Association Paléontologique de Villers-sur-Mer

Isle of Wight / Dorset Coast Fieldtrip
May 7-11, 2017

Villers-sur-Mer Palaeontological Association
(APVSM)
and
UK Colleagues

Leaders:

Professor Richard T. J. Moody
History of Geology Group
and
Dr Horst Gödicke,
Chairman, APVSM

This programme covers the southern coast of the Isle of Wight and the Jurassic Coast of Dorset.

The itinerary is:

May 7. Rendezvous in Portsmouth for evening meal and overnight stay. APVSM Group arrive in Portsmouth at 9:30 pm (local time). Hotel: Western Royal Beach, South Parade, Southsea, Portsmouth P04 0RN. Tel: 02392731281.

May 8. IOW Ferry - 8:30 am departure for Fishbourne, on the Isle of Wight. Visits to include Whitecliff Bay, Sandown Dinosaur Museum, Hannover Point, Shippards Chine, Alum Bay & The Needles. Hotel: Albion Hotel, Freshwater Bay, Isle of Wight, Freshwater, PO40 9RA, United Kingdom. Tel: 01983 755755. **Figures 1-14**

May 9. Departure (by coach) from Yarmouth to Lymington by ferry. Visits en route we will stop at Barton on Sea, Wytch Farm Oil field, Corfe Castle & Kimmeridge Bay and visit to Steve Etches Collection (Museum of Jurassic Marine Life). Overnight in Bournemouth. Hallmark Hotel Bournemouth Carlton, Bournemouth, BH1 3DN. Tel: 03300283411. **Figures 15-26.**

May 10. Leave Bournemouth fo**r** Durlston, Lulworth Cove & Durdle Dor, Osmington Mills. Overnight in Weymouth. Best Western Hotel Rembrandt, 12-18 Dorchester Road, Weymouth, DT4 7JU. Tel: 01305764000. **Figures 27-37**

May 11. Leave to visit the Isle of Portland, Chesil Beach, Burton Bradstock, Charmouth & Lyme Regis including visit to local church. Return to Portsmouth via. Group disperses; APVSM members leave by ferry to Le Havre. Departure of the ferry at 23hr30 (duration of passage: 8 hours). **Figures 38-49**

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Topography and Quaternary Geology of the Isle of Wight

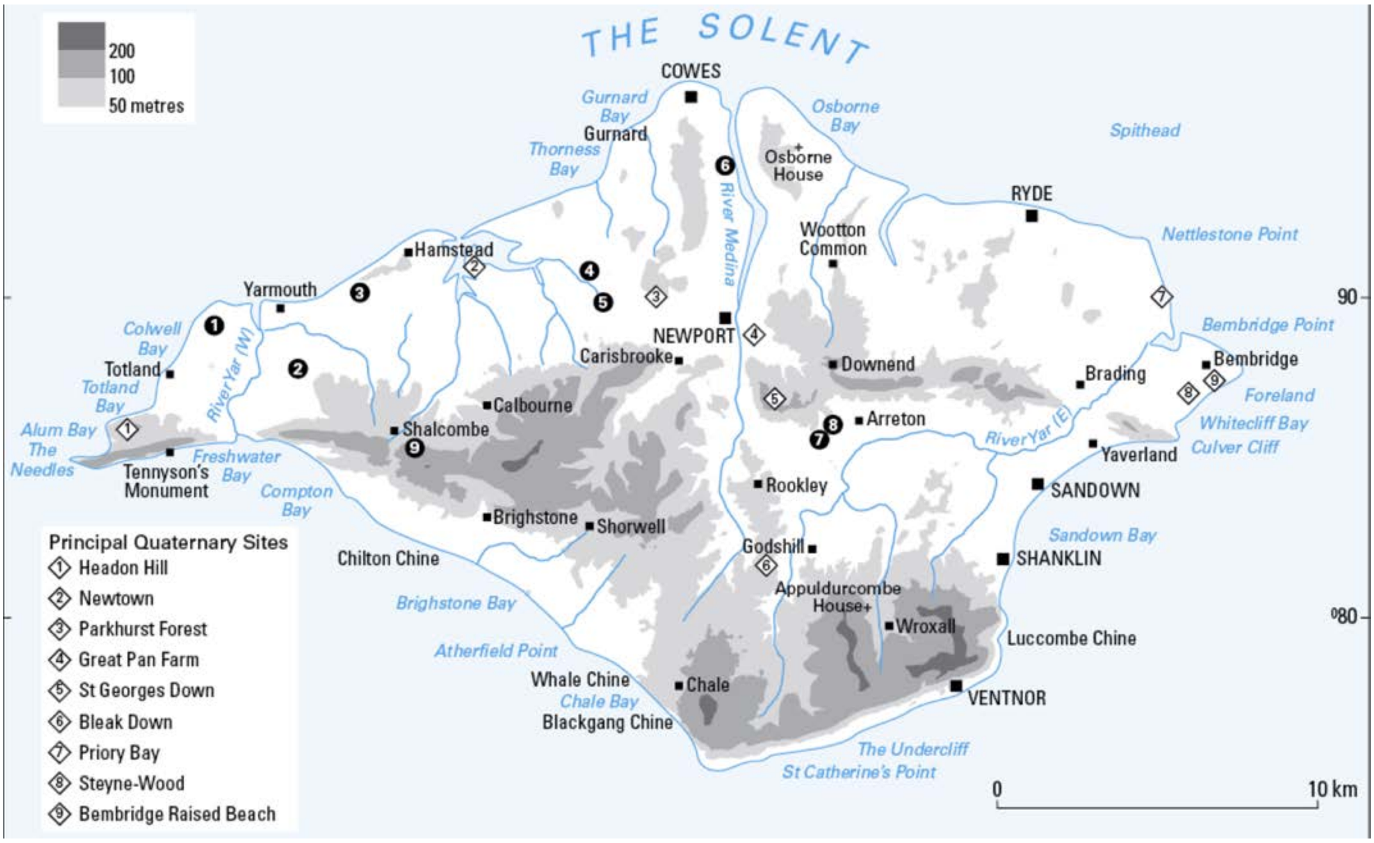


Figure 1. The outline topography, principal towns and locations of geological interest on the Isle of Wight.

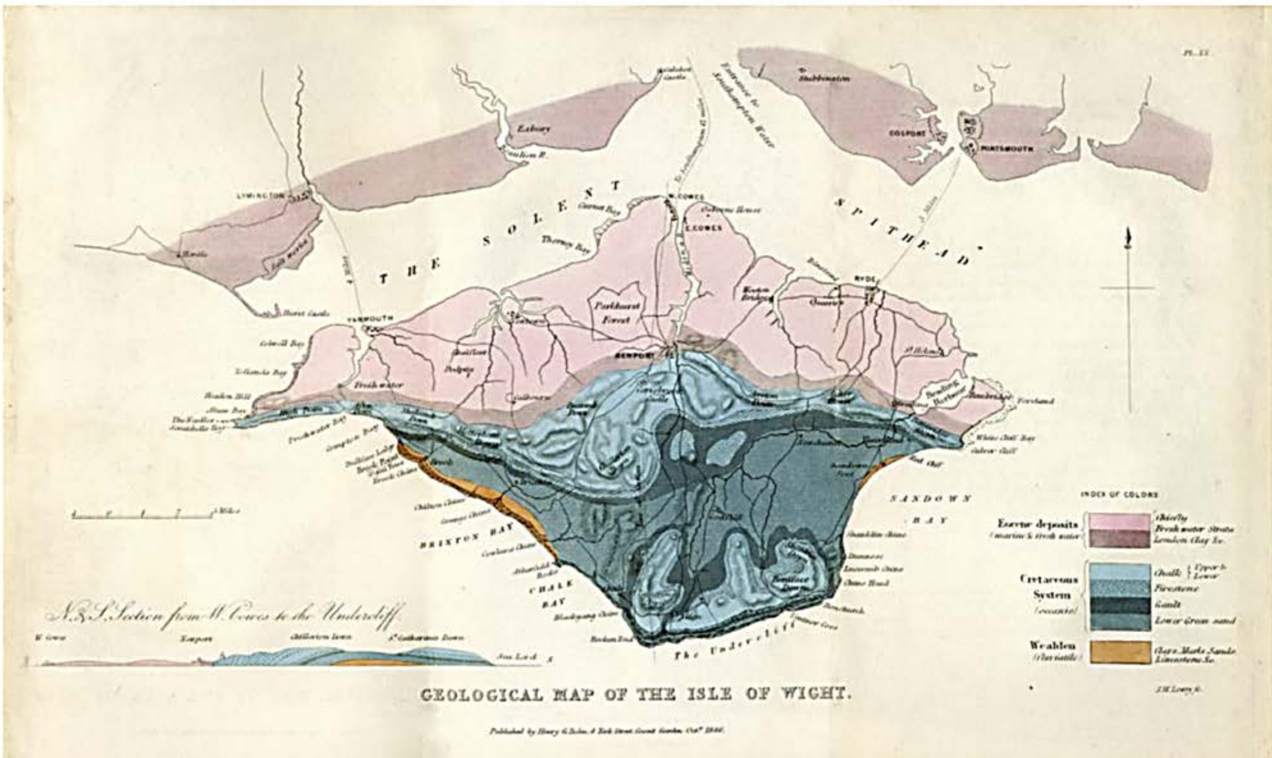
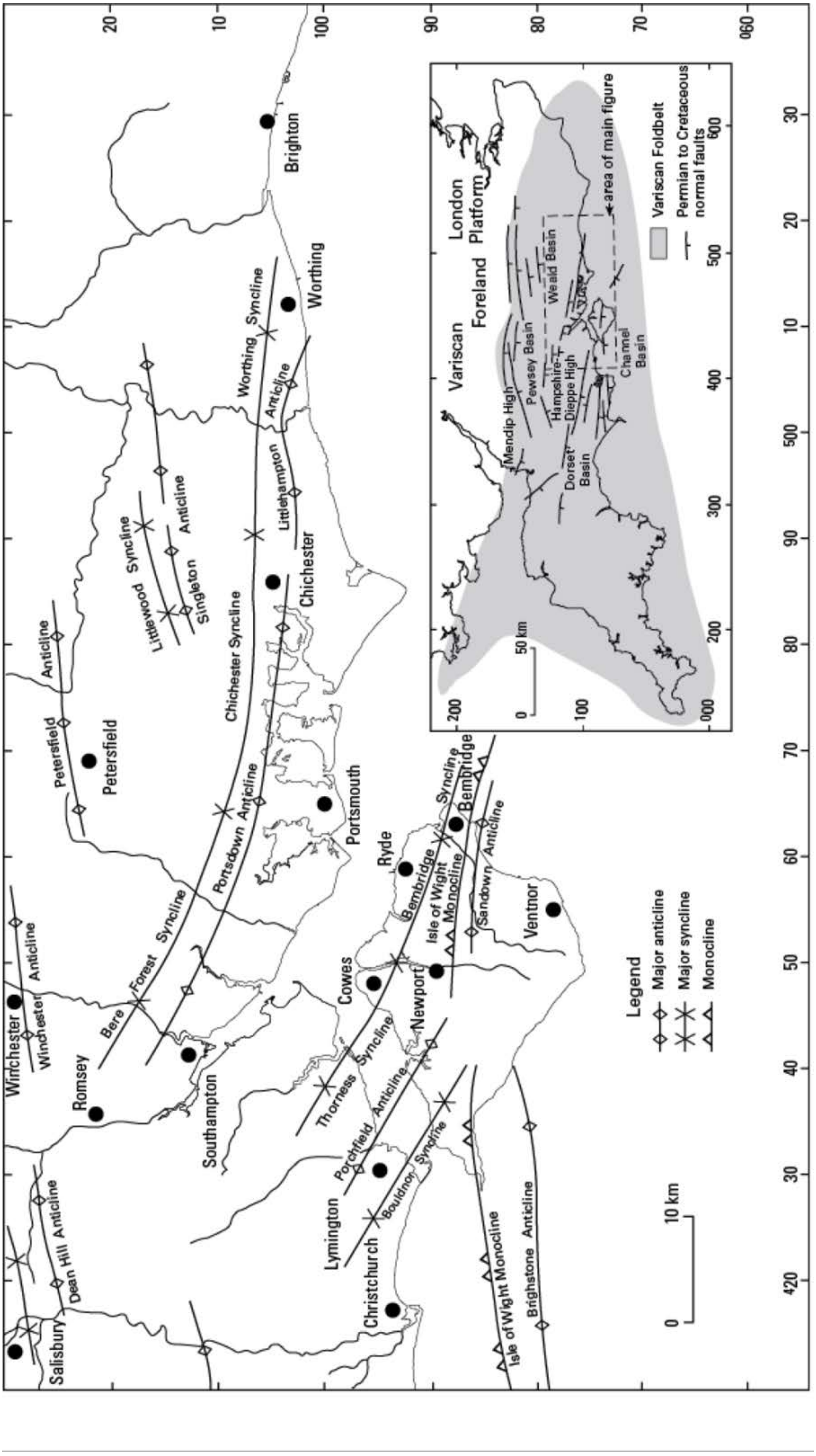


Figure 2. One of the earliest geological maps of the Isle of Wight taken from Mantell (1847), originally published in 1846 by Henry G Bohn of London.



Salisbury
Dean Hill Anticline
Winchester
Winchester Anticline
Romsey
Bere Forest Syncline
Southampton
Portsdown Anticline
Portsmouth
Petersfield
Petersfield Anticline
Chichester Syncline
Chichester
Littlehampton Anticline
Littlewood Syncline
Singleton Anticline
Worthing Anticline
Worthing Syncline
Worthing
Brighton
Lymington
Christchurch
Porchfield Anticline
Bouldnor Syncline
Thorness Syncline
Cowes
Newport
Ryde
Bembridge Syncline
Bembridge
Isle of Wight Monocline
Sandown Anticline
Ventnor
Brighstone Anticline
Legend
Major anticline
Major syncline
Monocline
10 km
Variscan Foreland
London Platform
Mendip High
Pewsey Basin
Weald Basin
Hampshire-Dieppe High
Dorset Basin
Channel Basin
area of main figure
Variscan Foldbelt
Permian to Cretaceous normal faults
50 km

Figure 3.

