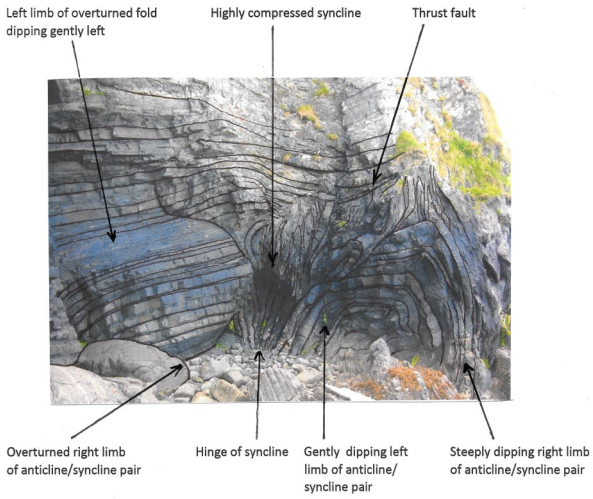

Image 4: Cationed to show structural details

I thank Dr. Owen for taking the time to interpret my photographs and for giving such a comprehensive summary.

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Kimmeridge Bay Field Trip 4th May 2019 led by Graham Hickman.
By Phil Burge

Introduction

A group of 15 members met at the car park at Kimmeridge Bay after an enjoyable drive through the country side on a glorious spring day. Having met, we walked eastwards to gather at the Wild Seas Centre where we reviewed the regional structural and tectonic history of southern England from the Variscan to the Alpine orogeny. This set the scene for the subsequent observations of the structural geology of the Bay and the origin of the thickness of the Kimmeridge Clay. Following this scene setting we walked back along the cliff top, past the car park and down the path at Gaulters Gap onto the beach. The first item of interest on the beach is the Mk25 pill box. A relic of the fears of an invasion during the early years of WW2. Apparently there were seven types of pill box designated, in true military fashion as Type 22 to Type 28.

Having contemplated on the potential efficacy of such a defensive structure the group reviewed the stratigraphy visible along the cliffs moving from east to west before being let loose to explore and, without the aid of hammers look for fossils. The Kimmeridge Clay is abundant in fossils. Although it is always exciting to find a fossil, our finds were as nothing compared to the fantastic exhibits to be seen in the Etches collection which was visited in the afternoon.

Structural Geology
There are two major structural features. The first is the fault system to the north, a product of the Variscan orogeny which occurred during the Carboniferous. It was likely reactivated during the Jurassic resulting in a downward throw to the south. Eroded sediments from land masses found in Wales, South East England and Scotland extending south into Yorkshire fed into a deep (+/-100m) boreal to sub-tropical sea, with the basin deepening as the fault moved. This resulted in, amongst other things, deposits of Kimmeridge Clay up to 550m in thickness.

The second major event is the folding along an east – west line during the Alpine orogeny of the late Cretaceous and thereafter. This tectonic event produced the anticlines of the North and South Downs and the syncline of the Weald. This tectonic event at Kimmeridge Bay formed a shallow dipping anticline as can be clearly seen in the cliff exposure.

Image 1: Car park at Kimmeridge Bay, Type 25 pill box, tank traps and formation dipping to the east

Kimmeridge Clay

The late Jurassic Kimmeridge dates from around 157 Ma to 150 Ma. The lower boundary is the Inconstans Bed of the Oxfordian and the Upper boundary is the Portland Sand of the Tithonian. Kimmeridge Bay is the type locality.

This formation is the major source rock of the North Sea Central Graben Oil Fields and is extensive across the UK from Dorset, (where it is exposed), north east towards Lincolnshire and out into the North Sea. The formation at Kimmeridge has been thermally immature for oil although historically 1 m thick highly organic black shale known as the Blackstone has been mined. Known locally as Kimmeridge Clay it burns with an unpleasant sulphurous smell. During the 19th century commercial mining extracted and refined paraffin wax.

