Black Country Geological Society Field Excursion Dorset

Friday 13th to Monday 16th September 2019

(Led by the Dorset Geologists' Association Group)

Organised by: Allan Holiday (DGAG) & Andrew Harrison (BCGS)

Leader Saturday: Richard Edmonds

Leader Sunday: John Scott

Monday: Steve Etches

Field notes by : Ray Pratt

Saturday. Isle of Portland

Meet at 09:30 at the New Ground Car Park, Isle of Portland just past the Heights Hotel (nearest post code: DT5 1LQ / GR: SY 68910, 73050).
Start to west in Tout Quarry, Inmosthay and Kingbarrow
Follow old rail lines, quarryman's tracks & trails
Established as a quarry park cica 1.5 miles walk

Overview of Dorset Geology

Geology, Palaeontology & Geomorphology . SSI on 3 points. Earth Heritage status on all three. E Devon to Studland in Dorset Coast complete section of Jurassic. Most complete section in the world. Overall regional dip to the east. Purbeck Monocline and Weymouth anticline complicating the structure.
Lulworth, grain of geology folded upright

9 fossil sites best in world. Lyme Regis richest source of Lower Jurassic reptiles, fish and insects.. Kimmeridge bay richest source of Upper Jurassic reptiles, fish and insects in the world. Durlston Bay near Swanage has insects, fish & reptiles & mammals.

Jurassic rocks start off with deep water clays then grade up to silts, then to sandstones then eventually limestone's. Blue Lias at Lyme Regis is muddy deep water deposits, as come towards Bridport give way to Bridport sandstone and eventually the Inferior Oolite which is a shallow water oolitic limestone. Then suddenly it reverts back into deep water Frome Clay (ex Fullers Earth) then back into silts and sands and limestone's of the Osmington Oolite, then back into deep water with the Kimmeridge Clay, then the Portland sand and then the Portland Limestone. All shallowing up sequences. Dorset in the Wessex Basin (edge of Dartmoor to Southampton) where the crust of the earth was pulling apart allowing subsidence enabling the sediments to be deposited as a full sequence

Geomorphology.

Chesil Barrier beach - superb example of barrier beach and Tombola
West Dorset & E Devon, magnificent landslides including the Great Lyndon landslide of 1839. Involved 16 acres of land. Only the second ever scientific description of a landslide. Richard has used Lidar & Tomography over 2 years to create a model on this landslide.

Chesil Beach. Water used to be able to drain through the beach into the harbour before they developed the area around the harbour. creating a problem. In 80s after big storm needed to install a new drain to accommodate the water from storm preventing storm damage. Enables rapid draining of the beach. Very successful scheme.

Portland Geology

Kimmeridge clay circa 2000m thick in Portland area. The expanse of Portland harbour is the soft expanse of the Kimmeridge Clay. The complete sequence of the Jurassic Coast is >5.5 thousand metres. If deposition is faster than subsidence will get a shallowing up sequence. Kimmeridge Clay (deep water deposit) into Portland sands then Portland Limestone**.**
The Portland Limestone has 3 layers;

- Top Roach Stone which is very Shelly.
- Middle Whitbed is slightly shelly
- Base bed very fine oolitic limestone no shells in it,

Above the Portland we have the fossil forest of the L Cretaceous Purbeck Group.
(The 3 layers of stone of the Portland Limestone were used to construct the Olympic logo by the Heights Hotel).