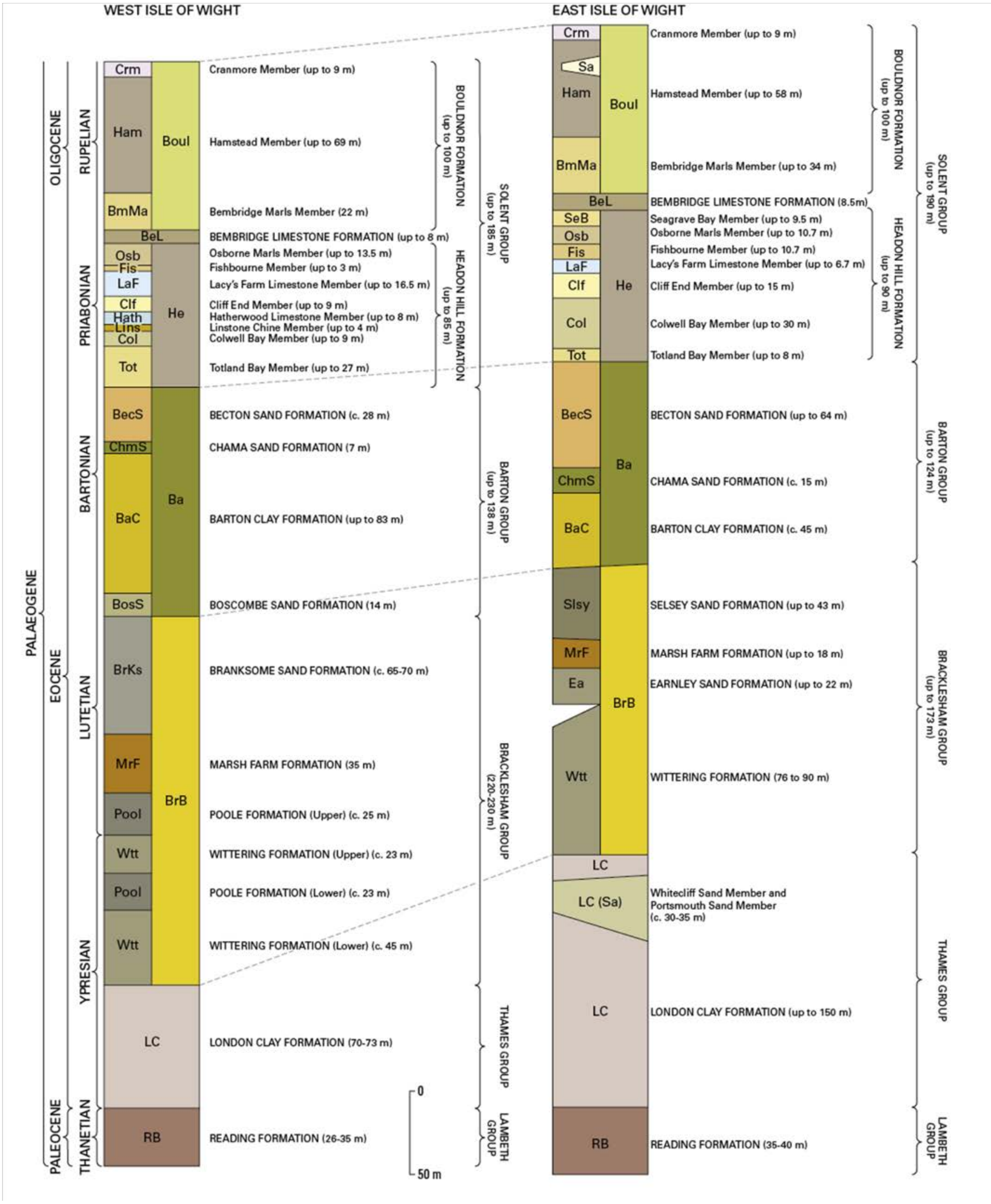


Figure 4. Palaeogene strata of the Isle of Wight

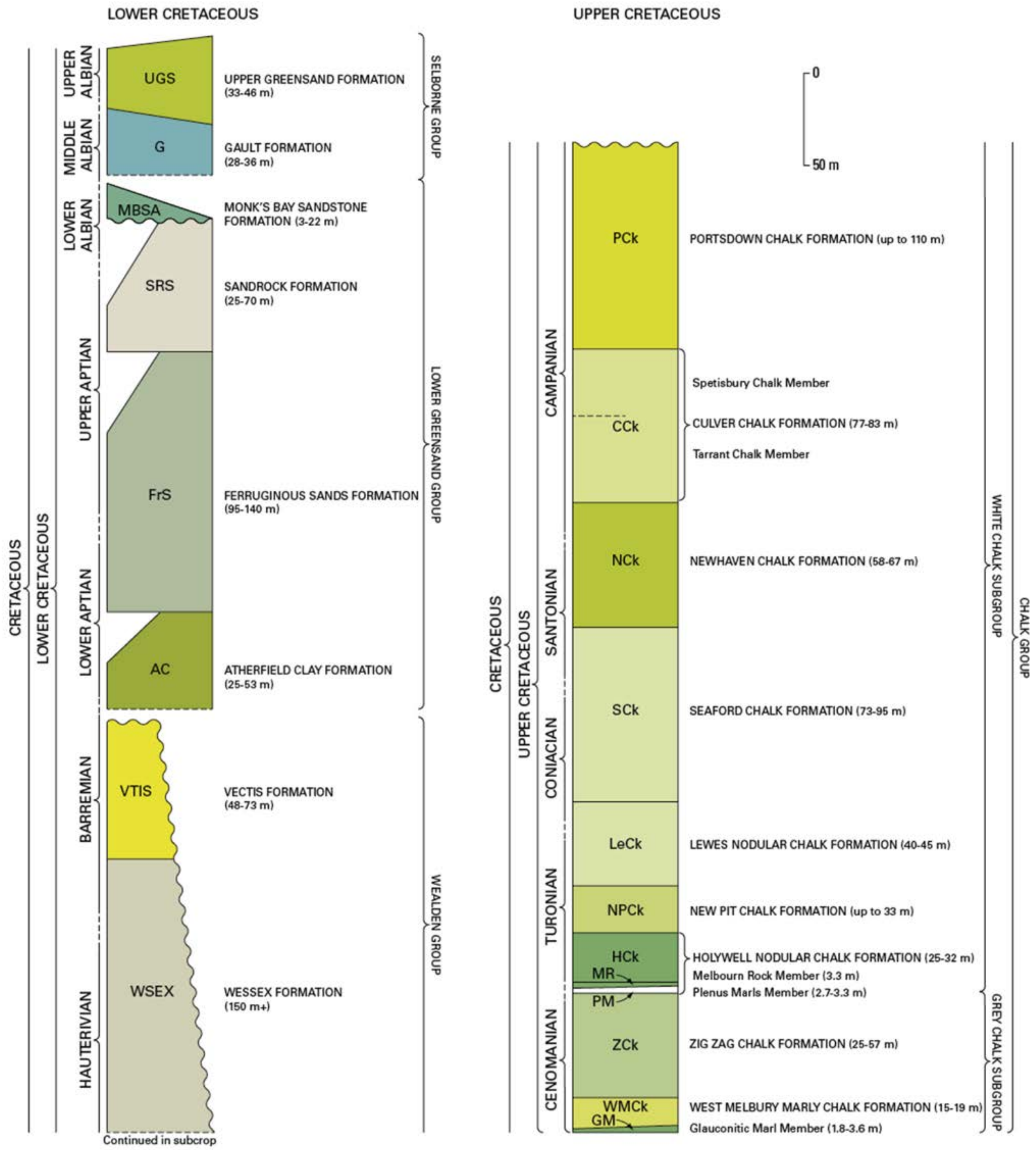
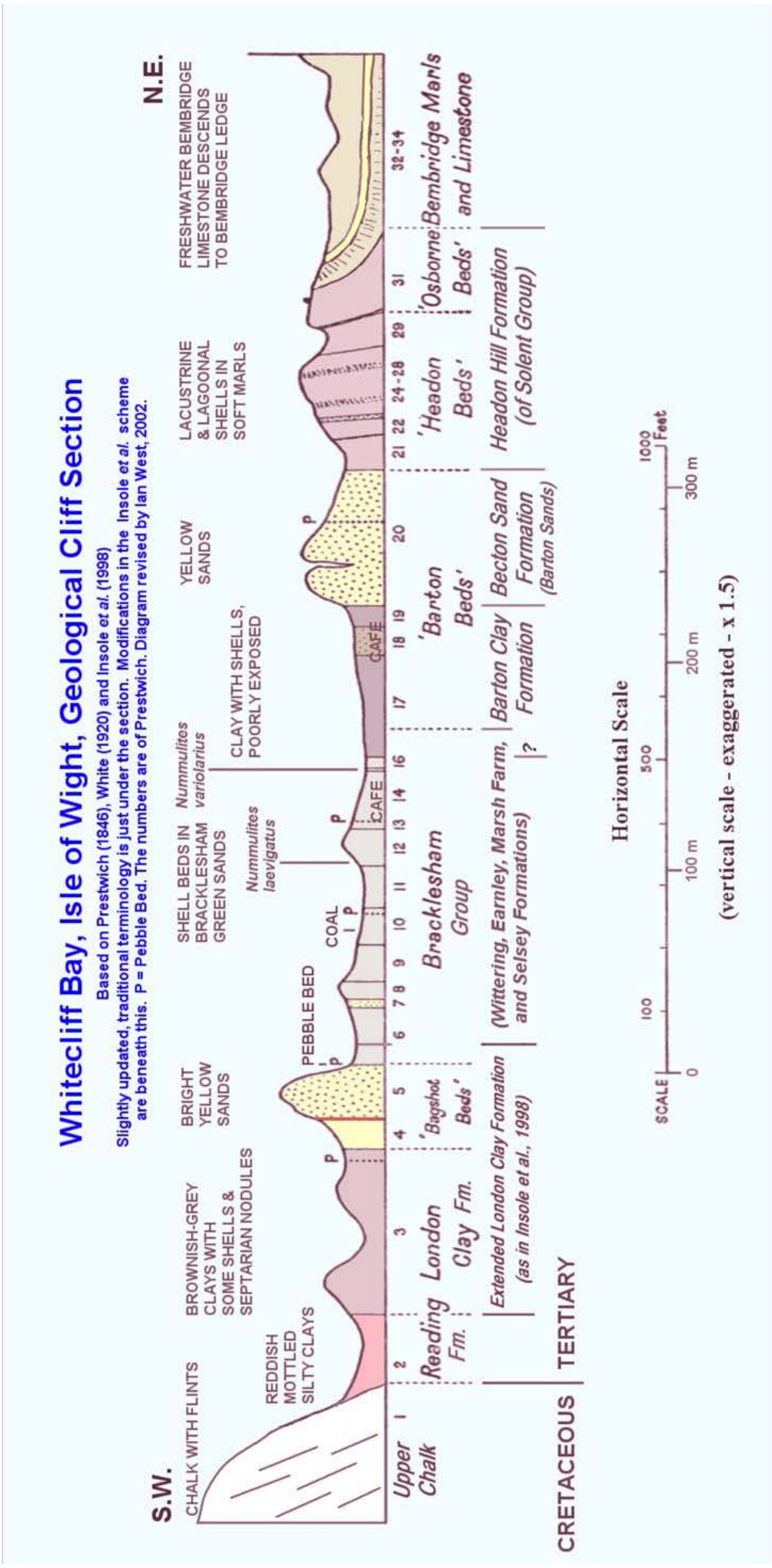


Figure 5. Cretaceous strata of the Isle of Wight

Whitecliff Bay

Figure 6.



UK Fossils Network (*ukfossils.co.uk)* like most visitors/geologists, to Whitecliff Bay (**Figures 1-6**) start from the west end of the bay. “There the Upper Chalk of Culver Cliff yields excellent sponges, such as *Porosphaera*. Echinoids, such as the small *Echinocorys subconicula* and belemnites (*Belemnitella mucronata)* can be seen from the Portsdown Member. This is at the top of the succession, so it is best to search the rocks that have fallen from this thin bed of marl. Occasional fish remains can also be found”.

Past the chalk **(Figure 7**), the Reading Formation can be seen, although much of it has been slipped and is covered by vegetation. This bed is mostly unfossiliferous, although a few silicified echinoids and a few derived microfossils from the chalk have been found. The London Clay and London Clay Basement Bed, immediately after the Reading Formation, are where most of the more interesting fossils can be found. Sharks’ teeth, worm tubes (*Ditrupa*) and a range of shells can be found. The London Clay Formation includes the Bagshot Sands which are unfossiliferous. Most of the fossils can be found from the first part of the sequence. Many various molluscs can be found from the Bracklesham Group, which include *Turritella* (a gastropod) and Venericor planicosta (a bivalve). These are from the Earnley Sand. It is also possible to find the large foraminifera, *Nummulites laevigatus*.

Figure 7. Aerial Photograph - Culver Cliff And Whitecliff Bay, Isle Of Wight.
Alan Holiday (c) 2011.Photograph: June 2011.

The northward-dipping Chalk in Culver Cliff is followed northward by a good Tertiary section in Whitecliff Bay. Pinkish Reading Formation is first seen, followed by greyish-brown London Clay. The Bracklesham Group is in front of the caravan site to the left of the path down. Barton Clay crops out near the main path down, with Barton Sand (Becton Sand) to the right. Text from Ian West, Southampton University, 2012.

The Barton Group is mostly covered up by a sea defence, although, during scouring conditions this is exposed on the foreshore. Here, the shells of the large foraminifera, *Nummulites prestwichianus* and *Nummulites rectus*, can be found. The Becton Sand follows this (again mostly covered up by defences). The Headon Hill Formation, which has been badly land-slipped, can yield a wide range of marine shells, including gastropods (*Viviparus*, *Galba*, *Planorbina*, *Melanopsis*, *Theodoxus*) and bivalves (*Potamomya*, *Ostrea*, *Psammotaea* and *Corbula*), as well as many other species. And, at the eastern end of the bay, the Bembridge Limestone yields superb specimens of *Planorbina* and *Galba*.
Most of the fossils from the London Clay can be found on the foreshore, mostly during scouring conditions when the clay is exposed.

The London Clay Building Stone layer can be also seen above, with occasional fossils. During scouring conditions, superb shells from the Bracklesham and Barton Groups can also be seen exposed on the foreshore. You should also search the boulders along the foreshore at the chalk end and in the landslips. Often, if you split these boulders, fossils can also be found inside. The Bracklesham and Barton Beds exposed in the cliff face contain shell beds, from which you can collect, although the shells are very fragile and require great care. At the east end of the bay, the Bembridge Marls and Bembridge Limestone are exposed, and fossils can also be found in these, where there are layers of shell". The overlying Headon Hill and Bembridge Formation are Late Eocene (Solent Group) in age. From Whitecliff Bay we will travel south-west to Culver Parade and visit the pterodactyl-shape building that houses the Dinsosaur Isle Museum (**Figure 8**).

Figure 8. For nearly a century the Museum of Isle of Wight Geology, above Sandown Library, housed the Island's geology and fossil collections. On August 10th 2001 this changed with the opening of Dinosaur Isle, a purpose built interactive museum which replaced the old museum. Dinosaur Isle provides the space and facilities to properly display and conserve the rich geological collections. Dinosaur Isle is managed by the Isle of Wight Council and cost £2.7 million, half of which was provided by a Millennium Commission grant.

HANNOVER POINT
(Off Military Road west of Brook)
(Figures 9-10)

Sediments exposed along this coastal section belong to the Wealden Group which is Lower Cretaceous in age

There are three main types of footprints known on the Isle of Wight, the Large "I*guanodon*" tracks from the Wessex Formation and the base of the Vectis, slightly smaller "Theropod" footprints from thin limestone beds in the Vectis Formation, and four-toed "*Polacanthus*" tracks from the Wessex Formation. There are also some reported "*Iguanodon*" manus prints and sauropod tracks. Of all of these, the "*Iguanodon*" tracks are the easiest to find, due to their unusual shape.

Footcasts of the Wessex Formation are generally trifid (three pronged) boulders, about 50 cm long with an average angle of 42° between digits II and IV, preserved in sandstone overlying a mud-stone substrate. There are also imprints, in a reddish-orange mudstone bed on the foreshore at Hanover Point. These were buried under the overlying mudstone beds, which have since been eroded away. There were also several trackways at Chilton Chine, but dinotrackers beware, they've eroded away since the 1970's, and there is nothing left.

‘In the Vectis Formation, there are many sandstone-preserved footcasts, of both "ornithopod/thero-pod" and "sauropod" dinosaurs, in the White Rock Sandstone, but there are also footprints pre-served in shelly limestone beds, the footprints being infilled with unionid bivalves (Radley et al., 1998). The preservation of the unionids would suggest that the tracks were made in the substrate, then the bivalves settled on the surface (Radley et al., 1998). Many of these footcasts, attributed to theropods, have what appears to be a claw impression at the tips of the digits (Radley et al.,1998); whether these are actual claw marks or artefacts of the substrate after the foot was removed is un-known’.

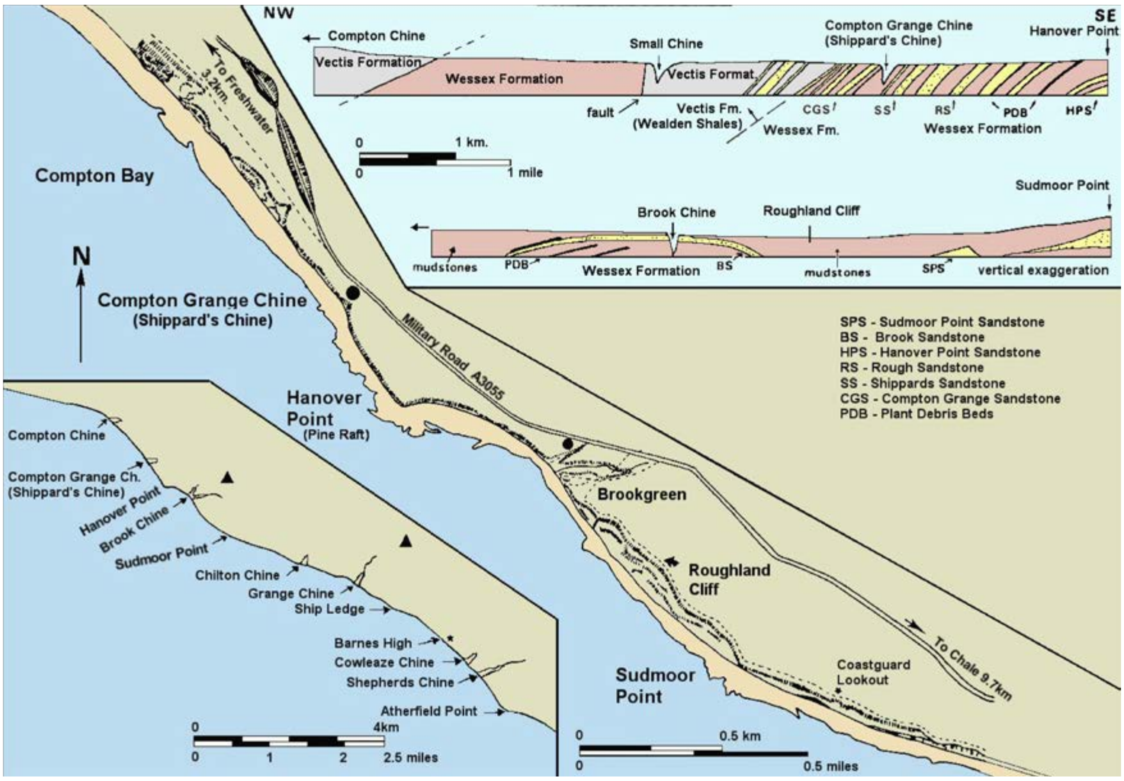


Figure 9. Location map for part of the southwest Isle of Wight coast, from Compton Bay to Sud-moor Point northwest of the Coastguard Lookout. The structural/stratigraphic sections are based on the sedimentological work of Slewut (1981) redrawn by Ian West & Tonya West, 2008.

