North Eastern Geological Society

Newsletter April, 2015

UPCOMING EVENTS

18th December, 2015

Members' evening

1. **John Waring** From Deserts to Deltas

2. **Les Barnes** The Isle of Purbeck; a geologist's paradise

3. **NEGS Members Rock**

Members favourites; what, where, why. Bring along a rock sample, fossil, photograph, map etc. that is important to you. Label it (Max 200 words), stating - what it is, why it's important (to you) **where it came from, and other relevant notes.**

FIELD TRIP REPORT

October 10th 2015.
Coldberry Gutter, Teesdale
Leader Brian Young

A bright, mild day greeted the seventeen members to the study of the local geology and evidence of past mining activity in the area NW of Middleton in Teesdale. We were to walk 2.5 km west, 1km NNE and 2km east in a circular route about Hardberry Hill. Start point 945288 on OS sheet 91 Landranger. The area was expertly introduced using landscape analysis methodology. The slope across Hudeshope Beck, on the flank of Monks Moor was deeply gashed by past lead mining activity. This slope had a thin drift cover allowing the extensive veining in the area to be seen at outcrop by medieval miners, their descendants work only stopping in the mid 1900's, a time span approaching 400 years.
Our starting point was on the opposite slope. As is often the case in the Pennines this slope acted as the stoss encouraging the deposition of glacial drift, which ice, moving SE, deposited. This limited the solid geology from helping to shape the topography; in sharp contrast to the thinly covered Monks Moor slope.
The solid geology in the area being studied was the Alston Group, overlain by the Stainmore Group which itself is overlain by the Coal Measures -- using the traditional nomenclature! Our area has thick deposits of the finer textured sediments, shales being prominent, with beds of sandstones and limestones which has allowed a staircase type surface to develop. As we moved into the main Teesdale Valley the view NW was considered in some detail. The Whin Sill exposure at Holwick Scar, the High Force waterfall and the absence of the sill on the east side of the valley offered ready evidence for the fault which has encouraged the development of the river valley in this part of Teesdale. Some discussion of the Whin like massive dyke exposure in Lunedale to the south allowed the various hypotheses for the Whin intrusion to be rehearsed. The association with the Burtreeford Disturbance was introduced and considered. The drumlins of the valley floor were also pointed out.
Sink holes were becoming quite abundant on our route, indicators of the Great Limestone which marks the divide between the Alston and Stainmore Groups. We were asked to note the location and character of the sink

holes and also discussed in some depth the character of the stone walls, largely flaggy sandstones. The value of these as indicators of changes in the local rock type was considered.

We continued down the 'stair case' of plantation surfaces as we approached a flooded quarry in the Great Limestone. The character of the limestone and fossiliferous ‘marker’ bands were discussed before lunch was taken.

We continued on a NNE route towards an area that had clearly been heavily mined. The trend of the surface of the sink holes were noted to be dipping into the stream ahead of us. This is interpreted as a dip into a fault system. Surface waste tips of coarse sandstones were very substantial bearing testimony to the huge and long lived exploitation of the rich lead veins by the London Lead Company. The spoil was largely free of lead minerals indicating the effective processing systems used and also a dearth of gangue mineralisation. The processing floors were pointed out together with the areas of bare earth attributed to the acidification of minerals, iron carbonates and sulphates been examples. Siderite was abundant but not in crystalline form.

We continued into Coldberry Gutter, this deep gash through the hillside represents hundreds of years of mining.

The gutter cuts through the watershed of Hardberry Hill and was used to explain that the mythical 'hushing' technique simply could not be responsible for the excavation we were examining. The massive beds of s sandstones for example, would require much physical force to breach them. The area could not have supplied the quantities of water that could account for such removal. The group studied an abandoned vein that had no commercial minerals evident and noted the mismatch of the rock formations across the gutter. This mismatch was excellent evidence for fault activity, this fitted well with mineralisation activity which had a close association with the faulting. An exposure of a columnar structured, doleritic rock was explained to be interpreted as part of the Cleveland Dyke structure with mineralogy, age and orientation evidence.

