and detached and folded lumps of rock. The base of the bed is composed of fragments of the porcellanous limestone, probably reworked from the underlying bed. The top surface of the bed shows truncated sedimentary structures and organic borings. Similar features associated with penecontemporaneous deformation are seen at two lower beds in the Langport Member (Hallam, 1960). Ripples were noted by Richardson (1906), and wedge-shaped beds are also common (Richardson, 1906; Hallam, 1960).

At the base of the sequence, and exposed on the foreshore at low tides, is the Cotham Member. This was described very briefly by Richardson (1906), who recorded little more than the presence of the Cotham Marble, the '*Estheria* Bed' and the shales. The Cotham Marble recorded had the 'landscape' form; and the '*Estheria* Bed' was described as a pale limestone containing concretions and *Estheria minuta.* Mayall (1983) reported that a deformed bed from the middle of the Cotham Member is poorly exposed at Pinhay Bay, and that it can be correlated with the section at nearby Culverhole Point. This bed is approximately 0.4 m thick and consists of a calcitic mudstone with ripples, lens es of silty material, and evidence for sediment deformation, interpreted as possibly reflecting contemporary seismic activity.

Structural geology

The dominant structural feature at Pinhay Bay is the fault picked out by a small stream and with the Blue Lias downthrown to the west against the Langport Member (Woodward and Ussher, 1906; Lang, 1924; House, 1989). Hallam (1960) described small-scale faults that cut through the Langport Member and extend into the Blue Lias, where they plastically deform the Lower Jurassic beds.

Palaeontology

The Cotham Member has yielded a number of fossils. Of particular note are the well-developed algal mounds and mats that form the 'Landscape Marble' (Hamilton, 1961). Also present (Richardson, 1906) are remains of the crustacean *Estheria minuta.* Palynomorphs have been recovered from this unit in the nearby Lyme Regis borehole (Warrington, 1997a).

The Langport Member has yielded a diverse fossil assemblage, including many invertebrate taxa and ichnotaxa. A full listing the fauna was given by Hallam (1960, pp. 54–6). Many of the beds contain an assemblage composed of bivalves and gastropods with rarer solitary corals, which occur in dense concentrations approximately 1 m across and a few centimetres deep in the thinly bedded limestones. The shelly-marl horizon, seen towards the top of the exposure, contains abundant oysters and the bivalve *Modiolus* scattered throughout the sediment. Trace fossils include burrows and borings, for example the U-shaped tubes of *Rhizocorallium,* especially well exposed on the foreshore, where truncation has removed the top few centimetres of the burrows. Microfloras from a nearby section were documented by Orkell (1973) and Warrington (1997a)

Interpretation

The Cotham Member beds at Pinhay Bay represent a lagoonal environment. The sedimentary structures seen in this facies support this conclusion; for example the 'Landscape Marble' forms masses and mounds that were produced by algal mats growing in an intertidal environment (Hamilton, 1961).

The overlying Langport Member has been interpreted as representing an environment characterized by warm, shallow shelf lagoons, with periods of emergence (Hallam, 1960; Wignall, 2001). For example, the desiccation cracks and mud flake conglomerate of the 'Sun Bed', seen at the top of the section, are characteristic of temporary exposure and the associated drying out of the sediment surface. Hallam (1960) also presented evidence that these sediments were subjected to changes in relative sea level in the rapid lithification or consolidation of the limestones, for example intraformational conglomerates, burrows, and borings. The limestones were hardened during periods of exposure, and sedimentation resumed when the land was submerged again. Hallam (1960) estimated that there had been some 60 cycles of this nature at Pinhay Bay (see also Hesselbo and Jenkyns, 1995).

