Home Counties North Regional Group

Newsletter - Issue No. 5– July 2017

WELCOME to the fifth edition of the Newsletter of the Home Counties North Regional Group. Sincere apologies for the delay in producing this issue, for which I have no valid excuse.

The programme of evening lecture meetings and one-day field trips continues, though attendance has been variable. The meetings have been held around the region and the programme has been varied.

Meetings of the Home Counties North Regional Group

1. LUSI: the geology and engineering of a mud volcano

Dr David Shilston

21 January 2017

At the Home Counties North Regional Group meeting at Sir Robert McAlpine in Hemel Hempstead, 22 people heard David Shilston of Atkins and past-President of the Geological Society give his talk on **LUSI: the geology and engineering of a mud volcano**, which formed an appropriate link between the Geological Society's Year of mud (2015) and its Year of water (2016).

SPEAKER *David Shilston has some 35 years experience of civil engineering and geological projects in the UK and many conntries overseas. Apart from his general working knowledge of civil engineering, geotechnics, geology and geomorphology, he has specific expertise in the assessment and management of geohazards, including landslides and erosion, collapsing ground, seismic hazards and problems encountered during construction and operation of projects. David has undertaken due dilkigence assessments and appeared as an expert witness in construction disputes, including disputes concerning power stations (Java and Finland), an airbase (Bahrein) and highways in Trinidad and Africa. David was the first engineering geologist to have been elected President of the Geological Society of London.*

ABSTRACT In May 2006, a new mud volcano erupted adjacent to an exploratory gas well in Eastern Java. Colloquially called LUSI (Lumpur Sidoarjo), the mud volcano is unlike naturally occurring mud volcanoes, as it has, until recently, maintained continuous and high flow rates of mud at high temperatures. Although there is much debate amongst geoscientists about the cause of the mud volcano, it is the social and economic impact that is of greater importance to the many thousands of people made homeless and to the economy of the area. Thetalk will describe LUSI, its evolution, its impact and what can be said about its future development.

Introduction

Mud is an interesting material, which, if water is added, becomes very sloppy but, when it dries out, it becomes hard. LUSI is an abbreviation of the Indonesian name for the mud volcano – Lumpur Sidoarjo – the word lumpur meaning mud. The speaker explained that the talk would cover what it is, its causes, its impact and mitigation and look at the potential future of it.

Mud volcanoes

As described in Dimitrov (2003), a mud volcano is a structure formed as a result of gas and water being emitted from the surface of the earth. Examples illustrated the El Tolumo mud volcano in Colombia and an Azeri mud volcano, at which the gas ignited and resulted in flares in October 2001 in Azerbaijan. Baku has a large number of mud volcanoes both on- and off-shore in Lake Batan, eg in 2012. There is a bedrock ridge with little mud volcanoes. The driving force for mud volcanoes is abnormally high fluid pressures due to rapid sedimentation so they are found at compression boundaries of tectonic plates, and in deltas and diapirs. 1,950 "prominent individual" mud volcanoes have been recorded and 65 erupt each year.

Searching in Wikipedia reveals a mud volcano in the UK at Royal Wootton Bassett. It is actually a mud spring rather than a mud volcano in a small wood 1Ha in size. Mud oozes out of the ground bringing up fossils from the Kimmeridge Clay at depth at Greenhill Common and Juniper Firs.

LUSI

LUSI is located on a plate boundary in an area with other mud volcanoes in eastern Java, Indonesia. The speaker was involved in its investigation with a team that included GCG, Ikon Science Compressive Technology, Durham University, Nigel Press Associates (now CGG) and Atkins.

LUSI first erupted in 2006 and is of enormous size – 3km north to south and 2km east to west. It had 2 vents in 2011.

Potential triggers for the eruption were twofold. A possible natural cause was a magnitude 6.3 earthquake 2 days before the eruption in Yogyakarta Province 30km to the west, which reactivated the Watukoset Fault and may have caused fractures intersecting high pressure water and gas. Alternatively it could result from human activity in that, immediately before the eruption, the drilling of the Banjar-Panji gas well encountered high pressure water and gas which fractured the ground.

