

## Notes to accompany the Malvern U3A Fieldtrip to the Dorset Coast

1-5 October 2018

<b>SUMMARY</b>	
<b>Monday 01-Oct</b>	Travel to Lyme Regis; lunch ad hoc; 3:00 pm visit Lyme Regis Museum for Museum tour with Chris Andrew, the Museum education officer and fossil walk guide; Arrive at our Weymouth hotel at approx. 5-5.30 pm
<b>Tuesday 02-Oct</b>	No access to beaches in morning due to tides. Several stops on Portland and Fleet which are independent of tides
<b>Wednesday 03-Oct</b>	Visit Lulworth Cove and Stair Hole; Possible visit to Durdle Door; Lunch at Clavell's Café, Kimmeridge; Visit to Etches Collection, Kimmeridge (with guided tour by Steve Etches). Return to Weymouth hotel.
<b>Thursday 04-Oct</b>	Burton Bradstock; Charmouth; Bowleaze Cove Beaches are accessible in the morning.
<b>Friday 05-Oct</b>	Drive to Lyme Regis; guided beach tour by Lyme Regis museum staff; Lunch ad hoc in Lyme Regis; Arrive Ledbury/Malvern in the late afternoon

<b>PICK-UP POINTS ( as per letter from Easytravel)</b>		
<b>Monday 1 Oct.</b>	<b>Activity</b>	<b>To Do</b>
Pick-ups and travel to Lyme Regis	Worcester pick-up	Depart Croft Rd at 08.15
	Barnards Green pick-up	08.45
	Malvern Splash pick-up	08.50
	Colwall Stone pick-up	09.10
	Ledbury Market House pick-up	09.30
	<b>Arrive Lyme Regis for Lunch - ad hoc</b>	13.00 – 14.00
	Visit Lyme Regis Museum where Chris Andrew from the Museum staff will take us for a tour of the Geology Gallery.	15.00 to 16.30
	Depart Lyme Regis for Weymouth	16.30
	Check in at Best Western Rembrandt Hotel, Weymouth	17.30
<p>At 6.15pm, we will meet Alan Holiday, our guide for the coming week, in the Garden Lounge of the hotel prior to dinner. Alan will give a short presentation and talk on the areas we shall visit on Tuesday, Wednesday and Thursday and join us for dinner afterwards at 7.00 pm.</p>		

## DAILY ITINERARIES

<b>Geological Field Excursion Details and Risk Assessment</b>	
Peter Bridges - Mobile No: 07785 258 094	
Alan Holiday - Mobile No: 07815 482 963	
<b>Date: Tuesday October 2<sup>nd</sup></b>	<b>Tides: not significant</b>
<b>Start Location: Newground Car Park, Portland,</b>	
<b>Grid Ref: SY689730, Post Code: DT5 1LQ</b>	
Start Time: <b>09.15</b>	Approx. Finish: <b>17.15</b>
<b>Lunch and Toilet Arrangements:</b> Packed lunches and drinks/water required. These can be purchased in Weymouth or Portland. Toilets near Newground Car Park, Easton Square and Portland Bill	
<b>Field/Safety equipment needed:</b> Stout footwear, wet weather gear, hand lens, hard hat.	
<b>Aim of Excursion:</b> To study the Late Jurassic and Quaternary geology of Portland, as well as some aspects of quarrying of Portland Stone.	
<b>Itinerary and Objectives:</b> <ol style="list-style-type: none"><li>1. View from the Heights Hotel plus examination of some specimens (fossil tree, etc.) in grounds; Kingbarrow Quarry for Fossil Forest section,</li><li>2. Brief visit to Portland Sculpture Trust, return to vehicle.</li><li>3. Drive to St George's Church Car Park, Grid Ref: SY686721 to see Fancy Beach and Bowers Quarries</li><li>4. Walk to West Weares to view coastal section.</li><li>5. Drive to Portland Bill to view raised beaches Grid Ref: SY677685, Postcode: <b>DT5 2JT</b>, then return to Chesil Cove to view Chesil Beach coastal protection Grid Ref: SY683733, Postcode: DT5 1AP.</li><li>6. If time permits drive Camp Road for brief walk along Fleet Shore to see Corallian section, Grid Ref: SY652722, Postcode <b>DT4 9HF</b>.</li></ol>	
<b>Terrain &amp; Length of Walk:</b> Mainly footpaths and pavements, around 3km.	
<b>General Low Risk Safety Hazards.</b> <p>Slips and trips, narrow path in Kingbarrow with drop on one side. Bowers Quarry is a working quarry so look out for heavy plant; <b>Wearing PPE (i.e. Hard hat, Hi-Vis Jacket, etc.) is essential. These will be provided by U3A and will be available on the bus.</b></p> <p>Vertical cliff at West Weares next to Coast Path. Weather: bring suitable wet weather clothes.</p>	
<b>Other Hazards</b> of Low, Medium or High Risk. Do not walk across inlets or bays in the Fleet as deep mud can be a hazard, walk along the beaches.	



**Geological succession for Portland - as seen in quarries and along West Weare Cliffs.**

	Divisions	Subdivisions	Thickness (m)	Comments
UPPER JURASSIC	<b>Purbeck Limestone Group</b> - overburden to the Portland Stone below.	Marl and Slat		
		Bacon Tier		
		Aish		Limestone
		Soft Burr		
		Great Dirt Bed		
		Top Cap		
		Lower Dirt Bed		Fossil Forest Horizon
		Skull Cap		
	<b>Portland Stone Formation</b> – selected horizons were mined and quarried for dimension stone e.g. St Paul's Cathedral.	Portland Roach	0.9	Oolitic limestone with abundant gastropods ( <i>Aptyxiella</i> ) and bivalves ( <i>Laevitrigonia</i> ) ('osses 'eads).
		Portland Freestone Whit Bed	2.4	Shelly Freestone with some chert near the base. Good dimension stone horizons.
		Curf and Chert	0-1.2	Limestone with abundant chert ( <i>Titanites</i> ).
		Little Roach		
		Base Bed	1.8-2.4	White oolitic freestone with few shells. Good dimension stone horizons
		Cherty Series		
		Basal Shell Bed		Rich ammonite fauna ( <i>Titanites</i> & <i>Kerberites</i> )
	Portland Sand		Basal unit of the Portland Stone Formation	
	Kimmeridge Clay		Poorly exposed on Portland	

**Locality 1.** Newground Car Park to visit part of Kingbarrow Quarry Grid Ref: SY 691727 to see 'fossil forest' horizon (similar to that at Lulworth Cove) and the fossil tree in the grounds of Portland Heights Hotel (**Locality 2**) Grid Ref: SY 688729.



Fig 2. View looking north from New Ground carpark towards West Bay, Chesil Beach, Portland Harbour and the Weymouth Anticline.



Fig 3. Fossil trees in Kingbarrow Quarry



Fig 4. Fossil Tree at the Heights Hotel

Move on to **Locality 3** - St George's Church (Grid Ref: SY 686720) to look at Fancy Beach Quarry, and Bowers Quarry.

Take footpath and coast path south to **Locality 4** Blacknor (Grid Ref: SY 678715) to see West Weare cliffs and exposures of the Kimmeridge Clay (at the base of the Upper Jurassic) to the basal Purbeck Beds.



Fig 5. West Weare Cliffs looking north from near Blacknor



Fig 6. The cliff section at Blacknor Fort showing part of the Portland and the overlying Purbeck Beds.

Fossils in the Portland Stone include:

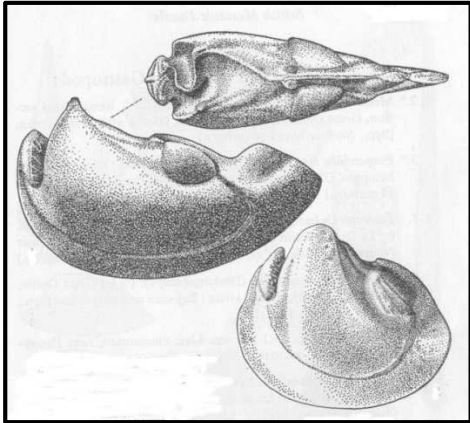


Fig 7 Internal casts of the bivalve *Myophorella* (formerly known as *Trigonia* and often called 'osses 'eads' commonly found in the Roach, Portland Stone.



Fig 8 Internal cast of the gastropod *Aptxiella portlandica* (often called the 'Portland Screw'), also commonly found in the Roach, Portland Sand.