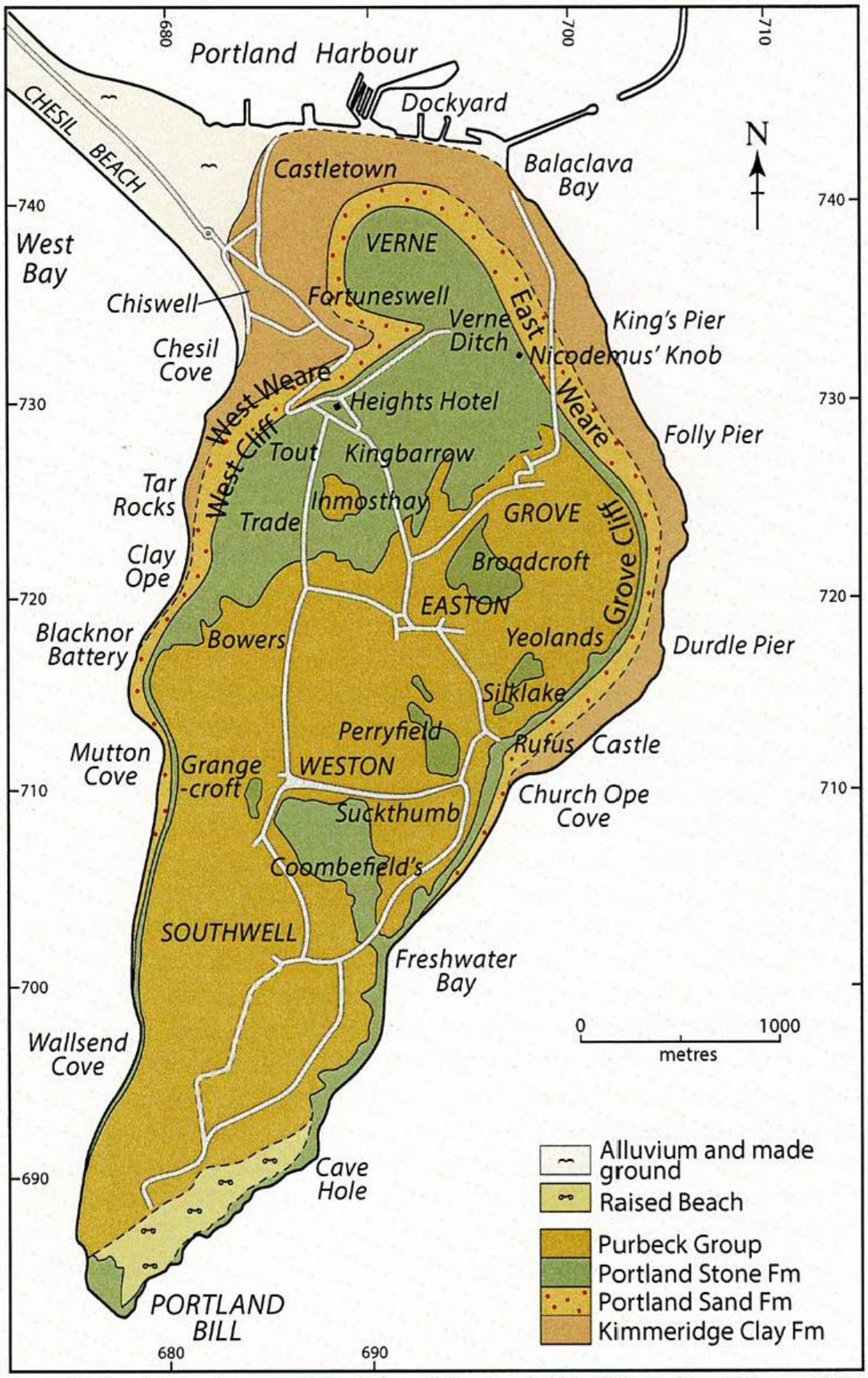


Figure 34. Geological map of the Isle of Portland. Modified after House (1989).

Heights Hotel Grounds

Hotel bought a collection of fossils found on Portland and used them in the hotel grounds. The trees of the time were Cyprus type trees and monkey puzzle trees. Similar to the New Zealand Podacarp trees with a characteristic twisted branch.

The fossil tree is preserved by silica, but unknown where the silica has originated from. There is chert in the Portland Stone below the Purbeck beds, but not above. The growth rings as seen in the fossil tree are sporadic. Periods of condensed growth rings and periods of wide apart rings, repeated over again reflecting a Mediterranean type climate with lots of flexibility. Periods of dry years show thinly packed growth rings. Wet periods were ideal for good growth rings. Therefore these growth rings show fluctuations in the climate. This fossil forest only exhibits 1-2 generations of trees. After the deposition of the roach stones sea levels dropped sufficiently for islands to form where soils and later trees became established. Elsewhere whilst the fossil forest was growing the Portland stone was still being deposited, similar to the Bahamas today (island, oolitic sands, lagoon).

The overlying Purbeck beds are probably the most complicated sequence of sandstones limestone's and silts with mud cracks, desiccation, salt crystals. All environments were close together, much like Arabia today where we have salt flats and sabkas going into shallow seas and lagoons with islands

	 Tree growth rings visible in this fossil tree. These are preserved down to a cellular level.	 Ammonite. Titanities gigantia. Shallow tropical sea like the Bahamas

Portland Stone riven by joints (called gullies by the quarrymen). All quarries worked along the joints which run NW-SW and NW-SE (Conjugate sets). The shape of the isle of Portland displays sections of sub-parallel sections of cliff. These are the NE-SW gullies, so it can be seen that these joints directly give the island its shape. The gullies also play a part in the driving mechanism of the landslides that are prevalent on the island.

West Wear Cliff

Walking down to West Wear Cliff see a big crack in the land and the pathway. 2012 this crack opened up and at some point will fail.

Views of West Wear Cliff

Failure of cliff imminent.

