Budleigh Salterton, Devon

[SY 055 815]–[SY 073 820]

Introduction

The site comprises a magnificent coastal section that exposes the full thickness of the Lower Triassic Budleigh Salterton Pebble Beds, a sequence of texturally mature conglomerates deposited by braided rivers. These include pebbles of Ordovician and Devonian rocks with indigenous faunas derived from erosion of a ridge of Palaeozoic rocks to the south or southwest. The conglomerates are overlain unconformably by aeolian and fluvial sandstones of the Otter Sandstone Formation that rest on a layer of wind-facetted pebbles (dreikanter).

Early accounts of the Budleigh Salterton Pebble Beds include Vicary (1864), Whitaker (1869), Ussher (1876), Irving (1888), and Woodward and Ussher (1911). More recent descriptions include Laming (1966, 1968), Henson (1970), Selwood *et al.* (1984), Cocks (1989, 1993), Holloway *et al.* (1989), Smith (1990), Smith and Edwards (1991), and Wright *et al.* (1991).

The site is part of the Dorset and East Devon Coast World Heritage site.

Description

The Triassic sequence is best seen in the cliffs west of the town of Budleigh Salterton (Figure 3.71), where the Budleigh Salterton Pebble Beds (BSPB) are seen resting on the Littleham Mudstone Formation of the Aylesbeare Mudstone Group, and underlying the Otter Sandstone Formation. The sequence dips to the ESE at 3° to 8°.

The conglomeratic BSPB is the lower formation of the Sherwood Sandstone Group at Budleigh Salterton, and is well exposed west of the sea front [SY 062 816]. The unit is some 30 m thick and generally fines upwards (Figure 3.72)a. It is composed of well-rounded pebbles, cobbles, and boulders in a sandy matrix that contains sporadic sandstone and mudstone lenses (Selwood *et al.,* 1984; Holloway *et al.,* 1989; Smith and Edwards, 1991). The clasts are predominantly of quartzite; minor amounts of vein quartz, schorl, sandstone, and porphyry also occur (Henson, 1970). Some of the quartzite pebbles contain Ordovician and Devonian fossils (Vicary, 1864; Cocks, 1989, 1993; Holloway *et al.,* 1989). Towards the base of the formation, the sediments largely comprise thick sheets of horizontally bedded conglomerates with sand lenses and patches of cross-bedding. These are overlain by thin beds of sandy conglomerate interbedded with sandstone lenses and sheets (Smith, 1990).

The lower part of the BSPB, approximately 14 to 18 m thick, contains planar-bedded and cross-bedded conglomerates that grade laterally into sandstone lenses and then back into conglomerates (Figure 3.72)a. The cross-bedded conglomerates typically show high-angle foresets with rhythmically bedded pebbly sandstone and gritty layers (Figure 3.73)a, and have layers of pebbles overlying scoured surfaces (Smith and Edwards, 1991).

The upper section of the BSPB, some 12 to 14 m thick, is characterized by thinner beds of conglomerate with a higher sand content and the presence of large gravelly foresets, all of which display a very crude fining-upwards sequence (Figure 3.72)a; Smith, 1990; Smith and Edwards, 1991). The conglomerates form sheets with lenses and partings of sandstone. The highest beds show well-developed multi-storey and multi-lateral channels infilled with trough cross-bedded pebble-rich sandstones and conglomerates, which merge laterally with cross-bedded conglomerates.

The BSPB is succeeded by a 0.3 m thick deposit of red mudstone that is, in turn, overlain by a layer of facetted pebbles (Figure 3.72)b, (Figure 3.73) that marks the boundary with the Otter Sandstone Formation. Wright *et al.* (1991, p. 517) described the red sediment, a palaeosol, as a 'clay- and silt-rich sand' that rests on a thin conglomerate below the slope of a bar, and on the cross-bedded rudaceous sediments of the bar top. The red clay has a blocky, angular texture and the blocks may have striated skins; it is composed of illite and semi-ordered illite-smec-tite. The silt and sand-grade component consists of quartz and feldspar. This layer also contains scattered clasts, many of which (especially towards the top of the horizon) have haematite or clay coatings.

The pebbles overlying this layer have facetted upper surfaces and flattened or rounded lower surfaces. The upper surfaces are polished and show flutes and pits, producing zweikanter, dreikanter, and multi-facetted forms (Leonard *et al.,* 1982). The upper surfaces display pockmarks and microscopic striations, and are coated with haematite. The lower surfaces are smoothed and irregular.

