U3A Field Visit to Dorset 1st – 5th October 2018

Led by Alan Holiday

Day 2. 2nd October 2018. Portland and Chesil beach.

The objective for this day was to study the Late Jurassic and Quaternary geology of Portland, as well as some aspects of quarrying of Portland Stone.

The Jurassic rocks studied on the Isle of Portland and the Chesil Beach area include the Corallian Group, which were the oldest seen on Day 2. The overlying formations become younger, topped by the Purbeck Group. The Purbeck Beds mark the top of the Jurassic and are overlain by the Cretaceous.

Locality 1. Heights Hotel, Portland.

Looking north at right angles to the eroded axis of the Weymouth anticline, which now forms Weymouth Bay.

The area near to the Heights Hotel held some interesting specimens which had been uncovered during quarrying on the Isle of Portland.

The Olympic Rings.

The Olympic Rings were created out of locally quarried stone to celebrate the 2012 games. The base was made using Roach Limestone which is full of brachiopods and bivalves, and though full of holes the rock is strong enough for ornamental structures. The upper part is made from the main limestones of Portland, the Whit bed with shelly fragments and the clean Base bed.

The Olympic Rings constructed in 2012, overlooking the sailing venue of Weymouth Bay.

Tufa flowstone.

.Tufa flowstone.

The main body of this large boulder is Portland Limestone, approximately 145my. Underground this rock fractures and is jointed. Slightly acidic rainwater dissolves the limestone. Water then runs down the joints and is re-precipitated as calcium carbonate $CaCO_3$. Quarrying in the past has exposed the tufa.

The local ammonite.

The local ammonite, *Titanites giganteus*, is the zone fossil for the Portland Limestone. Its rapid evolution allows it to be used for relative dating of the Jurassic and Cretaceous rocks. As a group the Ammonites began in the fossil record at the beginning of the Jurassic and continued throughout the Cretaceous.

The local ammonite *Titanites giganteus*.

Fossil tree.

Towards the end of the Jurassic conditions changed from the marine environment of the Portland to the lagoonal, freshwater conditions of the Purbeck. There was a long period of stability, which allowed the growth of large, coniferous trees. There were no flowering plants in the late Jurassic.

Fossil tree.

The specimen at this locality was from one of the Portland quarries. The original structure of the tree had been replaced by silica. Silicon dioxide SiO_2 is soluble in alkaline seawater. If conditions become more acidic, which is what happened when the conifers died and began rotting, silica is precipitated into the hard form. A lot of woody material was uncovered when rock was stripped away to get to the Portland stone beneath.

Wall of Hotel.

A variety of different types of Portland limestone have been used to build the wall. Roach limestone is very shelly. The shell material has been dissolved away to leave an

external mould. There is also some re-precipitation of calcite. The original shells were aragonite, and through the process of diagenesis the original material has been replaced by calcite. Diagenesis is the change of sediments into another sedimentary rock, taking place at temperatures and pressures below that required for metamorphic rock formation.

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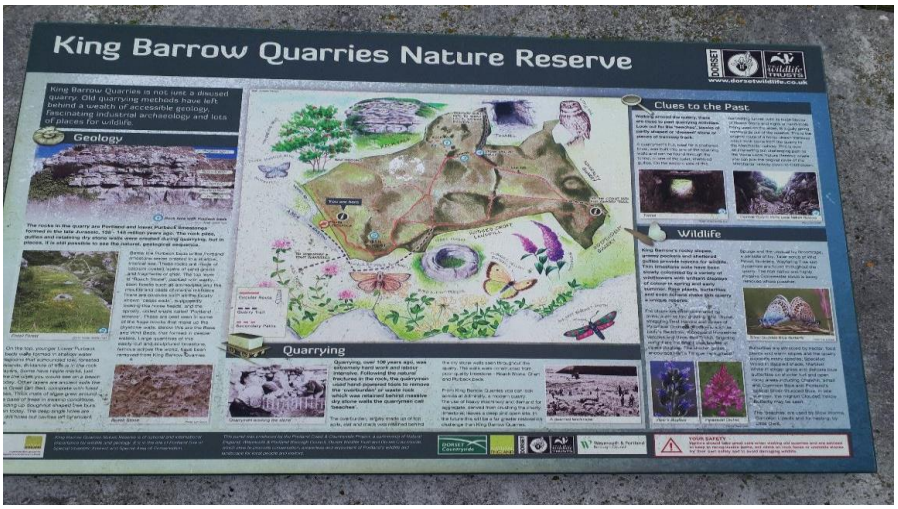
Portland shelly Roach Limestone.

Blocks of oolitic Portland Limestone.

The oolitic limestones were formed in shallow, tropical waters similar to those of the Caribbean. Differential weathering was evident in the different limestones. Some of the Purbeck limestone has stromatolites.

<u>Locality 2.</u> King Barrow Down Quarry.



Now owned by the Dorset Wildlife Trust, this quarry has not been properly worked since Victorian times. Currently there is a problem with Cotoneaster, but a grant has been obtained to eradicate this plant.