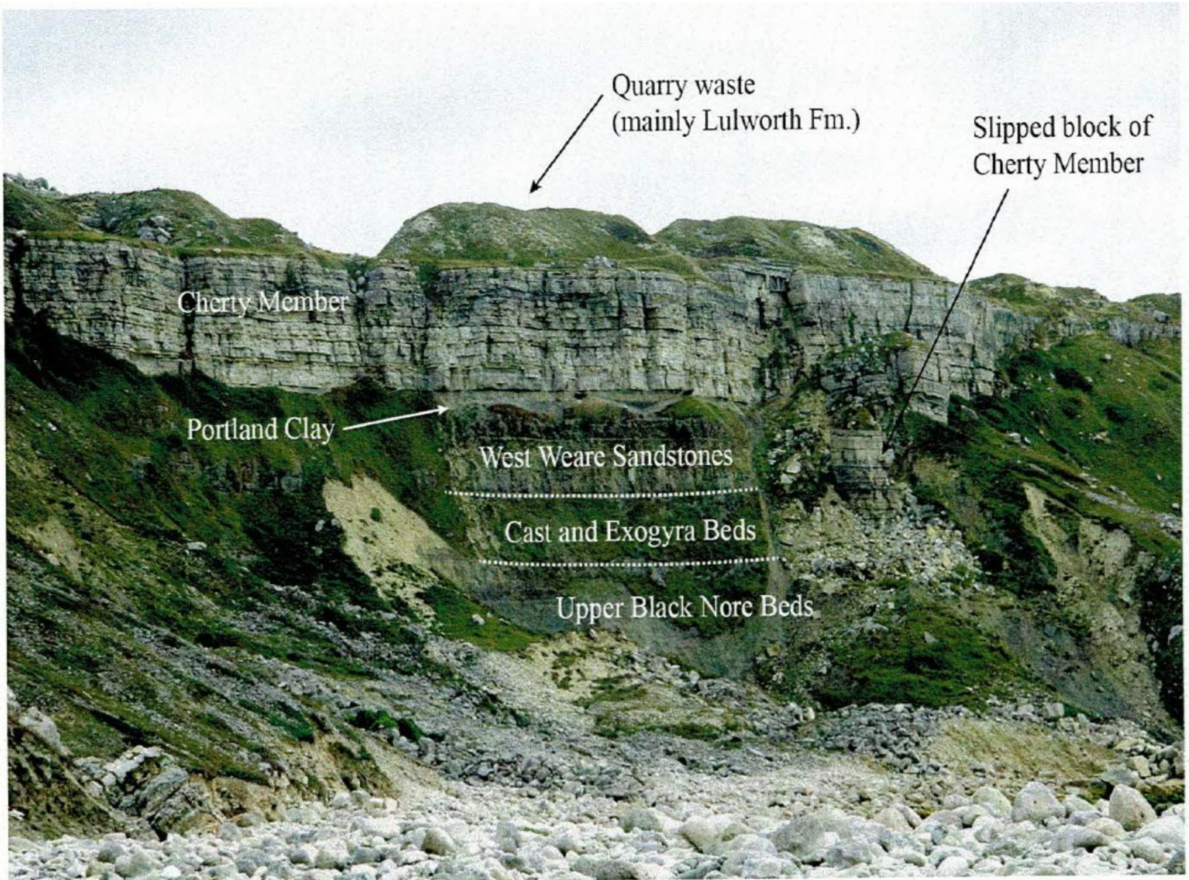


Figure 35. West Weare cliff showing the Portland Sand section overlain by the Portland Clay and Cherty Member. The cliff here would originally have been at least 12 m higher; the overlying Freestone Member and the Lulworth Fm. have been quarried away.

Portland Stone has been quarried off the top. The Quarry men only wanted the Face bed, the whit bed and the Roach stone The waste on the top (grassed) is mainly Lulworth Fm. This cliff face is a limestone with layers of black chert known as the Cherty Member at the base of the Portland Stone. This was of no value for building. It sits on a thin zone of Portland Clay

(Portland Clay, basal unit of Portland Stone Fm. above)

West Weare Sandstones (hard brown dolomites)… … … … … … … … … … … 12·0 m

Cast Beds (soft dolomitic silts with harder nodules with bivalves) … … … … … … 1·5 m

Exogyra Beds (dolomitic clayey silts with *Nanogyra* throughout but abundant towards base in a harder band)… … … … … … … … … … … … … … … … … … … 7·5 m

Upper Black Nore Bed (silty clays and dolomites) … … … … … … … … … … 8·5 m

Black Nore Sandstone (dolomitic siltstone)… … … … … … … … … … … … 1·5 m

(Lower Black Nore Beds below)

The waste from the quarry was often brought to the edge of the cliff and cascaded down the hill. There was too much to simply fill in the quarried area once operations moved ahead. Landslides are very sensitive to water within the landslide system. They are also sensitive to erosion at the toe of the landslide. They are also sensitive to additional weight being added to the top. Here the quarrymen have added hundreds of thousand tonnes to the landslide slope which is probably the reason the crack has appeared in the footpath leading to this point.

Several types of landslide can be seen. Here we see Toppling. This is because the regional dip of the beds is to the east so the beds are dipping into the cliff at this point. It is also dipping seawards so absolute dip is to the SE. The water permeates through the permeable beds to the impermeable clays. The water builds up in the joints making the top heavy and the face begins to separate and eventually topple out. Beyond the topple is a fresh topple landslide from 2012.