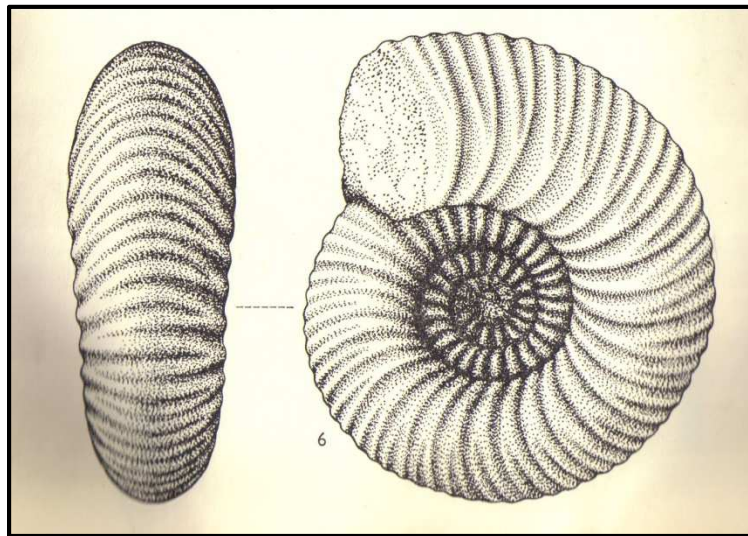


Fig 9 *Titanites giganteus*, the ammonite zone fossil for the Portland Stone

Drive to **Locality 5** - Portland Bill - to see raised beaches east and west of the Bill. (Grid Ref: SY 677684).

**You should remember Localities 1 to 5 above are Sites of Special Scientific Interest (SSSIs) and no hammering should take place.**

Return to Victoria Square and Chiswell parking (Grid Ref: SY 683736) to see Chesil Beach and flood defences.

Most of the day will involve driving between localities and walking using the coastal footpath and accessing quarries via tracks.

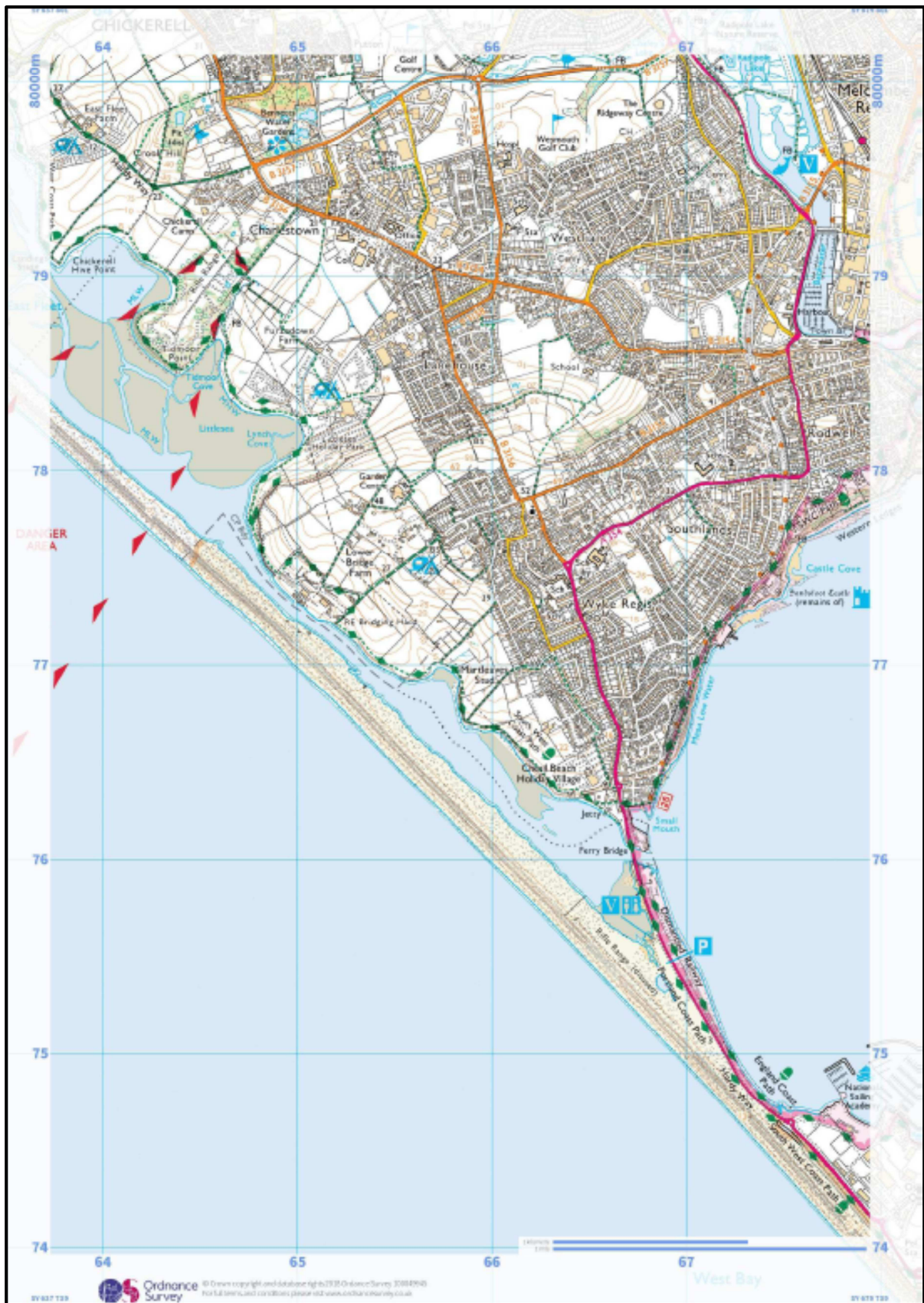


Fig 10 Locality Map – Chesil beach and the Fleet





Fig 11 Locality Map of the Lulworth Cove area showing localities of interest

The aim of the field trip is to study the rocks exposed in cliff sections at Stair Hole, Lulworth Cove, Man o' War Cove and Durdle Door. Bus parking is at Lulworth Church (Grid Ref: SY 823807) or at the Cove Car Park (Grid Ref: SY822803).

The succession seen:

Series	Stage	Succession
Upper Cretaceous	Cenomanian	Chalk
Lower Cretaceous	Albian	Upper Greensand
	Aptian	Lower Greensand
	Valangian to Barremian	Wealden Series
	Berriasian	Purbeck Series
Upper Jurassic	Portlandian	Portland Stone

The rocks exposed are all sedimentary and of Upper Jurassic and Cretaceous age (140 - 70 m.a.).

The rocks vary in origin, some being marine containing ammonites, e.g. the Portland Stone, whilst others are of continental origin. The Wealden Series is of fluvial (river) or lacustrine (lake) origin.

The rocks are steeply dipping; those nearest the sea dip to the north at about 45°, however moving to the back of Lulworth Cove the beds get steeper and are over-turned dipping towards the south.

The dip of the beds is linked to earth movements associated with the Alpine Orogeny (mountain-building episode) which had a significant effect on the rocks now exposed along this section of coastline.

Present-day mass movement takes place, both on the clays of the Wealden Series and the Chalk. Because the strata high up on its back wall are dipping towards the Cove, significant falls can occur. The location of these can be seen looking at the whiter cliffs, which are less well vegetated.

### Locality 1 - Stair Hole (Grid Ref: SY 822798)

The sea has cut through the Portland Stone barrier on the southern seaward side and is now cutting back into the weaker Purbeck and Wealden Beds to the north. The Portland Stone limestone is competent but is jointed. These joints have been exploited to open up natural arches that have then collapsed (typical evolution of coastal landforms).

The less competent Purbeck Beds (thinly bedded limestone and clays) have been cut through as well as part of the Wealden Series. The steep slope at the back of Stair Hole allows mass-movement (clay flows) in wet weather.

The beds here are steeply-dipping allowing fairly rapid erosion into the younger beds. The fold structure (the Lulworth Crumple) shows how the strata were deformed by the Alpine Orogeny linked to fault movement below the surface. The competence of the rocks varies and those that are less competent show greater degrees of deformation (Purbeck Beds). The Portland Stone is more massive and dips at about  $45^{\circ}\text{N}$ . The dip varies from  $45^{\circ}\text{N}$  to overturned as you move north in Stair Hole. A good view point can be accessed on the west side of Stair Hole at Grid Ref: SY 822799 where the Lulworth Crumple is clearly seen.