King Barrow Quarry marks the beginning of the Purbeck on Portland, and contains the fossil forest horizon. At Lulworth this horizon is within the firing ranges. During the life of these fossilized forest trees, sea level rose and the land became flooded with hypersaline water. The trees began to die and laminated microbial structures encrusted them. These structures are stromatolites which appear as preserved fossil rings. The stromatolites formed from layers of cyanobacteria, (a single-celled photosynthesizing microbe) which removed calcium carbonate from sea water which was then precipitated as the stromatolite structures. These photosynthetic structures added oxygen to the atmosphere. Those at King Barrow Down are dated at 145My. Other stromatolites from the fossil record include two sites in Scotland, the Cambrian at Durness and the Pre-Cambrian of Assynt.

Also in this quarry were holes in the rock faces where previously branches had been growing; and a palaeosoil covering the stromatolites, which is unlithified and still quite soft.

Stromatolite rings in Purbeck Limestone.

<u>Locality 3.</u> Bowers Quarry and Mine.

Within this quarry a fossil tree was sliced in one night to show the silicified tree rings.

Fossilized tree showing growth rings.

Portland chert.

Portland screw in Limestone.

Fossils were evident, particularly the gastropod known as the Portland screw. Also within the Portland is a band of rock known as the cherty series. This occurs near the top of the Portland sequence. The Portland chert is silica rich and working this stone is difficult. Quarrymen put it to one side to be used as rock armour in sea defences. In places it is evident that shells and the oolitic texture have been replaced molecule by molecule with silica. In a block of Portland stone a fossil saltwater bivalve which used to be known as *Trigonia*, and is now *Myophorella*, was seen as a cast.

Cast of saltwater bivalve *Myophorella*.

Myophorella impression in Portland Limestone.

At the top of the Portland ripple marks can be seen. Shallow water, lagoonal conditions prevailed and winds blowing across the lagoon created the ripples.

Ripple marks on the top surface of the Portland Limestone.

This mostly freshwater lagoon stretched from Dorset as far as the Paris Basin. A Mediterranean climate existed with periods of drought. The lagoon periodically dried out and as a consequence became salty. Halite crystals with their characteristic cubic shape, formed on the lagoon floor. The next time water ingressed the salt crystals dissolved and were replaced by sediment as pseudomorphs.

Halite crystal pseudomorphs.

At the quarry edge workings are evident. The Portland limestone was exploited for a long period of time through adits (horizontal shafts). Currently the quarrymen work the rock with chain saws. Steel bags, filled with water, are then inflated and lift the sawn rock. Blocks of any precise size can then be cut. Using this method it is possible to mine the massive limestone from underground, rather than opencast.

Bowers Quarry.

At the top of the Portland Stone there is a hard band of rock which is not commercially viable. This band forms a roof to the mine and negates having to cut down through the thin, rubbly Purbeck Beds above. Stromatolitic limestone with tree remains forms the base of these beds.

<u>Locality 4.</u> West Weares – at the coastal edge of Bowers Quarry facing west.

The cliff face has the complete sequence of rocks to be found on Portland. The oldest, and therefore at the base of the cliff, is the Kimmeridge Clay, overlain by Portland Sandstone, succeeded by Portland Beds and lastly at the top, the youngest, rubbly Purbeck Beds.

West Weares cliff, facing west.

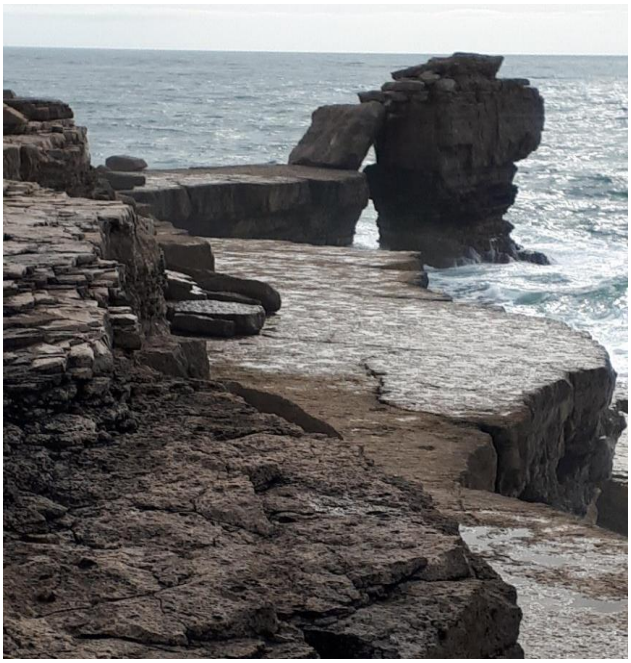
This cliff face has been actively eroded by the sea and waters percolating down from above. Some of the rocks have undergone rotational slip. However, some of the movement may have been during the Ice Ages. Waste rock from quarrying was also dumped over the cliff.

<u>Locality 5.</u> Portland Bill Raised Beaches.

The raised beaches are synonymous with significant fluctuations of sea level and climate change during the last two Ice Ages.

Beach 1.