Other landslides are translational and rotational. On the other side of the island is one of the largest recorded historical landslides. There the rocks are dipping seawards allowing huge blocks to translationally slide. A translational surface is a shear surface on the bedding. Looking to the north we see buildings on an old landslide which today is inactive. This failure probably occurred during the ice ages when sea levels were much lower. At the end of Portland Bill east side there is a raised beach (125000 YO) which is 5m above SL. On the west side we have a raised beach (350000 YO 8m above SL). Appears that this coast is still uplifting. Means that the SL were higher in the past interglacial's than they are today. The slide with the building on it is probably from 125000 YA.

The mechanisms for the formation and movement of **Chesil Beach** are also related to the historic sea levels. Most of beach made of chert and flint which originates from east Devon and west Dorset. Transported to the east by currents and waves. Dominant wave direction from the SW. During last cold period SLs lower. This instigates more movement in the landslides as they seek equilibrium. As sea levels rise they winnow away at this debris mobilising the sediment in the dominant current direction. Chesil Beach has probably formed several times at the end of each ice age. Dominant thinking is that the strong SW bring the cobbles to Portland and the lesser SE currents carry the finer grains westwards. The coarser the material the steeper it is. The east of Chesil Beach is much higher & steeper than the west end. However, when the beach is stripped out after a storm, little pebbles are seen her n the east end. The bigger pebbles move more easily. After a storm there is always a line of bigger pebbles due to their larger surface area, therefore move more quickly.

Walk into first quarry

Roach Stone

The succession in the Freestone Member recorded by Arkell (1947) is typical of that for the north of the island, but successions further south differ:

Roach. Oolitic limestone with mouldic preservation of *Laevitrigonia*, *Aptyxiella* and *Protocardia*… … … … … … … … … … … … … … … … … … 0·9 m

Whit Bed. Shelly freestone, sometimes with some chert 0.9 m from base … … … … 2·4 m

Flinty Bed. Limestone full of chert. *Titanites*… … … … … … … … … … … … 0·6 m

Curf. Soft micritic limestone, occasionally oolitic. Abundant chert … … … … … 0–1·2 m

Base Bed Roach. Shelly oolite with moulds of *Laevitrigonia* etc. … … … … … … 0–0·6 m

Base Bed or **Best Bed**. Good workable white oolitic freestone with few shells … … 1·8–2·4 m


Portland stone showing minor channels and current bedding features


Ripple marks in Portland stone

Initial quarrying done by hand. Created a lot of waste. Built stone walls with waste, called Beaches. These were filled with overburden (Purbeck beds). Also left a lot of stone that was simply too big to move. In later life when technology and mechanisation became available much of the old quarries were reworked. Some used in masonry, lots used for sea defences. The land was privately owned. If a quarry operator could not buy a strip of land they worked around it. Now form islands in the quarry. The rock faces are the gullies that the quarrymen used to use for extracting the rock. These are often coated in flowstone.

Above the Roach at the base of the Lulworth Formation is the thin Skull Cap succeeded by the Lower Dirt Bed (the Fossil Forest Horizon), then the Hard (or Top) Cap which in turn is succeeded by the Great Dirt Bed and the Aish limestone. Former quarrying methods required the removal of this Purbeck Group overburden before quarrying the Portland Stone beneath, but nowadays much rock is mined from large adits, the Purbeck roof to the mines being secured by extensive use of rock bolts.

Anthony Gormly sculpture

- The top deposits are lagoonal limestone's, very thinly bedded These are very disturbed and in Lulworth are known as the broken beds where there are up to 20m of these contorted and collapsed limestone's as a result of evaporite dissolution. The depositional environment was a saline lagoon. The salts within the sediment were later dissolved out causing the rocks to collapse.

- Under these rocks is the Great dirt band a fossil soil (looks conglomeritic from afar)
- A limestone band known as the Top Cap can then be seen
- Below this is the grassed area which contains the Fossil forest with - a fossil soil.
- The Hard cap sits on top of the Roach Stone. The Roach stone has been eroded down so the boundary is unconformable. The first bed above is known as the Hard Cap as it is a really hard algal limestone formed in a lagoon. All beds above the Roach are Purbeck Beds, known as Slat or Bacon Slat.
- The bed above the sculpture is the Roach Stone (very shelly Portland Stone)
- The main body of the sculpture is the Whit bed (a shelly oolitic freestone)
- The head of the sculpture is just inside the base bed (Good workable white oolitic freestone with few shells)
- At the base we see the thinner beds of the Portland stone with the black cherts

The Jurassic Cretaceous boundary used to be at the boundary of the Portland and Purbeck beds, but now located in the lower part of the Purbeck


Three holes remnants of trees (fossil forest). Holes surrounded by algal growth

Holes surrounded by algal growth. Brackish-water tufas (microbialites) formed around the bases of trees, or independently from trees, and these form the nuclei to microbial mounds, up to four metres thick and 20m across.

Portland Purbeck boundary

Kingbarrow Quarry. Stromatolites. Formed around base of trees in Purbeck beds.