The sediments are predominantly clays, calcareous clays, calcareous mudstones, organic-rich shale and limestone or dolomite beds. More detail is found in Fig 1.

Rock type	Description
Marl	Medium dark - dark grey
Shale	Medium dark - dark grey - greenish black
Shale	Dark grey - greenish black – olive black - laminated
Mudstone	Greyish black – brownish black
Limestone	Medium to dark grey or medium bluish grey
Dolostone	Olive grey or dark yellowish
Figure 1	

Image 2: Interbedded mudstones and dolostones

Image 3: Close up of dolostone (45 cm thick) showing massive texture

Cyclicity

A distinct cyclicity is evident in the Kimmeridge Clay as measured by total organic carbon content and radioactivity levels, gamma ray logs from boreholes and magnetic susceptibility measurements. Within this sequence changes in magnetic susceptibility are due to changes in ferrocalcite concentrations.
Numerous explanations have been given for this cyclicity. The Etches museum states one option being changes in sea level. This was challenged during our trip by both Graham Hickman, our leader, and Professor Tucker.
The accepted interpretation is that the reason is due to Milankovitch cycles. Over known frequencies the Earths movement changes in terms of eccentricity of orbit, axial tilt (obliquity) and precession of the orbit. These variations in orbit and tilt occur approximately every 19ka and 23ka. Both effect climate. *Warming ocean temperature increases the volume of carbonaceous plankton (coccoliths) which are a major component of the dolostones.*
Interesting structures are exhibited on the exposed upper boundary of the "Flats" dolostone as shown in Images 4, 5 and 6.

Image 4: Dolostone clasts "floating in displasive sparry ferroan dolomite. Photo from author, description from Bellamy J., 1977. Subsurface expansion megapolygons in Upper Jurassic Dolostone (Kimmerdige, UK), Journal of Sedimentary Geology, Vol 47, No 3.

Image 5: Sinuous ridges running predominantly East –West on top boundary of Flats Dolostone

Beyond saying that these structures appear to be the consequence of some form of burial expansion, readers are invited to pursue their own further research!

Image 6: Portion of "megapolygon" of approximately 6 8 meters in diameter

Image 7: Side elevation of Dolostone showing distinctively different structure of structure

Fossil Hunting

The Kimmeridge Clay is richly fossiliferous, though it takes an expert of the calibre of Steve Etches to find and prepare exquisite specimens.

The dominant and easy to find fossils are Ammonites. These have generally been crushed. The Upper Kimmeridge can be classified using the Ammonite zone Autissiodorensis.

Image 8: Typical crushed Ammonites found in dark grey mudstone (Beach rubble)

Image 9: Poorly preserved bivalves

For truly superb fossils a trip to the Etches collection is well worth it. We did this after eating lunch on the beach, admiring those hardy souls braving a swim in the sea off of the convenient limestone ledges.

The range of fossils found at Kimmeridge includes, not only the common bivalves and Ammonites but larger species including various fish, (e.g. Thrissops; see Photo 10), marine reptiles including plesiosaurs, pliosaurs and ichthyosaurs. The state of preservation and the effort required to excavate and prepare the specimens is awe inspiring. A must see visit.

Image 10 above: Scales of Lepidotes fish (Etches Collection)
Image 11 below: Ray finned fish Thrissops (Etches Collection)

Image 12: Pliosaur vertebrae and paddles (Etches Collection)

Oil Exploration at Kimmeridge

This section was taken from Graham Hickmans field trip guide and an extract from *The Hydrocarbon Prospectivity of Britain's onshore Basins, DECC.,2013 pg. 8*