There are twenty species of dinosaurs recorded on the Island. They are:

Order Ornithischia

Suborder Ornithopoda ("bird-footed", bipedal herbivores)
Iguanodon bernissartensis
Mantellisaurus atherfieldensis (formerly Iguanodon atherfieldensis)
Valdosaurus canaliculatus (known from partial material)
Hypsilophodon foxii: Named after Rev. William Fox, a fossil collector of the Isle of Wight who found several skeletons.

Suborder Thyreophora ("shield-bearers", armored herbivorous dinosaurs)
Polacanthus foxii: Also named after the Reverend Fox. Notable as no head to the specimen has ever been found and reconstructions are based upon suppositions from similar ankylosaurians.

Order Saurischia

Suborder Sauropodomorpha ("sauropod-like", giant long-necked herbivores)
The 'Barnes High' sauropod: A member of the Brachiosauridae family, most likely *Eucamerotus* or *Pelorosaurus*. This is the most complete specimen from the Wealden era.
Baryonyx, a large theropod, was found with fish scales in its stomach, indicating that it may have been a piscivore.

Suborder Theropoda ("beast foot", bipedal carnivores)
Baryonyx walkeri: Teeth are common on the Island. Hand bones have also been found.
Eotyrannus lengi: A tyrannosauroid. First identified in 1997 and named in 2001 from a single specimen found on the island.
Neovenator salerii: The holotype skeleton was found on the island.
Yaverlandia: The holotype partial skull was found at Yaverland. It was initially believed to have belonged to a pachycephalosaurian.

Figure 10. The most common dinosaur fossils at Hanover Point are the footprints and trailways of three-toed forms such as *Iguanodon.* The casts and moulds are found on the foreshore. They are protected by the National Trust as a Site of Special Scientific Interest (S.S.S.I).

ALUM BAY AND NEEDLES
Figures 11-15

Figure 11. Ian West of Southampton University with his back to Alum Bay. The hilltop pathway to the Old Battery ends with spectacular views of the Needles. To the left is Headon Hill,where there are excellent exposures of the Headon Hill Formation. Photo: 25th July 2009. *Ian West (c) 2009.*

The Isle of Wight is a beautiful area with numerous outcrops and wonderful vistas. According to Rudwick and Torrens (2007) ‘records from the earliest 19th Century reveal that Thomas Webster (1773-1844) an architect and artist was appointed by the Geological Society as librarian, curator and draughtsman in 1812. He was also commissioned by the wealthy Sir Henry Englefield to visit the island and work out its geology and make drawings of it natural features’. In 2013-2014 after further visits Webster’s description of the geology of the island was considered as one of the most significant works on the geology of Western Europe which together with the publications of a number of European geologists confirm the huge scale of the movements of the Earth’s Crust. By 1856 the stratigraphy of Alum Bay (see Henry Bristow below (Figure 12) was well known and together the with the earlier works of Brander (1766) and Cuvier and Brongniart (1811) enabled early geologists to correlate geological sections and interpret environments across various basins.

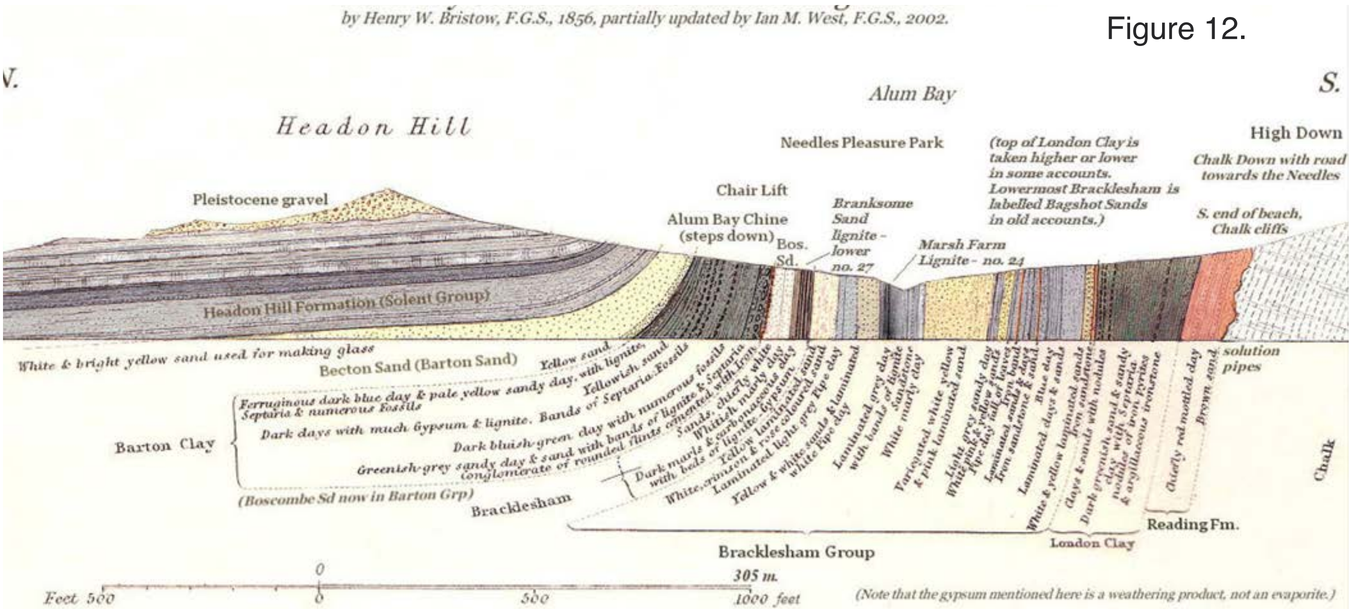


Figure 12.

Significant Fossils (Figures 7-8)

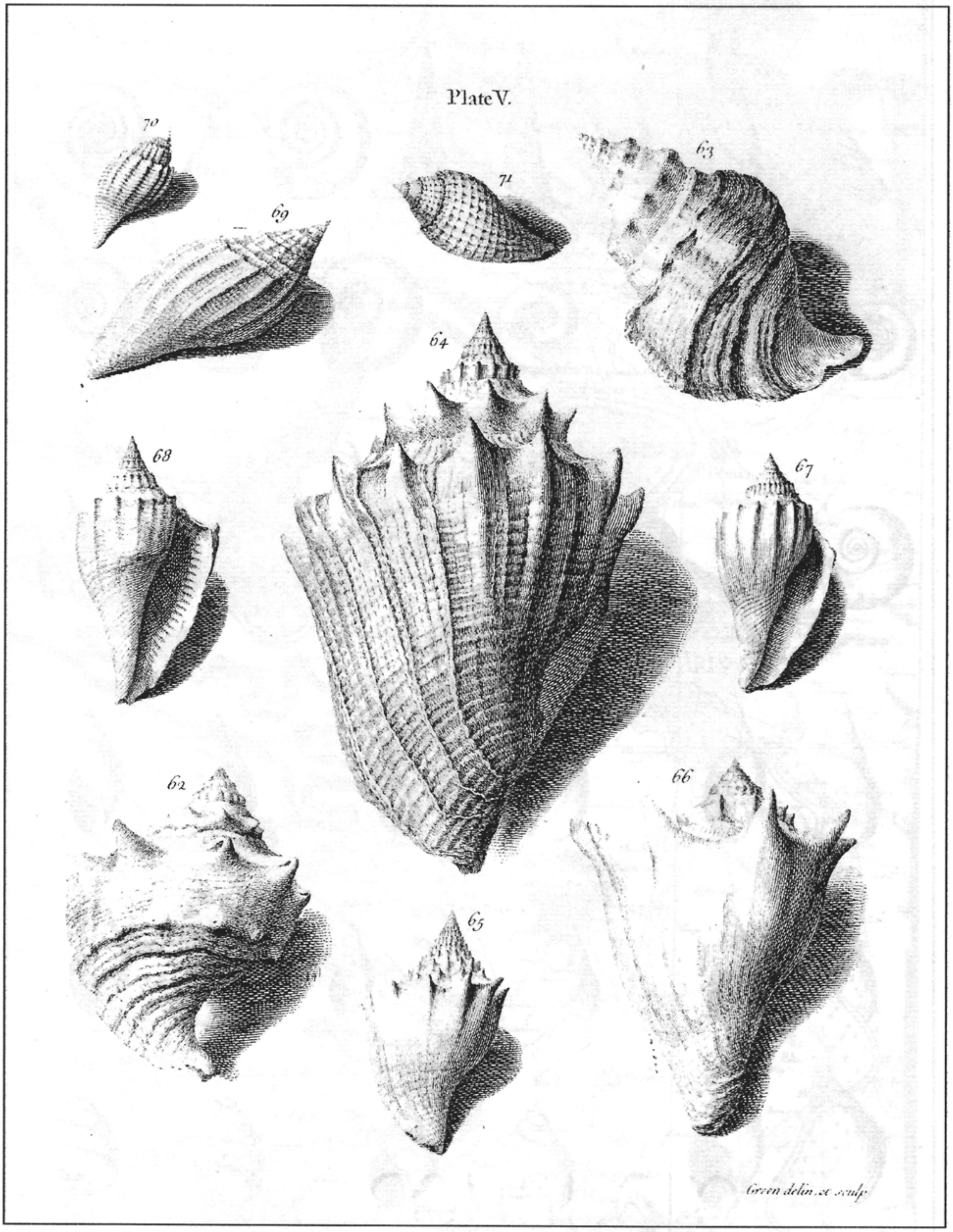


Figure 13. Brander 1766: fossil mollusc shells from the coastal cliffs at Hordwell (now Hordle) on the English mainland west of the Isle of Wight, similar to living marine species; the same fossils were found by Webster (1811-1814) in the Alum Bay strata. Fossil molluscs from the Paris Basin described by Brongniart (1810).

Mineral Exploration in Alum Bay etc

No. 11. Warrant to Mr. Richard Worsley to search for Allum Ore in the Isle of Wight. 1561

AFTER my right harty Comendacons - Whereas the Queans Majesty [Queen Elizabeth the First] being infermyd that there is within that Isle certen Oure of Alume [i.e. Alum Ore at Alum Bay]. For Trial and Profe wherof Her Highness purtley sendith thither the Bearer herof One Bendall. There shall be in her Majesty's name to require you with your Authorite and favour so to assist him in that behalf, as he may revise such partes there as he shall thynk to be meete for the purpose and bring with him some part of the sayde Oure [said Ore - pyrite] to this end he therof make some Profe [proof] here in the Realme. In this part, as her Highness trusteth, You will give Order that no man there shal impede and resist him; So he hath Charge to use himself with such moderation and respect of behavior as shall apperteyne. And thus I byd You hartely well to fare - From the Court at Westmynster the 7th daye of Marche 1561.

Your Assured Frend,

W. CECIL

[William Cecil, First Baron Burghly, chief advisor to Queen Elizabeth 1, Secretary of State and Lord High Treasurer.]

No. III

Figure 14. Panoramic view of the Needles from above the chairlift at Alum Bay.

BARTON TO KIMMERIDGE VIA BOURNEMOUTH
Figures 15-18

The Barton Clay, the Barton Sand and the overlying Headon Hill Formation (of the Solent Group) seen in Alum Bay fare well-known in Hampshire Basin, and are well exposed at Barton and Highcliffe in Christchurch Bay. The strata are of the Bartonian and Priabonian Stages of the Upper Eocene Series deposited between about 42.1 and 35.4 million years (Harland et al., 1982). They correspond roughly in age with the famous Eocene gypsum deposits of the Paris Basin (Plaster of Paris).

The type-section of the Barton Clay and Barton Sand at Barton Cliffs on the mainland consists of sandy clays in the lower part, dark sandy clays and stiff drab clays in the middle part, and clayey sands and light-coloured sands in the upper part (29.26m). The total was given as 69m by Burton (1929) but Barton (1973) has more recently considered the Barton Clay to be thicker (46.4m) and given a total figure for the Barton Beds of 75.4m (note that Bristow, Freshney and Penn (1991) gave the range of the Barton Clay thickness in the Bournemouth area as 20 - 60m, less than this figure but probably based on Burton).

According to West (2017) - "most of the strata are very fossiliferous. The Barton Clay has yielded more than 500 species of fossil mollusc shells. These are quite robust and can easily be cleaned by simply washing them with a soft brush. They range from minute corals (*Turbinolia*) and the little, prickly gastropod *Typhis pungens t*o the robust and fairly common gastropod - *Clavilithes macrospira* to the rare fan-shell *Hippochrenes amplus* . The turreted gastropods *Turritella imbricateria* and *Turritella sulcifera* are very common, and sharks teeth and ray-fish teeth (see above) can be found from time to time. Both the sea-defences and the retreat of the coast away from the most fossiliferous strata has much reduced the fossil-collecting potential. Nevertheless good specimens can still be found in the Naish Farm area between Barton and Highcliffe, and the cliffs at the back of the beach here are well-worth a visit".

Figure 15. Recent discoveries from Barton includes the turtle shown opposite. The specimen was found by a local collector named Adrian Smith. Are lives in Lymington not far from the ferry to the Ilke Of Wight.The specimen is probably the skull of the Eocene genus *Argillochelys*. Sadly it has been poorly preserved and it seem impossible to allocate it a given species. A skull found nearby was referred to the genus and species *Argillochelys athersuchii* by Moody (1980).