Picture below: Cleveland Dyke structure

We continued to the watershed before turning east. Walking over a heavily disturbed surface we descended towards our starting point. The slope has had an extensive water collecting culvert cut into the contour of the slope. This had originally supplied water for a counterbalance system associated with the downslope transport of the lead ore.

See picture

The group showed their appreciation for a really excellent day that had demonstrated geology and the mining past of the area. This was the last excursion for our group in the 2015 season. The efforts of our field secretary in organising the programme, Eric Johnson, were greatly appreciated.
Gordon Liddle.

LECTURE REPORT

1. **On October 16th the first lecture of the season was given by Dr Ceri Nunn on The Structure of Mount Etna**

Ceri introduced the audience to her research using seismic tomography to examine the character of the geology below Etna. She uses the extensive seismic station network that is present on Etna. In particular she constructs models of the P and S wave velocity, and the ratio between the P and S wave velocities. The research was a European project (MED-SUV) that was looking into a long term strategy that could be of value in the prediction of activity on a volcano thus aiding the development of a risk management strategy

Etna is 3300m high, a basaltic stratovolcano with gaseous eruption events. Historically a variety of eruption events have been recorded. The 1669 example of protecting a town from a lava flow with a wall was introduced as an example of how eruption modification methods have a long history. Similarly the Zafferana event in 1992 demonstrated the use of a constructed earth wall 400 m long and 20 m wide to contain the lava. The lava pooled behind the wall for about a month, eventually breaking through. Engineers then blasted the main lava tube with explosives and dropped concrete blocks into the vent to slow the lava flow. The eruption subsided and the lava no longer threatened Zafferana. This seismic approach can thus be seen as the latest in a long history of hazard management

Tectonically Etna sits on the leading edge of the African Plate, and in a very complex region. Much of southern Italy is subject to compressive stresses, but Etna is in a small part of eastern Sicily that is in extension. Etna's lavas are very different from Italy's other volcanoes. The volcanic islands of Stromboli and Vulcano, and Vesuvius near Naples, are all thought to be related to subduction beneath the Calabrian arc. But Etna, although it lies near to these volcanoes, has lavas which are not subduction related. It may be caused by the rollback of the Calabrian subduction zone, which can cause decompression melting of the asthenosphere beneath Etna

Seismic tomography was used to look at the 3D structure. Ceri illustrated the potential with an example from the Pacific that showed how a situation at 70 km depth differed markedly from the position at 150 km

Focussing on the seismic tomography of Etna, Ceri showed an eruptive cycle from 2001 to 2002. Previously published work separated this eruptive cycle into three periods: an initial pre-eruptive period, a second pre-eruptive period where the ground started to inflate and an eruptive period. The published work showed that the ratio between the P and S wave velocity changed between the three periods. Ceri used new code (known as TOMO4D) which looks at data from two different periods simultaneously. In contrast to the published work, Ceri showed that the data for all three periods could equally be fit using the same model. The model showed a central region of faster wavespeeds at the centre of the volcano, close to the area with the most earthquakes. Ceri interpreted this high wavespeed region as high density igneous material, probably a system of pipes that are feeding the volcano. The surrounding lower wavespeed area was interpreted as looser volcanic sediments

The interpretation was not straightforward and various problems were identified including how the data coverage affects the final model. Ceri also showed how the choice of parameters in the modelling process could affect the magnitude of the wavespeeds recovered. Her solution was to interpret the pattern of the tomographic model, as opposed to the exact numbers

In conclusion, the modelling technique shows potential to see underneath the volcano and compare changes on a month by month basis. However, by using the new code she found that she would need more accurate data to recover changes over the eruption cycle. She stressed that seismic tomography is a good tool to see beneath the surface of the Earth, but the interpretation of seismic models needs great care.

The audience were very appreciative of the demonstration of this technique and thanked Ceri for her full responses to some challenging questions.

2. The November 20th meeting saw a good turnout for the lecture by Dr F.W. Smith – "The Polyhalite deposits in North Yorkshire"

The audience was treated to a tour de force by Rick (a consultant with FWS Consultants, from Spennymoor) as he brought together the current thinking on the formation and characteristics of the Permian evaporites in North Yorkshire and summarised the planned mining of the polyhalite deposits.