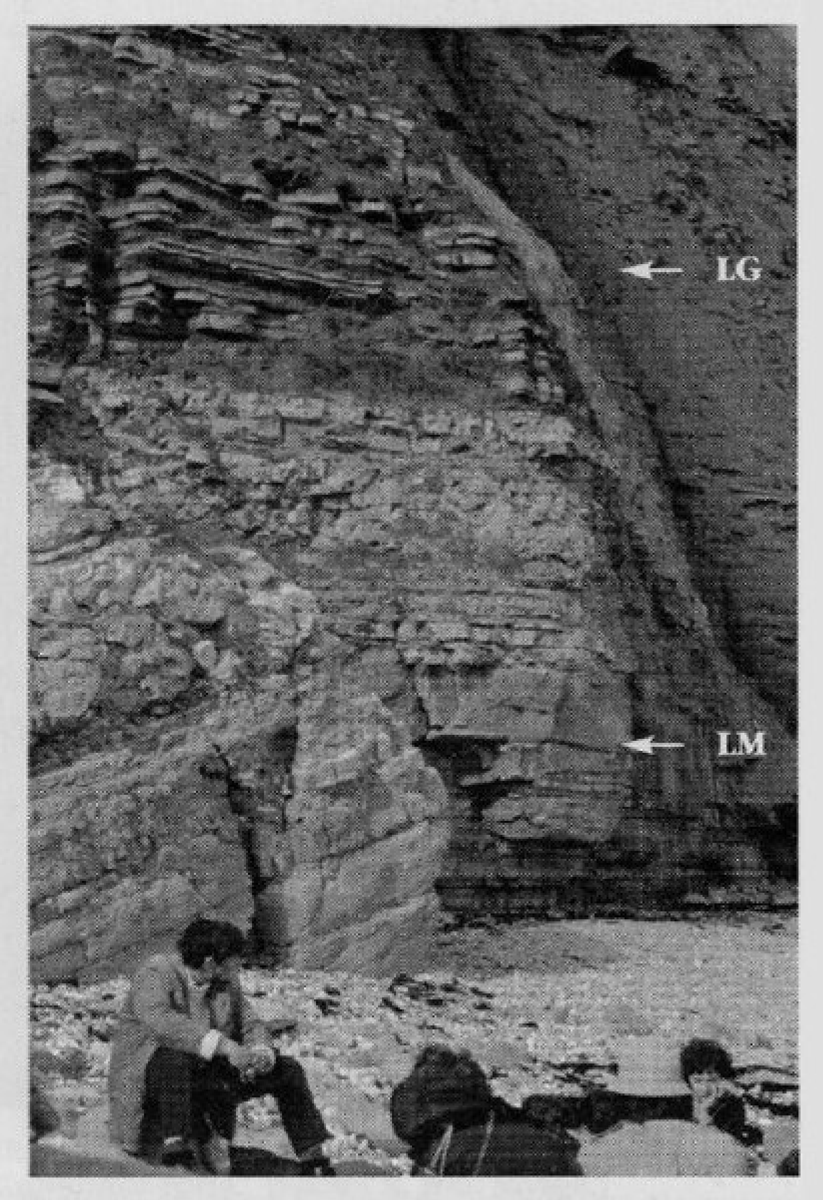
The sedimentary structures seen in the main slump bed have been interpreted as indicating high levels of disturbance on the sea bed. Consolidated brittle limestones were broken into angular fragments, rather than plastically deformed. The mass flow incorporated parts of the underlying porcellanous limestone into the debris flow. The intraformational breccia may have formed in a three-phase process (Wignall, 2001): (1) formation of a hardground that was lithified and bored; (2) local erosion of the hard-ground under a shallow sea to produce the conglomerate which was itself lithified; and (3) subaerial emergence and production of a fissured and pitted top surface. At nearby Charton Bay the equivalent bed is dominated by fractured sediments, showing that the sea floor there was at least partially lithified (Hallam, 1960).

There are certain similarities between the main slump bed at Pinhay Bay and a deformed bed seen in the Cotham Member of the Lilstock Formation. The Cotham Member deformed bed is characterized by microfaults, water-escape structures, and folds. Mayall (1983) considered this bed to have been initially deposited under shallow water conditions. Tectonic activity caused the unconsolidated silty beds to liquefy and the more consolidated sediments to fracture.