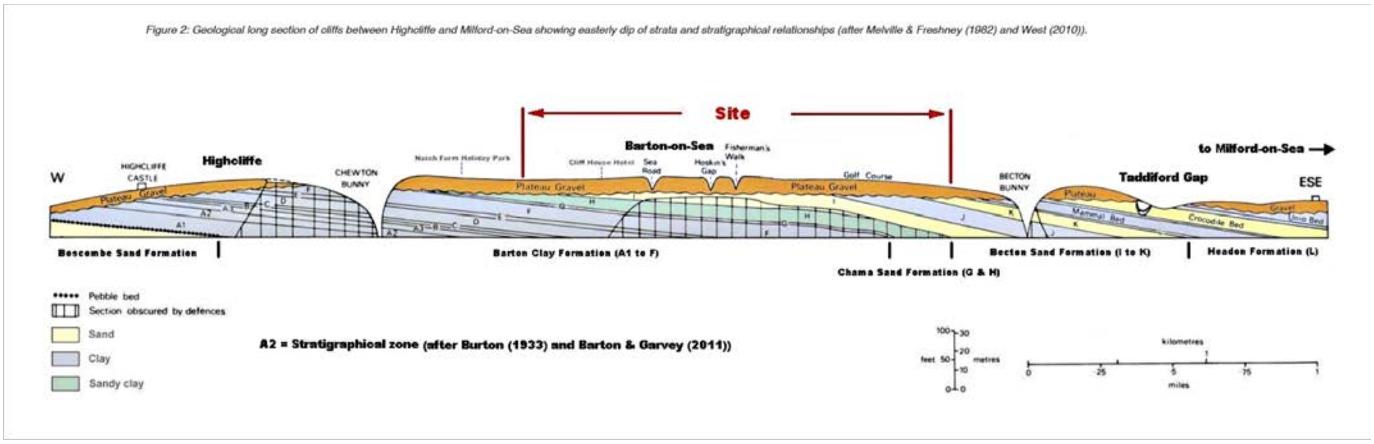
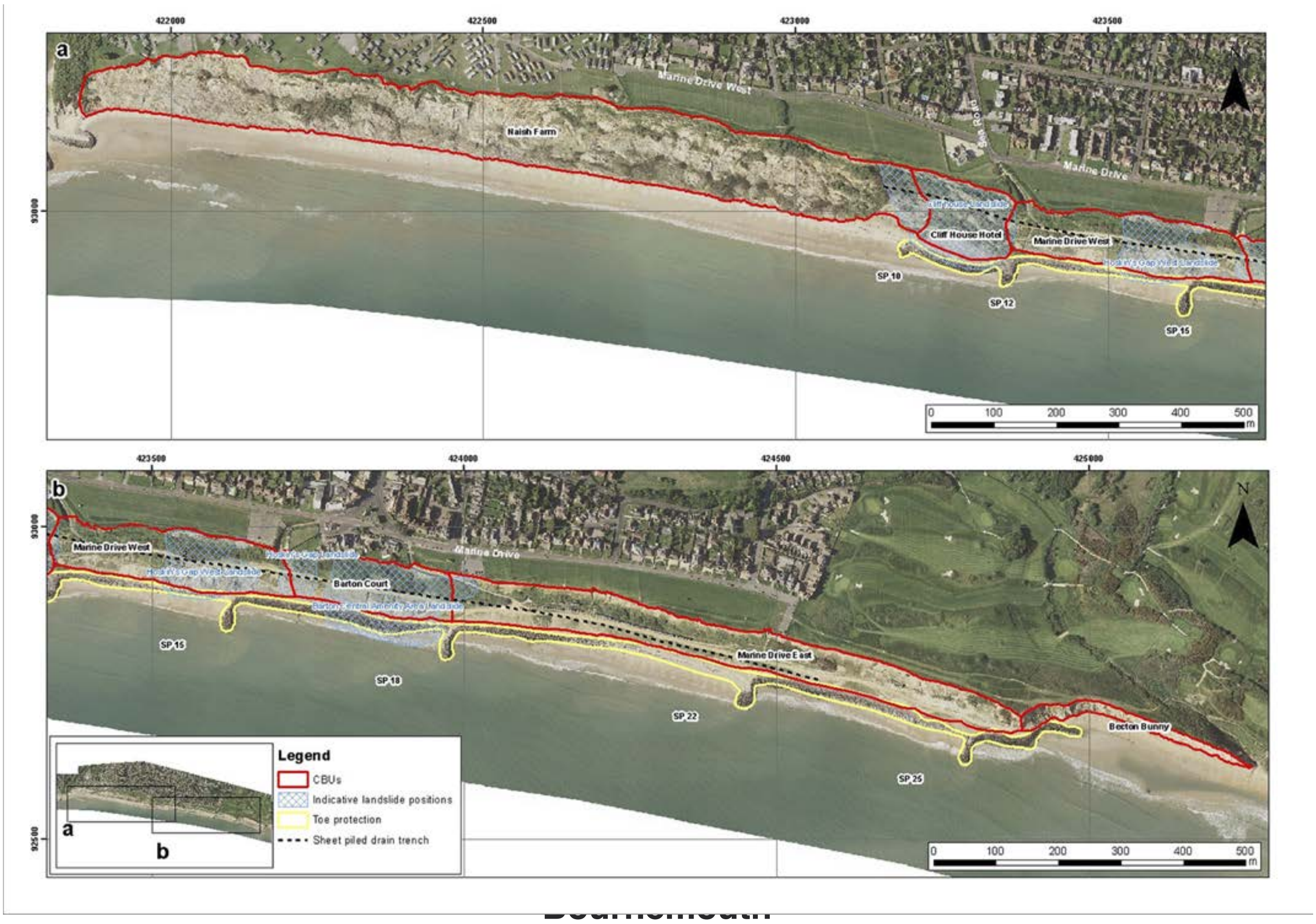


Figure 16. Sketch of Barton Cliffs from west of Highcliff Castle to beyond of Taddiford Gap in the east. The overall dip is to the east. The crosshatch pattern marks the areas that have been strengthened against tidal erosion and landslips. The stratigraphy ranges from the Eocene Boscombe Sands to the Headon Formation in the east.

Due to frequent and significant coastal slumping or landslides little of the Barton Clay can be seen from Barton eastward to the end of the Marine Drive East. The cliffs have large blocks of limestone at the base, some timber piles, much gravel spread above and some iron sheet-piling here and there. This central section is instructive with regard to the development of landslides, the use of and failure of sea-defences. It is also a good area to see the Pleistocene gravel at the top of the cliff and the yellow, oxidised Barton Sands or Becton Sand Formation. Apart from geologists it is of interest to geography students, environmental science students and civil engineering students. A visit is recommended.

Figures 17a-b. below



En route to Bournemouth we cross the border between the Counties of Hampshire and Dorset at Christchurch. Bournemouth is essentially an upmarket holiday resort with three funicular railways found at East Cliff, West Cliff and Southbourne, they are of similar design and all run by the local council. Bournemouth like many British resorts is recent with the first settlement with 695 inhabitants recorded in 1851. The first stagecoach stopped there in 1840 and the railway reached the town.

In 1877 the Prince of Wales built the Red House for Lilly Langtry and the town soon became the place to be seen in the Summer months. The population is now 186K and Bournemouth AFC is close to relegation from the Premier Division.

The geology of the cliffs is mainly comprised of sands and clays of Eocene age capped by Pleistocene gravel terrace or blown sands. To prevent erosion and collapse however, the authorities have built extensive seawalls and planted the cliffs and access to the sediments is restricted to a few exposures which yield fossil leaves and other plant materials.

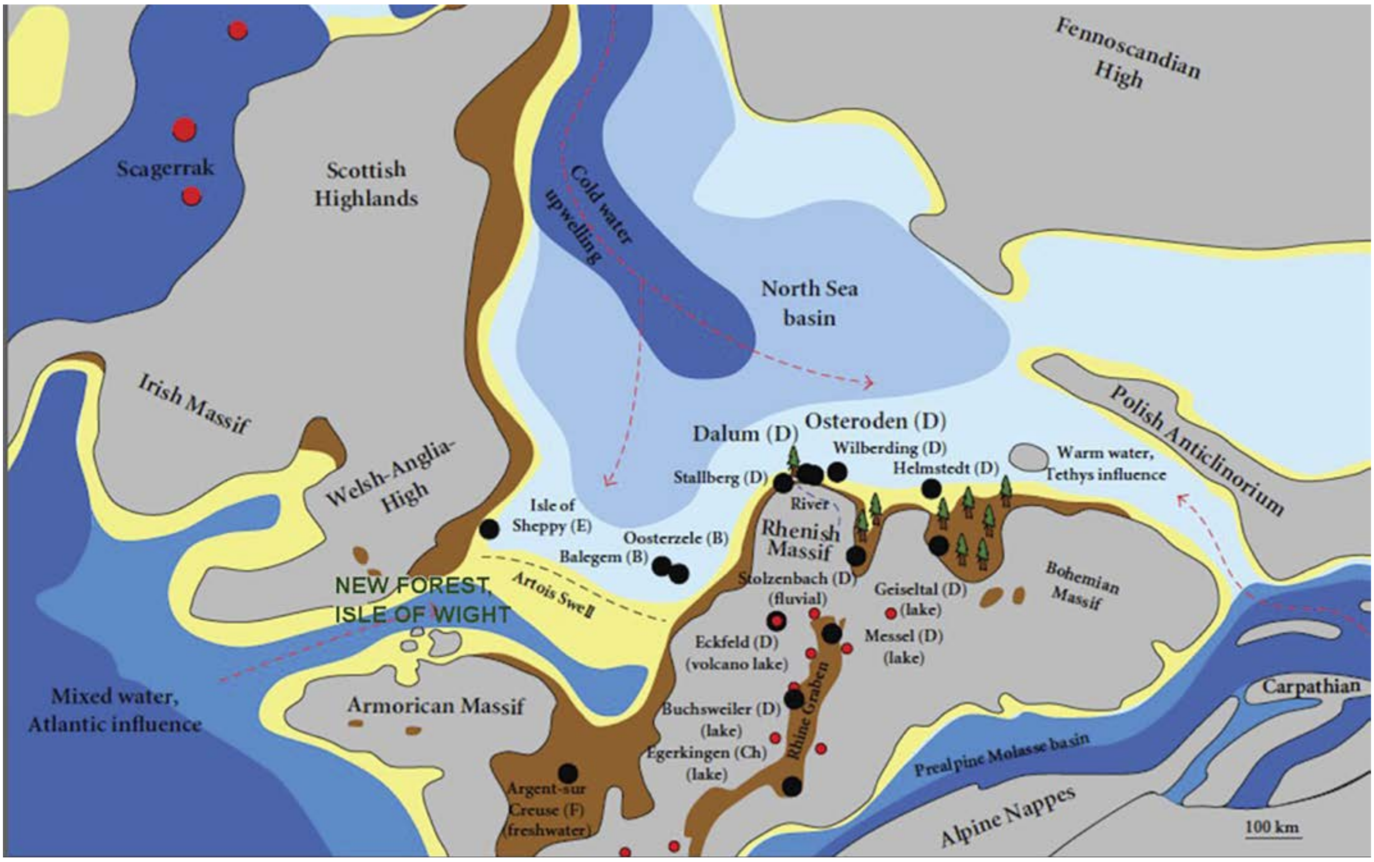


Figure 18. This is a part of a palaeogeographic map, after Diedrich (2012). Mixed water under Atlantic influence is affecting the New Forest and Isle of Wight region. It is of passing interest that the storm beaches of Bournemouth (Boscombe Sands pebble beds) were hit by very large waves so as to produce the big, rounded, battered flint pebbles. Detailed evidence suggests fierce winds from the east, perhaps over the Artois Swell. Modified after Diedrich; Ian West© 2016.

The car ferry from Sandbanks, at the entrance to Poole Harbour, to Studland takes us across to the Isle of Purbeck and the County of Dorset.

DORSET PETROLEUM
Figures 19-20

Wytch Farm Oil Field near Corfe Castle and the Nodding Donkey of Kimmeridge Bay

There are three commercially viable deposits of very different scales in Dorset. They area: Wytch Farm, Wareham and Kimmeridge, all of which have been developed.

Kimmeridge (Discovered 1959, D'Arcy Exploration (BP)) remains a small-scale operation, and continues to produce oil steadily at 100 barrels per day, well beyond its expected life. It is the longest of the oil fields in Dorset and the single nodding-donkey has become an established part of the Kimmeridge landscape.

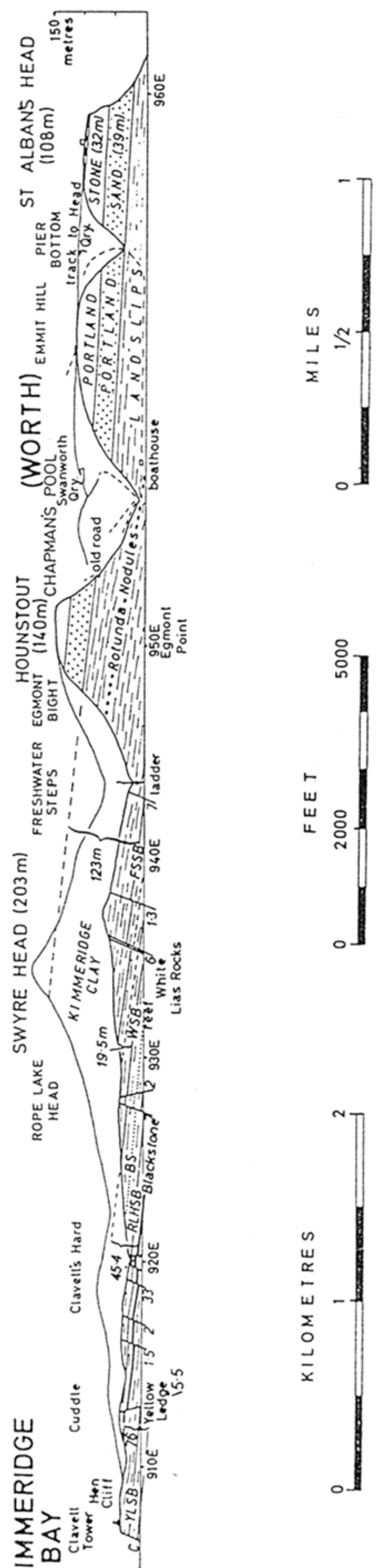
Wareham (Discovered 1964) is slightly larger, but still a small oilfield, producing between 2,000 and 3,000 barrels per day, from 2 wellsites located to the west of Wareham. It is connected to the Wytch Farm gathering station by pipeline.

Wytch Farm (Discovered 1977), in contrast, is Western Europe's largest onshore oilfield – and the sixth largest oilfield in the U.K. Its original daily design capacity was for 65,000 barrels of oil, 10,000,000 cubic feet of gas and 400 tonnes of propane and butane. The site has been substantially modified and in recent years handled in excess of 100,000 barrels per day. (1 barrel = 159 litres = 35 gallons) for a long period. The field is know producing 40,000 bpd and is a joint project between Perenco of France and Premier Oil, it remains Europe's largest on-shore oilfield.

The economic benefits of oil exploration in Dorset are seen at a national level. Locally, the industry is not labour-intensive, but provides an appreciable number of jobs (BP estimate that Wytch Farm employs 230 people when in steady production, and more during drilling work). BP make efforts to place contracts with local companies where possible, and estimate the local expenditure of the field between 1984-1998 is £250 million, with spending in 1997 of £6 million.

Figure 19. Ian West and geologists at Nodding Donkey in Kimmeridge Bay

Figure 20. Coastal section from Kimmeridge Bay to St Albans Head



Coastal sections of the South and East Dorset coast from Owermoigne Corner, 3.5km north-east of Weymouth, to Durlston Head, south of Swanage. Vertical exaggeration ×3.

CORFE CASTLE

(Text from Website (**Figure 21)**

Corfe Castle is the name given to both the village and the Castle. The village is constructed almost completely from the local grey Purbeck limestone.The first castle buildings would have been built of wood. In 979 King Edward was reputedly murdered by his step-mother so that her own son Ethelred the Unready could become King of England. In the latter half of the 11th Century the Castle was rebuilt in stone by William the Conqueror and for the next six hundred years was a royal fortress used by the monarchs of England and latterly their constables.

Figure 21. By 1572 warfare had changed and Corfe Castle was sold by Queen Elizabeth I to Sir Christopher Hatton, her dancing master and favourite. In 1635 the Castle was bought by Sir John Bankes, who was Lord Chief Justice, as an occasional private residence.

As trouble brewed for Charles I, the Bankes family took up permanent residence. By 1643 most of Dorset was occupied by the Parliamentarians, and Lady Bankes and her supporters successfully withstood a six week long siege. Sir John Bankes died in 1644 and the family endured a series of half-hearted blockades by Parliamentary forces. Late in 1645 Colonel Bingham Governor of Poole started a second siege, and treachery by one of the garrison allowed a Parliamentary force into the castle in February 1646. The Roundheads allowed the family to leave the Castle and then it was systematically destroyed by Parliamentary sappers.

Sir Ralph Bankes, son of Sir John, built a new home, Kingston Lacy House, to the west of Wimborne and managed to gather together many of the plundered possessions to furnish the new house.

The Castle remained in the ownership of the Bankes family until 1982 when it was bequeathed as part of the Kingston Lacy and Corfe Castle Estate to the National Trust by Mr.H J R Bankes.

KIMMERIDGE BAY
(Figures 22-26)

At Kimmeridge Bay you will see the Nodding Donkey at the cliff top. This well is producing from the Cornbrash in a possible rollover anticline structure. The oil is a 39° API Liassic sourced crude, identical to the oil in the Sherwood reservoir at Wytch Farm. The well has produced in excess of 2 mmbbl since production started in the mid- 1960s, demonstrating plumbing of a much larger reservoir than can be accommodated in the Kimmeridge structure alone.

