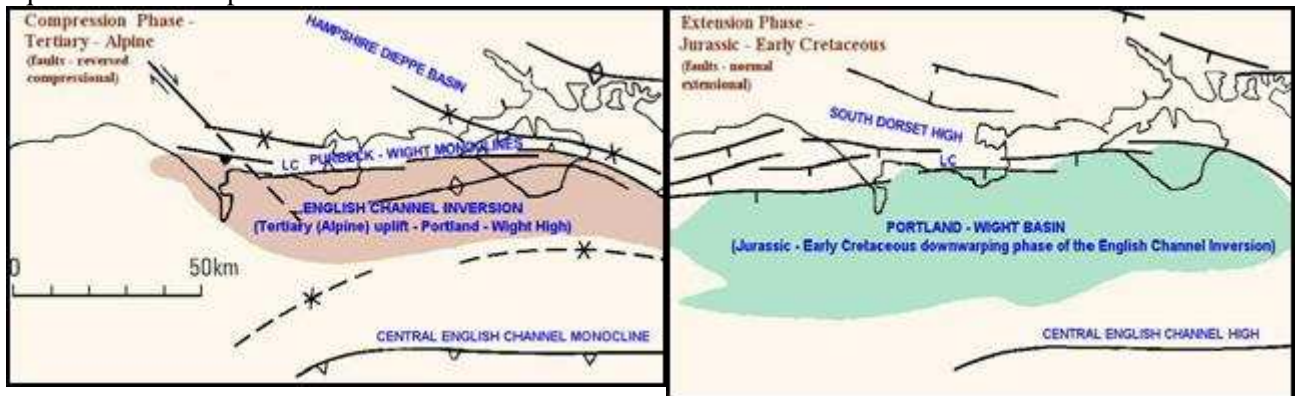


A journey to Mupe Bay, Dorset
FGS field trip, 3 August 2008

A visit to Mupe Bay, Dorset, provides evidence for the opening of the mid-Atlantic, global sea-level rise and Africa's collision with Europe.

Structural setting

The opening of the mid Atlantic in the Mesozoic caused crustal extension and thinning; huge areas subsided along a series of great listric (curved) faults to form basins such as the Weald and the Portland-Wight. Our journey around the back of Lulworth Cove, onto the lower slopes of Bindon Hill, and east to Bacon Hole and Mupe Bay, takes us along the major fault system which formed the north margin of the Portland-Wight Basin. Mesozoic sedimentary formations in the Portland-Wight basin are 2 1/2 times thicker than their equivalents on the platform to the north.