In the late Permian the area lay deep in the interior of the Laurasian supercontinent at about 20 degrees north. The conditions were hot desert, well below contemporary sea level, not unlike-the present day Qattara Depression. In a very short period a seaway opened to the Boreal Ocean hundreds of miles to the north. The depression flooded and the five Zechstein evaporite cycles were initiated. There are no current analogues, but a similar sequence of events happened in the Mediterranean during the Messinian five to seven million years ago. Our deposits formed over a relatively short period of just 5-6 Ma. We still use the name Zechstein for them, although the period of deposition is now formally known as Wuchiapingian, named after a fossiliferous sequence in China. They are essentially fossil-free in the area being studied!

The flooded area was similar in size to the Mediterranean Sea, and returned to inland desert conditions after the basin was filled and the evaporite cycles stopped. Our area was at the margin of the Sea, occupying the NW corner of the Zechstein Basin, and not far from the Pennine Orefields. Compared with the rest of the Zechstein this area is abnormally rich in potassium salts; occurring mainly as sulphates in the second, or Z2 cycle known as the Fordon Formation.

The deep depression allowed a great thickness of sediments to accumulate. Each cycle contains elements of the classical sequence of Ca-Mg carbonate, anhydrite, halite and finally bittern salt (K-Mg minerals that include the usual potash ores sylvite and carnallite). Wind-blown sands and anaerobic muds are also present marking boundaries between cycles. How such huge thicknesses of salts could accumulate from seawater evaporation in such a short period remains an issue, as does the variation in thickness of each mineral – compared with what is expected from simple evaporation of a column of seawater. Rick restated the understanding that evaporating an ocean to dryness could not produce either the observed quantity of salts, even from a hyper saline water body; or the variation in mineral assemblages. Thus external sources such as coastal brine pans, or alternatively some form of brine reflux, need to be invoked. Whilst gypsum, anhydrite, rock salt and potash minerals such as sylvite and carnallite do precipitate directly from marine water, Rick was very clear that his work allows him to be convinced the polyhalite (the ore mineral to be mined by York Potash, from low in the Z2 cycle) is a replacement mineral. It is not a bittern salt. There appears to have been an original deposit of gypsum that was converted almost immediately to anhydrite. Very soon after that the material reacted with dense K-Mg rich brines flowing across the sea bed, down the basin margin ramp, and for a limited period the anhydrite transformed to polyhalite, thus forming the Fordon Polyhalite seam. The origin of the 'introduced' potassium and magnesium radicals and the localization into our corner of the vast basin has produced a variety of theories such as Rick's favorite, a link to the hydrothermal mineralisation in the Pennines, but the quantity and timing are real problems.

One slide Rick showed had gypsum pseudomorphs now converted to polyhalite but retaining their original size and shape showing a tilt that could reflect the effect of an ocean bottom current when the original crystals (or gypsum lawn) were developing.

Polyhalite is made from potassium, magnesium, calcium, sulphates and some water of crystallisation. It has never been mined anywhere in the world before. Polyhalite is lower grade (13% potassium) and has a much lower solubility, than sylvite, which is the typical evaporite mined for potash and has around 50% potassium. It is marketed as a slow release fertilizer – and in that way can compete successfully. It also has no chlorides and so is useful where soil salinity is an issue. In North Yorkshire the whole Zechstein can be 600 m thick. Within this, the typical primary bittern potash salts are usually less than 10 m in overall thickness, but in contrast the replacement polyhalite deposit can reach nearly 80 m. Since it is hard like anhydrite, deep mining is feasible by pillar and stall methods using modern machinery; despite rock temperatures of 50 degrees!

Rick described how the Zechstein evaporites were first found in England by accident, in a borehole drilled in the 1850s for fresh water to supply the Middlesbrough iron industry. Salt and anhydrite were discovered instead! Solution mining was soon developed in the rock salt and became a foundation of the Teesside chemical industry. Conventional deep mining by ICI at Billingham later produced 33 M tonnes of anhydrite between 1927 and 1971 for use in cement and fertiliser manufacture.