The overlying thick sequence of medium- to fine-grained, reddish-brown, cross-bedded sandstones belong to the Otter Sandstone Formation (Holloway *et al.,* 1989), which is described in more detail in the Ladram Bay to Sidmouth site description (below). At Budleigh Salterton, this formation is exposed in the cliffs near to the town [SY 071 819] and to the east of the Otter River [SY 080 821]. The lower beds of the Otter Sandstone Formation, immediately above the BSPB (Figure 3.73)b, consist of cavernous weathering, cross-bedded aeolian sandstones that pass upwards into horizontally and cross-bedded fluvial sandstones that contain abundant concretions and sheets of calcite (Purvis and Wright, 1991). The concretions are typically elongate (up to 1 m long) and cylindrical, with a diameter between 0.1 and 0.15 m. They generally cut the bedding planes at right angles and are limited to laterally continuous sandstone horizons, which are often capped by channel lag deposits (Purvis and Wright, 1991). The sheets of calcite, each up to 0.1 m thick, are laterally continuous for up to 10.0 m and are preserved parallel to the bedding planes.

Interpretation

The sediments cropping out along the coastline west of Budleigh Salterton preserve evidence for a complex palaeoenvironmental regime, dominated by fluvial and aeolian activity Of particular significance are the ventifacts and deflation layer, and the palaeosol, at the top of the BSPB. During the deposition of the Sherwood Sandstone Group the climate of this part of Britain was hot and dry, as suggested by the presence of anhydrite, calcretes, and deflation surfaces with ventifacts (Henson, 1970; Leonard *et al.,* 1982; Holloway *et al.,* 1989).

The conglomerates and sandstones of the BSPB were deposited in substantial, low-sinuosity, gravel-bedded rivers on an alluvial fan or fluvial braidplain (Laming, 1966; Leonard *et al.,* 1982; Smith, 1990). The lower part of the formation, consisting of thick units of planar cross-bedded sandstone, has been interpreted as large channel-fills with distinct phases of conglomerate and sandstone deposition, the sediments having been deposited on the edges of large linguoid bars, probably in a gravel-bed stream. The upper part, typified by thinner beds and more sandstone, was deposited as sheets in shallow, poorly-channelized streams. Here, the coarser-grained material was deposited in the deeper parts of the channel, and the sandstone in the shallower areas. The contact between these two distinct facies is erosional, and was produced during the lateral migration of the river channels (Smith, 1990; Smith and Edwards, 1991).

The rivers that deposited the BSPB drained an area of high ground that was situated to the south of the Wessex Basin (Figure 3.74). This is confirmed by palaeocurrent measurements on the BSPB at outcrop, which indicate transport to the north and NNE. The fossil-bearing clasts indicate a source from the Armorican Massif (Cocks, 1989, 1993), which lay to the southwest, in the present area of Brittany and Normandy.

The fine-grained horizon with angular pebbles at the top of the BSPB has been interpreted as a 'reg' palaeosol (Wright *et al.,* 1991). Reg soil profiles typically consist of a ventifact horizon overlying a fine-grained layer that shows evidence of clay enrichment and coated grains, and are characteristic of desert environments. It is thought that this palaeosol bed represents an extended period of land surface stability, probably of many thousands of years in duration (Holloway *et al.,* 1989). The ventifact layer represents a deflation surface characterized by little or no net sediment deposition, and probably formed over an extended period of time.