The cliffs each side of Kimmeridge Bay expose an almost complete succession of the Kimmeridge Clay, which in this area is over 500m thick, being deposited during the Kimmeridgian and Volgian stages. In detail, the Kimmeridge Clay is composed of parallel laminae of bituminous shale, marl and micrite which can be highly fossiliferous. It very closely resembles the shales of the Lower Jurassic (e.g., Blue Lias seen at Pinhay Bay). Within the Kimmeridge Clay, horizons of "Kimmeridge coal" are found. These highly bituminous oil shales have been used as fuel from the beginning of the 17th century and for ornaments since well before that time.

Figure 22. Ammonite from Kimmeridge Bay.

The Kimmeridge Clay also contains beds of dolostone which, when initially studied in the field, contain abundant microstructures which suggest strong tectonic compression. Small scale thrusts, hanging wall anticlines and pop-up structures all occur in the dolostone beds.

Five main lithologies are present between Kimmeridge Bay and Clavells Hard, 1 km to the east, all of which contain significant quantities of organic carbon:

Clays are medium to dark grey and usually extensively bioturbated. They contain a rich fauna, but usually dominated by only a few species.Bituminous shales consist of fine laminations of alternating clay and kerogen. This lithology always stands proud of the cliff faces and when weathered it splits easily into wafer thin sheets along the organic rich horizons. In thin section the organic matter appears as lenticular reddish-brown masses. The shales are not bioturbated but locally contain large mono-specific assemblages of bivalves.

Oil shales (Blackstone) are rather dark brown rocks containing 30-60% organic carbon. They are very finely laminated and so organic rich that they burn easily when exposed to a naked flame. (The red colour of part of the cliff at Clavells Hard is a result of the cliff catching alight some years ago!). Some oil shales also contain irregularly shaped ovoids of carbonate (probably faecal pellets).

Figure 23. Burning shale

Coccolith limestones are best seen higher in the succession. They usually consist of finely laminated coccolith and kerogen alternations, often containing complete coccospheres.

Cementstones and concretions occur sporadically throughout the sequence. These are diagenetic in ori-gin although in some cases they may have nucleated around originally carbonate-rich horizons. The small nodules found high in the succession (e.g. the Rotunda Nodule Bed) are calcitic and non-ferroan; the more massive units which we will see consist of ferroan dolomite or ankerite (many weather to yellow or orange because of the iron).

The Blackstone, the main Kimmeridge oil shale is best seen at and near Clavell's Hard, east of Kimmeridge. It was worked on what is now a rather inaccessible cliff quarry. Underground mining took place from levels or adits, one of which still remains. The oil shale was also mined inland of here. The Blackstone occurs in the Upper Kimmeridge Clay above the level of the strata at Kimmeridge Bay. Proceeding eastward firstly Hen Cliff, Yellow Ledge and Cuddle is seen. The oil shale is then reached at Clavell's Hard or Blackstone Point (Figs. 20&21) about one kilometre east of Kimmeridge Bay. Here and in the adjacent bay to the west there have been fires in the oil-shale.

The mudstones, bituminous shales and oil shales show a crude cyclicity, with the coccolith limestones, where present, usually associated with the most organic-rich levels.
The organic matter present is typical marine algal in origin and it has been suggested that each facies cycle represents progressive entrophification of a restricted basin . During clay deposition bot-

tom waters were relatively oxygenated-ed and most of the organic matter was destroyed by aerobic bacteria. This led in turn to oxygen depletion and, as organic deposition continued, the sediment surface first underwent a period of fluctuating oxidising/reducing conditions (giving the bituminous shales) and eventually the whole water column became anoxic and oil shales were deposited. Occasional overturn of the anoxic nutrient-rich water column, causing mixing with the oxygenated surface waters, may have led to seasonal coccolith blooms to produce the laminated coccolith limestones.

The origin of the concretions has been studied using carbon and oxygen isotope ratios of the carbonate. Oxygen isotope ratios reflect, in part, the temperature of precipitation: this is related to the depth in the sediment at which the concretion formed. Carbon isotope ratios reflect the source of carbon. Under moderately reducing conditions, bacterial sulphate reduction releases CO2 with S13C values around -25%. Carbonates formed in this zone will have comparable isotope ratios and will be non-ferroan (e.g. the Rotunda nodules) because the H2S released at the same time precipitates any free iron as free iron as sulphides. At greater burial depths, where no sulphate is left, bacterial fermentation reactions release isotopically heavy CO2 (up to +15%). Carbonates precipitated here will be isotopically heavy and usually ferroan. Finally, at even greater depths, thermal decarboxylation of the organic matter releases iso-topically light CO2 again giving rise to isotopically light ferroan carbonates. All of these processes are reflected in the chemistry and isotopic ratios of the carbonates in the Kimmeridge Clay.

STEVE ETCHES MUSEUM KIMMERIDGE

I first met Steve Etches when I was President / Vice President of the Geologists' Association in the 1990s. Steve had been collecting fossils since he was 5 years old but by the time met him he had amassed a huge collection of fossils ranging from fossilised fish-eggs to complete ichthyosaurs, all displayed beautifully in his garage.

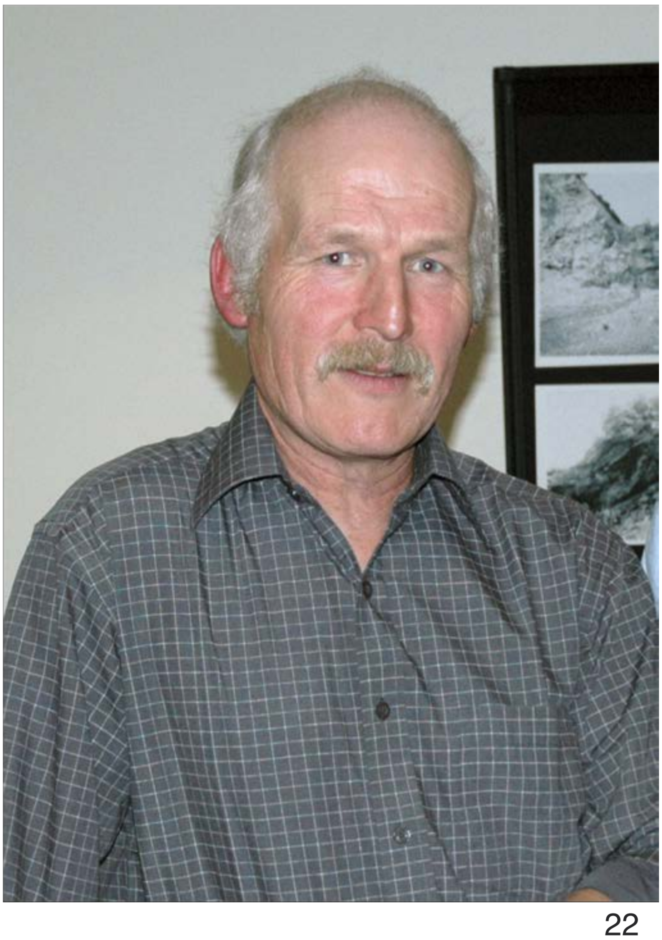


Figure 24. Steve Etches

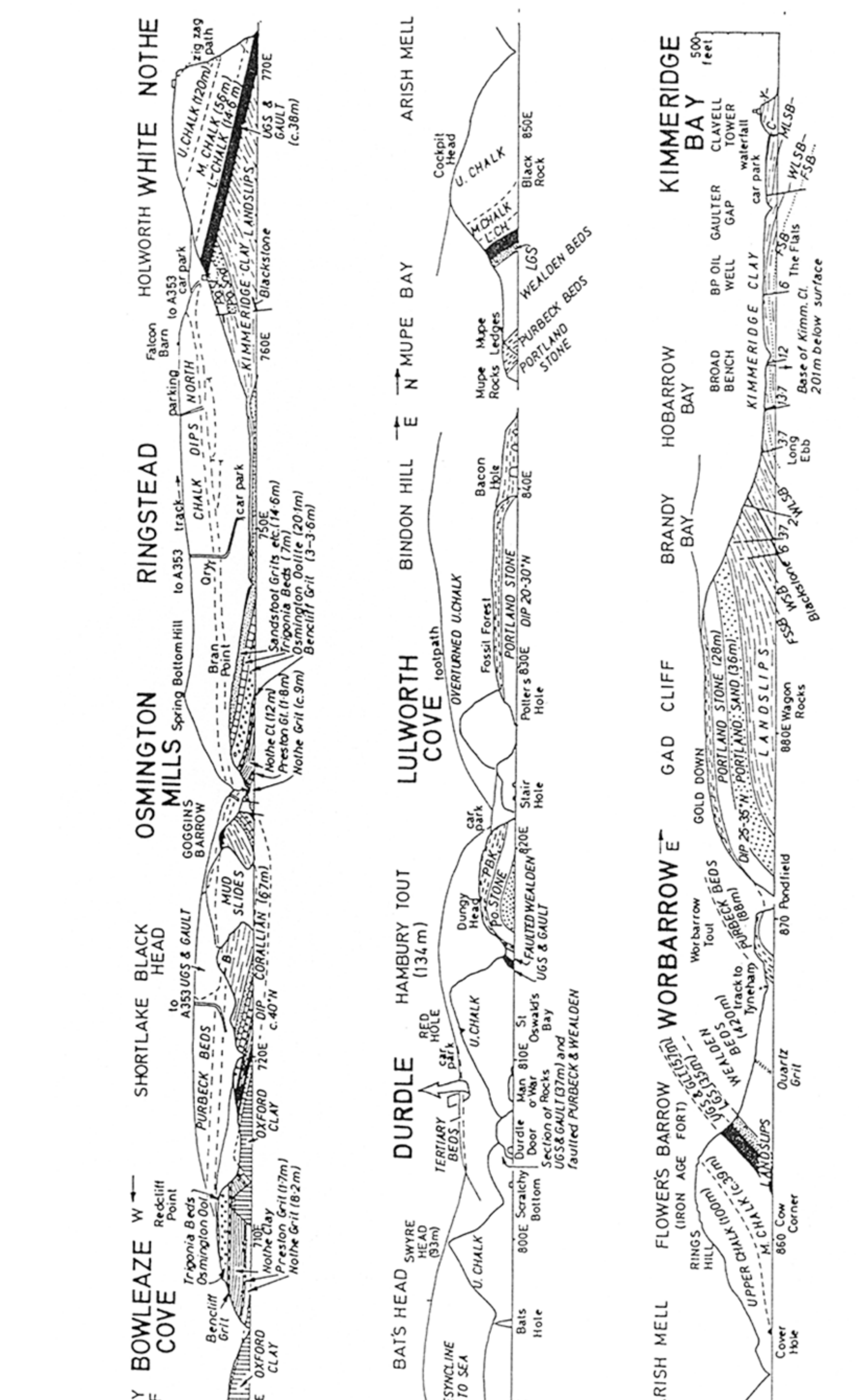
The Etches Collection is housed in a multiimillion pound project documenting the geohistory of The Kimmeridge Formation. This outstanding museum, nestles in the village of Kimmeridge on the .Dorset coast, bringing 150 million years of mainly marine fossils to life. Giant fossilised femurs and two metre long jaws of pliosaurs line the walls alongside predators and the remains of their prey. Pliosaurs, sharks and ichthyosaurs glide the surrounding digital waters.

Steve received an MBE in 2014 for his services to palaeontology. His aim has always been to make the collection available to the public and 'share the remarkable stories behind the extraordinary creatures'.

	STAGES		ZONES	DIVISIONS		THICKNESS in metres
UPPER JURASSIC	PORTLANDIAN	TITHONIAN OR VOLGIAN	*Cypridea setina* *Cypridea vidrana* *Cypridea granulosa* *Cypridea dunkeri* *Titanites (?) oppressus*	PURBECK BEDS (PARS)	LULWORTH BEDS	62
			Titanites anguiformis *Galbanites kerberus* *Galbanites okusensis*	PORTLAND BEDS	PORTLAND STONE	73
			Glaucolithites glaucolithus *Progalbanites albani*		PORTLAND SAND	
	UPPER KIMMERIDGIAN		*Virgatopavlovia fittoni* *Pavolvia rotunda* *Pavolvia pallasioides* *Pectinatites pectinatus* *Pectinatites hudlestoni* *Pectinatites wheatleyensis* *Pectinatites scitulus* *Pectinatites elegans*	KIMMERIDGE CLAY	UPPER	242
	(LOWER) KIMMERIDGIAN		*Aulacostephanus autissiodorensis* *Aulacostephanus eudoxus* *Aulacostephanus mutabilis* *Rasenia cymadoce* *Pictonia baylei*		LOWER	c 290
	OXFORDIAN		*Amoeboceras rosenkrantzi* *Amoeboceras regulare* *Amoeboceras serratum* *Amoeboceras glosense* *Cardioceras tenuiserratum* *Cardioceras densiplicatum* *Cardioceras cordatum*	CORALLIAN BEDS		60
			Quentstedtoceras mariae	OXFORD CLAY UPPER		c.90

Detailed Upper Jurassic Stratigraphy (House 1990)

Figure 25.



Geological sections from Bowlease Cove to Kimmeridge Bay.

Figure 26

PEVERIL POINT, DURLSTON BAY, SWANAGE

(General view from the cliff-top of the bay, looking northeast)

(Figures 27-28)

Figure 27. Peveril Point is a small promontory that forms the southern end of Swanage Bay. Historically it was an ideal look out position for spotting some of Dorset's elusive smugglers. The 'free-traders' used all sorts of cunning means to try and import tea, tobacco and of course, wine and spirits from the continent to avoid the government taxation. The Coastguard cottages were built to house the men trying to catch the smugglers who would use the remote caves and inlets along the coast to land their contraband whenever there was a 'smugglers moon' – a dark night.

The limestone and shales of the Purbeck Formation are dipping northward at a low angle. The east-west strike is shown by the reefs. The syncline of the Broken Shell Limestone is conspicuous, but the narrow anticline to the north cannot be seen. The shales of the Chief Beef Member and the limestones of the Corbula Member are visible in the cliff nearer to the camera. **Ian West** (c) 2011.

The rocks on the headland represent the geological type-section of the Purbeck Group (" Purbeckian " - or "Purbeckien ") and the geology has been much studied since it was first described by Thomas Webster in 1816.

Recently Johann Schnyder et al (Paris) wrote a paper entitled: the *Conjunctive use of spectral gamma-ray logs and clay mineralogy in defining late Jurassic–early Cretaceous palaeoclimate change (Dorset, U.K.)* Their work on gamma ray resulted in the presentation of a very detailed interpretation of the climatic changes that took place in the Durlston Jurassic-Early Cretaceous as depicted in the Lulworth and Durlston formations of the Purbeck Limestone Group.The base of the section at Peveril Point indicates an evaporitic-Sabkha phase. Where as the Upper was indicative of Marine invasion and freshwater incursions.