Within weeks the mud was starting to cover large areas, an earth bank was builtby end-tipping weathered volcanic materials in an effort to contain it but this was overcome. The Executing Agency is the Sidoarjo Mudflow Mitigation Agency (BPLS). Concern arose about potential effects on The River Parong, a canalised river, which only flows at certain times, important infrastructure in a road and railway to the west and the River Catapang to the north. The main east-west Java toll road ran south-east to north-west across the area but it is no longer n existence and a gas main explosion killed 6 people.

Origin and evolution

Davies, Swarbrick, Evans and Hause (2007) report the geology as Kujung Formation limestone of Oligocene/Miocene age overlain by Pliocene sands and muds, Pleistocene deposits then recent alluvium. The consensus among scientists is that the gas well drilling penetrated high pressure water which fractured the gas well below casing depth and fractured the rock through to the surface. The resulting vent formed a pioneer cone and, as mud depleted, the original surface has subsided with the sag extending beyond the limits of the mud volcano, currently defined by earth banks. The source of the water is at 2,300m +.

Not far away from LUSI is the Parong feature, a natural analogue, which can be seen in the geophysics as a sagging depression 750m deep resulting from a fractured zone at 4,500m. The zone of deformation extends over 4km but there is nothing to see on the surface.

When it first erupted, LUSI was emitting 170,000m3/day. In 2010-11, it was at about 10,000m3/day and now it is possibly at 20-30,000m3/day. The prediction in 2007 was that it would continue for 25-30 years.

Impact and mitigation

LUSI has had major impact on people, the environment and the economy. 20-40,000 people have been made homeless. The first attempts at mitigation by BPLS involved pumping mud from the pool and discharging it into the Parong River but this did not work well and there was concern that the mud would block the river and cause overtopping in the rainy season. There was also an attempt to block the vent using large concrete balls, which illustrates the desperation felt, but, again, this did not work.

The main mitigation was the construction of earth banks around the mud pool and BPLS is basically maintaining those banks. Every now and then, there is a small over-topping of the bank with mud flowing over and killing the vegetation. In the northern sector, the bank failed in a translational slide and muddy water went into the Katapang River, though the mud itself stopped only a short distance beyond the failure. The earth bank has had 5 or 6 lifts, needed to overcome subsidence but it was 6 years before the first geotechnical paper (Agustaniyaya, 2012) was published

The earth bank is forcing the ground down in a bearing capacity effect but the sag extends beyond where that would be expected. There are examples of houses leaning back due to local settlement and a significant number of properties have been flooded by surface water. The Parish council have been given grants from BNPLS to raise the banks of the Katapang River. Life-size statues erected on the mud as the Survivors memorial in May 2014 were down to waist level by December 2014. Maximum settlement has been estimated at 40m+ (Williams and Wibauro, 2010), though survey measurement on sites were quickly overrun by the mud. Settlement contours show 0.2m just outside the mud pool itself.

The use of radar interferometry, which needs a solid target on the ground such as the corners of buildings, shows that the ground is going down at LUSI and at an active gas field to the west but the Tangulangia gas field is going up. Initial measurements were between May 2006 and February 2007 and measurements from July 2012 to May 2013 show a cumulative drop of 0.2m, which correlates with the ground survey.

Impact

Economic impacts have included factories, cottage industries, agriculture and horticulture, infrastructure, travel, supply lines and services. 12 villages, 33 schools, 15 Islamic Centres, 65 Mosques, 30 factories, 4 village offices, sugar cane plantations, rice fields and other plantations are all now buried under many metres of mud. The 40,000 displaced people have now mostly been relocated but there was significant psychological impact of an event that was completely out of the blue and for which no known end can yet be seen. Further details can be found in

Disaster management

The responsible parties for disaster management were the Drilling company (Lapindo Brantas Inc) and the Indonesian Government (through BPLS).

Engineering impact and mitigation has included bund construction and mud pumping, attempts at stopping the eruption and dealing with flooding by groundwater and surface water.