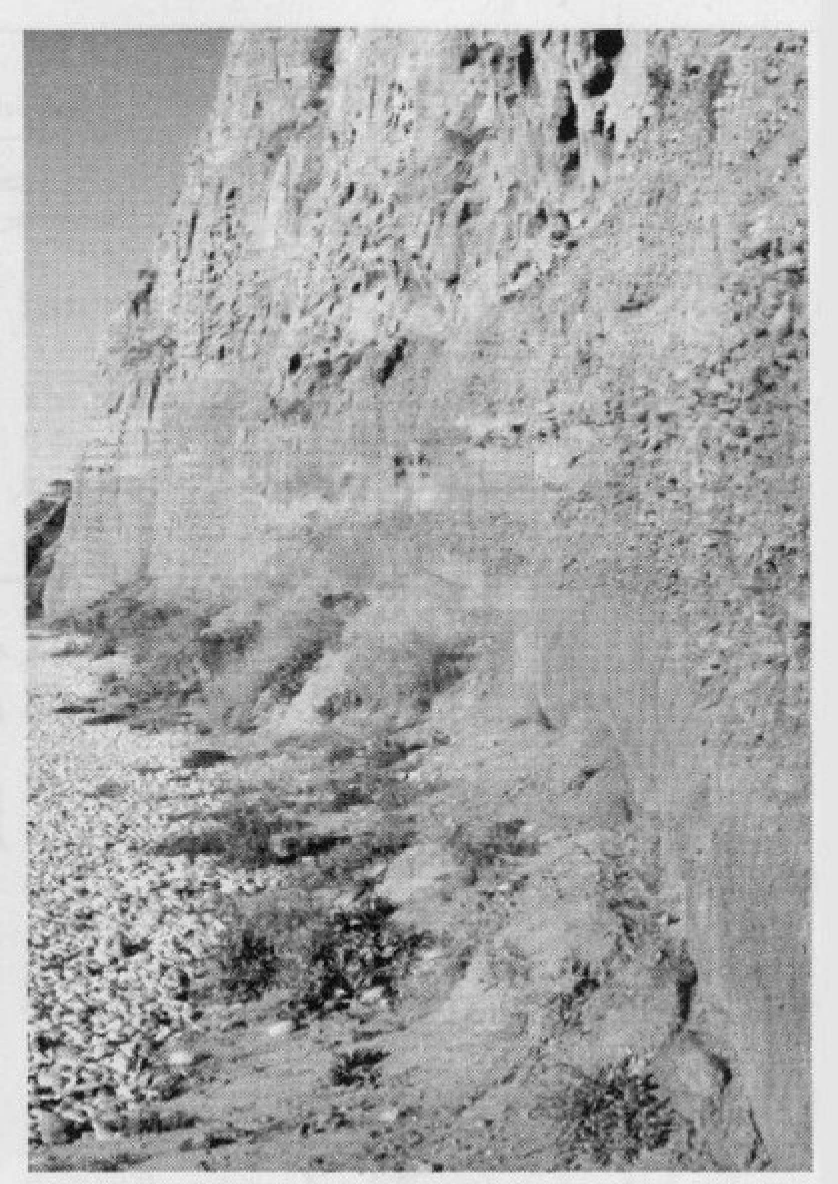
The ventifact layer is overlain by the Otter Sandstone Formation, the lowest 14 m of which has been interpreted as deposited by aeolian processes, which resulted in erosion of pebbles to form ventifacts, followed by the formation of large dunes (Henson, 1970). This interpretation is supported by the presence of large-scale cross-bedding, an absence of mica and coarse-grained clasts in the sandstone, and the high degree of rounding of the clasts (Newell, 1992). The sedimentary sequence preserves enough detail for tentative identifications of the dune types to be made. The lower sequence of trough cross-bedded sandstones was probably deposited on the slip faces of barchan or transverse dunes. The overlying low-angle laminated sandstones and associated mudstones may represent smaller dome-shaped dunes and interdune areas. These are overlain by fluvial, horizontally- and cross-bedded sandstones (Purvis and Wright, 1991).

The base of the BSPB was arbitrarily taken as the base of the Triassic succession in Devon (Warrington *et al.,* 1980), although others (e.g. Edwards and Scrivener, 1999) adopt a lower level for that boundary, placing it at the base of the Aylesbeare Mudstone Group (see Chapter 2, p. 84). Though direct palaeontological evidence for age is lacking, the BSPB is dated as Early Triassic in age. This age is poorly constrained by Late Permian miospores in the upper part of the Exeter Group (below the Aylesbeare Mudstone Group, which underlies the BSPB; see Chapter 2), and the faunas of Mid Triassic (Anisian) age in the overlying Otter Sandstone Formation (see below and Benton and Spencer (1995) and Dineley and Metcalfe (1999).