Thrombolites. The tufas are complex vuggy lithologies but are principally constructed by thrombolites (microbial limestone's. with a clotted texture) with minor stromatolites, but also invertebrate burrow boundstones that form initially
around the trees. This unusual facies is formed of peloidal mud's that are bound by burrow walls to form collars around the trees. Microbial filaments trap, bind and cement the locally produced peloidal, skeletal and intraclastic grains to form a framework that is itself cemented by early calcite cements.

The Fleet

Second Stop: Meet on Camp Road, near to the Bridging Camp (nearest post code: DT4 9HF or GR: SY 65360, 77630) .

Looking out towards Portland we see the apparent dip is to the south. The real dip is to the SE. Looking to the harbour and to the Ridgeway, we see what we have is an anticline with Portland on the southern limb. and the northern limb diving back into the Ridgeway where it is a steep fold, part of the fold seen at Lulworth, which is Alpine, and the most northerly crumple from the formation of the alps. No other true alpine features further north.

This Weymouth anticline is simply an extension of the Lulworth coast and as we move in this direction (west) there is still an Alpine structure with a lot of faults. The landslide west of Lyme Regis there is a tectonic structure that is part of this Alpine feature, but thinning out westwards.

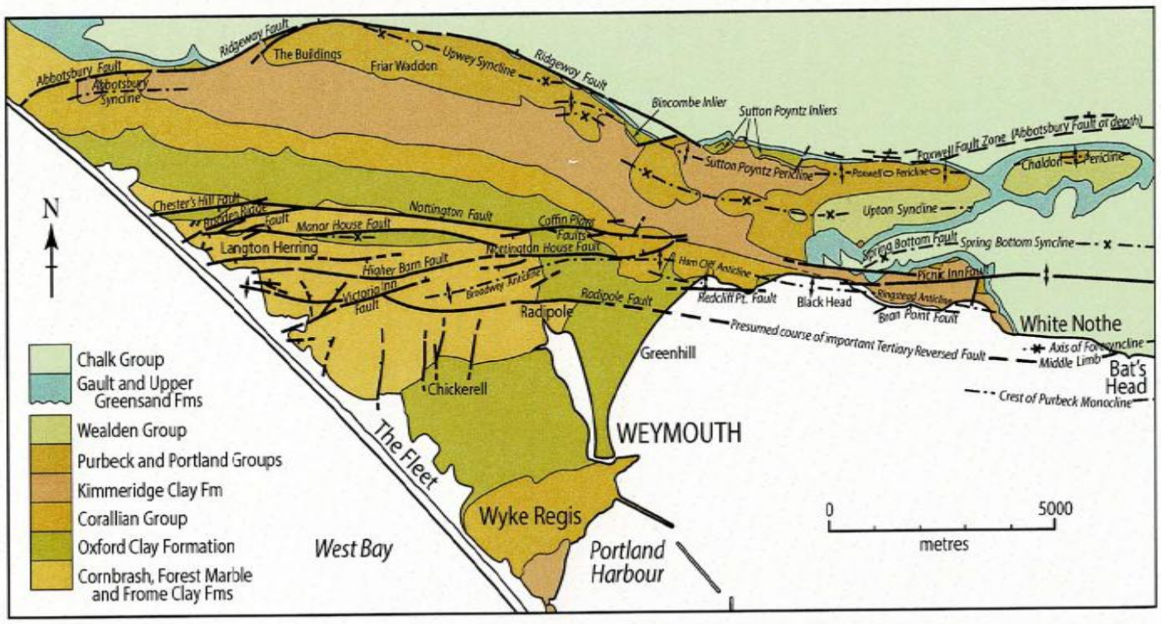


Figure 30. Geological structure of the Weymouth area. Modified after House (1989).

Chesil Beach

The back of Chesil Beach have periodic scours at the back, locally known as Cans. When there is a big sea and the water permeates through the shingle over the top of the clay core and creates these features as it pours into the Fleet. There location could be due to the variability of height of the core of the sandbar. The core of the beach was formed after the end of the last ice age when sea levels rose and the gunk was pushed up out of the bay to form this core of silt and mud. The shingle supply began with the increasing landslides from west Devon and Dorset as they became reactivated with the rising sea levels. Chesil beach changes with the environment and it is only a matter of time before the sea breaches it. Some suggest that if the beach were not there then the strand line would by now be close to Dorchester. After big storms, particularly down towards Abbotsbury West Bexington, (west of Weymouth), we get enormous lumps of peat washed up onto the seaward side.. This peat would have formed in a peat lagoon that was further offshore than it is today. As the beach moves landwards then the peat formed in a lagoon behind the beach becomes exposed to the open water and gets ripped up during storms. Good evidence that the beach is migrating inshore.

