# 8 May 2017
# Tenby

## South Beach, Tenby.

Traverse in the Carboniferous Limestone across the Tenby Anticline to Castle Hill. Lots of shelf-sea fossil localities and very good exposures of the lagoonal Caswell Bay Mudstone.

### Locality 1. South Cliff, Tenby.

At the south end of the beach the cliffs expose on an E-W strike section, strike 280-140 and dip 078°S, through the Hunt's Bay Oolite Formation.

**Figure 1: Dipping rocks of the Hunt's Bay Oolite Formation.**

This is a light-grey, fine-grained bioclastic (limestone derived from shell fragments and similar organic remains) and oolitic limestone. It is indicative of a warm, shallow shelf area and provided an ideal environment for life to proliferate. Seen through a hand lens it is full of fossils and tiny spheres – ooliths. In the field it is a bedded sedimentary rock, which scratches easily and effervesces with 10 % HCL. Many of the bedding planes are crowded with the remains of brachiopods *Composita ficodea*, *Cyrtina* and *Productus*. The fossils were used to check whether the beds were the right way up. Because of tectonics, way up was determined by observing the shells of brachiopods and whether they were in the correct growth position or upside down. The fossils were infilled with calcite, producing a geopetal structure: this is a sedimentary fabric which records the way up at the time of deposition. Geopetal structures are commonly found in cavity fills within limestones, where the lower part of the cavity has been filled with limestone sediment and the upper part has been filled later with crystalline calcite cement which was mineralised in the Triassic. The beds were the right way up. Massive calcite veins were formed when the thin Triassic cover allowed percolation of minerals in solution to cause staining. Some cracks were filled with mud, possibly the early stage of collapse breccia deposits.

Further east along the beach a large horizon of the limestone was crowded with valves of *Gigantoproductus giganteus*, many of which were in the life position.

**Figure 2: Fossil remains of the largest Carboniferous brachiopod - *Gigantoproductus giganteus*.**

Calcite mineralized slickensides were observed on some of the bedding planes associated with two E-W trending fault planes.

## Locality 2. South Cliff.

Close to the base of the Hunt's Bay Oolite large displaced colonies of *Syringopora (Lithostrotion) martini* - a large coral with a hexagonal cross-section.

**Figure 3: South Beach – corals in the Hunt's Bay Oolite.**

Holes in the rocks could have been made by piddocks, bivalves with specially-adapted oval shells which can excavate burrows in rock.

Slickensides were used to determine the slip direction of bedding planes in this locality. The rougher surface going up the rock, smoother going down indicated a dextral slip.

Working down the succession led to the contact between the Hunt's Bay Oolite and the top of the High Tor Limestone.

**Locality 3. South Cliff.**

Towards the top of the High Tor Limestone was a horizon of *Lithostrotion* and vesiculate coral reef.

**Figure 4: *Lithostrotian* coral.**

A fall in sea level meant the top of the limestone reef was eroded and redeposited in the surf zone. Iron staining could be indicative of emergence. Glaciation and deglaciation on Gondwanaland every 100,000 years was the probable cause.

At this locality interbedded limestones and mudstones form the Caswell Bay Oolite with *Caninia*, and Caswell Bay Mudstone. Below the High Tor Limestone in a contact layer of red mudstone – a palaeosoil, which continues through an undulating contact with potholes which have been in and out of water signifying an emergent horizon.

**Figure 5: Rugose coral in Caswell Bay Oolite.**

At the base of the mudstone is a palaeokarst (a buried fossilised karst). Caused by glaciation in Gondwanaland – the sea level fell then rose (ice melt). The fall in sea level gave rise to the first appearance of lagoonal conditions and the formation of coloured mudstones. During drier periods desertification cracks and evaporates might have arisen. The 'chicken wire' anhydrites – typical of present-day sabka (salt flat) environments also formed during these drier periods. After deposition the anhydrite was replaced by calcite.

Common in the Caswell Bay Oolite were lagoonal algal mats. The crinkly cryptalgal laminations were formed by algae in very shallow water.