Fig 12. View looking east over Stair Hole. Lulworth Cove is in the background

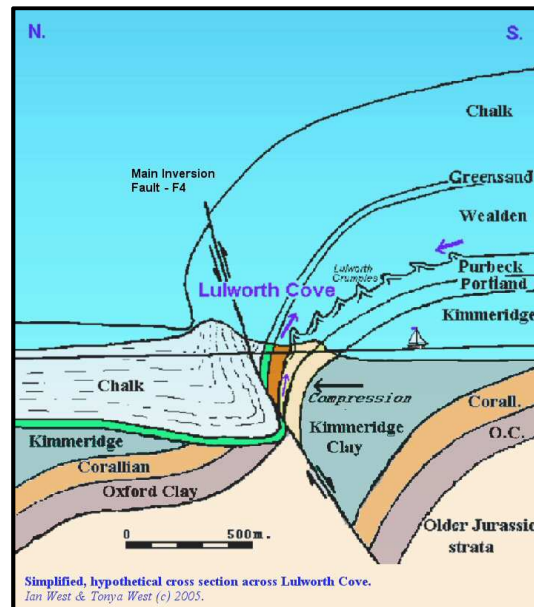


Fig 13 Cross-section of Lulworth Cove looking east

**Locality 2 - Lulworth Cove** Lulworth Cove is much larger than Stair Hole because of erosion by the Lulworth River. This cut through the barrier of the Portland Stone on the seaward side of the cove and allowed the sea to scour behind the Portland Stone barrier and form the present cove. Because of wave refraction, marine erosion is probably not occurring to a great extent at present. However, damage occurred at the back of the Cove during the storms in February 2014. Mass movement brings rocks down onto the beach, which can be slowly removed by wave attack.

**The original idea of Lulworth Cove being a second stage in the evolution of the coast after stage 1 of Stair Hole has generally been discounted.**

On the seaward side of the Cove the Portland Beds can be seen but not really studied.

Moving north, the thinly bedded limestone and clay of the Purbeck Beds are seen as well as the Wealden Beds - especially on the eastern side of the Cove. The Wealden Series contain sands and

clays of varied colours, which were deposited by rivers and in lakes in the early Cretaceous around 120 m.a. ago. These contain fossil wood (lignite) an indication of the continental origin of the deposits. Other fossils are rare.



**Fig 14. View west across Lulworth Cove**

The Lower Greensand is not well exposed but the Upper Greensand can be seen towards the back of the Cove. This sandstone is green because of the presence of the iron silicate mineral, glauconite. This was precipitated from seawater as the sandstone was deposited and is forming in tropical marine environments today. The Upper Greensand contains fossils - especially a marine worm called *Rotularia*. Other fossils include ammonites and brachiopods, also indicating a marine environment, although these are uncommon.

The Chalk at the back of the Cove shows evidence of the intense tectonic processes that were associated with the Alpine Orogeny. The dip of the strata varies from 50-60° N at beach level to overturned high up the back of the Cove. The Chalk is hard and brittle because of diagenetic processes linked to the Alpine Orogeny. There is evidence of low-angle thrust faulting.

#### **Locality 6 - Man o' War Cove and St Oswald's Bay (Grid Ref: SY807803)**

These are seen from the cliff top path as you approach the Durdle Door viewing area. The strata seen are similar to those at Lulworth Cove but the sequence is attenuated due to thinning of the Wealden Beds westward, probably due to tectonics.

The relative strength of the strata can be seen because remnants of the Portland sequence can be seen as stumps and stacks in the sea, while the Purbeck, Wealden Beds and Greensand have been eroded.

The strata are vertical or even overturned on both sides of the Durdle peninsula. The Upper Greensand is well exposed on the west side of the Durdle peninsula and working further west towards Bat's Head good evidence of tectonic disturbance can be seen with low angle faults and evidence of slickensides. If the tide is suitable it is possible to walk towards Bat's Head and see lines of flint nodules on a wave-cut surface indicating the vertical dip of the Chalk.

**Note: There are additional sites of interest to the east of Lulworth Cove – the Fossil Forest, Mupe Rocks and Mupe Bay. However, they lie with the Lulworth army firing range and are only accessible during weekends and school holidays.**

## Thursday 4 October 2018 - Burton Bradstock, Charmouth and Bowleaze Cove

<b>Date:</b> Thursday October 4 <sup>th</sup> .	<b>Low Tides</b> 07:20 (0.83m)	<b>High Tides</b> 14:10 (1.44m)
<b>Start Location:</b> National Trust Car Park at Burton Bradstock.		
<b>Grid Ref:</b> SY 490888, Postcode: DT6 4RG		
Start Time: 09.15    Approx. Finish: 17.15		
<b>Lunch and Toilet Arrangements:</b> Packed lunches and drinks/water are required and can be purchased in Weymouth or Charmouth. Toilets at Burton Bradstock and Charmouth.		
<b>Field/Safety Equipment Needed:</b> Stout footwear, wet weather gear, hand lens, hard hat.		
<b>Aim of Excursion:</b> To study the Lower Jurassic Lias strata (Bridport Sand and Black Ven Marl) as well as active mass-movement processes.		
<b>Itinerary:</b> View Bridport Sand at Burton Bradstock and the impact of faulting. Evidence of weathering and the NW section of Chesil Beach (contrast this area with our previous Portland visit). Drive to Charmouth Grid Ref: SY364930, Postcode: <b>DT6 6QX</b> ; drop off at Charmouth Heritage Centre. Study section NE and SW of the Heritage Centre. Drive to Bowleaze Cove G.R. SY 702819, DT3 6PW. Walk to beach and study section to east of Bowleaze Cove. Corallian Upper Jurassic rocks with trace fossils and sedimentary structures		
<b>Terrain &amp; Length of Walk:</b> Beach sections on shingle, boulders at Bowleaze Cove. Total around 3km		
<b>General Low Risk Safety Hazards.</b> Slips and trips <b>Risk of rock falls especially at Burton Bradstock.</b> Take note of warning signs. Weather: bring suitable wet weather clothes.		
<b>Other Hazards of Low, Medium or High Risk:</b> Depending on weather large waves can break on the beach at Burton Bradstock.		

### 1. West Bay and Burton Bradstock

Start at the National Trust car park at Burton Beach by the Hive Café. (Grid Ref: SY 491888 Postcode DT6 4RG) and walk northwest along the beach below Burton Cliff. **Keep away from cliffs and beware of falling rocks!**

The beach is made of pea grit (flint or chert clasts) and sand and this is the most westerly part of Chesil Beach. There are also coastal defences with gabions and rock armour, the latter being made of Inferior Oolite limestone which contains a number of good examples of nautilus with simple suture lines. The low cliff nearest to the Café shows periglacial head.

The succession seen in the cliffs:

Middle Jurassic	Bajocian	Forest Marble
	Aalenian	Fuller's Earth Clay
		Inferior Oolite
Lower Jurassic	Upper Lias (Toarcian)	Bridport Sands

The Bridport Sand is Upper Lias (Toarcian), and marks the top of the Lower Jurassic. It is a fine sand of mainly good porosity depending on the degree of cementation. This porosity has resulted in the Bridport Sand being one of the reservoir rocks for the Wytch Farm oilfield in east Dorset.

The bedding is clear in the cliffs with a gentle dip to the E or SE which means that the Bridport Sand is 900 m below the surface at Wytch Farm. Major vertical joints occur which facilitate rock falls – see Fig 15 below. This is also helped by the under-cutting of the cliff by wave action during high tide and storm conditions. The pea grit (made of flint and chert) easily erodes the base of the cliffs by corrasion.

Excellent examples of honeycomb weathering, due to carbonation, can be seen sometimes picking out trace fossil burrows. The rock is fossil-poor possibly due to diagenetic decalcification.

The Bridport Sand is a diachronous (across time) horizon when compared with similar lithologies in the Yeovil Sand, Bath Sand and Cotswold Sand which are progressively older as you work northwards.

The sandstone at the Freshwater end of the cliff shows good evidence of trace fossils (Thalassinoides) on bedding planes.

In the Bridport Sand cliffs fractures can be seen filled with later Jurassic material. These are Neptunian Dykes. The fractures were formed by rifting during the Jurassic.

Working NW towards Freshwater, the cliff rises to around 30 m with a capping of Inferior Oolite and Fuller's Earth Clay. The Inferior Oolite is a condensed sequence of around 4 m. The Inferior Oolite and Fuller's Earth Clay can only be studied in Burton Cliff, towards the Freshwater end of the section, in cliff falls which occur quite regularly especially in winter.