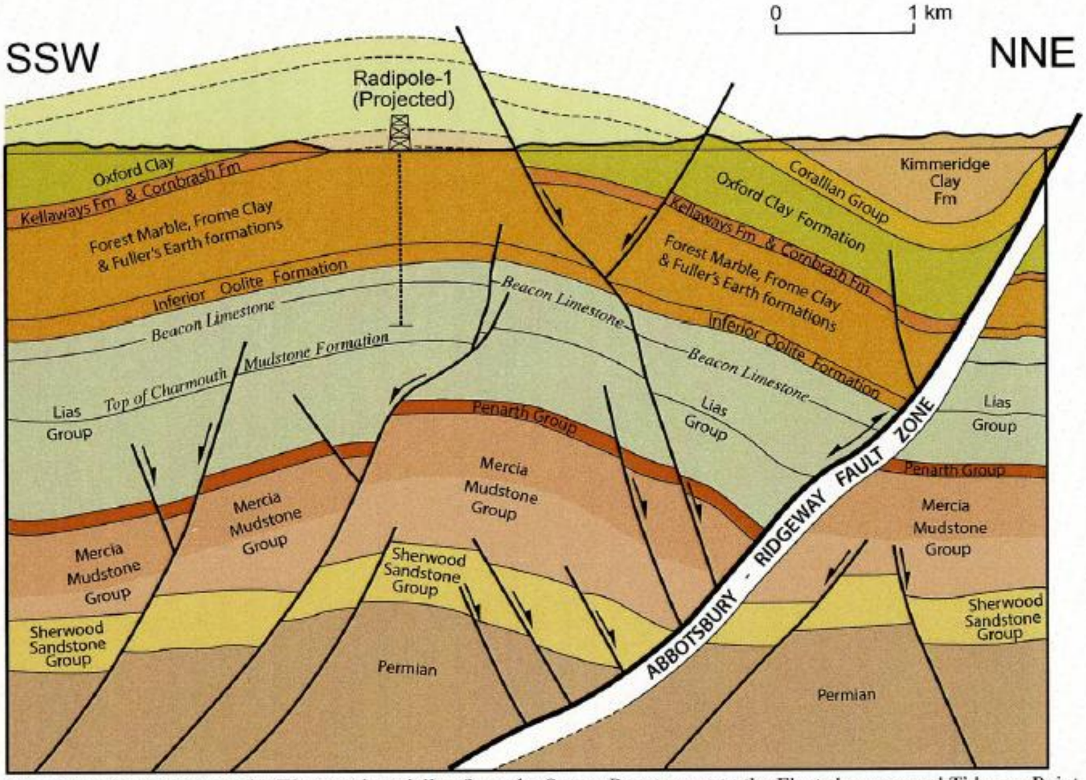


Figure 32. Section across the Weymouth anticline from the Sutton Poyntz area to the Fleet shore around Tidmoor Point. The Radiole Borehole was slightly to the west of this section. Note the dip discordance above and below the Mercia Mudstone Group and due to décollement (structural detachment) within the salt horizons in this Group. Modified after Underhill and Paterson (1998).

We will walk east along the northern coast at the eastern end of East Fleet Lagoon looking at its formation and exposures of Middle to Upper Jurassic strata (Oxford Clay, Corallian Beds and Kimmeridge Clay).

Walking along the fleet we look at a section from the bottom to the top

- Kimmeridge Clay
- Sandsfoot Grit
- Sandsfoot Clay
- Clavellata FM
- Osmington Oolite FM & Bencliff Grit

We start seeing plenty of thalassinoides burrows (made by shrimps)
Osmington oolite, visible oolites. (Younger than the Inferior oolite.)


Moving east and up sequence we see a hard limestone which is likely to be the Clavellata Fm. It has a hard uneven surface, vuggy porosity. Thalassinoides burrows and lots of oyster shells

Looking back towards the Osmington oolite and Clavellata formations. The bay is carved into the weak clays of the Sandsfoot clay

Sandy Limestone

Grey colour but weathers yellow brown due to its iron content. Nodules of iron (Chamosite) can easily be seen. Low grade ironstone. Sandsfoot formation. Belemnite shells sticking out

Ringstead Clay

The fleet lagoon gets wider where clay formations occur. The clays become very soft and plastic when wet, Knife easily pushed into the clay.

Burton Cliff - Burton Bradstock

Parked at the Burton Beach NT Car Park and walked westwards along the beach (Burton Cliffs)