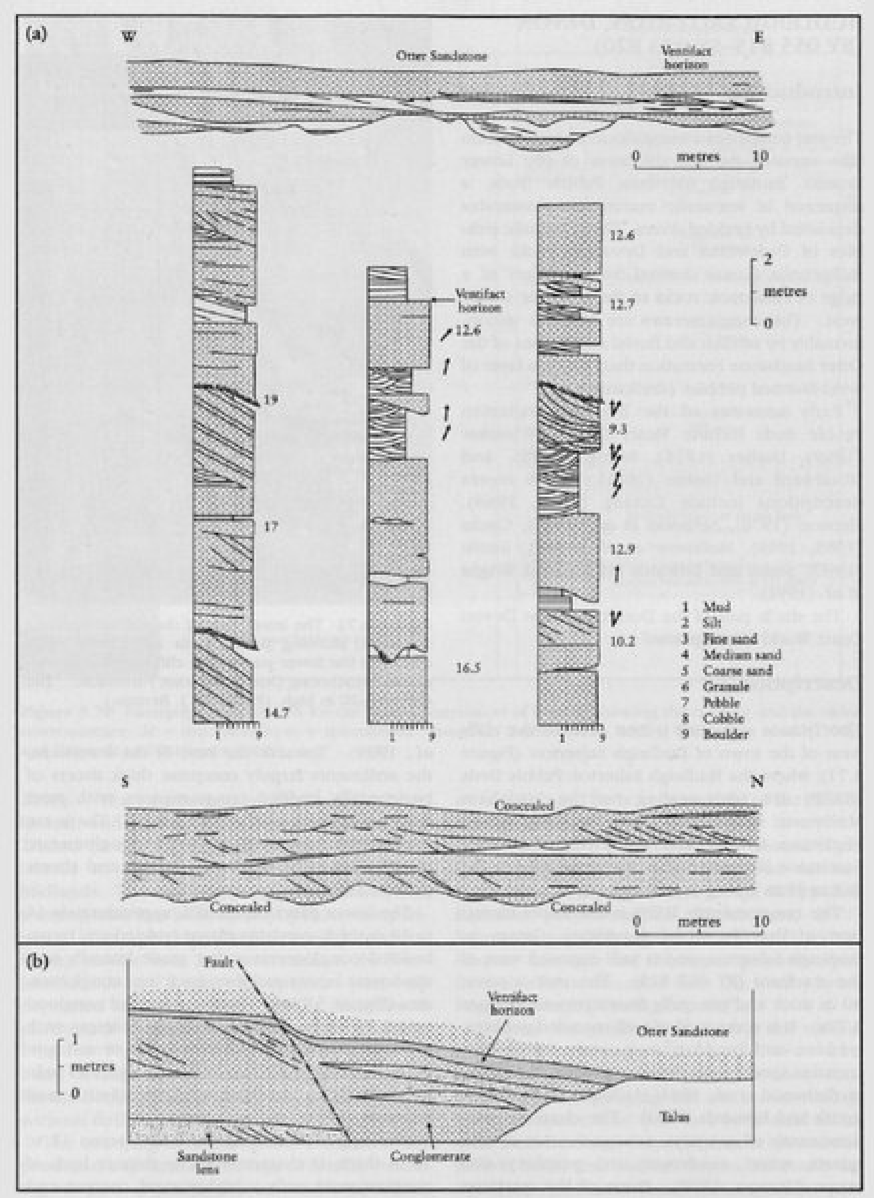
Conclusions

The sea cliffs in the vicinity of Budleigh Salterton expose an excellent section of Triassic fluvial and aeolian sediments, including a complete section of the Budleigh Salterton Pebble Beds. The provenances of pebbles assessed from included fossils aid palaeogeographical reconstructions. Of particular significance is the ventifact and deflation horizon at the top of the BSPB, a feature common in modern deserts but rarely preserved in the geological record. This is a world-famous site, with a classic section through fluvial conglomerates, and critical for the understanding of British Early Triassic palaeoenvironments and palaeogeography.