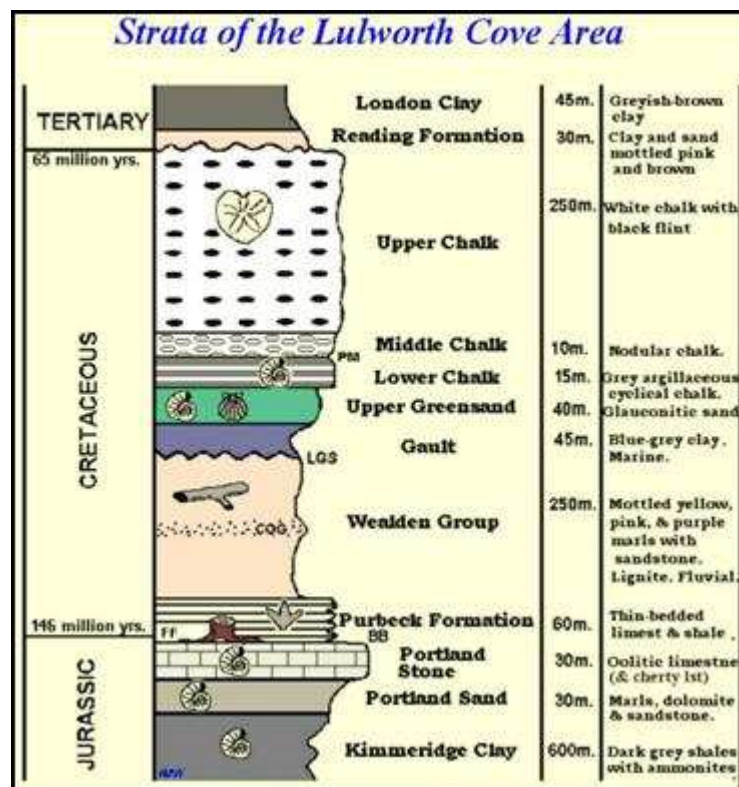


Mid Palaeocene (~61ma) collision of Africa with Europe began a long phase of crustal compression. In the mid Palaeocene there was regional uplift of NW Europe. In the Miocene a period of more intense compression caused "Basin Inversion"; the listric faults were "mended" and this led to elevation of the excess (compared with the platform sequence to the north) sediment in the basins into large asymmetrical anticlines with steep northern limbs - as in Lulworth Cove and the Isle of Wight. These steep, sometimes vertical, limbs above the basin forming faults are intensely deformed and fractured, clearly illustrated in the Chalk on the north side of Lulworth Cove. The southern limbs dip at a low angle and are comparatively undisturbed, for example, the Wealden beds of Worbarrow Bay.



Stratigraphy

The sequence consists of Cretaceous rocks, from the Purbeck beds to the Upper Chalk. There are two significant unconformities; regional uplift and tilting in the Aptian (Kimmerian) led to erosion of Lower Greensand and uppermost Wealden sediments; consequently Gault Clay rests unconformably upon Wealden sediments. Mid Palaeocene (~61 ma) uplift led to some 5my of erosion which removed early Tertiary Danian Chalk, and Maastrichtian and late Campanian Chalk. Consequently, late Palaeocene or early Eocene sediments (Reading Beds) rest directly upon eroded Campanian Chalk.



The Purbeck formation of Lulworth consists of Platform sediments (cf the Basin sequence at Durlston). There is a mixture of shallow marine, coastal, lagoonal and terrestrial sediments, which include limestone and evaporite beds (gypsum and anhydrite), and Dirt Beds. The Dirt Beds are fossil soils, and some of them have tree trunks and roots similar to those of modern Cypress or Juniper trees. The overall trend of sedimentation is a transition from the marine sediments of the underlying Portland Limestone up into terrestrial (fluvial and lacustrine) Wealden Beds. There are some remarkable deposits

within the Purbeck, including:-

the Cinder Bed - a shelly limestone packed with *Praeexogyra* oysters; this is a widely correlateable bed, once used by British stratigraphers to indicate the Jurassic-Cretaceous boundary;

the Great Dirt Bed - a fossil soil with tree trunks and roots; the trees that grew in this thin Rendzina (carbonate-rich) soil were inundated by the sea which formed a very shallow lagoon; stromatolites grew on the dead trees thus preserving their form and shape before the wood rotted away; the Broken Beds - a sequence of thin limestone, gypsum and anhydrite beds deposited in a shallow lagoon subjected to a high level of evaporation; much of the gypsum and anhydrite was subsequently dissolved, and the remaining limestone beds collapsed into rubble; the "Purbeck Marble" - a limestone deposited in fresh water and packed with *Viviparus* snails; it has been used as a decorative stone in local churches.

The Wealden Group of terrestrial mottled red, purple and brown clay and sand beds often contain lignite. Although the basin continued to subside, sedimentation kept rate with subsidence, and the sea was unable to flood the basin; consequently, terrestrial sediments were deposited both on the Platform and in the Basin. The Lulworth "Platform" sequence is

~150m thick, whilst the Worbarrow Bay "Basin" sequence is over 400m. There are fluvial sandstone beds, some of which are remarkably coarse grained and contain tree logs eg the Coarse Quartz Grit.

There is an active oil seep near the slipway in Lulworth Cove. A conglomeritic oil sand at the foot of the steps leading down to Mupe Bay is believed to be a river into which oil seeped during the early Cretaceous.