Fig 15 Cliff Section showing a capping of Fullers Earth overlying Inferior Oolite and Bridport Sands. Note the well-bedded nature of the Bridport Sands making up most of the cliff face and the scars of recent cliff falls

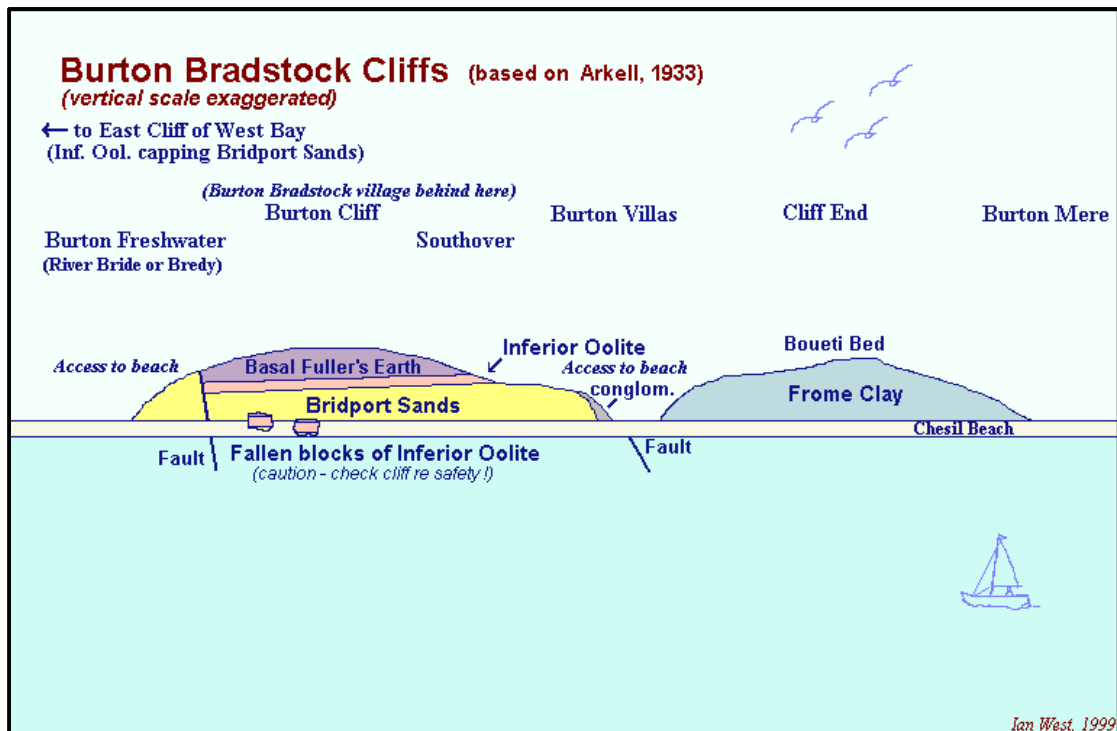


Fig 16 Diagrammatic section through the same succession

The fallen blocks of Inferior Oolite are extremely fossiliferous with abundant ammonites, belemnites, bivalves, brachiopods and sponges. Extracting the fossils can be quite difficult as it has been well lithified by diagenetic processes.

There are also interesting sedimentary structures called snuff boxes which are very distinctive. The snuff boxes seem to be formed of algal stromatolitic (microbial) laminations of an unusual ferruginous type, centred around bivalve shells and other nuclei.

Ooliths are also present, suggesting the shallow water origin of this sequence as well as a number of erosion surfaces. Some observers however suggest that this is a sequence of deeper water origin!

Return to the Hive Car Park along the cliff path noting the excellent views to the west past Freshwater to West Bay, Golden Cap, Lyme Regis and beyond. To the SE you can see the low profile of the coastline along the Fleet and the then the wedge shape of Portland on the south side of the Weymouth Anticline.

Return to the beach by the Hive Café and walk east. The low cliff of grey Fuller's Earth Clay is obvious and contrasts markedly with the orange colour of the Bridport Sand cliff to the west. The clay is exposed here because it is down-thrown along a fault by at least 30 m, with the fault running along the valley by the Hive Café. The clay is marl (a calcareous clay) which dries out and cracks readily. When it rains it absorbs water and slumps readily hence the degraded nature of the cliff. The clay is not very fossiliferous but there are oyster beds within it and pieces of this can be readily found on the beach.

Above the Fuller's Earth Clay is the Forest Marble which is exposed in disused quarries around SY 502 886 near the car park on the B3157. The drystone walls also have excellent examples especially near the Orthona Retreat at Grid Ref: SY 511884 where large bivalves are obvious. The beach along this section is interesting with a number of plant species of interest colonising the shingle beach.

If time allows we shall go on to West Bay (park at Grid Ref: SY465904, Postcode DT6 4GA and walk to the harbour) where further exposures of Bridport Sand can be seen to the southeast. To the northwest there are exposures of Forest Marble and Frome Clay (Fullers Earth Clay).

## 2. Charmouth

The rocks of the Charmouth Beach area comprise part of the Lower Jurassic sequence overlain by Cretaceous rocks; the two being separated by an unconformity at the base of the Cretaceous.

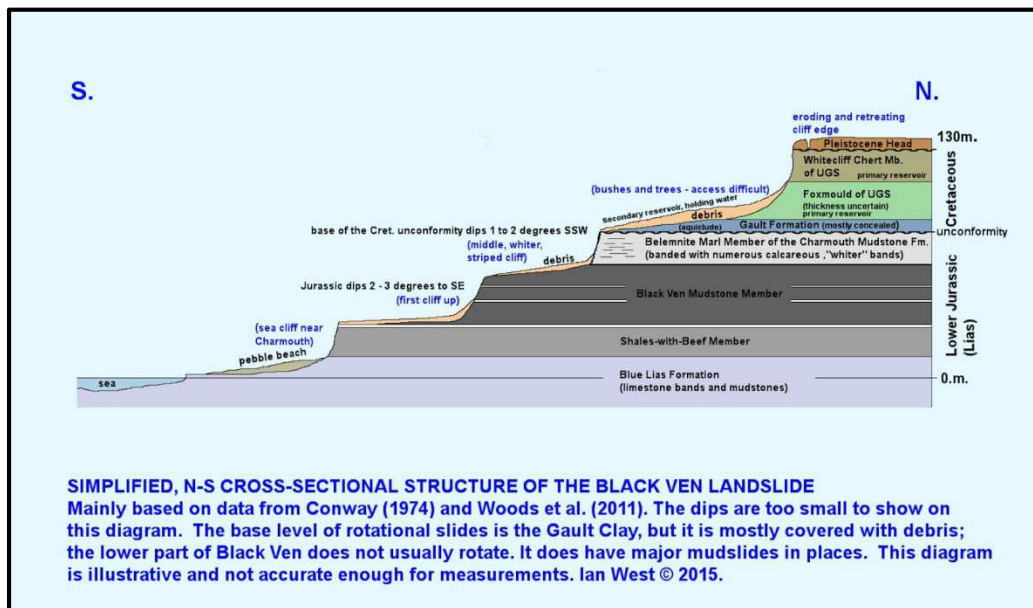


Fig. 17 Simplified cross-section of the Black Ven Area (after Ian West)

Fig 18 shows a more complete Lower and Middle Jurassic succession than that seen at Charmouth. The unconformity has occurred just above the Belemnite Marl and has stripped away the upper part of the succession.

The Black Ven Marls, lying above the Blue Lias are prone to mudslides when saturated after prolonged periods of rain – see Fig. 19 below. **Where the mudslides have occurred, great care must be taken; do not cross the slides as you can easily become trapped in the soft mud.**

The oil in the Wytch Farm oilfield of eastern Dorset is sourced from organic shales in this Lower Lias succession which have been buried at depths sufficient oil to raise the temperature to between 100 and 150 °C.

At higher temperatures, oil is destroyed and methane gas is produced.

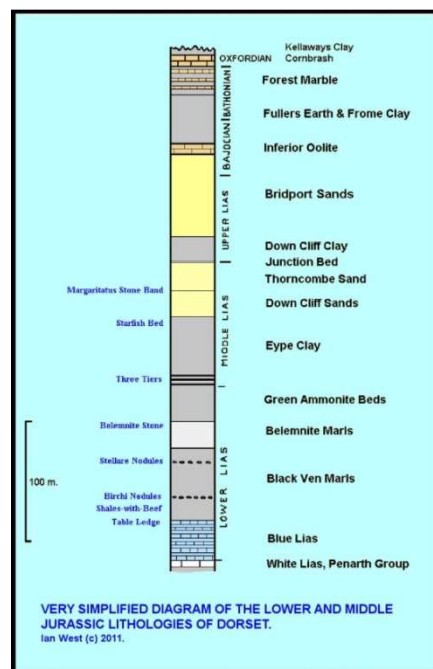


Fig 18 Simplified Lower and Middle Jurassic Succession showing the strata missing at Charmouth.