**Figure 6: Cryptalgal laminations.**

At the base of this horizon and the top of the next the contact is very irregular. The mudstones cut out an erosional surface and fossiliferous limestone reappeared. This is a sign that sea level rose rapidly and the deposits are once again of a pure, open marine type. This was a transgressive surface of marine erosion. There are about eight palaeokarst surfaces in this horizon.

**Locality 4. Gunfort Gardens.**

Initially the rocks here have the same dip as those at Locality 1, to the south. However, the WNW trending and easterly plunging axis of the Tenby Anticline intersects the cliffs just to the north of Gunfort Gardens. The southern limb is more gently dipping than the steep northern limb.

**Locality 5. Castle Sands.**

On the northern limb of the Tenby Anticline the succession of the southern limb is repeated. The Caswell Bay Oolite overlies the Caswell Bay Mudstone. A complex faulted minor crumple fold has developed above a low angle 35° E small thrust.

**Figure 7: Low angle thrust in Caswell Bay strata.**

**Locality 6. Castle Hill.**

The hill is isolated by splays of the Ritec Fault, evidence for which is recorded by the sheared and brecciated dolomites at the southern margin of the headland.

**North Beach, Tenby. Tenby Harbour.**

Complex structure of the Namurian strata exposed on the foreshore and in the cliffs.

First Point – Telpyn Point Sandstone, an example of an incised valley fill with sequence boundary well exposed along the base of a tight syncline.

**Locality 7. North Beach, Tenby.**

The Namurian of Tenby Harbour is poorly exposed and consists of goniatite-bearing *Homoceras beyrichianum*, a succession of black shales and thin erosively-based quartz arenites, all of which have been deformed into a syncline. The sandstones contain structures which can be used to indicate way up.

The rock sequence is cut by three southward dipping splays of the Ritec Fault. Two of the faults have thrust a wedge of sheared and brecciated Carboniferous Limestone into the section as seen at Barrel-post Rock.

**Locality 8. Gosker Rock.**

Gosker Rock is a tectonically complex outcrop. It has been dated by the few trace fossils found. The usefulness of way up structures has determined that the whole rock forms part of an inverted syncline. It is a southward dipping stack, composed of siltstones that coarsen upwards into ripple cross-laminationed micaceous sandstones. The ripple marks are continued evidence of a south-easterly flowing palaeocurrent.

**Figure 8: Gosker Rock.**

A dextral tear/wrench fault has displaced the sandstone by 125m seen in the outcrop at North Cliff.

**Locality 9. First Point, Tenby Harbour North Beach.**

Telpyn Point is an example of an incised valley fill with a sequence boundary well exposed along the base of a tight syncline.

At this point the rocks were vertical and deformed into a tight syncline.

The base of the Telpyn Point Sandstone is an important horizon. It has a very irregular surface of conglomerate composed of ironstone clasts, pebble lag deposits, ironstone bands and nodules reworked into the base of the sandstone.

**Figure 9: Base of the Telpyn Point Sandstone with irregular conglomerate horizon.**

A lag deposit is the deposition of material winnowed by physical action. Aeolian, fluvial and tidal processes can remove the finer particles of a sedimentary deposit leaving the coarser material behind. It is a deeply eroded horizon. Just below the surface is a thin plant-bearing shale which has been deeply eroded with log casts, coal streaks and a mudstone melange.

The sandstone body is interpreted as a multi storey fill of an ESE trending incised valley and consequently its erosional base represents a sequence boundary. Rib and furrow structures provide evidence for the current direction.

The plant bed is considered to represent the remains of a terrace deposit formed during the erosion of the incised valley. The fluvio-deltaic deposits cut below the normal level, due to a massive falling in sea level by as much as 100m; which in turn led to a rapid down cutting by streams and rivers. A subsequent rise in sea level meant rivers flooded and the incised valleys were infilled – this gave rise to the next marine band.

Economically these sometimes very porous rocks became reservoirs and stratigraphic traps for oil and gas.

