North Eastern Geological Society

Newsletter December, 2016

UPCOMING EVENTS

Members Night. 16th December. Bring some festive cheer along and support your fellow members presentations.

FIELD TRIP REPORT

The final field trip of the year took place on Sunday 9th October when Louis Golightly led a group of 14 on an exploration of the geology of **Holy Island**. The weather was kind and we were able to see the dyke wall at beach level just south of the village, with a 'skin' of metamorphosed limestone. Along the shore the fossiliferous limestone provided many examples of small brachiopods and orthoconic nautiloids.

As if that weren't enough, near the boat ramp were amygdales, elongated and showing 'ropy flow' structures indicating closeness to the original surface of the Holy Island dyke which were in a *generally* easterly flow. We observed how the sill outcrops are en echelon.

We had lunch in sunshine beyond Lindisfarne Castle and then made our way northwards observing the Sandbanks Limestone, and dropping to a ledge of sandstones in which there were many fossilised rootlets. From there at Cross haven to the northwest was Snipe Cove

where we were able to observe the folds in the Acre Limestone (effects of the Variscan Orogeny). We then took the path over the dunes to return to the car park where our leader was heartily thanked for a splendid day filled with much of interest.

LECTURE REPORTS

21st October, 2016

An evaluation of Mesozoic rift-related magmatism on the margins of the Labrador Sea: implications for rifting and passive margin asymmetry.

This first lecture of the autumn/winter season was delivered by **Alex Peace, Durham University.** Unfortunately lecture notes were not taken for the newsletter, but a synopsis can be found here:

http://geosphere.geoscienceworld.org/content/early/2016/09/29/GES01341.1

The small audience was provided with an excellent full colour handout of the slides used in the talk which discussed the research aims, the methodology and the study undertaken in Makkovik Province, Labrador. Alex showed the results and discussed his preliminary conclusions that:

i) basement metamorphic fabric may have been orientated such that it was particularly susceptible to a rift propagating from the south

ii) deformation event characterised by the epidote mineralisation event is younger than ~600 Ma –possibly related to Mesozoic rifting

iii) Possibly all brittle deformation is related to this event – the epidote is a localised effect.

The handout was greatly appreciated as the material was in great depth, the diagrams and photographs being available for later reference. The presentation was reported as very interesting by those who attended. Many thanks given to Alex for opening our 2016/17 lecture season.

18th November, 2016

Human-induced earthquakes.

Prof. Gillian R. Foulger. Durham University

A substantial audience welcomed Professor Foulger to give a presentation on the impact of human activities on seismic events.
A Magnitude 3 event originating from the Dutch Groningen gas field in the North Sea led to Gills' latest interest in this area. The Dutch government wanted to know if the depletion of the gas field could cause a more serious seismic event. The field generated 10% of tax income for the government, as we see later with a Spanish example, the loss of such a resource can be very serious financially.
Research into events recorded in reputable publications identified > 700 such events; Mining accounting for 267 or 38%, reservoirs 168 or 24% and the oil and gas activities 15%. Other causes included nuclear testing, groundwater extraction and fracking. The events were located in most areas including the USA, Europe, SE Australia and China.
The published data presented some conflicting situations as the causes could be geological, delayed and a combination of factors but **typically related to changes in the stress field.** Examples illustrated the situation**.**
Surface reservoirs have become very large and cyclical extraction and recharge affects the stress field. There were five cases where a magnitude 6 event was recorded. The Koyna Dam in India, built 1962. In 1967 a magnitude 6.3 event occurred, with 600 associated deaths, fortunately the dam itself did not fail. The focus was 5 km. deep. The area has a pattern of 4 large (>5.1 magnitude) a year with many (>20 a day) smaller events. The relationship to extraction and recharge appears delayed so the precise cause is not readily apparent.
Large mass superimposed on the crust. The Taipei 101 building, in Taiwan, is the heaviest structure in the world at 700,000 tons. A stress of 0.5 MPa is recorded. The area had small seismic events prior to the construction but these increased to magnitude 3 when it was built. The cause may be linked to the stress effect on the groundwater. The frequency of seismic activity increased with the foci located 10 kms below the area.
Quarry, the Wappingers Falls quarry in New York has removed 50m of surface material over a large area. This caused a reduction in stress of 1.5 MPa. In 1974 a magnitude 3.3 event occurred which was attributed to the extraction of rock. This example supported the correlation of scale of the change in stress with the maximum seismic event.
Water extraction, in 2011 near Lora in southern Spain the use of groundwater for irrigation had led to a lowering of the water table of 250m. This example has implications for many areas using groundwater. Saline water will contaminate the irrigation system potentially rendering it useless. The seismic event of Magnitude 5.1 served as a warning of the danger. The surface subsided by 2 metres. Nine people died in the earthquake and 100's were injured. There was no history of seismic activity. Holland and India are two