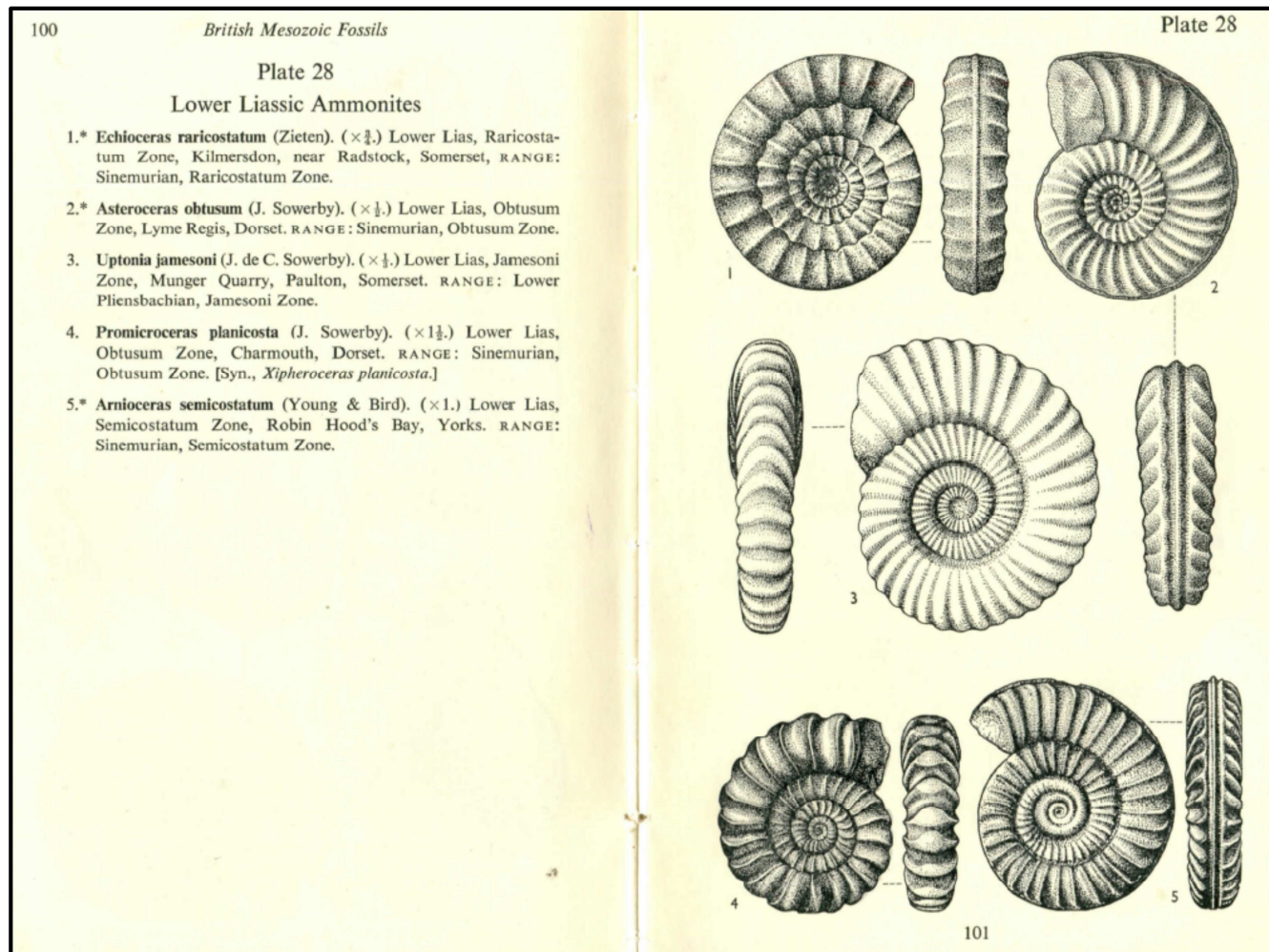
Fig 19 Mudslide in Black Ven Marls

		STAGES	ZONES	DIVISIONS	THICKNESS in metres
LOWER JURASSIC	TOARCIAN	UPPER LIAS	<i>Dumortiera levesquei</i>	BRIDPORT SANDS (PARS)	43
				DOWN CLIFF CLAY	21
			<i>Grammoceras thouarsense</i> <i>Haugia variabilis</i> <i>Hildoceras bifrons</i> <i>Harpoceras falciferum</i> <i>Dactyloceras tenuicostatum</i>	JUNCTION BED	4
	PLEINSBACHIAN	MIDDLE LIAS	<i>Pleuroceras spinatum</i>	MARLSTONE ROCK BED	0.6
				THORNCOMBE SANDS	27
			<i>Amaltheus margaritatus</i>	MARGARITATUS BEDS	2.3
				DOWN CLIFF SANDS	26
				EYPE CLAY	68
				THREE TIERS	10
	SINEMURIAN	LOWER LIAS	<i>Prodactyloceras davoet</i>	GREEN AMMONITE BEDS	34
			<i>Tragophylloceras ibex</i>	BELEMNITE STONE	0.15
			<i>Uptonia jamesoni</i>	BELEMNITE MARLS	23
			<i>Echioceras raricostatum</i> <i>Oxynoticeras oxynotum</i> <i>Asteroceras obtusum</i>	BLACK VEN MARLS	46
			<i>Caenisites turneri</i> <i>Arnioceras semicostatum</i> <i>Arietites bucklandi</i>	SHALES WITH BEEF	25
HETTANGIAN		<i>Schlotheimia angulata</i> <i>Alsatites liasicus</i> <i>Psiloceras planorbis</i>	BLUE LIAS	32	

**Biostratigraphy of the Dorset Lower Jurassic, with lithological units and maximum thicknesses.**  
 Modified after House (1993) and Cope (1980). Ian West, 2004. (revised 2011, Ian West (c) 2011.)

Fig 20 Biostratigraphy of the Lower Jurassic

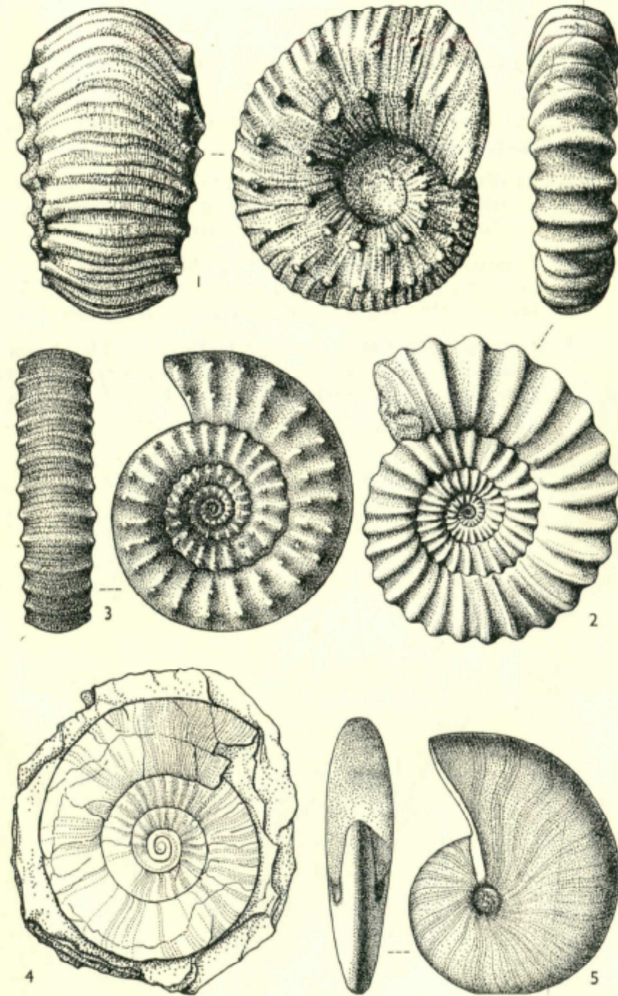
Some common Lower Lias ammonites are shown below (from British Mesozoic Fossils, 4<sup>th</sup> Edition, British Museum (Nat. Hist.) (1972))