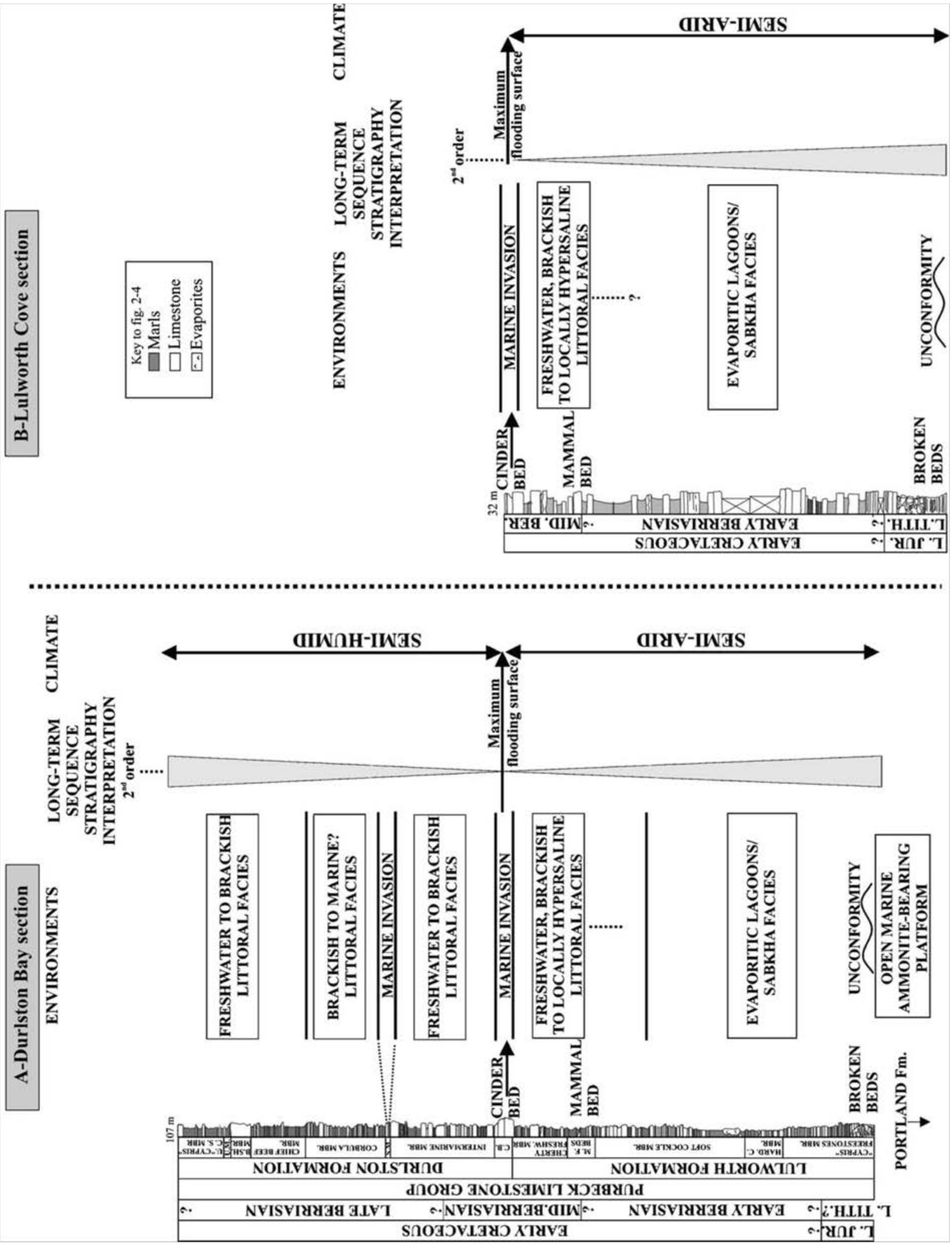

A-Durlston Bay section
B-Lulworth Cove section
Key to fig. 2-4
Marls
Limestone
Evaporites
ENVIRONMENTS
LONG-TERM SEQUENCE STRATIGRAPHY INTERPRETATION
CLIMATE
SEMI-HUMID
SEMI-ARID
Maximum flooding surface
2nd order
FRESHWATER TO BRACKISH LITTORAL FACIES
BRACKISH TO MARINE? LITTORAL FACIES
MARINE INVASION
FRESHWATER, BRACKISH TO LOCALLY HYPERSALINE LITTORAL FACIES
EVAPORITIC LAGOONS/ SABKHA FACIES
UNCONFORMITY
OPEN MARINE AMMONITE-BEARING PLATFORM
CINDER BED
MAMMAL BED
BROKEN BEDS
PORTLAND Fm.
107 m
32 m
EARLY CRETACEOUS
L. JUR.
L. TITH.
EARLY BERRIASIAN
MID. BERRIASIAN
LATE BERRIASIAN
MID. BER.
PURBECK LIMESTONE GROUP
LULWORTH FORMATION
DURLSTON FORMATION

Figure 28

LULWORTH COVE/ STAIR HOLE
(Figures 29-31)

From Durlston Bay we will travel west along the Jurassic Coast to two localities that expose the Portland to Chalk succession within the so-called "Lulworth Crumple" - a minor structure formed during inversion on the major listric faults.

The Chalk at the back of Lulworth Cove is vertical, with the dip decreasing further down the succession. Of particular interest are the "Broken Beds" within the Purbeck, which are thought to result from disruption of a rock which was initially weak because of dissolution of evaporites.

Sedimentologically the sequence represents the transition from marine limestones in the Portlandian to sabkha (arid coastal plain) deposits with soils in the Purbeckian, fluviatile Wealden sediments associated with a second phase of rifting, then progressive flooding of the land during Greensand times into the pelagic Chalk.

Oil seeps from the Wealden Sands occur at a number of localities, although it is best seen in Stair Hole. The oil is moderately biodegraded but sufficient biomarkers are still present to correlate the oil the with that of the Wytch Farm.

Figure 29. View eastwards from above Stair Hole to Lulworth Cove. Upper Jurassic strata to the south with white chalks of the Upper Cretaceous behind the beach in Lulworth Cove. Image RTJM

‘Stair Hole, just to the west of Lulworth Cove, is a remarkable small cove with natural arches cut into steeply-dipping Portland and basal Purbeck limestones. Through these arches and a gap where one has collapsed the sea enters to erode the softer parts of the Purbeck limestones and shales. Soft multicoloured Wealden strata slump southwards towards the sea. The most remarkable feature of Stair Hole is seen in the eastern cliff. Here is a cross-section through the Lulworth Crumple, where small folds in the Purbeck strata are present within the steep northern limb of the Purbeck Monocline'. (From West 2010-11)

The remains of fossil trees, about 140 million years old, can be seen, most are empty moulds, but there is some preservation as silicified wood. There are also stromatolites or, more strictly, thrombolites which encrust the trees and interesting evaporite and tectonic features. The washing away of the evaporites and breccia reveals the remains of Late Jurassic trees and thrombolite mounds surrounding them. The trees are mainly of an ancient Cypress type (*Protocupressinoxylon*). They are rooted in a calcareous palaeosol (ancient soil), the Great Dirt Bed. Above the trees is are microbial mounds of thrombolitic ("stromatolitic") limestone. Above this the unusual Broken Beds, a limestone breccia that was originally evaporitic (a cargneule). This is the thin margin of the Purbeck Anhydrite under much of southern and south-eastern England and well-known to the oil industry as a seismic reflector. This marginal facies of the Purbeck evaporites is well-seen at the Fossil Forest and the adjacent Potters Hole.

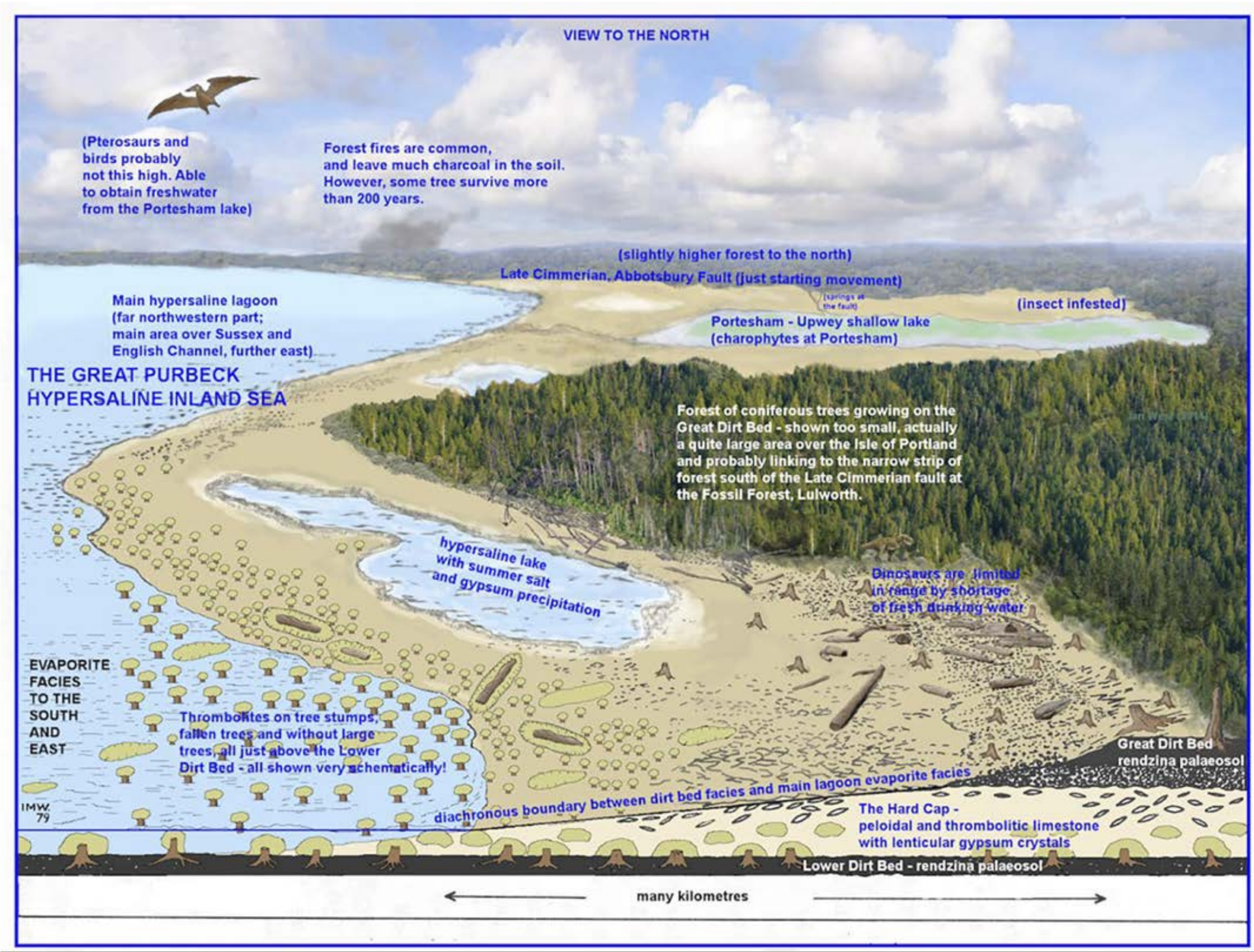


Figure 30. Reconstruction of landscape during the Purbeckian (Upper Jurassic-Lower Cretaceous). The landscape is the result of a major regressive phase resulting in a restricted but interesting fauna and flora. We have already seen the type section at Durlston Bay near Swanage, east of Kimmeridge Bay where the section is 119m thick and is comprised of alternating lagoonal and lacustrine limestones, shales and marls. Fresh-brackish shell beds, fossil turtles, crocodiles, dinosaurs, fish and insects, ostracods and gastropods are commonplace.

	STAGES	ZONES	DIVISIONS	THICKNESS in metres
MIDDLE JURASSIC	CALLOVIAN	*Quenstedtoceras lamberti* *Peltoceras athleta*	OXFORD CLAY MIDDLE	c.70
		Erymnoceras coronatum *Kosmoceras jason*	OXFORD CLAY LOWER	c.70
		Sigaloceras calloviense	KELLAWAYS ROCK KELLAWAYS CLAY	c.20
		Macrocephalites macrocephalus	CORNBRASH UPPER	5·0
	BATHONIAN	*Clydoniceras discus*	CORNBRASH LOWER	2·1
			FOREST MARBLE	75
		Oppelia aspidoides	FULLER'S EARTH (UPPER OR FROME FORMATION)	38
		Procerites hodsoni	WATTONENSIS BEDS	c.7·6
		Morrisiceras morrisi *Tulites subcontractus* *Procerites progracilis* *Asphinctites tenuiplicatus*	FULLER'S EARTH (LOWER)	250
		Zigzagiceras zigzag	ZIGZAG BED	0·15
	BAJOCIAN	*Parkinsonia parkinsoni* *Strenoceras garantiana* *Strenoceras subfurcatum* *Stephanoceras humphresianum* *Emileia sauzei* *Witchellia laeviuscula* *Hyperlioceras discites*	INFERIOR OOLITE	6·0
	AALENIAN	*Graphoceras concavum* *Ludwigia murchisonae*	SCISSUM BEDS	1·3
		Leioceras opalinum	BRIDPORT SANDS (PARS)	2·0

Detailed Middle Jurassic stratigraphy (From House 1990)

Figure 31.

	STAGES		ZONES	DIVISIONS	THICKNESS in metres
LOWER JURASSIC	TOARCIAN	UPPER LIAS	*Dumortieria levesquei*	BRIDPORT SANDS (PARS)	43
				DOWN CLIFF CLAY	21
			Grammoceras thouarsense *Haugia variabilis* *Hildoceras bifrons* *Harpoceras falciferum* *Dactylioceras tenuicostatum*	JUNCTION BED	4
	PLEINSBACHIAN	MIDDLE LIAS	*Pleuroceras spinatum*	MARLSTONE ROCK BED	0·6
				THORNCOMBE SANDS	27
			Amaltheus margaritatus	MARGARITATUS BEDS	2·3
				DOWN CLIFF SANDS	26
				EYPE CLAY	68
				THREE TIERS	10
		LOWER LIAS	*Prodactylioceras davoei*	GREEN AMMONITE BEDS	34
			Tragophylloceras ibex	BELEMNITE STONE	0·15
			Uptonia jamesoni	BELEMNITE MARLS	23
	SINEMURIAN		*Echioceras raricostatum* *Oxynoticeras oxynotum* *Asteroceras obtusum*	BLACK VEN MARLS	46
			Caenisites turneri	SHALES WITH BEEF	25
			Arnioceras semicostatum *Arietites bucklandi*	BLUE LIAS	32
	HETTANGIAN		*Schlotheimia angulata* *Alsatites liasicus* *Psiloceras planorbis*		

Detailed Lower Jurassic stratigraphy (From House 1990)

OSMINGTON MILLS
(Figures 32-35)

The cliffs at Osmington Mills expose the Corallian facies of the Late Jurassic (Oxfordian) (Fig. 13) The Corallian facies were deposited on the southern margin of the then emergent London-Brabant massif. In general, the sediments are limestones, clays and sandstones which form four regressive cycles. An idealised cycle has an erosive base overlain by limestones (which locally can be reefal), clays and finally sandstones. Talbot (1973) concluded that the erosive base to these cycles represents a rapid marine transgression, which subsequently diminished the area of land available to supply terrigenous detritus. Therefore, carbonate deposition predominated during periods of high stand. As relative sea level fell, so clays derived from the London-Brabant massif reached the south coast area. As the south-ern shores of the massif prograded southwards, nearshore, tidal sands were deposited upon the offshore clays (Fig. 15). A notable exception to this general model is the Osmington Oolite Group which we will study. In this group, the offshore clays are overlain by oolites which were deposited as a southward-migrating carbonate sand barrier. Overlying the oolites are lagoonal sands, silts and clays.

The oldest part of the Corallian we shall see is the Nothe Grit. The complete succession of cycles 2 (Berkshire Oolite) and 3 (Osmington Oolite) are accessible. Within the Bencliff Grits of the second cycle, oil seeps are clearly visible. It was these seeps that prompted the drilling of the first UK "offshore" hole on Lulworth Banks. Progressively younger beds will be examined by walking eastwards:

Nothe Grit - This grey sandstone has siltstone and mudstone laminations and large carbonate cement-ed concretions.

***Trigonia hudlestoni* Bed** - This grainstone marks the base of the second cycle and has a diverse fauna dominated by bivalves.

Nothe Clay - This is a bluish clay with well cemented sandstone laminae and stringers. This unit is poor-ly exposed due to Pleistocene-Recent landslips along this incompetent clay unit.

Bencliff Grits - These yellow-brown, medium grained sandstones are commonly oil stained (Fig. 17). They show a wide range of sedimentary structures including parallel lamination, low angle crossbed-ding, ripple lamination, flaser bedding, scours and swaley cross-stratification (Allen and Underhill 1989). Fauna is limited, but trace fossils and plant debris is abundant indicating a nearby land source. The most distinctive feature of this unit, however, are the large, well-cemented "doggers" or concretions (paramoudra).These sandstones were probably laid down in a tidal flat or estuarine setting with a dom-inant unidirectional flow regime (Allen and Underhill 1989).