Mitigation of the social impact has been through compensation in the form of assistance payments, compensation for lost properties or enterprises, resettlement of evacuees and training for new jobs.

The future

The predictions in the report in mid-2007 were that, by 2015, the risk of collapse of the earth banks would reduce then increase as they decay and that there would be continued ground movement. Major change in LUSI could entail a constant chance of a new vent and/or an increase in flow rate, the chance of the vent collapsing increases with time and the chance of mud damming the Parong River increases with time.

Long-term prospects

In the long term, ground movement will continue, water management will be needed to deal with pollution incidents, the earth banks will need to be maintained and the mud pond may eventually be restored or remediated, possibly by treating as a mine tailings area and dealing with the run-off using reed beds. The mud is very chemically aggressive.

On 7 January 2016, Lapindo Brantas announced that they plan to redrill the gas well near the centre of the mud flow while compensation to victims is not yet fully dispersed. The intention is to drill to 1km depth and they want all parties to participate in supervising the drilling. They are quoted as saying – “geologically, drilling would not cause a problem!”

Report by Dave Brook

2. A brief history of life in 10 fossils

Paul Taylor

17 March 2016

At the Home Counties North Regional Group meeting at Sir Robert McAlpine in Hemel Hempstead, 26 people heard Dr Paul Taylor of the Natural History Museum talk on **A brief history of life in 10 fossils**.

SPEAKER: *Paul Taylor is a research palaeontologist specialising on bryozoans. He is a graduate of the University of Durham and stayed there to complete a PhD (1977) in the Department of Geological Sciences before moving to the University of Swansea for a postdoctoral research fellowship. Paul has worked at the Natural History Museum in London since 1979 and has published more than 300 scientific articles as well as three popular books, the latest of which is* A History of Life in 100 Fossils *(Taylor & O'Dea, 2014. Natural History Museum Publications, London). He is also the Editor-in-chief of the* Journal of Systematic Palaeontology.

ABSTRACT: The history of life is written in the rocks, or more precisely in the fossils contained within the rocks. This talk will showcase 10 important fossils that either represent milestones in the development of life on earth, or provide key evidence about the processes of evolution. They also tell human stories of discovery, interpretation and misinterpretation.

Introduction

This talk was inspired by a book – *The history of the world in 100 objects* – which took 100 objects from the British Museum collection to illustrate the history of the world. This was followed by a number of similar titles covering different aspects of history and, in 2014, the speaker and Aaron O'Dea published *A history of life in 100 fossils*. The aim was to look at landmarks in the history of life and what fossils can tell us about the evolution of life. It also sought to illustrate fossils that are aesthetically pleasing and looked at some of the personalities involved. For this talk, 10 of the examples in the book have been selected in stratigraphical order.

1. The world's oldest fossil

Apex Chert

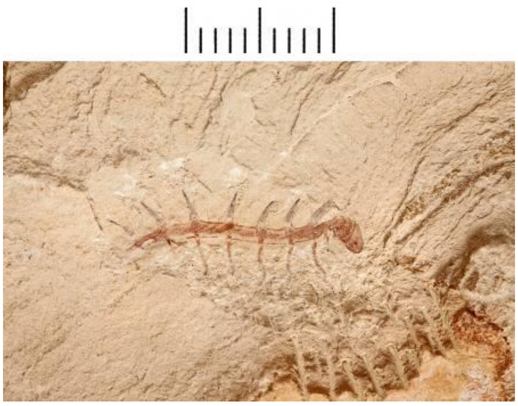
Probably the world's oldest fossil are carbonaceous filaments described by Bill Schopf, which are only visible in thin section. They are from the early Archaean Apex Chert (3,465±5Ma) of Western Australia. They are all rather vague. They are composed of kerogen but there is some doubt that they are really fossils and they may be just inorganic remains. They have been compared with cyanobacteria but they are much smaller.