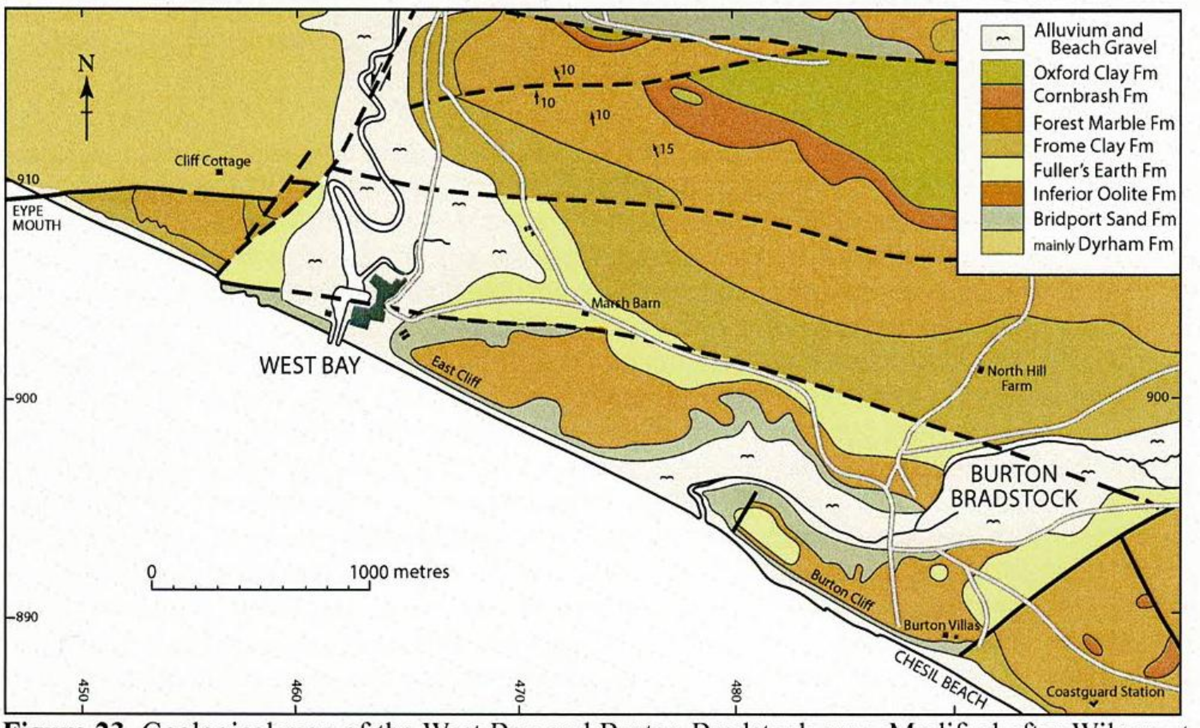


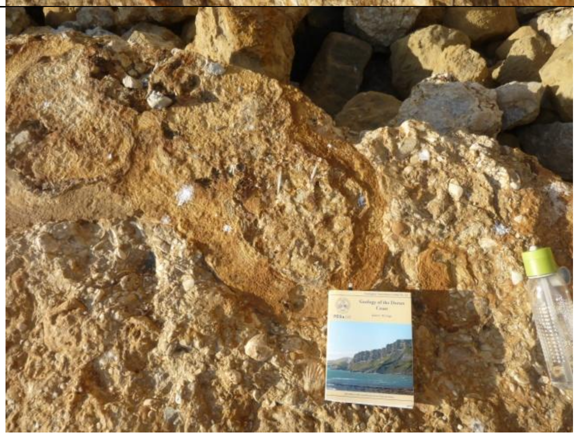
Figure 23. Geological map of the West Bay and Burton Bradstock area. Modified after Wilson *et al.* (1958).

It is easiest to examine the Bridport Sand at the western end of Burton Cliff (Fig. 23), where it is normally possible to examine the bedding surfaces as well as examining the beds in vertical section. This is the southern end of the outcrop of these sands, which have an almost continuous outcrop from the Cotswold Hills, southwards to Bridport. As early as 1889, Buckman was able to show by the contained ammonites, that deposition of the sand was completed in the Cotswolds before it began on the coast here. This was thus a good example of a diachronous deposit. The bright yellow colour of the sands is due entirely to oxidation of their contained iron salts; seen in borehole material these same rocks are a dull blue-grey. The alternation of hard and soft beds, that forms these striking cliffs, is due to differences in the amount of calcite cement in the sands. There is also an important difference in the micas as in the softer beds the mica flakes are crumpled, whereas in the harder beds they are undistorted, showing that cementation of the hard beds occurred before compaction took place (Sellwood *et al.*, 1970). Davies (1967) interpreted the sands as a southward-moving offshore bar; more recently Pickering (1995) recognised swaley cross bedding in the sands, a sure indication of storm deposition. The sands have attracted a good deal of attention in recent times as they form the upper of the two reservoir horizons in the Wytch Farm oilfield in Purbeck (see below). The hard bands have proved problematic in oil extraction as flow is inhibited across the bands.

Burton Cliffs, Bridport sands

Proceeding eastwards along the shore, the Inferior Oolite (Fig. 25) soon caps the cliffs and then a small fault brings down the lowest parts of the Fuller's Earth above the Inferior Oolite. Around here large fallen blocks of the Inferior Oolite can be examined at leisure on the beach at most states of the tide; high shingle levels may sometimes obscure some blocks. Remarkably here the Inferior Oolite is only 4 m thick; the corresponding rocks in the Cotswold Hills are up to 100 m thick, whilst on the Isle of Skye, the Bearreraig Sandstone of the same age is some 550 m thick. The Burton Cliff Inferior Oolite is thus a condensed deposit; the south Dorset region was starved of sediment during this time (Fig. 26) and so a thin and an incomplete record of Aalenian, Bajocian and basal Bathonian rocks is represented here. Some beds are quite distinctive and it is suggested that the succession shown in Figure 27 is used to identify the way-up and succession in various blocks. One of the most readily recognisable horizons is the Snuff Boxes, large rounded limonitic concretions that are algal build-ups around shell fragments; another readily recognisable level is the Sponge Bed, with abundant calcareous sponges often beautifully weathered out on exposed bedding planes.