Potash was discovered in 1939 by oil and gas exploration near Whitby. At first it was the presence of potassium-rich brines that attracted attention, but exploration after the War, for deep mining of potash in the Z3 cycle, resulted eventually in the sinking of Boulby Mine in 1969-73. Annual production averaged around 1 M tonnes of potash, used for fertiliser and approx.. 0.5 M tonnes of road salt. Today we are aware that Boulby potash mine has just announced stopping working the Z3 sylvite deposit and is to concentrate, like York Potash, on the deeper polyhalite deposits.

York Potash, part of Sirius Minerals plc, has been exploring the Fordon Polyhalite seam, south of Whitby, since 2010 and recently won planning permission to mine. Their intention is to develop at approx.. 1600m below surface and eventually to mine up to 15 M tonnes a year. Boulby, in contrast, has current capacity to extract around 2 to 3 M tonnes, but is of course well-established and at shallower depth. .

York Potash's mine location in the heart of the National Park necessitates that the polyhalite will be transported underground from the mine to Wilton and Teesport via a 37 km long, 6m diameter, conveyor tunnel bored in the Lias Mudstones; thus solving the potential problem of traffic.

Rick described the exploration work carried out by his firm, and the development of a geological model. It is estimated that 2.7 billion tonnes lie inside the current mine curtilage; and that represents just a small proportion of the total in the region. Wireline logs were used in all the exploratory borehole. These included gamma, density and neutron activity; and were used to identify the principal mineralogy and even estimate potassium grade. Sylvite for example, has a high gamma signature, but low density and neutron activity. 1000 km of seismic data from earlier hydrocarbon exploration projects were supplemented by infill survey work to give a very good picture of the geological structure of the area. The drillholes cored up to 80m of high grade polyhalite. Samples were analysed by the BGS using Quantitative X-Ray Diffraction in a pioneering process.. Studies have identified an extraordinary range of trace and minor exotic minerals to be present in the seam, including some first occurrences for the UK. Kalistrontite, composed of potassium and strontium, is an extremely rare mineral yet is present here in quantity. Boron and fluorine minerals are also present in profusion. The early reconnaissance results encouraged Sirius to sink a final array of 10 holes plus numerous offsets, culminating in the choice of a minehead site at Dove's Nest. Since it is the National Park, a host of features have been incorporated in the design. For example, in addition to the conveyor tunnel to the coast, the headframe will be counter-sunk into the shaft tops so that no more than single-storey buildings will be present at surface, and the whole development will be hidden in a landscaped tree-belt to minimize further the visual impact. Shafts will be 1600m deep to the seam, with an inset at 360m below surface for the conveyor tunnel to Wilton. Three intermediate shafts are planned along the tunnel, each of which will be landscaped using the spoil from tunnel excavation. At Wilton the tunnel will rise to the surface to a blending and crushing plant prior to conveyor transport to a river docking facility. This will allow bulk tankers to collect the material. The market will probably be the China -India area. It is hoped that excavation will start in 2016.

Rick's closing message was that our region contains a deposit of global significance that is capable of supporting a large scale mining industry for long into the future.
The presentation had excellent visual support illustrating the geology and landscape. There are several web sites that provide similar images such as: Marine Permian of England-JNCC or
jncc.defra.gov.uk

The audience gave Rick a very enthusiastic thanks for a really exceptional presentation and took the opportunity to present some perceptive questions.

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NEWS AND LOCAL EVENTS

Final **Limestones Landscapes** Event and book launch on 17th December at Sunderland Museum.

Joint YGS/ NHSN meeting on January 30th at Hancock Museum, Newcastle.

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Bringing up the rear

Earth Science Picture of the Day
Low water in Great Salt Lake reveals 'rocks that are alive' http://ow.ly/VxQlj

Image: (Francisco Kjolseth | The Salt Lake Tribune) Researchers gather on the North shore of Antelope Island in search of small rock like structures formed by bacteria that have become visible as the waters of the Great Salt Lake recedes.

As Utah's Great Salt Lake continues to drop during recent years of drought, something strange and wonderful is coming into focus in the shallows and exposed lake bed. "It's rocks that are alive," biologist Bonnie Baxter of Westminster College said, surveying an expanse of domed calcium-carbonate structures where the water meets Antelope Island's receding northwest shore. These are microbialites, or bioherms, rocks typically formed by bacteria in shallow hypersaline water.

Known as microbialites, some of the specimens will be on display at the Natural History museum.