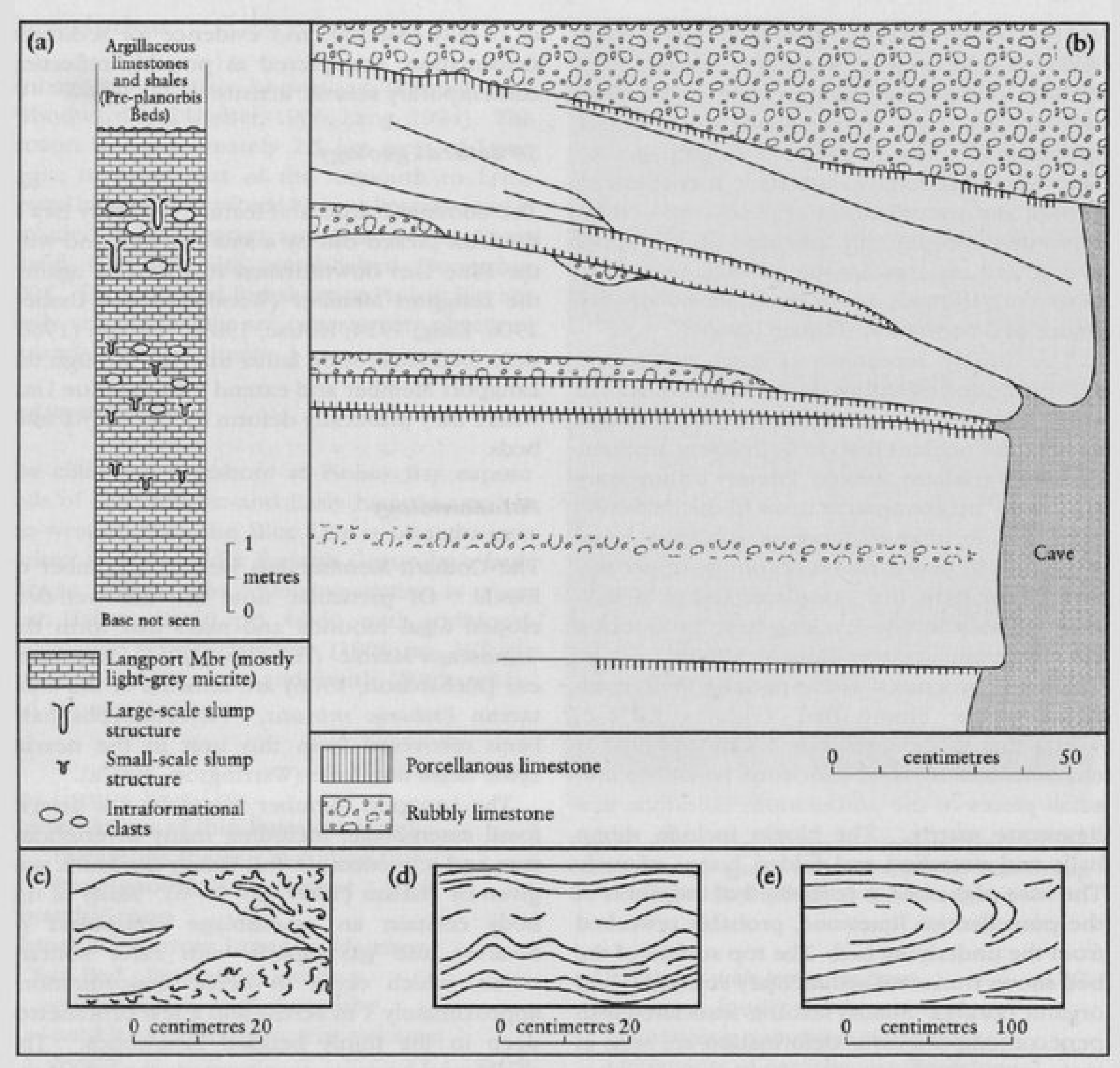
Conclusions

Pinhay Bay shows an excellent exposure of Upper Triassic and Lower Jurassic sediments. The Penarth Group strata include the Cotham and Langport Members of the Lilstock Formation. Several of the limestone beds of the Langport Member display excellent examples of soft-sediment deformation associated with debris flows, probably initiated by earthquakes or other tectonic activity. The site is especially important for evidence for ancient palaeoenvironments and critical in reconstructing the palaeogeography of southern England, near the end of Triassic time.

