oil higher. Resistivity tools are designed with a range of depths of investigation with modern FEMWD resistivity sensors having a depth of investigation of over 60 meters and provide measurements in multiple (32) discrete directions. This is called azimuthal measurement, where azimuth refers to high side of the hole. Using the combination of deep and shallow measurements oncoming bed boundaries or faults or proximity to the oil – water contact can be predicted and the well steered in the appropriate direction.

Nowadays many geosteered wells are coordinated from a Real Time Operations Centre. Data from the rig is sent to an office facility manned by geologists, geophysicists, directional drillers and FEMWD analysts. All the expertise necessary to drill a complex well are collocated and can collaborate to achieve the objectives of the well. A spin off of this technology is that a group of experts can collaborate on a number of wells simultaneously reducing the demand for expertise at the rig site.

Summary

The combination of directional drilling and downhole sensor technology has been a game changer in terms of the types of well that can be drilled, the size of targets, the redevelopment of older fields, the capability of horizontal drilling and the development of shale plays. The latter has been instrumental in driving the development of many technologies in addition to directional drilling.

The industry has moved from individual disciplines, and tension between these disciplines, to a much more of a collaboration brought about by the move away from geometry and towards geology as the deciding factor in placing a wellbore.

References

The geology of geomechanics: petroleum geomechanical engineering in field development planning M. A. ADDIS Rockfield Software Ltd, http://sp.lyellcollection.org/

[2] MacDonald, G. C., & Lubinski, A. (1951, January 1). Straight-hole Drilling in Crooked-hole Country. American Petroleum Institute.

[3] http://www.iadc.org/wp-content/uploads/2015/08/preview-dd.pdf

[4] www.petrowiki.org

[5] Emmermann, Rolf & Lauterjung, Joern. (1997). The German Continental Deep Drilling Program KTB — Overview and Major Results. Journal of Geophysical Research. 102.

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Tintern Geology Field Trip – Led by Dave Green
By Bob Mustow.

The discussion over the first sample Dave showed us, a stone off the path he had just broken open, went like this:
Dave: "You can see what this is…"
Me: "Limestone"
Dave: "…Sandstone"
So don't expect anything too technical in the following article!

The Wye Valley at Tintern is 217m at a trig. point near the car park north of Tidenham Chase, and 10m at the river, so about 207m or 680ft deep and covers a period from the end of the Devonian, (about 340mya), to the beginning of the Carboniferous, (about 360 mya).

Two theories of the way the Wye meanders ignoring any geological or geographical features. The generally accepted one is that the curves of a mature river formed in some higher material subsequently eroded way and, helped by uplift, caused the path to be eroded into the underlying strata. Or, secondly, the route may have been carved by huge volumes of glacial melt water loaded with debris perhaps flowing from a collapsed lake dam. Whatever the cause, it has given us easy access to the geological sequence here.

Fig 1: Heathland

We started by walking from the free car park just north of Tidenham Chase, through the wood and, crossing Miss Grace's Lane, (which leads to the second longest cave system in the Forest of Dean area), out onto the plateau grassland towards Offa's Dyke and the Devil's Pulpit [Fig 1]. This area is Dybrook Sandstone; a free-draining, porous, non-cemented material, grey in colour as it is free of iron which would colour it red. Soluble bases leach down to lower strata leaving the quartz rock free of basic minerals, so the soil is acidic giving rise to areas of heathland here which are the subject of a project to restore these to their natural state [Fig 2].

As we approached the trees above Offa's Dyke we crossed thin bands of Whitehead Limestone and then Crease Limestone. The Whitehead Limestone formed in quiet lagoons over the Crease Limestone around 340 mya. It is fine grained and was known as 'Chinastone' by quarrymen because of this and the white colour.

The Crease Limestone is more dolomitised than the Whitehead: some of the Calcium has been replace by Magnesium giving rise to $MgCO_3$ rather than $CaCo_3$. It does not fizz so much with hydrochloric acid. It is quite a dark grey here, massive with vertical joints, and glints in the light.

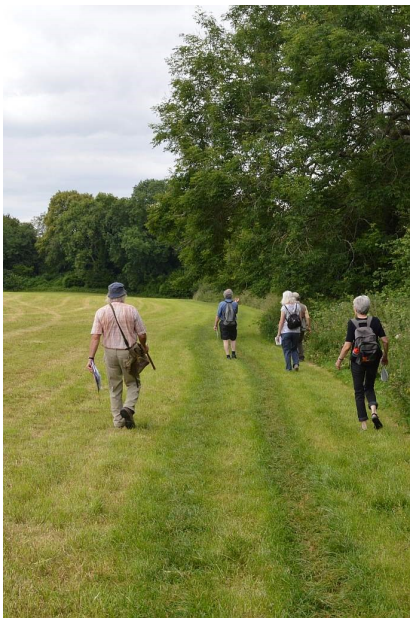

Fig 2: Grassland

Dropping down a little the next rock layer is the Lower Dolomite and the obvious features here are the Devil's Pulpit, Offa's Dyke and a fine view of Tintern Abbey way below across the river Wye through a gap in the trees thoughtfully provided by the Forestry Commission [Figs 3 and 4]. In years past there were few trees here, giving a wide panoramic view. In a small, old quarry on the other side of the Dyke to the Devil's Pulpit is an ancient yew tree, with its roots grown into and around a pile of limestone rocks. Presumably the quarrymen decided to leave this tree in place [Fig 5].