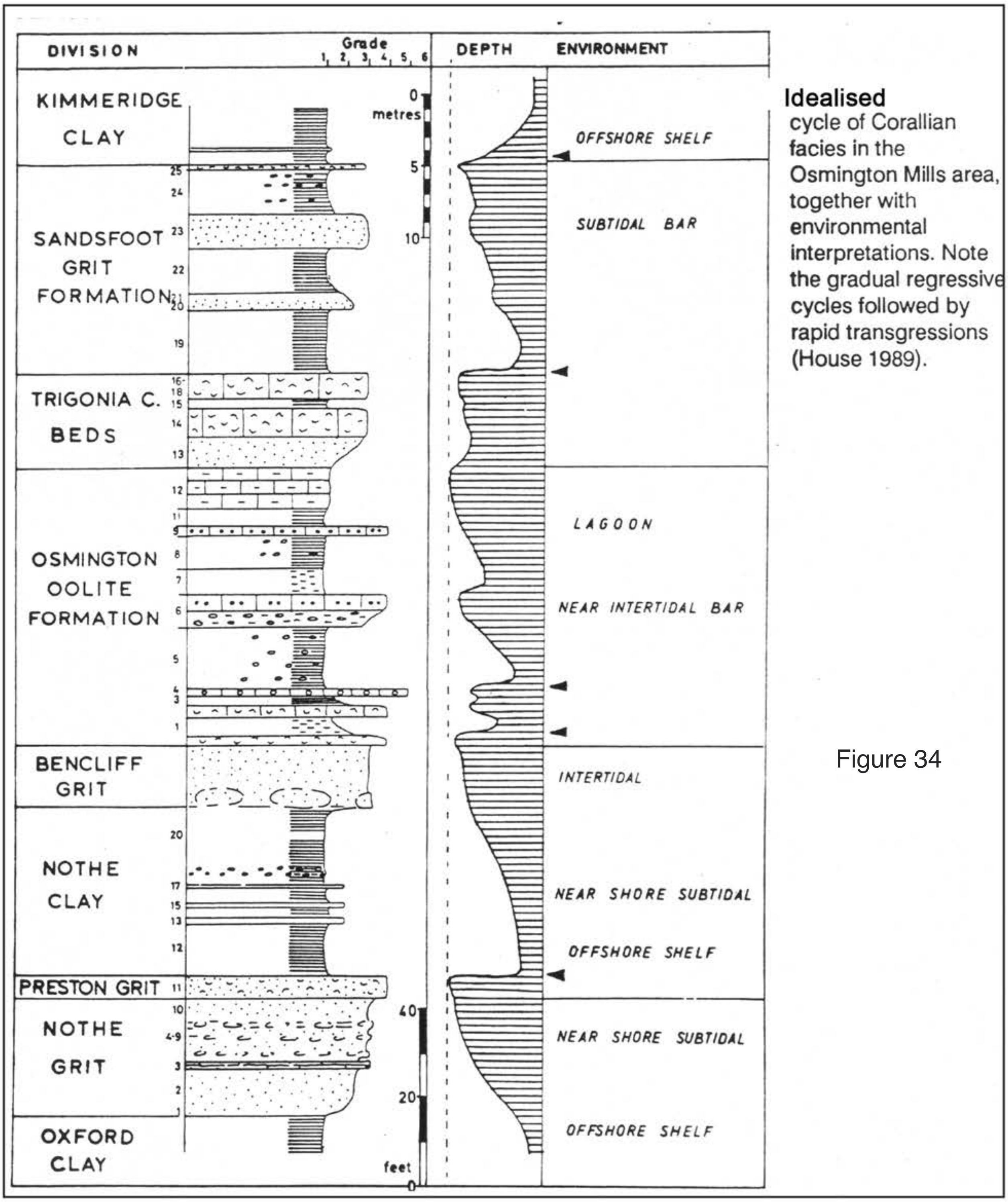
Osmington Oolite Formation - This unit is composed of calcareous clays separated by limestone beds, the most notable of which is a several metre thick oolitic unit from which the formation takes its name. This oolitic unit is pale cream and cross-bedded with abundant internal erosion surfaces. Although it contains few body fossils it has an abundant ichnofauna, dominantly Skolithos type burrows.

The Oolite was deposited as a southward migrating carbonate sandbody. The limestone beds beneath the oolitic unit are skeletal wackestones with one unit of oncolitic pack-stone. The ichnofauna in these beds is prolific. These sediments were deposited on the open shelf in front of the advancing oolite shoal. Above the oolite unit, the limestone beds contain a different ichnofauna to those below and were deposited in the lagoon which formed behind the oolite shoal.

***Trigonia clavellata* Bed** - This thin limestone bed is well exposed on the foreshore and is composed of skeletal packstone/grainstone, with the dominant grains being well preserved trigonid bivalves.

Figure 32. Within the Bencliff Grits of the second cycle, oil seeps are clearly visible. It was these seeps that prompted the drilling of the first UK "off-shore" hole on the Lulworth Banks.

Figure 33. The most distinctive feature of the Bencliff Grits are the large, well-cemented "doggers" or concretions (paramoudra).These sandstones were probably laid down in a tidal flat or estuarine setting with a dom-inant unidirectional flow regime (Allen and Underhill 1989).



Idealised cycle of Corallian facies in the Osmington Mills area, together with environmental interpretations. Note the gradual regressive cycles followed by rapid transgressions (House 1989).

Figure 34

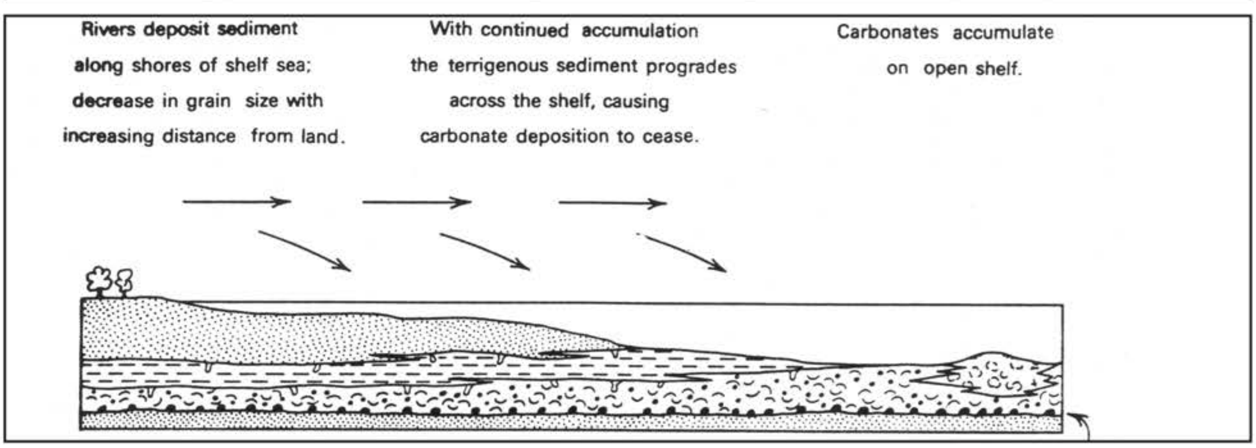
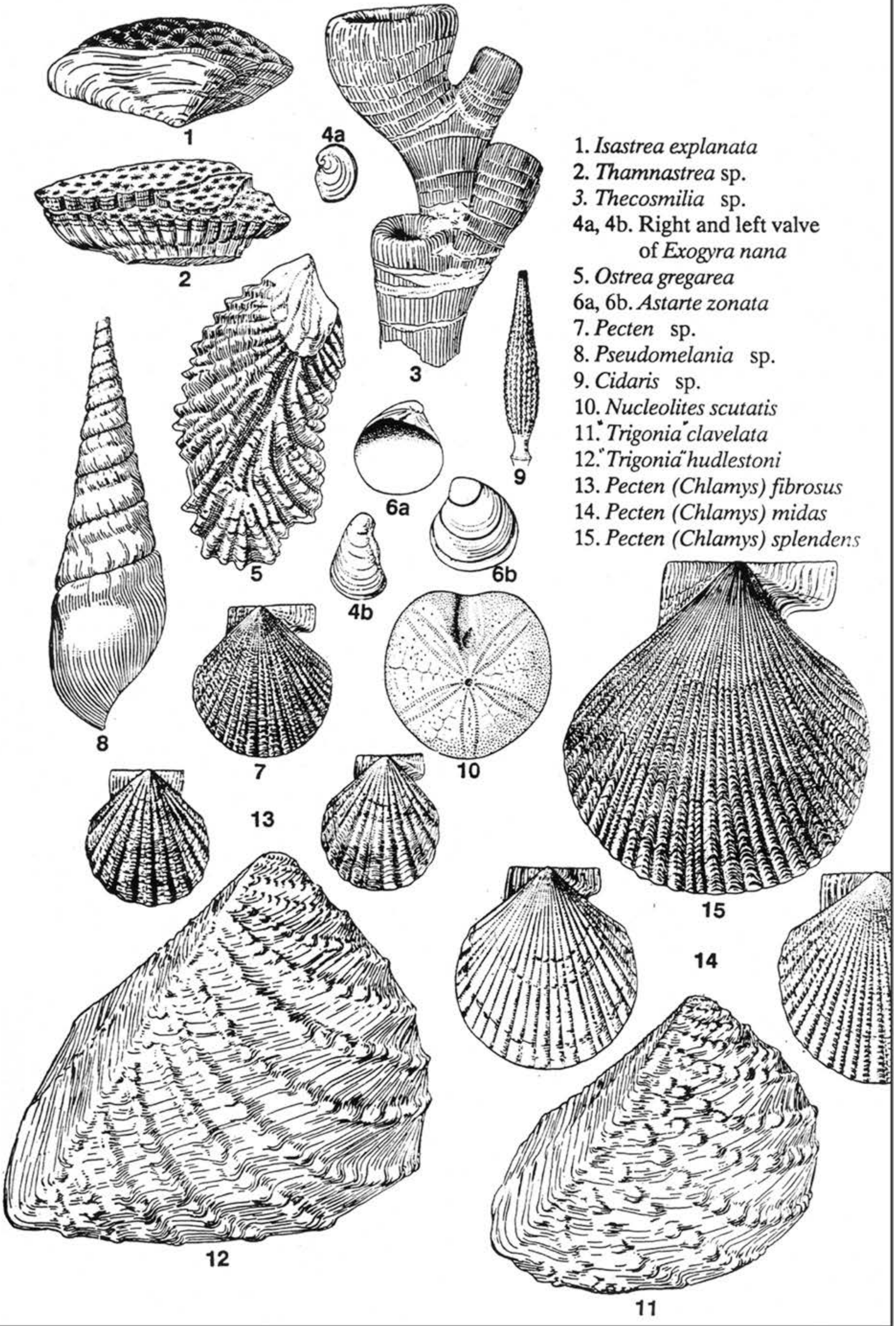


Figure 35

Figure 16

Common fossils from the Corallian facies.



1. *Isastrea explanata*
2. *Thamnastrea* sp.
3. *Thecosmilia* sp.

4a, 4b. Right and left valve of *Exogyra nana*

5. *Ostrea gregarea*

6a, 6b. *Astarte zonata*

7. *Pecten* sp.
8. *Pseudomelania* sp.
9. *Cidaris* sp.
10. *Nucleolites scutatis*
11. "*Trigonia*" *clavelata*
12. "*Trigonia*" *hudlestoni*
13. *Pecten (Chlamys) fibrosus*
14. *Pecten (Chlamys) midas*
15. *Pecten (Chlamys) splendens*

REDCLIFF
(Figures 36-37)

Redcliff, Preston, Weymouth. This cliff section east of Weymouth is part of the Jurassic Coast. The cliff exposes Redcliff Formation of the Corallian Group (Jurassic). The upper cliff is formed of Osmington Oolite and Bencliff Grit. Below this Nothe Clay is exposed and at beach level the Nothe Grit and Preston Grit is seen. The low cliff is quite stable helped by little marine erosion due to protection by the natural boulder beach.

Figures 36-37

However, the Nothe Clay flows from the middle section onto the beach and the overlying Bencliff Grit and Osmington Oolite is affected by rotational slip. Movement in the area has been occurring for decades but a particularly large section started to move in early April 2016 (100 metres long and 10 metres wide). This has continued to move to the present time, the block having dropped around 3-4 metres. Fortunately, there is nothing of particular value affected by the movement. However, it is a classic example of mass-movement.

THE ISLE OF PORTLAND
(Figures 38-40)

An aerial of the island shows that is pockmarked by countless quarries where the Portland and Purbeck limestones in this area being quarried for building and facing stone for hundreds of years, with many of the local towns originating as quarrying towns. Like the dockers and more recently the printers the industry was a closed guild with only direct descendants of quarrymen were admitted.

The island is joined to the mainland by Chesil Beach with the oldest rocks - of the Kimmeridge Formation exposed along the northern rim of the island.

Geologists tend to gather inside or outside, the well-named Heights Hotel before visiting the various outcrops and quarries many of which stopped functioning over a 100 years ago. It is worth remembering however, that the quarries were first really exploited after the Great Fire of London in 1666 having been previously being chosen by Inigo Jones (1573-1652) for the Banqueting Hall in Whitehall from 1619-1622 and as local building stones by the Romans.

King Barrow Quarry is now an S.S.S.I and a Wildlife Trust Reserve, an important habitat for wild flowers and butterflies, part of the quarry is of particular geological interest and it is maintained by the Dorset Geological Sites Group which is devoted to the preservation.

'The rocks in the quarries are Upper Jurassic Portland Stone with Purbeck Limestone strata lying conformably above. Our interest is a small remnant of a fossil forest similar to that seen at Lulworth. A number of circular algal limestone structures are visible on a ledge at the western edge of the quarry. In recent years these have been overwhelmed by the growth of cotoneaster to such an extent that they were barely visible. In 2010 an effort was made to clear the site with good results.
The structures are in the lowest Purbeck strata (the Caps & Dirts Member) laid down about 146 million years ago. The British Isles was at the latitude of southern Spain and northern Africa about 30 to 35 degrees north of the Equator. The Portland Stone was laid down in marine conditions but, by Purbeck times, water levels had dropped and the area was low lying land covered by coniferous trees bordering an extensive lagoon. The 'Dirt Beds' refer to beds of fossil soil in which fossilised roots of coniferous trees have been found elsewhere on Portland. The 'Caps' are algal limestone situated immediately above each Dirt Bed in the sequence.

Later the water level in the lagoon began to rise and gradually flooded the area causing the trees to die. Calcium carbonate secreting algae living in the lagoon colonized the area around the bases of the tree trunks. They gradually built up a limestone sheath around each trunk which increased in height as the water deepened. The tree trunks themselves, in most cases gradually decayed. An impression of the bark often remains on the inner wall. Sometimes remnants of silicified wood have been found still within the central hole.'

The conifers are *Protocupressinoxylon purbeckensis*, now extinct. The painting was one of four illustrations of Purbeck life used in the Purbeck CD project in 2009.