Following the award of the first prospecting license under the Petroleum Production Act. (1934), drilling was carried out during 1936-1937 at Broadbench, in Kimmeridge Bay with traces of oil noted on joints in grey sandstone in the Upper Jurassic, (Corallian beds; Sandsfoot Grit), at a depth of about 825 feet (250m). The well was plugged and abandoned at 943 feet (287m), still in the Corallian, (Osmingtom Oolite), as the limit of the rig had been reached. Twenty two years elapsed before the full significance of this discovery was appreciated. In 1958, shows of oil in the Upper Lias, (Lower Jurassic), sandstones from a well to the west of Radipole, near Weymouth, led to renewed interest in Kimmeridge Bay. Three wells were drilled as part of a programme; Broadbench 2 (later renamed Kimmeridge-1) in 1959, ENE of Broadbench-1. Oil was encountered at a depth of 1,880 feet (570m) in the Cornbrash Limestone, top of the Middle Jurassic. Core oozed oil from partially leached calcite veins and a series of production tests and acid treatments yielded between 30 and 4,300 bopd. The well was completed as a producer in the Cornbrash. Two other wells were drilled to the producing horizon to the east (Kimmeridge 2) and southwest (Kimmeridge 3), proving the extent of the oilfield. Kimmeridge 4 was an appraisal well drilled in 1960, to further test the geological structure, but it was terminated due to mechanical difficulties.

The field began producing in 1961 and following the discovery and successful appraisal of the Wytch Farm Oilfield, there was renewed interest in the prospectivity of deeper reservoirs in the area. In 1980, Kimmeridge 5 was drilled as an exploration well to test the deeper potential of the Kimmeridge structure in the Sherwood Sandstone (Lower Triassic), with the Bridport Sands (Lower Jurassic) as a secondary target. Weak gas shows and minor fluorescence were recorded throughout the Jurassic. The Sherwood sandstone, encountered deeper than prognosed, had

weak soil shows but reservoir quality was significantly poorer than at Wytch Farm.

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Landscape and Geology of the Burren: Co Clare Ireland
By Isabel Buckingham

I first went to the dramatic landscape of the Burren as a student in 1968, and have returned several times. There was little change when I visited in 1973, but dramatic differences when I visited in May 2018. A great deal of information is found at http://www.burrengeopark.ie/ . The Irish know how to market geology with walks, information boards and a Centre. To the south east and abutting, is the Burren National Park, just under 2,000 hectares, bought by the Government before they ran out of money and run on traditional lines. More information can be found at http://www.burrengeopark.ie/.

A Cromwellian Officer described the country "as not enough water to drown a man, wood to hang one, nor earth enough to bury them. This last is so scarce that the inhabitants steal it form one another yet their cattle are very fat. The grass grows in tufts of earth two or three foot square that lies beneath the limestone rocks and is very nourishing". It is a fairly apt summary.

Image 1: Dryas octopetala usually a Boreal plant—Part of the May flower extravaganza in the Burren

The Carboniferous Limestone dips very gently to the south east, never more than 5 degrees, but often less. This area is a long way from the Variscan Front. A layer of the impervious Clare shales is found above the limestone, and on some hill tops the Gronagort sandstones form the summit area. This area has been glaciated several times, has Galway granite erratics and also from the most recent glaciation, the ice sweeping round from the north and heading west to the sea. Some of the higher ground may have been ice free during the last glaciation and the terminal moraine can be seen in the Shannon Estuary. There is a clearly marked alignment to striations and glacial deposits.

Traditional Karst scenery is better developed than in England, because of the large area and depth of Carboniferous Limestone and also the very gentle dip. One unusual feature is the Turloughs. These seasonally fill up with water in winter and drain away in the summer when rainfall is less. Some have peat development but the lush summer grazing is important in the cattle rearing economy. The largest is at Carran being 4.5km^2. After prolonged or heavy rain the Polje fills up to form the turlough, but when less wet the Castletown river flows over the surface before going underground.

Image 2: Folded limestone on Mullaghmore Burren National Park

Image 3: Edge of a turlough in May. Water was rapidly drying, but warm and I'd never seen so many tadpoles. A thin film of silt covered the hard rock.

Caves range from the very recent and superficial at the present shale/limestone boundary to well-developed systems with several levels, some under sea-level. Many are wet and prone to flooding.

Image 4: View from Mullaghmore to Lough Gealain