**Locality 10. Amroth (east).**

The east end of the type locality for the Telpyn Point Sandstone. In east Amroth the Coal Measures include a Westphalian classic coarsening-up deltaic sequence, approximately 50m thick. The Amroth ‘slump sheet’ is developed below ripple laminated fine sandstones of a more proximal aspect. The distributary channel sandstone marking the top of the sequence displays an erosive base that at one point almost washes-out the Lady Frolic coal seam.

**Figure 10: Eastern end of Amroth beach – looking towards Telpyn Point Sandstone which includes the Lady Frolic Coal Seam and the Amroth slump sheet.**

In west Amroth, which was not visited, the Lower Westphalian Coal Measures contain the Amroth Freshwater Limestone.

Working up the succession at east Amroth.

The base is formed by the *Gastioceras subcrenatum* Marine band. A lake environment with no sediment coming in allowed the build-up of a mussel bank.

**Location 11: Non-marine bivalves.**

In a distal bar environment, siltstones with wavy streaked laminations and climbing ripple cross-lamination are shown in darker mud and sand.

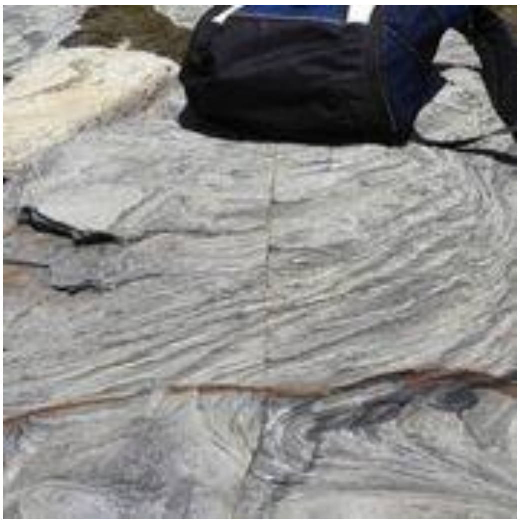

**Figure 12: Climbing ripples**

The sand was in a higher flow regime than the mud and indicates a lake with tidal conditions i.e. a lagoon with abundant *Lingula*.

Above lies the Amroth ‘slump sheet’. A very important horizon, first identified in 1945 by a Dutchman. It comprises contorted balls of sandstone which have moved down slope. Formed by earth movement on the Rheic fault, they were caused when the shock waves converted mud to liquid and sand balls fell into the mud. This lithification of liquefaction indicates sediment mobilization on the Carboniferous delta front.

**Figure 13: Amroth 'slump sheet' with the Lady Folic Coal Seam above.**

Overlying, and in shallow water at a delta mouth bar, fine grain sandstones with micro-trough cross laminations were deposited.

Next siltstones with plant remains are capped by a thin seat earth. An interdistributary bay is represented as a discoloured horizon. The seat earth is a seam of humic acid that attacked clay minerals and removed them. The seat earth contains quartz rich ganisters. In Northern England ganisters are close grained, hard siliceous rock found in the Coal Measures and used for furnace linings or refractory bricks.

Continuing up the sequence, lies a very thin dark coloured sandstone with a coal seam. This is the Lady Frolic coal seam representing an interdistributary marsh.

Finally at the top of the sequence at this locality lies a medium grained, cross bedded, stratified sandstone, with an erosive base that cuts off the Lady Frolic coal seam. Formed in an incised distributary channel, this horizon caused a major problem if it was overlying the coal. As it is a porous rock the coal seams could be washed out. Miners knew when they were approaching the 'wash out' sandstone.

**Locality 11. Saundersfoot – Ladies Cave Anticline.**

Exposed 300m to the south of Saundersfoot Harbour, the Ladies Cave Anticline presents as an asymmetric, chevron fold with long straight limbs, an inter-limb angle of 65° and a narrow hinge zone.

**Figure 14: Ladies Cave anticline, Saundersfoot.**

The steeper limb is to the north because the maximum pressure came from the south. The flow of mudstones into the hinge of the fold have created features such as sub-vertical limb thrusts and small saddle reefs. At the core of the fold the shales have a convergent fan cleavage. Part of the core has been eroded away where the shale is weaker and was also crushed during tectonic events.