## Plate 29

## Lower Liassic Ammonites

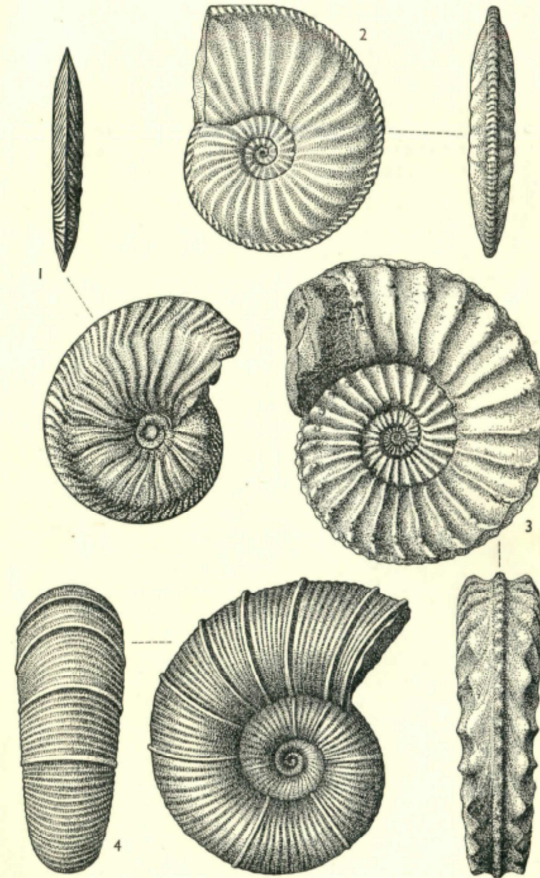
- 1.\* *Liparoceras cheltiense* (Murchison). ( $\times \frac{1}{2}$ .) Lower Lias, Ibex Zone, Cheltenham, Glos. RANGE: Lower Pliensbachian, Ibex Zone.
2. *Androgynoceras lataecosta* (J. de C. Sowerby). ( $\times \frac{3}{4}$ .) Lower Lias, Davoei Zone, Stroud, Glos. RANGE: Lower Pliensbachian, Davoei Zone. [Syn., *Aegoceras lataecosta*.]
3. *Microderoceras birchi* (J. Sowerby). ( $\times \frac{1}{2}$ .) Lower Lias, Turneri Zone, Lyme Regis, Dorset. RANGE: Sinemurian, Turneri Zone.
- 4.\* *Psiloceras planorbis* (J. de C. Sowerby). ( $\times \frac{3}{4}$ .) Lower Lias, Planorbis Zone, Watchet, Somerset. RANGE: Hettangian, Planorbis Zone.
5. *Tragophylloceras loscombi* (J. Sowerby). ( $\times \frac{1}{2}$ .) Lower Lias, Lower Pliensbachian, Davoei Zone, Golden Cap, near Charmouth, Dorset. RANGE: Pliensbachian, Davoei and Margaritatus Zones.



## Plate 30

## Lower and Middle Liassic Ammonites

- 1.\* *Oxynoticeras oxynotum* (Quenstedt). ( $\times \frac{1}{2}$ .) Lower Lias, Oxynotum Zone, Cheltenham, Glos, RANGE: Sinemurian, Oxynotum Zone.
- 2.\* *Amaltheus margaritatus* de Montfort. ( $\times \frac{1}{2}$ .) Middle Lias, Margaritatus Zone, Ilminster, Somerset. RANGE: Upper Pliensbachian, Margaritatus and Spinatum Zones.
- 3.\* *Pleuroceras spinatum* (Bruguière). ( $\times \frac{1}{2}$ .) Middle Lias, Spinatum Zone, Down Cliff, near Bridport, Dorset. RANGE: Upper Pliensbachian, Spinatum Zone. [Syn., *Paltopleuroceras spinatum*.]
- 4.\* *Lytoceras fimbriatum* (J. Sowerby). ( $\times \frac{1}{2}$ .) Middle Lias, Upper Pliensbachian, Margaritatus Zone, Lyme Regis, Dorset, RANGE: Lower and Upper Pliensbachian, Ibex to Margaritatus Zone.



### 3. Bowleaze Cove

The aim of the field trip is to study the rocks in a cliff section from Furzy Cliff (Jordan Cliff) and Bowleaze Cove SY 704818 to Redcliff Point SY 712816.

**Safety:** tides are not generally a problem on this section but a low tide is preferable. The beach is covered with large boulders and care is need when walking along the beach. It is not always possible to reach the cliff path at Redcliff Point, and it may be necessary to walk farther east to return to Bowleaze Cove

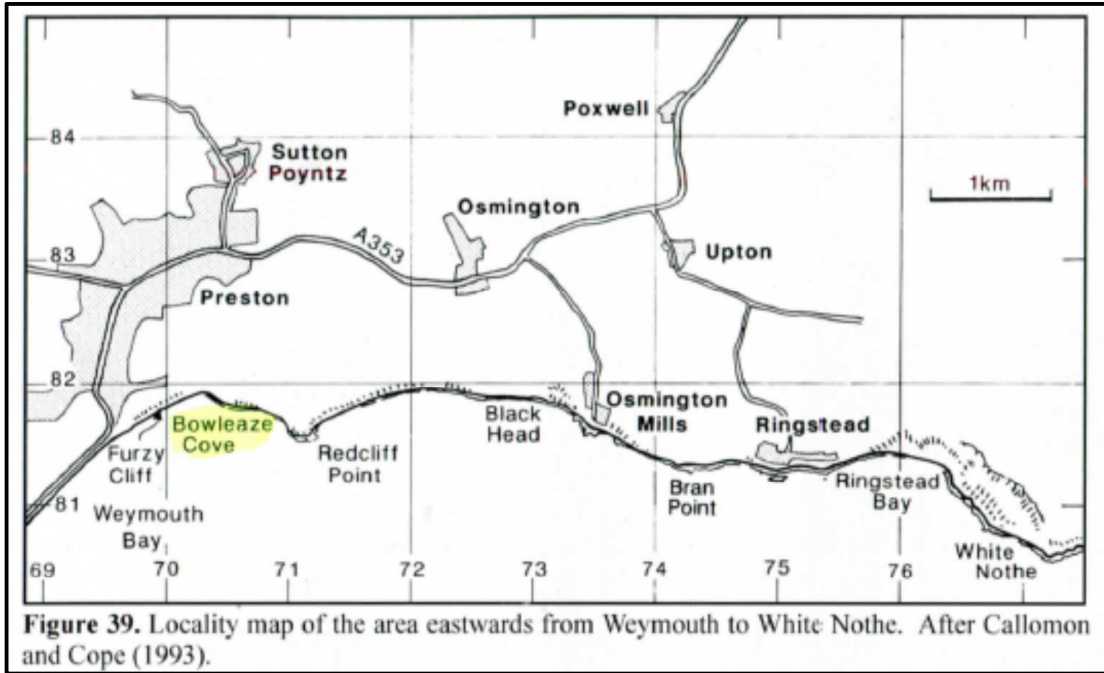


Fig 21 Locality Map of the Bowleaze Cove Area

**Succession seen:** part of the Upper Jurassic Series, Oxford Clay Formation and Corallian Group.

Formation	Member	Comment
Osmington Oolite	Shortlake	Oolitic Limestone
Redcliff Formation	Bencliff Grit	Sandstone with concretions
	Nothe Clay	Grey and sandy mudstone, circa 8 limestone horizons. Locally abundant bivalves.
	Preston Grit or Trigonia Bed	Now called <i>Myophorella huddlestoni</i> bed.
	Nothe Grit	Sandstone with pervasive bioturbation ( <i>Thalassinoides</i> and <i>Rhizocorallium</i> )
Oxford Clay	Oxford Clay	This forms Furzy Cliff and Redcliff Point. Massive clay with little bedding

The **Oxford Clay** exposed in Furzy Cliff is a mudstone, a massive type of clay with little evidence of bedding. The exposure is not brilliant because of the effects of mass-movement (rotational slip and clay flows) mixing the clay with the overlying Corallian sandstone (orange). Occasional bivalves, especially the oyster *Gryphaea*, and ammonites can be found indicating deposition in a marine environment.

Red nodule concretions can be found - a marker horizon for the top of the Oxford Clay. The eastern end of Furzy Cliff has an orange sandstone capping which is the base of the Corallian.