countries with significant lowering of the water table in some areas.
Other shallow seismic events include the event in New Zealand near Canterbury where a 7.1 quake originated 10 km down. At New Madrid, USA, in 1812 a magnitude 7.5 event occurred near the confluence of two large river systems. One explanation may be hydrological but other hypotheses are proposed.
Gas extraction. The largest human activity linked event has been at the Gazli, Uzbekistan gas field. A magnitude 7 event is associated with a stress reduction of 5 MPa linked to rapid extraction of gas. The area is now used to store gas. The change in stress may have led to movement on a fault. Seismic activity continues but the causes are not simple.
The USA has had a magnitude 6 event in 1983 at Coalinga, California. This is an oil/ gas extraction area. Movement occurred on a blind thrust fault 10 km down. 6 people died when a seismic event occurred at Whittier Narrows in the USA, this appears similar in origin.
Injection. Fluid injection into the crust has become commonplace as hydrocarbon extraction increases, fracking being a recent development. Waste fluids are also being injected into the ground as a cost effective disposal technique. Oklahoma USA has 7000 brine injection wells. Analysis suggests the rapid and significant increase in seismic activity in Oklahoma is linked to the injection. The area is now more prone to seismic events then California but the buildings lack the Californian construction controls leading to worse damage. The oil wells in the area have been present for a long time with little evidence of resulting seismic activity, the increase in injection appears to be the key factor. The Prague event was a 5.7 magnitude earthquake causing real concern. Events of magnitude 2 are daily with magnitude 5 being annual, this affects an area of 1000 km.
In Spain, Amposta is an offshore gas field near to the Lora area. It was being used for gas storage but earthquake activity to magnitude 4.3 was recorded leading to the closure of the storage facility at huge cost to the Spanish government.
In the USA the Nevada nuclear test site is linked to fault reactivation (see 'faultless earthquake' on YouTube)
https://www.youtube.com/watch?v=BzI5KkU7og8
a simple relationship has been noted, the larger the test, the larger the seismic events that follow.
Study of atmospheric events on seismic activity and earth tide events show that the largest seismic events lie between the stress linked to these two natural phenomena. This is one dimension of the complexity of attributing responsibility for seismic activity.

In summary Gillian displayed rainfall and seismic activity maps of the U.K. To demonstrate a remarkable correlation of these two events.
The audience were delighted with the professional, clear and enjoyable exposition which highlighted an area of real concern that the research of her team has highlighted.

Gordon Liddle

STUDENT PRIZE

The 2016 winner of NEGS Student Prize, **Zoe Hodges** was presented with her Award by NEGS Chairman Gordon Liddle at the November meeting.

PROGRAMME

Joint NEGS / YGS Meeting

Saturday 28th Jan 2017, 2 to 5 pm

North Atlantic - from Origin to Energy

Arthur Holmes Lecture Theatre, Science Site, University of Durham.

NEGS is pleased to announce a joint half-day meeting, to be held in conjunction with the Yorkshire Geological Society. The topic will address different aspects of North Atlantic geology, from initial opening through to controls on the hosting of major energy resources.

The following dates for your diary are a few of the 2017 Field Visits for your diary. Some of these will be Joint Field meetings with NOUGS.

May 7th. **Mega scale glacial lineations**. Led by Derek Teasdale

May 20th. **Roseberry Topping/Cliff Rigg Quarry**. A Joint Field Meeting with NOUGS led by Karl Egeland-Erikson

July 23rd **The Dufton Inlier.** A Joint Field Meeting with NOUGS led by Karl Egeland-Erikson.

The following is a contribution from member Dr Andy Lane

AFTER ABERFAN

The 50th anniversary of the Aberfan disaster has just passed, and for me it has raised strong memories of the aftermath and my early career as a geologist.

I was not present in Wales when the tragedy occurred, but just setting off as a very new PhD for Uganda to take up a mining post. A year later I was back in the UK due to family circumstances, on the look-out for a job. By mid 1967, I was in post with the South Wales Geological Services, a unit formerly concerned with coal production but now rapidly expanding, taking on staff to cover tip site surveys.

Those of us of a certain age will perhaps never forget the tragic event in which 144 people died, 116 of them children who died in their school class rooms, totally overwhelmed by slurry.

The disaster happened because colliery spoil (non-coal material generated by mining and coal preparation) was tipped as was the norm then on hilltops and valley sides, without any thought as to the sites' suitability. The fact that spoil often slid down the slopes was thought of as a bonus – it allowed more space for dumping on top. At Aberfan, a complex of seven tips accumulated on the eastern flank of Mynydd Merthyr, overlooking the village and pit (Merthyr Vale) and unfortunately over several spring lines. Geologically, the hillside comprised of several thick permeable sandstone horizons (the Upper Carboniferous Pennant Sandstones, interbedded with much less permeable thick shale and coal horizons – some of the latter worked in the past in from the hillside. Considering the heavy rainfall experienced by South Wales, it is no surprise that spring lines could be found on every hillside close to the base of the sandstones. Sometimes, as at Aberfan, boulder clay pushed the water higher up the slope, so the hydrogeology was often quite

complicated. In the event, over time, vast amounts of water accumulated in the tips, resulting in Tip 7 collapsing as a slurry run on the morning of Oct 21st 1966.