West Pleistocene Raised Beach. At Pulpit Rock, the massive Portland limestone is almost a sea stack. The top of this outcrop forms the raised beach which dates from approximately 210,000 years ago when, during a warm interglacial phase of the Pleistocene Ice Ages, sea level was almost 50 feet higher than now. Rounded, flinty, chert pebbles became bound with calcium carbonate and became fully lithified. This beach deposit has little or no shells. On top of the raised beach is a layer of periglacial head, caused by solifluction and a period of drying and wetting. Solifluction is the gradual movement of wet soil or other material down a slope, especially where frozen subsoil acts as a barrier to the percolation of water.



Pulpit Rock and the raised first beach.

The raised beach with head material resting on the top.

Head material with rounded, flinty chert pebbles.

Beach 2. East Pleistocene Raised Beach.

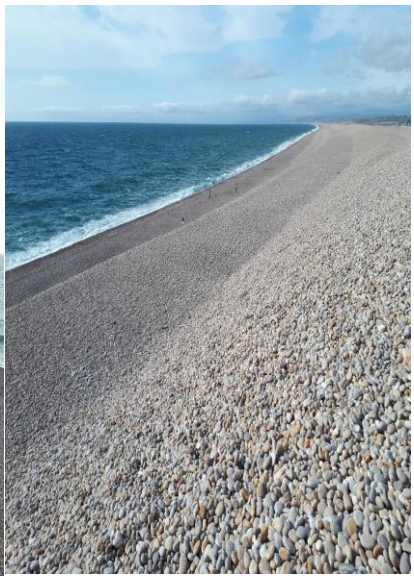
Dating from approximately 125,000 years ago this beach is covered with the shells of molluscs, for example *Patella* and *Littorina*, that when living fed on seaweed. During the late Pleistocene Ice Age the beach was disturbed by cryoturbation; the mixing of materials due to freezing and thawing in permafrost soils.

The second raised beach.

Chesil Beach.

Locality 6. Chesil Beach. Eastern end nearest to Portland.

Chesil Beach looking towards Portland.



Chesil Beach looking west.

From the east end of Chesil Beach to West Bay at the west end the structure, classified as a barrier beach which has "rolled" landwards, is 18 mile (29km) in length. Pebble size varies from pea grit in the west to larger pebbles towards Portland at the eastern end. A serious storm in 1978/79 did a significant amount of damage. Post this date a concrete sea wall and a wave return wall, with gates to close in the event of a storm, was constructed. This structure was topped by a gabion tower mattress. However in 2014 six storms, each one rated a one in fifty year event, took place in a six week period. The tower and mattress were wrecked. The cost of the present sea defences was one million pounds. At the east end of the beach undermining caused damage to the sea wall, this has been replaced by steel sheeting and concrete. As a result the beach has built up again quite significantly. There is now a storm warning system in place. A wave buoy sends messages to a receiving centre in Blandford and warnings are relayed from there.

Chesil Beach showing the gabion tower matress.

The formation of Chesil Beach is the result of sea level change in the last ten thousand years. Constituent beach material is made up of red/brown quartzite pebbles from the Triassic Budleigh Salterton pebble beds, chert from the Upper Greensand, and the highly fossiliferous limestone and banded chert of the local Jurassic rocks.

Fossiliferous limestone pebble.

Red/brown quartzite pebble.

Looking at the leeward side of Chesil Beach, there are large gulley like depressions known as cans. These were formed when storm waters flowed through the beach material.

<u>Locality 7.</u> Camp Road, The Fleet.

At this locality the Corallian of the Upper Jurassic forms an extensive deposit. Further down the succession from the rocks at Portland, the beach and cliffs here are made up of Osmington Mills oolite. The beach is composed of ooliths with the irregular, heart-shaped echinoid *Nuclealites scutatus* contained within the limestone.

Echinoid *Nuclealites scutatus*.

Irregular heart-shaped echinoid *Nuclealites scutatus*.

These echinoids have one plane of symmetry, and in life lived buried in sediments. Regular echinoids lived on the sea floor and upon death were easily destroyed, whereas the irregular species were more likely to be preserved.

Trace fossils were also seen in the limestone as vertical tubes. The surface holes to the tubes – skolithes – were very frequent, indicating a rich fauna.

Trace fossil in Osmington Mills limestone.

Gastropod in Osmington Mills limestone.

The Rocks of Dorset

Quaternary – raised beaches and glacial deposits Portland Day 2.

East

Cretaceous

Chalk - Lulworth Day 3.

Upper Greensand - Lulworth Day 3.

Lower Greensand - absent.

Wealden Group – Lulworth Day 3 and Portland Day 2.

Purbeck Group – Lulworth Day 3 and Portland Day 2.

Jurassic

Purbeck Group – Lulworth Day 3 and Portland Day 2.

Portland Group – Lulworth Day 3 and Portland Day 2.

Kimmeridge Clay Formation – Portland Day 2 – poorly exposed.

Corallian Group – The Fleet Day 2.

Bridport Sand – Burton Bradstock Day 4.

Oxford Clay – Bowleaze Cove Day 4.

Lias Group – Lyme Regis Day 5.

West