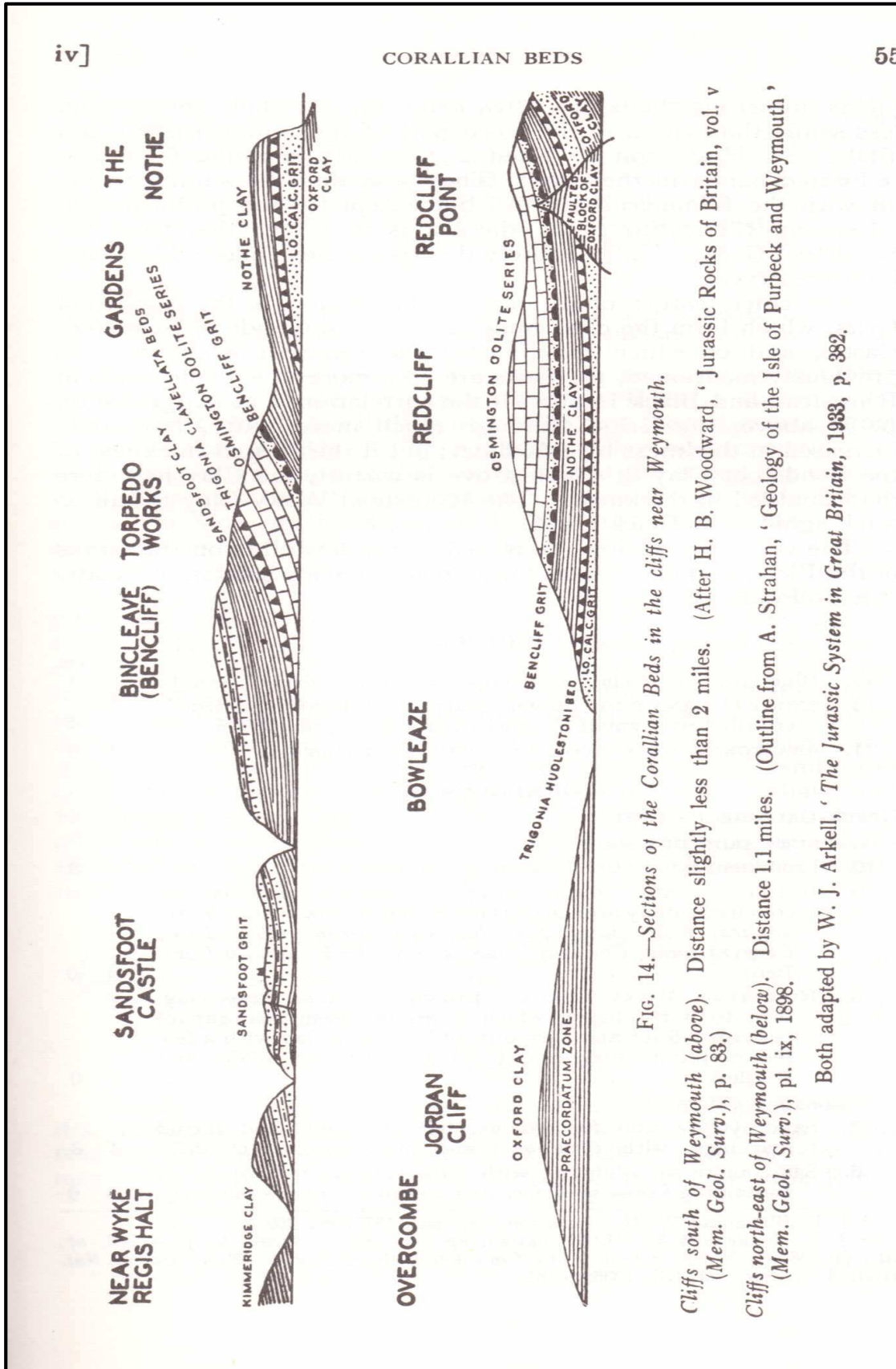


Fig 22 Diagrammatic Section along the coast from Bowleaze Cove to White Notthe

The lower cliff east of Bowleaze exposes sandstones of the **Nothe Grit Formation**. This is made of different types of sandstone with varying degrees of cementation. Some are well-cemented and relatively hard, others less well-cemented and are easily eroded away. The less well-cemented sandstones have some better-cemented parts which form nodules or **concretions**. These are particularly well developed in the Bendcliff Grit. They weather out of the cliffs and form large rounded boulders on the beach. The softer sandstone around the nodules is worn away by surface processes. The better cemented beds are well-jointed in places allowing the blocks to be affected by mass movement leading to these tumbling on to the beach. They can be studied more easily but they have lost their true orientation. This applies to other blocks such as the oolitic limestone mentioned later.

The blocks show variation in colour. This is probably a diagenetic change as colour change seems to follow bedding planes and joints. Groundwater moving along bedding planes and joints would move into the pore spaces in the sandstones depositing chemicals or changing the chemicals present especially iron compounds.

The blocks are **fossiliferous** but the fossils are often fragmented suggesting they were deposited in a high-energy environment. This is confirmed by the grain size of some of the sediment which is a medium to coarse sand. The presence of **ammonites** indicates a normal marine environment in terms of salinity as already pointed out. The ammonites are also good zone fossils telling us that the rocks are Mesozoic (Jurassic or Cretaceous) in age. It is difficult to identify the ammonites because they are not very common or well-exposed in the rock. **Bivalves** such as Pecten and Myophorella (previously called Trigonina) are common. These are typical of the Corallian succession. **Fossil wood** (lignite) also occurs and this probably floated in from nearby land (Dartmoor or further west) when the sediments were being deposited. Often the lignite is associated with **pyrite**.

The bacteria breaking down the wood ran out of oxygen so they broke down sulphate ( $SO_4$ ) releasing oxygen ( $2O_2$ ) and leaving sulphur (S). The sulphur then combined with iron salts to produce FeS (iron pyrites). The presence of pyrite suggests anaerobic conditions but the abundance of fossils especially trace fossils suggests well-oxygenated conditions. The anaerobic conditions were only very local around the wood (sunken tree trunks and branches). **Other minerals** found include gypsum (calcium sulphate -  $CaSO_4 \cdot 2H_2O$ ) - these often occur as small needles. Calcite (calcium carbonate -  $CaCO_3$ ) also occurs as veins. This material is probably derived from the solution of fossil shells within the sandstone. This could also be the source of the carbonate cement for some of the sandstones.

**Trace fossils** (burrows of worms and crustacea) are abundant suggesting a soft substrate for some time after the sediment was deposited. Sand sediments (siliclastic) take a long time to lithify - thousands of years or longer. Long tubes which criss-cross the surfaces (Thalassinoides) as well as various types of burrows occur. U shape burrows are common with Arenicolites and Diplocraterion parallelum. In the case of Diplocraterion the U shape form was moved up and down in the sediments according to whether sediments were deposited or eroded from the surface. The organisms producing the burrow could move up and down within the sediment as was necessary. Solitary single tubes of Skolithos also occur. Some of the sediments have been so burrowed that the original bedding was destroyed or very deformed. This is called bioturbation. See Fig 23 below for trace fossil identification.

**Sedimentary structures** such as **ripple marks** are common in the sandstones. These are formed on the sediment surface by moving water. Tidal currents lapping back and forth produce symmetrical ripples which often occur as parallel ridges. Ripple nets occur where tidal currents interact with waves moving in different directions.