Fig 3: Devil's Pulpit

Fig 4: Tintern Abbey

Fig 5: Quarry Yew

We now walked steeply down the valley side through a thicker band (about 50m) of the Lower Dolomite. As limestone is generally less easily eroded than sandstone, the slopes are steeper here than over the sandstone. Here the limestone is dark grey and an exposure can be found where the path drops down after crossing a forest track at about the 120m contour. [Fig 6]. It is known as 'Stinkstone' because it smells strongly if broken, reminiscent to me of stagnant ponds or a damp room or maybe a gasworks, all things that are rarely experienced these days. It is presumably from decayed organic matter trapped in the formation 350 million years ago.

Fig 6: Interbedded Lower Sandstone Shales

We were told that dolomitised rock is harder than a copper coin and calcite is softer. Also, if you hit sandstone it gives a dull thud whereas limestone rings. Dave Green feds us a continuous flow of useful information!

We then came to a second rough flight of steps, each step created from a level in the strata. I believe this is the top of the Tintern Sandstone formation [Fig 7].

Fig 7: Steps

At the bottom of these steps, at about the 80m contour, we are back on the less-steep sandstone, the Tintern Sandstone, which is light grey here although the soil gives it a red appearance. The dismantled Wye Valley Railway, opened in 1876 and later run and owned by the Great Western Railway, runs in a tunnel under here, through the Sandstone, on its way from Chepstow to Monmouth.

At the bottom of the final flight of rocky steps is the track bed of the branch line that ran over the Wye into Tintern. There, on the other side of the A466 and up the Angidy Valley, had been extensive wireworks for 300 years. The branch was ready a year or two before the main line but, in that time, the works ceased trading! Another company did briefly run a tinplate and wire works some years later but no passenger station was opened so a hoped-for tourism traffic did not materialise. The line closed in 1935.

Anyway, returning to these lower sandstone steps, there are at least two bands of a whiter rock which is calcrete [Fig 8]. It was formed from water percolating through the porous sandstone depositing calcite, clay and silt forming a nodular form like dolomite.

Fig 8: Steps, calcrete

In the afternoon we climbed steeply up the north side of the Angidy Valley, up Barbadoes Hill. There, in the woods, we found a quarry of Tintern Sandstone which is thought to be where the rock used to build Tintern Abbey came from. It would have been relatively easy to lower the rock down the hillside to the road [Fig 9]. Other quarries in the area are unlikely to be the source as the rock is simply not the same type.

Fig 9: Tintern Sandstone potential Abbey Quarry

So ended another excellent day with Dave Green, it is a pity so few attended.

Thanks to Mike Parr and Sue Price for some of the photos.

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Port Askaig tillite
By Isabel Buckingham

I have seen this deposit in the Garvellach Islands when I'd walked much of the length of Grabh Eileach, been taken round the islands by boat and seen the justifiably famous drop stone.

Image 1: The scale object is a 2p piece. I chose this location as the clasts were well rounded and of various sizes. As the rock face was wet the fine laminations show up. I thought "down" was in the 8 o'clock position.

Image 2: This was just to the right of the first image and with the scale object. The pink coarse grained granite clast is very different; larger and angular with the corners not smoothed at all.

Having been on Islay for almost a week, I'd seen a variety of recent fluvo-glacial deposits including what is generally accepted to be a diamictite formed under a floating ice shelf.

Simply, as the continent of Rodinia broke up, (approximately 750 ma ago), and the Iapetus Ocean started to form, initial spreading was followed by the formation of a series of rifted basins. At the base sits the Argyll group (670-600 Ma) which contains the Port Askaig tillites indicating glaciation. This is followed in the sequence by warm water carbonates.

There is not much parking space in Port Askaig. The superb section illustrated in the guide* is now 7/8ths bolted and netted to prevent rock fall onto the traffic. Only the most easterly part can be approached and seen clearly as trapped debris obscures much of the remainder. It is nothing like what I saw on the Garvellachs. The dark grey matrix is very fine grained and has just perceptible laminations and tiny ripples. The rocks was of very varied sizes, some smooth and rounded and others very angular as shown with 2p as scale object. I could accept this as formed under floating ice.

*A guide to the Geology of Islay by
David Webster, roger Anderton & Alasdair Skelton.

This guide includes 12 geological walks with a whisky recommendation for each. Carol Isla distillery is built on this deposit.

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