It is not commonly known that Tip 4 at Aberfan collapsed in a similar way in 1944, and a couple of years earlier there was an exact model for the disaster: at Penrhiwceiber, across the mountain a major tip collapsed and slid many hundred metres to block the main road and railway in the next valley. But these were the dark days of World War Two – nobody was killed or hurt, so nobody "in authority" took any notice – nor did they till late 1966!

Strangely, the tribunal that followed did not lay the blame anywhere, but it did cause the Mines and Quarries Act to be updated to include the safety of tip sites, with the requirement for geological surveys of all disused, active and future sites to be made as soon as possible. Hence my recruitment by the NCB in South Wales in 1967.

Until this point there had been absolutely no geological input at all into tip site selection and management. Geologists had been employed only to deal with coal production. The expanded South Wales Geological Services included four "old hands" to continue the coal production work, three new boys such as myself and a geologist acquired from the Opencast Executive to work on the tip site surveys. Only the latter had any experience of the shallow geology of the coalfield. We were fully supported by clerical and drafting staff. Of the geologists employed in the unit, only two of us still survive to the best of my knowledge!

The NCB has quite rightly been pilloried many times over because of the Aberfan disaster. But at least at grassroots level, its specialist staff and operatives made great efforts to redress this shocking situation. The upcoming Act meant that tens if not hundreds of sites both large and small needed a careful survey and report. We did our best, our efforts often not being appreciated by senior management who for one thing did not accept that geologists should express an opinion! All reports were submitted as paper files in those days and it became standard practice to retain a personal copy of everything passed up the chain in case of dispute. (Indeed, I think that somewhere up in my loft I have still a bundle of 30 or so of these reports!).

Those of us working on tip site surveys had a very large list to cover. We were firstly directed to inspect those tips threatening lives and property, and those whose collapse might interfere with the NCB's prime activity. We surveyed possible future tipping sites, along with those currently in use, and disused tips, however old. We were learners at this stage and we made use of all available methods, some of which must seem very basic today. Personally, I gained invaluable experience of methods of surface exploration and survey, which served me well in later years. Some of the techniques used to collect data were as follows:

- Surface mapping of solid outcrop and superficial deposits.
- Ability to map using topographic features (absolutely vital).
- Basic hydrogeology based on an understanding of lithology and structures, augmented by borehole data and well dipping.
- Location of boreholes and core logging (and the liaison with drillers and consultants).
- The study of old topographic maps, especially with regard to the locations of wet ground or spring lines, and maybe old drifts – mine entrances - now buried by spoil (another source of water).

- Examination of plans of old, current and future workings within the vicinity of tip sites to get some idea of ground movement
- Air photo interpretation.
- Liaison with colliery survey staff and tip site operatives.
- Logging of any nearby shallow drifts of roadways to help understand the geology.

In a rare episode of enlightenment, we were even enrolled on short courses on rock and soil mechanics at the then UWIST (now Cardiff University).

After field work and data collection we were then required to prepare a site map and report, identifying any features of significance or concern. However, we were not permitted to refer to any of these as "problems" or "threats" as we were not senior engineering staff and thus were not in a position to come to valid conclusions! Strangely though, we were expected to identify locations for the drilling of additional boreholes at contentious sites – often at considerable expense.

Working with colliery staff in the office or up on the mountain top was always a pleasure. Information was given freely, usually with a cup of tea, and no end of useful tips picked up. These people did more to help clear up the mess (on all scales) than is given credit for.

Field work on the tip sites led to many a long and physical day, often in all weathers, and not without its hazards. I had several encounters with seemingly bottomless bogs (there's a story about a sheep!) and one of my most scary experiences was being caught on a mountain top in a thunderstorm, having to cover an area crossed by steel ropeway pylons. And in those days it still snowed in winter! In many ways it was the ultimate in field work based geology, and one that shaped me for the future, but perhaps it would not suit everybody today.

When the pressure eased a little, I took the chance to take on some underground production work, so gaining a different range of skills. Eventually, I resigned from the NCB, and took up firstly university teaching, then government survey mapping work in Zambia. On my return to the UK in the early 1980's all had changed. Pit closures were the norm, and much of the tip site work was in the hands of consultants. Of the South Wales Geological Services, little remained – retirement and redundancies having whittled it away. Even some of the most prominent tip sites such as at Aberfan had been removed or safely landscaped. So my next move was to Sunderland, to teach geology at the Polytechnic then University, and the rest is history as they say.

I really do believe that the Aberfan disaster was of no fault at all of the NCB workforce, nor the lower echelons of management. There was no background training for any event of this type scale, even though the warning signs were there, and today would be obvious! Everybody I met was keen to learn and make sure nothing similar ever happened again. Of the higher management, I don't feel so kind, having experienced pomposity, narrow mindedness and jealousy of status. I suppose this was compounded by an alarming amount of ignorance, and perhaps even a feeling of guilt. And to what an extent was it a matter of being wiser after the event? It is good to think that management practice is in a different world today, and that any procedure followed by the resource and extractive industries is bound by a strict legal framework – at least in this country!

Dr Andy Lane,

Nov 3rd 2016