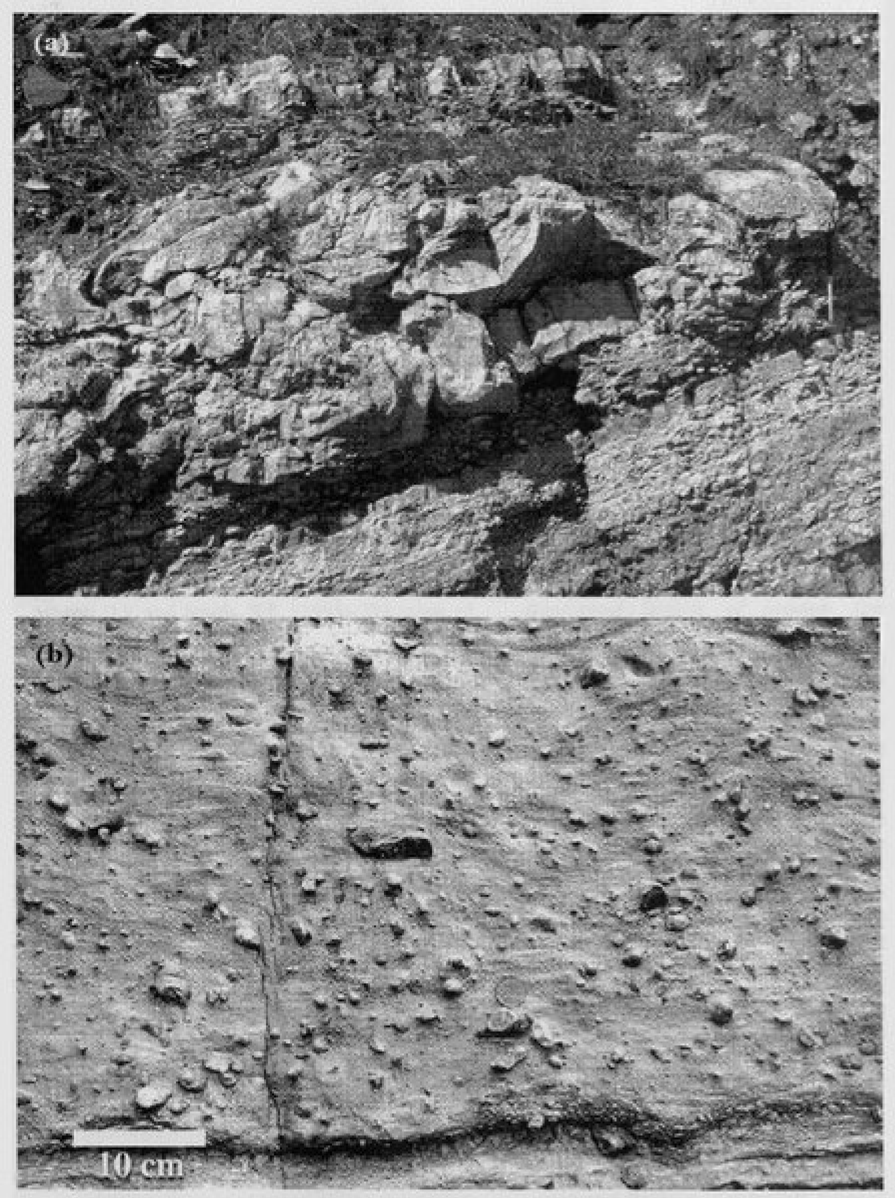
References



(Figure 4.26) The Langport Member (LM) of the Penarth Group (paler beds) overlain by Lias Group (LG) at Pinhay Bay. (Photo: R. J. G. Savage.)



(Figure 4.27) The Langport Member succession at Pinhay Bay. (a) Diagrammatic section. (b) Diagram of a section on the west side of Pinhay Bay, showing wedge bedding, rubbly limestones, and porcellanous selvages. (c-e) Synsedimentary deformation of the Langport Member; (c) part of a folded limestone bed in the Slump Bed, the core of which has been plastically squeezed and tapers to a point; (d) minor contortions, including pseudo-ripple marks, near the base of the section; (e) part of a limestone bed within the Slump Bed that has been folded on itself (a, after Swift, (1995); b-e, after Hallam, 1960.)



(Figure 4.28) Sedimentary structures in the Langport Member at Pinhay Bay. (a) The 'main' slump bed, showing soft sediment deformation features caused by downslope movement of a semi-consolidated sediment (b) A thick resedimented limestone containing numerous pebbles derived from the break-up of earlier Langport Member beds. (Photos: Andrew Swift.)