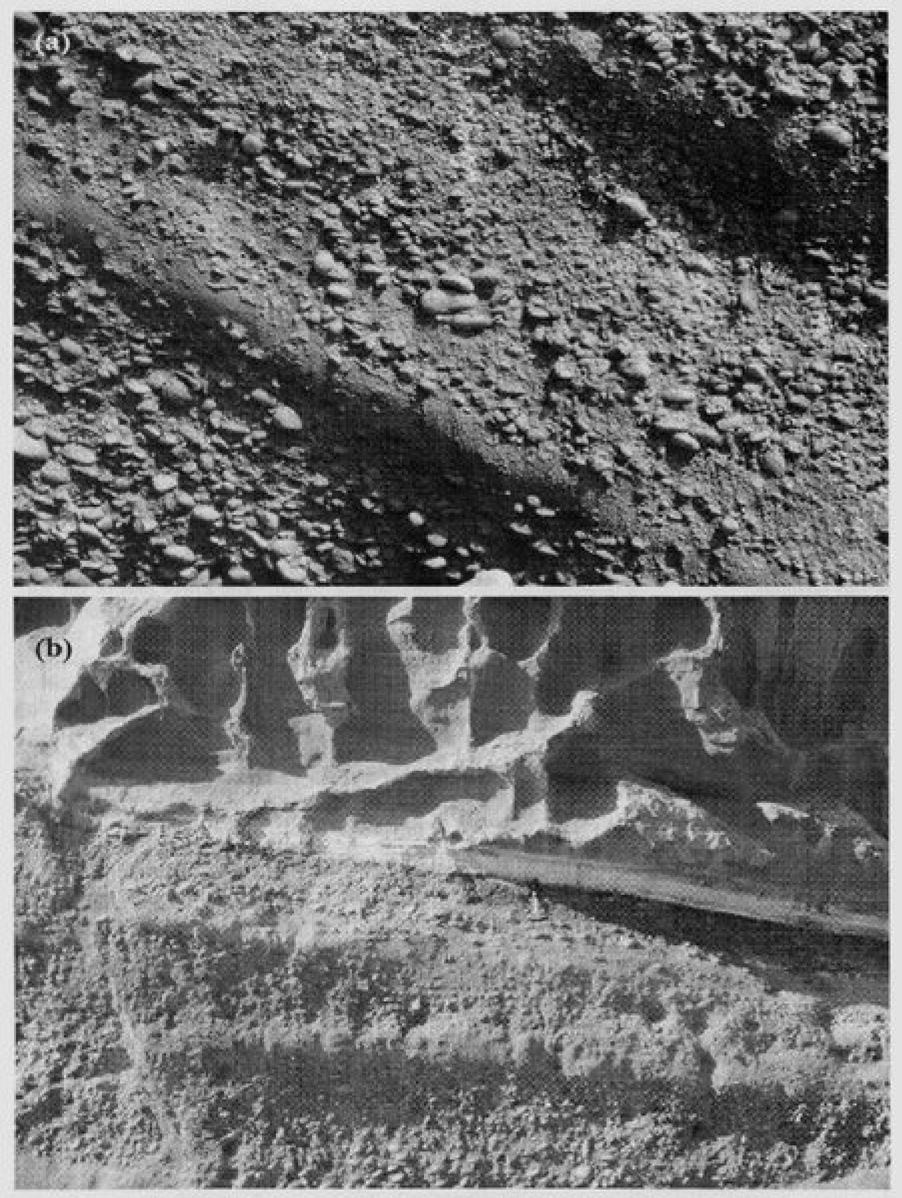
References



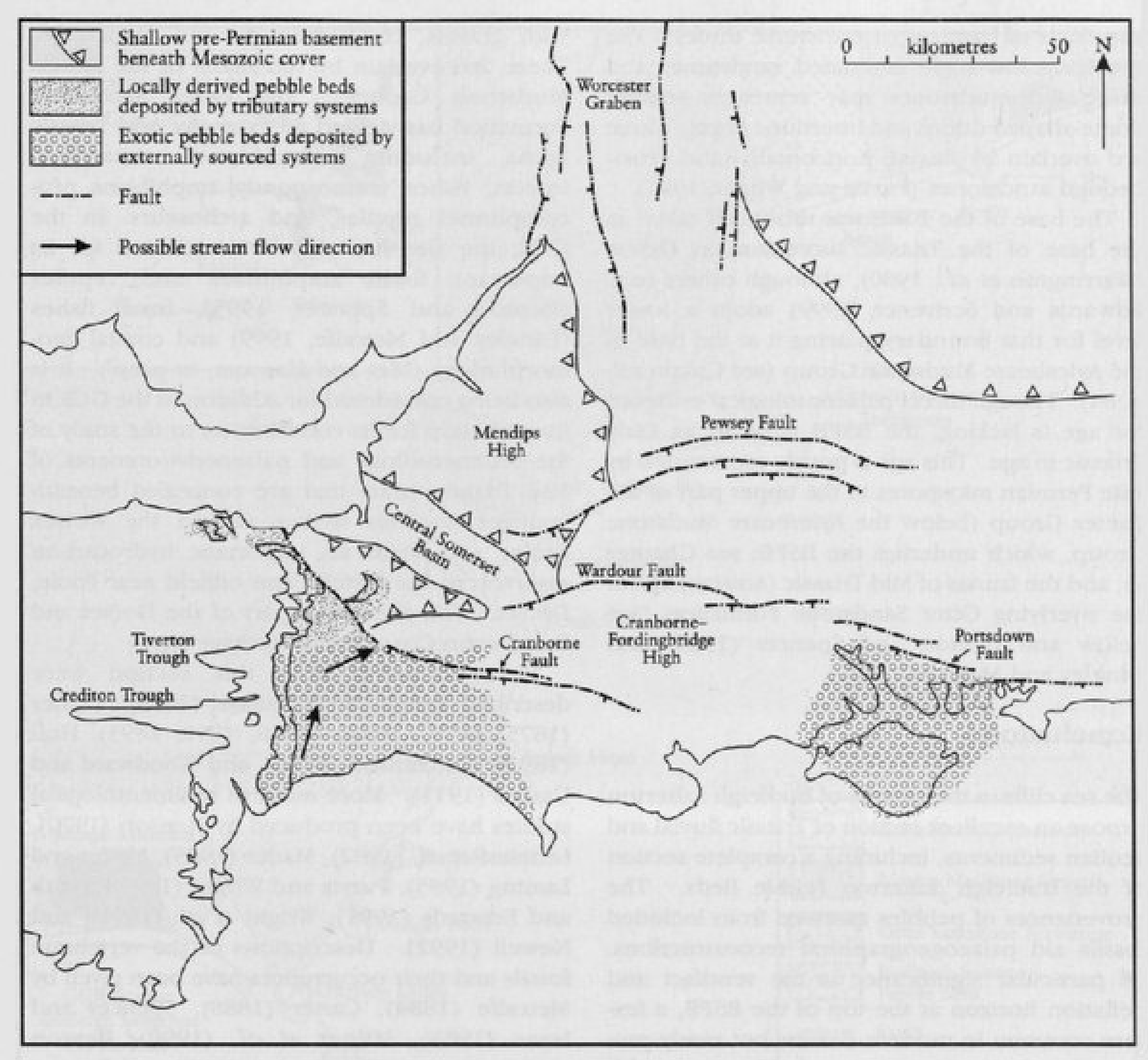
(Figure 3.71) The lower part of the cliff at Budleigh Salterton, showing pebble beds and coarse sandstones in the lower part of the cliff, overlain by cavernous weathering Otter Sandstone Formation. The cliff is15–20 m high. (Photo: M. J. Benton.)



(Figure 3.72) Sedimentary features in the Budleigh Salterton coast section: (a) graphic sedimentary logs measured at three points through the Budleigh Salterton Pebble Beds (BSPB), and sketches of the upper and lower parts of the cliff section; (b) field relationships of the top of the BSPB, at the eastern end of the GCR section [SY 062 816]. Based on Smith and Edwards (1991) and Wright et al. (1991) respectively.



(Figure 3.73) Sedimentology of the Budleigh Salterton Pebble Beds. (a) Close-up view of rounded pebbles, partly imbricated, in large foresets; field of view about 1 m. (b) The top of the Budleigh Salterton Pebble Bed overlain by cavernous weathering sandstones of the Otter Sandstone Formation. The ventifact horizon underlies the light-coloured band at the base of the Otter Sandstone Formation, and is marked by the top of the hammer shaft. (Photos: P. Turner.)



(Figure 3.74) Palaeogeography of the south of England during the deposition of the Budleigh Salterton Pebble Beds, showing the location of outcrops, and concealed occurrences detected by boreholes in Dorset and in the Hampshire Basin. Major palaeocurrent flow directions are indicated. Abbreviations: CF, Cranborne Fault; CFH, Cranborne–Fordingbridge High; CSB, Central Somerset Basin; MH, Mendips High; PF, Pewsey Fault; PDF, Portadown Fault; WF, Wardour Fault; WG, Worcester Graben. (After Smith and Edwards, 1991.)