Fallen blocks of Inferior oolite can be found at the base of the sea cliffs



Fullers earth at cliff top

Landslip of fullers earth and underlying inferior oolite

Blocks of inferior oolite on the beach. Snuff box concretions, as seen in these photos below, are large rounded limonitic concretions that are algal build-ups around shell fragments.


Geology of the Dorset Coast

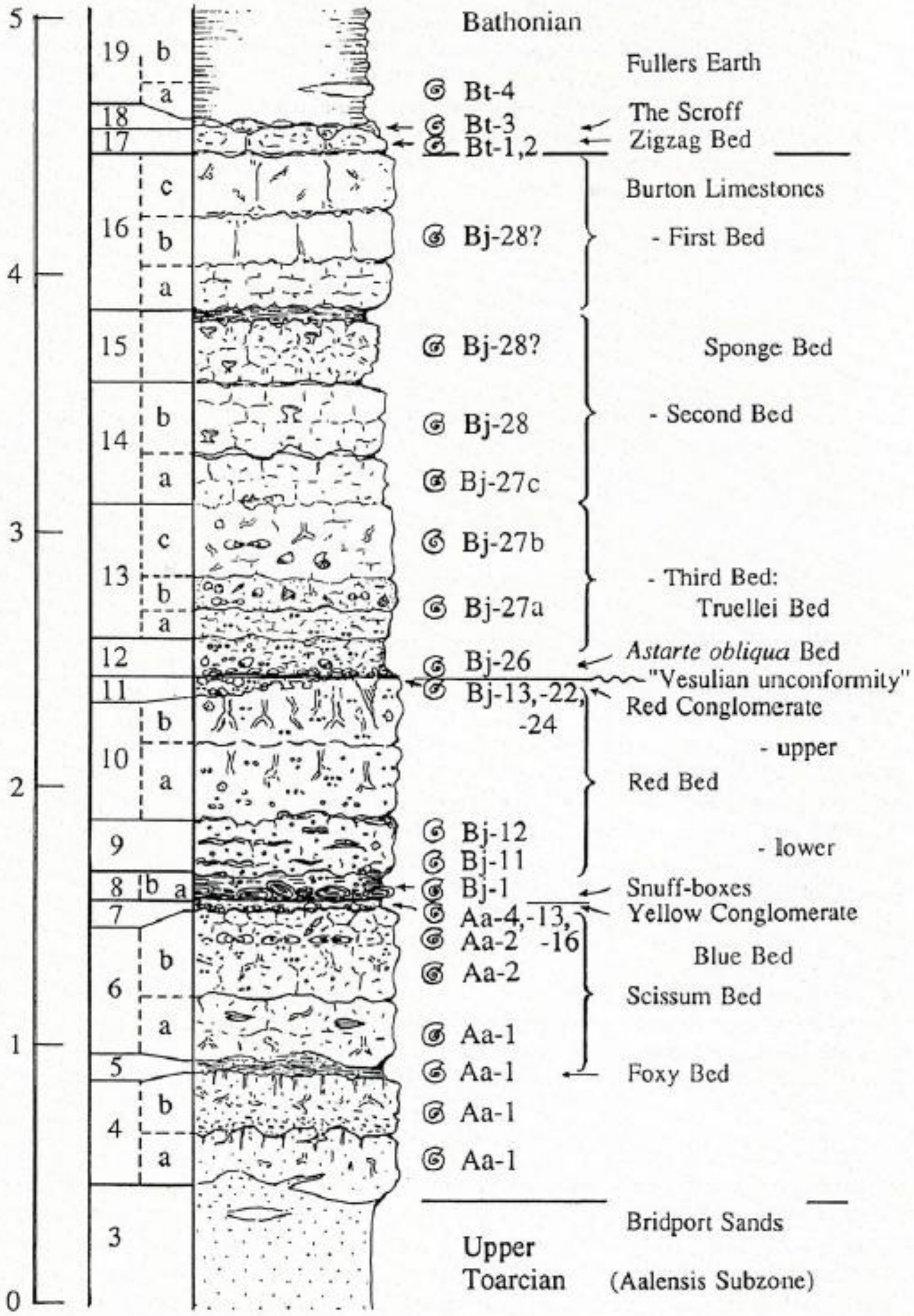


Figure 27. Section of the Inferior Oolite at Burton Cliff. The incompleteness of the Aalenian and Lower Bajocian in this section can be seen by reference to Table 7. After Callomon and Cope (1995). Reproduced by permission of the Geological Society of London.