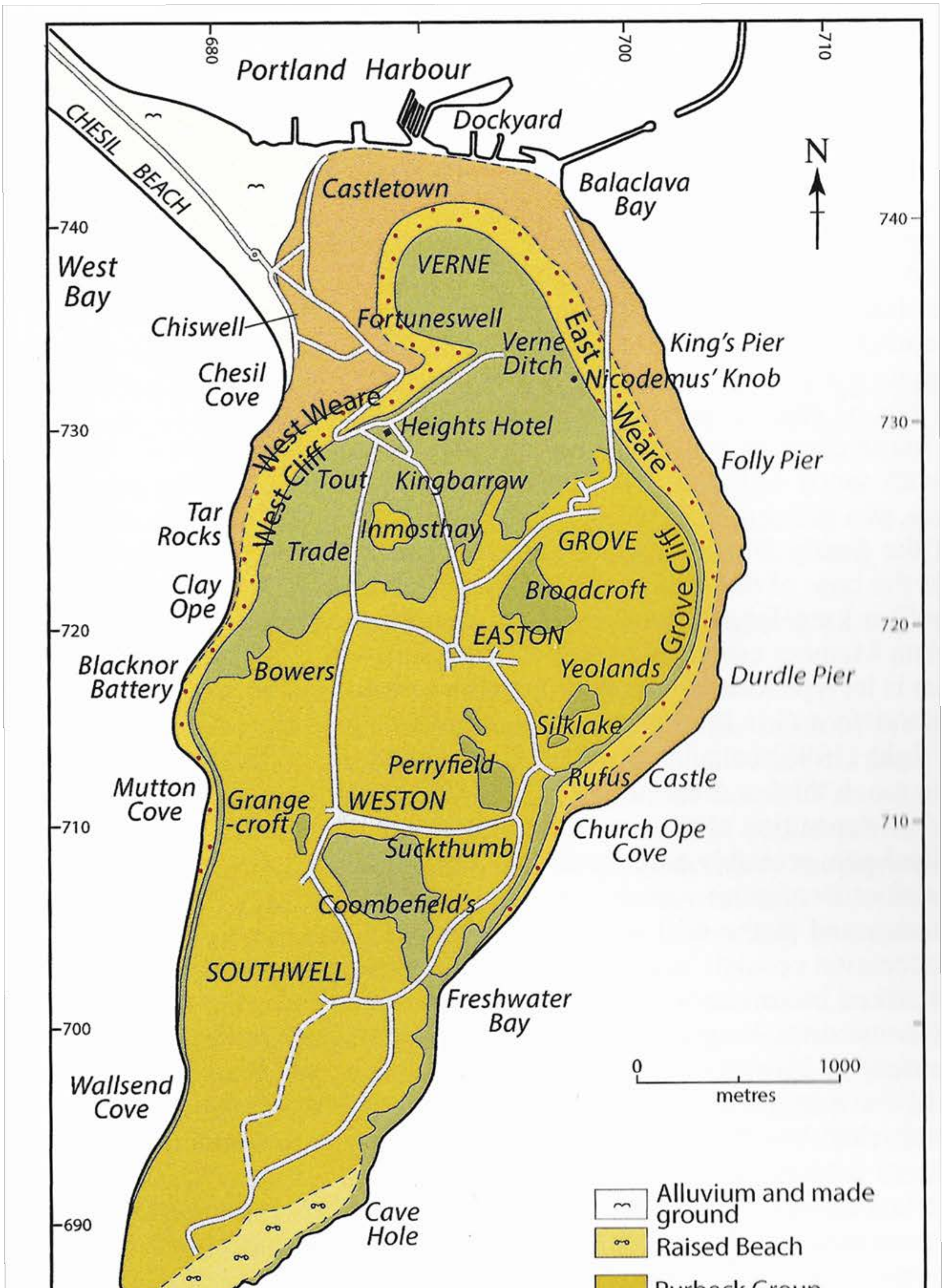

Portland Harbour
Dockyard
CHESIL BEACH
Castletown
Balaclava Bay
N
West Bay
VERNE
Chiswell
Fortuneswell
Verne Ditch
East Weare
King's Pier
Chesil Cove
Nicodemus' Knob
West Weare
Heights Hotel
West Cliff
Tout
Kingbarrow
Folly Pier
Tar Rocks
Inmosthay
Trade
GROVE
Grove Cliff
Clay Ope
Broadcroft
EASTON
Blacknor Battery
Bowers
Yeolands
Durdle Pier
Silklake
Perryfield
Rufus Castle
Mutton Cove
Grange -croft
WESTON
Church Ope Cove
Suckthumb
Coombefield's
SOUTHWELL
Freshwater Bay
0
1000
metres
Wallsend Cove
Cave Hole
Alluvium and made ground
Raised Beach
Purbeck Group
Portland Stone Fm
Portland Sand Fm
Kimmeridge Clay Fm
PORTLAND BILL
680
690
700
710
720
730
740

Figure 38

Figure 39. Bedding plane in King Barrow Quarry showing how calcium carbonate secreting algae lived in the shallow lagoons colonized around the bases of tree trunks.

Figure 40. Until 2009 fossils of *Protocupressinoxylon purbeckensis* were known only from the Purbeckian of the UK but now they are recorded from Switzerland and Northern Spain (Asturias). See Phillipe *et a*l 2009

CHESIL BEACH AND PORTLAND ISLAND
(Figure 41)

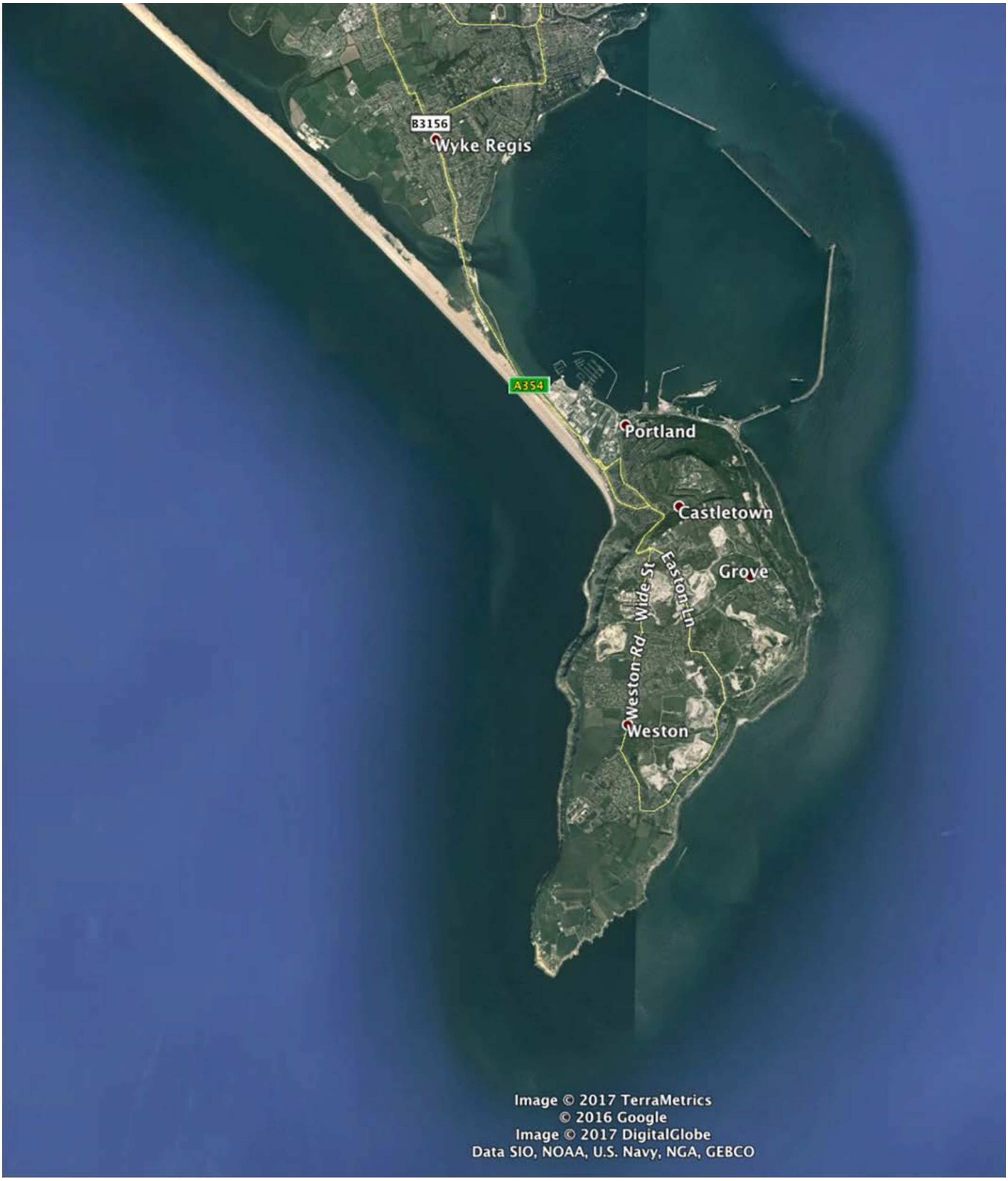


Figure 41. Google Earth image of Portland Island, Chesil Beach, the Fleet Lagoon and Weymouth Harbour. An excellent view will be available, weather permitting, from near the Heights Hotel.

BURTON BRADSTOCK
(Figure 42)

Immediately west of Burton Bradstock, the Bridport Sands (Lower Jurassic-Upper Liassic) (Figs.) are well exposed. The sands young to the south. On the foreshore, they are folded into a relatively tight anticline with a dark plastic clay in the core. Bioturbation is abundant but primary sedimentary structures are still visible. These include ripple-drift lamination and cross-lamination which give bi-modal NE-SW palaeocurrent data. Source studies suggest that the sands come from the south, which was probably the emergent Armorican massif. The general depositional environment of the Bridport Sands is undoubtedly shallow marine, although a detailed interpretation is difficult. Davies (1969) suggested the sands were deposited as a southward migrating sandbar..

These sandstones, initially thought to be too silty and muddy to be a reliable reservoir unit, form the upper reservoir of the Wytch Farm Oil Field (Selley and Stoneley 1987).

At the top of the cliffs two metres of rubbly, iron-stained limestone are seen which are equivalent to the Inferior Oolite Group (Fig.). These limestones are equivalent to 50-100m of oolites to the north and west. The lime-stones are only occasionally oolitic, more commonly being skeletal packstones and grainstones with horizons rich in abraded bivalves, ammonites and belemnites. Commonly, these allochems have an algal coating forming well developed oncoids. In addition to these oncoids the algae has also formed small laminar and columnar stromatolites (Fig. 12). Encrusting bryozoans, seen in thin section, appear to have colonised the carbonate sediment, suggesting the presence of hardgrounds. This further supports a condensed sequence model for the Burton Bradstock lime-stones.

Figure 42. Stacked Bridport Sands overlain by 2-3m of the Inferior Oo-lite. The cliffs form a spectacular background to many films and televi-sion programmes.

CHARMOUTH
(Figure 43)

The cliffs between Lyme Regis and Charmouth exhibit an excellent section through the Lower Lias (Hettangian-Sinemurian). To the west of Charmouth, in Black Ven the Shales-with-Beef are overlain by the Black Ven Marls. A lighter-coloured cliff is visible at mid-level in Black Ven, marking the presence of Belemnite Marls (Early Pleinsbachian) occur above the darker Black Ven Marls. At the top of the cliff are yellow sands and chert of the Cretaceous Upper Greensand (Albian). The Shales with Beef are characterized by the presence of thin layers of fibrous calcite (“Beef”). The shales are crumbly in texture. The top of the shales is marked by the birchi nodular level.

To the east of Charmouth the Black Ven Marls (Charmouth Mudstone Formation of the Lias Group) out-crop at the base of Evan's Cliff, Stonebarrow Hill In the year 1858 James Harrison of Charmouth was quarrying the cliffs presumably for the manufacture of cement. He found a few fragmentary fossils of limb-bones which Sir Richard Owen subsequently referred to the genus *Scelidosaurus*.

The Black Ven Marls are overlain by the Belemnite Marls (23m), the 'Green Ammonite Beds (20m) and the Eype Clay which is overlain unconformably by the Gault.

Figure 43. Google Earth Image of the coastline with Charmouth Heritage Centre to the west of the River Char.

During Liassic times, sediment deposition in southern England was concentrated in basins between a low lying archipelago. The archipelago appears to have acted as a sediment trap, separating shelf clays and sandstones to the north from carbonates on the open shelf bordering the Tethyan Ocean to the south.

The Blue Lias consists of interbedded black laminated shales/marls and light coloured marls and lime-stones. The laminated shales are generally devoid of benthic fauna and are not bioturbated

- they were probably deposited under anoxic conditions.

The marls and limestones are mostly primary in origin but have been considerably modified by re-distribution of carbonate during early diagenesis. In addition, purely diagenetic cementstones are developed locally in the laminated black shales. The trace fossil assemblage in the light marls points to deposition in a range of bottom water oxidation conditions: large burrows such as *Thalassinoides*, *Diplocraterion* and *Rhizocorallium* could only have formed under well oxygenated conditions, but smaller branching burrows such as *Chondrites* may still form under quite reducing conditions.

LYME REGIS
The Pearl of Dorset
(Figures 44-49)

Figure 44. The cliffs to the east of Lyme at Church Cliffs expose the proposed source rocks for the Dorset oils and seeps - the Blue Lias, Shales with Beef, and the Black Ven Marls (see Figs.. The section here is immature but offshore from Wytch Farm it has been downfaulted to sufficient depths for oil generation and expulsion. The image above was taken during the on-going slippage of the Liassic rocks of Black Ven. In 1839, a huge landslide occurred at Downlands, to the west of the town. Today, this area is known as the Undercliff.

The source of the oil-prone organic matter in the Lias is phytoplankton and bacteria This material is only preserved under oxygen depleted or deficient conditions so we must invoke either anomalously high productivity (to outpace oxygen supply) or some mechanism of stratification in the water column to explain its presence. Most probably, organic matter preservation in the Blue Lias is a result of stratification caused by freshwater capping by runoff from the archipelago of islands (Fleet et al., 1987). The rhythmic alternation of shales and limestones may reflect a periodicity in wet/dry climatic cycles, possibly related to changes in the Earth's orbital parameters ("Milankovitch cycles").

Petroleum source potential in the finely laminated black shales is generally between 15 and 20 kg/t.

The History of Lyme Regis

Lyme is sited on the River Lym.

Known to Romans as Lym Supra Mare.

Given by Cynewulf, King of Wessex, to the Abbot of Sherborne, in order to set up a salt works**.** Circa 774 AD.

"Lyme Regis – perched like a herring gull on a ledge suspiciously peering both ways into Devon and Dorset" : John Fowles (1926-2005).

Fowles lived in Lyme Regis from 1968 with Lyme being the setting for *The French Lieutenant's Woman*). His appointed curator of the Lyme Regis Museum in 1979, a post he held until 1989.

1284. Lyme was granted a Royal Charter by King Edward I, hence the name 'LymeRegis'.

1644. Town under siege by Royalist forces. The town defeated Royalists but,suffered many casualties.

1685. The Duke of Monmouth landed at Lyme Regis but failed with the ill-fated rebellion against the King.

18th Century. By the mid-18th century, Lyme Regis was a popular seaside resort attracting many famous writers and painters such as Henry Fielding, Turner and Whistler and the writer Jane Austin who wrote 'Persuasion' there between 1803 and 1804.

By 1903 the railway reached Lyme Regis.

Perhaps the most famous daughter of the town was Mary Anning who born there in 1799. When she was 12 she became the first person to excavate an ichthyosaur fossil from the cliffs. Mary became a very well-known collector of Jurassic fossils so much so that she attracted the majority of well known palaeontologists of the day, to her home to see her wonderful collection. Mary's life has been the focus of numerous authors including:

Mary Anning of Lyme Regis. 1996 by Crispin Tickell and John Fowles

The Fossil Girl: Mary Anning's Dinosaur Discovery. 1999 by Catherine Brighton

Stone Girl Bone Girl: The Story of Mary Anning of Lyme Regis. 2006 by Laurence Anholt and Sheila Moxley

Mary Anning and The Sea Dragon. Nov 2012 by Jeannine Atkins and Michael Dooling.

*Jurassic Mary: Mary Anning and the Primeval Monsters***.** Mar 2014by Patricia Pierce.

Mary Anning's Curiosity. 2017 by Monica Kulling and Melissa Castrillon

Many of these books are inspired by the work of Huw Torrens who presented the Presidential

Geological section from the Cobb west od Lyme Regis to Ridge Warer east of Charmouth.

Figure 45

Figure 46. Above: Commemorative Window to Mary Anning on the north wall of the knave in St Michael's Paris Church, Lyme Regis, it is written that "*This window is sacred to the memory of Mary Anning of this parish, who died 9 March AD 1847 and is erected by the vicar and some members of the Geological Society of London in commemoration of her usefulness in furthering the science of geology, as also of her benevolence of heart and integrity of life*."

Figure 47. This Blue Plaque was placed on the site of Mary's first birthplace and

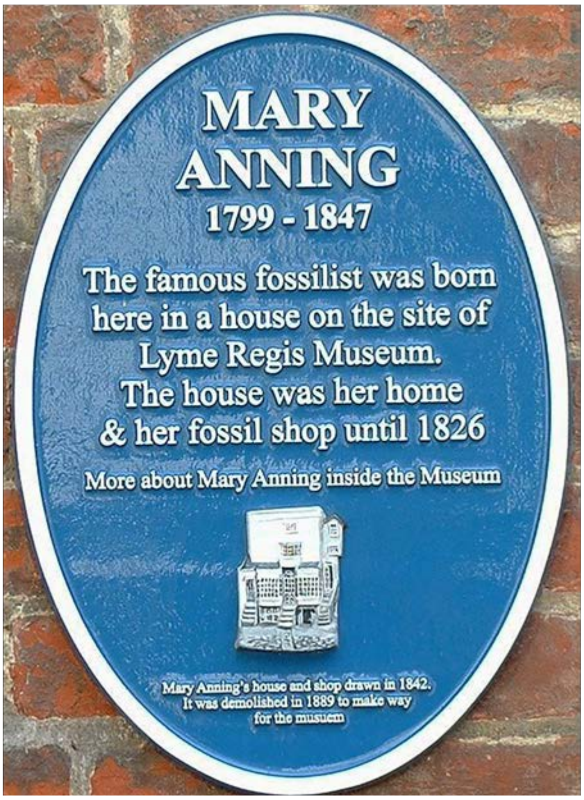


Figure 48. On the outside of the church stands the headstone of Joeseph Anning and Mary Anning. Their parents had 10 children but only Joseph (1796-49 and Mary 1799-1847) reached adulthood.

Figure 49. Mary's pick.

Field Notes