The Lower Greensand may be represented by a few cm of impersistent ironstone which contains shallow marine molluscs - eg *Preaeexogyra*. There is an unconformity at the base of the overlying Gault Clay. The ironstone may be a remnant deposit formed during erosion of Lower Greensand and uppermost Wealden prior to Gault deposition.

Global sea level rise resulted in inundation, and deposition of marine blue-grey Gault Clay with molluscs and ammonites. There is a basal pebble bed, composed largely of lydite and vein quartz, which represents a beach at the start of the marine transgression. Above is the upper Greensand, a sometimes muddy, bioturbated glauconitic sand; there were abundant molluscs, but the porous nature of the sand has allowed passage of fluids which dissolved the aragonitic shells to leave only moulds and casts. There are some *Exogyra* oysters; these were preserved because they have more resistant calcite shells.

As the sea rose and spread there was less and less land to weather, erode, and provide sediment; consequently, clastic material becomes finer grained and decreases up the sequence. The Lower Chalk consists of cyclical limestone and muddy limestone beds, bioturbated, with molluscs, ammonites and echinoids. The overlying Plenus Marl is a thin condensed muddy limestone unit with numerous disconformities. Above, the Middle Chalk is a clean nodular limestone, overlain by clean Upper Chalk limestone with flint layers. The Chalk is very hard, brittle and splintery, with numerous faults and fractures; this is a consequence of intense compression and deformation at the basin boundary fault during the Miocene.

Locations – Lulworth Cove

On the far side of the Cove, Purbeck Beds, to the right, pass up into reddish Wealden, grey Gault and U Greensand, and pale grey Chalk.



The whole Cretaceous sequence can be seen within a very short distance, because the beds are nearly vertical. Upper Chalk is exposed high in the cliff at the back of Lulworth Cove; at the foot of the cliff is Middle Chalk; east and west of this point are Plenus Marl, Lower Chalk, Upper Greensand, Gault, Wealden, Purbeck and eventually Jurassic Portland Limestone beds. The intense faulting cuts out parts of the sequence; to the east the Upper Greensand is in faulted contact with the Lower Chalk and there is a distinctive fault breccia. At the back of the Cove is a Pleistocene raised beach, with some pebbles derived from the Budleigh Salterton Pebble Bed - their transport to this location is something of a conundrum.

The fossil forest

There is a ledge and fossil cliff high in the cliffs south of Bindon Hill, cut during an Ice Age interglacial when the sea was higher than to-day. Along this ledge there is an

outcrop of Lower Purbeck Beds which includes the Great Dirt Bed with the Fossil Forest of Juniper and Cypress like trees, and the overlying Broken Beds.



Two tree boles, and a fallen tree trunk



The Broken Beds; Jack is sniffing the Great Dirt Bed !



Looking East, with the Chalk cliffs of Arish Mel beyond



Looking West, Portland Limestone at cliff base, Wealden top right



Mupe Bay: the great Chalk Cliffs of Cockpit Head; left the low cliffs of Wealden

East of the fossil forest, Bacon Hole is a deep cove cut into the cliff line to expose a complete sequence of Purbeck Beds, overlain by Wealden Beds. The Cinder Bed is exposed towards the bottom of the cliff.

Mupe Bay and Worbarrow Bay

Beyond Bacon Hole there is a great bay cut through the line of Portland Limestone Cliffs. The eastern side is Worbarrow Bay, which exposes a large ("basinal") thickness of Wealden. On the western side is Mupe Bay which exposes a much thinner ("Platform") Wealden sequence. At the back of the bay on either side of Arish Mel, is a sequence of Gault, Upper Greensand and then the Chalk which is exposed in the great cliffs at Cockpit Head. The structural attitude of the sequence is similar to that of Lulworth, an antiform with steeply dipping intensely faulted and fractured beds dipping steeply to the north, passing southwards into gently dipping beds with minor parasitic folds.

Graham Williams (Figs 1-4 by Ian West)