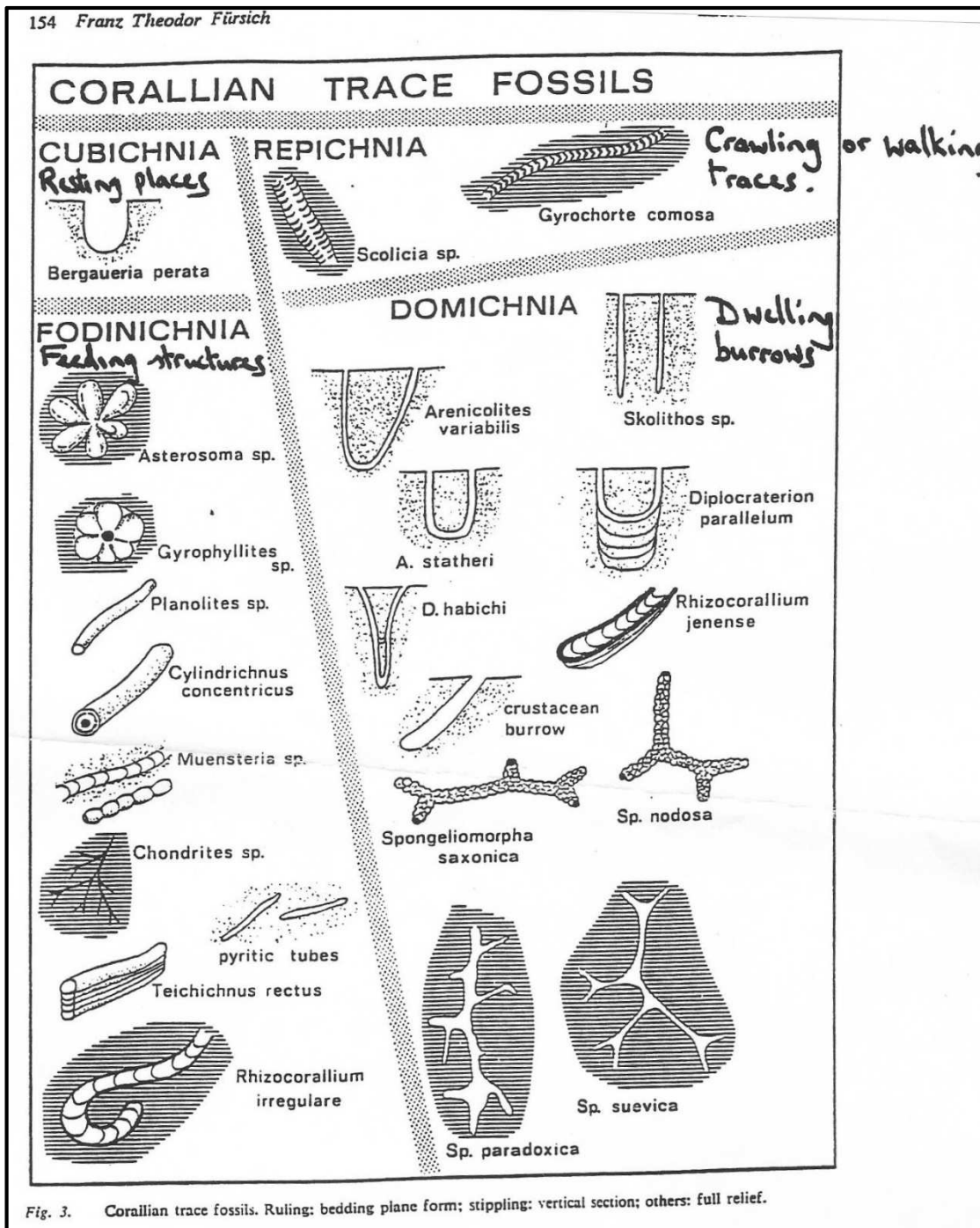


Fig. 3. Corallian trace fossils. Ruling: bedding plane form; stippling: vertical section; others: full relief.

Fig 23 Corallian Trace Fossils

Blocks of oolitic limestone can be seen on the beach nearer to Redcliff Point. These are from the upper cliff of **Osmington Oolite**. The oolitic texture is readily seen with small spherical particles of sediment, lime mud having coated sand grains or shell fragments as they are moved by currents in shallow water. The high-energy conditions break up any shell material so fossils are rare. **Cross bedding** occurs because currents moves sediment and it is deposited on an inclined plane forming cross bedding or false bedding rather than normal horizontal bedding. Cross bedding is often seen in the sandstones, particularly the boulders (concretions) which are better cemented.

Apart from the sedimentary geology there is good evidence for modern processes (mass movement) and engineering geology linked to coastal protection. Mass movement processes have been active

along this coastline for the last 30 years (pers. Comm. Alan Holiday). Secondary source evidence suggests that Furzy Cliff has retreated around 100 metres since the 1860s. At low tide a Portland Stone artificial reef can be seen off-shore and this possibly marked the coastline in Victorian times.

Clay flows occur when the Oxford Clay mudstone becomes saturated. This takes place during most winters. Further east along Furzy Cliff where the Corallian Sandstone (Nothe Grit) caps the clay, rotational slip takes place.

East of Bowleaze Cove, the more complex geology with interbedded sandstone limestone and clay produces a variety of processes. Rock falls occur especially in the well jointed and bedded Preston Grit. The large blocks topple over onto the beach. Clay flows occur, especially in the Nothe Clay, mostly in winter, which helps to transport more competent rock but also destabilises the upper cliff (Osmington Oolite). Significant talus has developed in recent winters on the beach immediately to the west of Redcliff Point. The combination of flow and rotational slip has caused recession of around 5 metres in the past 2 or 3 years. Outstanding examples of rotational slip can be seen between Bowleaze Cove and Redcliff Point. The blocks stay intact for some time, gradually tilting backward more and more steeply. A particularly large block broke away in April 2016; it is at least 100 m long by 10 m wide

**Coastal protection:** Attempts to stop coastal recession have been occurring since the 19<sup>th</sup> Century. The Portland Stone reef, mentioned above, located off Furzy Cliff bears testimony to this. An early attempt to stop mass movement on the east side of Bowleaze is shown by gabions (stone filled wire mesh bags). Mass movement in the past has deformed the line of gabions. It is not clear when these were put in place but there hasn't been any obvious movement in the last 30 years. In 1978/9 work was carried out on the cliff below the Pontin's Riviera Hotel which involved putting in drainage, reducing the steepness of the upper cliff as well as supporting / protecting the lower part of the cliff with gabions. This project cost £60,000 at the time and has proved successful, as little subsequent movement has been apparent. However, since 1979 mass movement just to the east of the Riviera Hotel has accelerated significantly and the original coast path has largely disappeared, the footpath having been redirected via the end of Bowleaze Cove Way. In AH's opinion, although not based on any significant evidence, that material moved in 1978/9 destabilised this part of the cliff. Certainly, there seems to be a cause and effect relationship with the accelerated process in the last 30 years. There isn't any significant attack by the sea because of the large blocks of sandstone on the beach. The processes are almost exclusively sub-aerial.

In 1984 the coastal protection scheme at Overcombe Corner was built at a cost of around £400,000. Prior to this the area had been a car park which needed regrading after every winter. Winter storms regularly attacked the cliffs causing mass movement. This caused the end coastguard cottages to become unsafe. It was also projected that the Spyglass Inn (formerly the Embassy Hotel) would end up in the sea around the year 2000, given the rate of recession. With the building of the sea wall at Overcombe, mass movement has ceased, at least as far the end of the sea wall, and the area has been redeveloped with housing on the former car park and the rebuilding of the café, now the Oasis. The brewery company that owned the Embassy Hotel (Devenish), the local council and the Ministry of Agriculture and Fisheries paid for the sea wall. The owner of the car park land did very well out of this piece of coastal protection converting virtually worthless land into prime real estate.

In 1995/6 the implementation of the Preston Road Scheme resulted in a beach replenishment scheme as well as the replacement of the old sea wall. The unexpected (by the Environment Agency) movement of the shingle by longshore drift has resulted in the build-up of shingle below Furzy Cliff and this has reduced the marine wave attack. The cliff is now becoming increasingly degraded and may eventually become more or less stable to the advantage of property owners in Bowleaze Cove Way.

<b>Friday 5 Oct.</b>	<b>Activity</b>	
<p>It is very important we leave the hotel at 9.15 prompt in order to meet Chris Andrew at the Boat Building Academy (in the Monmouth Beach Car Park) at 10.30 am in Lyme Regis.</p> <p>Chris will take us on a walk of approximately 1 ½ hours to see the Ammonite Pavement, Monmouth Beach and the surrounding area. The exact route will depend on the tide, hence the need to start as early as we can. The later we are the less we shall see of the spectacular sights.</p> <p>If you have charged items to your room during your stay, please settle your account the previous evening to avoid delays on departure on Friday morning.</p>		
<b>Low Tide: 10:32 AM</b>	<b>Lunch 12.30 to 13.30</b>	<b>Ad Hoc</b>
<b>At 1.30 pm Depart Lyme Regis for Ledbury</b>		

### **Acknowledgements**

These notes have been put together from a variety of sources but I would particularly like to thank Alan Holiday for his extensive contributions.

### **References.**

Geology of the Dorset Coast. J.C.W. Cope. Geologists' Association Guide No. 22.

Geology of south Dorset and south-east Devon and its World Heritage Coast. N.E.R.C. British Geological Survey.

Geology of the Dorset Coast. John C.W. Cope. Geologists' Association Guide No. 22.

Coast and Country CD of geological walks. Dorset Geologists' Association Group. Search on internet for DGAG. D.G.A.G. now available only as a CD.

Classic Landforms of the East Dorset Coast. Andrew Goudie and Dennis Brunsden. Geographical Association (sister volume to Classic Landforms of West Dorset Coast by same authors).

Dorset and East Devon Landscape and Geology. Malcolm Hart

Also, go to Ian West's excellent website on Dorset Geology at:

<http://www.soton.ac.uk/~imw/Lulworth.htm>