2. *Dickinsonia*

Reg Sprigg, a prospecting geologist discovered *Dickinsonia* in the Ediacaran (the last period in the Precambrian at *c*. 600Ma) in South Australia but it is now known from other parts of the world, along with other Ediacaran fossils such as *Charnia*, originally described from Charnwood Forest, and *Spriggina*, named after Reg Sprigg. It is unusual in that the segments on either side do not continue across the mid-line of the fossil. As it is soft-bodied the question arises as to why it was fossilised – it may be a death mask formed by microbial mats. Other questions arise as to how it relates to living organisms or whether it was an evolutionary dead end and how it lived with no obvious mouth or anus.

3. Hallucigenia

This was originally described by Simon Conway Morris from the Lower Cambrian Burgess Shale of Canada. He identified what appeared to be a single row of tentacles, which he reasoned passed food forward to the mouth, on the top of the body with pairs of stilt-like props on the underside. However, the discovery of better material has shown that what appeared to be a single row of tentacles were in fact a double row of walking legs and what he had indentified as props were spines on the back of the animal – his reconstruction was upside down. *Hallucigenia* seems most closely related to the onycophorans (velvet worms) and it was part of the major Cambrian radiation of life.



Hallucigenia

4. Eryops

From the late Palaeozoic, *Eryops* was a giant amphibian 2m long, belonging to the temnospondyls, from which modern amphibians later evolved. Specimens on display in the Natural History Museum and in the Museum National d'Histoire Naturelle, Paris have 4 and 5 digits, respectively, on the front legs. The Paris specimen is wrongly reconstructed from a typical fossil assemblage consisting of lots of bones that are not articulated and a fifth digit was wrongly attributed to this specimen. Modern amphibians are much smaller, though the largest, the Chinese Giant Salamander approaches it at 1.8m. *Eryops* was not the largest Palaeozoic amphibian, as *Prionosuchus* was 9m long.

5. A William Smith ammonite, *Pictonia baylei*

This ammonite, along with others, was critical to the map published by William Smith (1769-1839) in 1815. The map resulted from Smith's understanding of the 3-dimensional structure of rocks and his use of fossils to identify particular strata, *Pictonia bailei* being characteristic of what Smith called the Oak Tree Clay (now Kimmeridge Clay). However, Smith's work was published long before Darwin's *Origin of species*, which established the credibility of evolution. So, why did Smith believe that the fossil assemblages of different strata were different? Smith's catalogue of fossils he sold to the British Museum (1817) attributed each layer to a separate creation, suggesting an adherence to the Catastrophism beliefs expounded by his contemporary Georges Cuvier.

6. *Iguanodon*

Named by Gideon Mantell (1790-1852) in 1825, *Iguanodon* was actually discovered by his wife in 1822. It is also interesting to note that Mantell's home in Lewes had ammonitic capitals, a popular architectural style at the time. *Iguanodon* lived in the early Cretaceous. When he produced the Crystal Palace dinosaurs, Benjamin Waterhouse Hawkins (1807-89) imagined *Iguanodon* as a lizard-like creature with a horn on its nose. However, it is now known that the 'horn' is in fact a thumb spike and *Iguanodon* was much less lizard-like than he thought. The understanding of fossil organisms relies very much on analogy with living organisms.

***Iguanodon* tooth**

7. Belemnites

Illustrated by *Belemnitella* from the Maastrichtian (70 Ma), belemnites first appeared at the base of the Jurassic (200 Ma). Normally all that is found is the calcite guard, which was the counterweight to a squid-like organism, but they also had a chambered shell, the phragmacone, made of aragonite and so metastable, which was full of fluid to regulate buoyancy. The last of the belemnites lived around the Cretaceous–Tertiary boundary, a time of major mass extinction when ammonites, belemnites, rudist bivalves and inoceramid bivalves disappeared, as well as dinosaurs.

Maastricht belemnite

8. *Neptunea contraria*

This is a left-handed gastropod, one of the commonest fossils in the early Pleistocene Red Crag of Suffolk and Essex. Among modern marine gastropods described in Lindner (1977) *Seashells of the world*, 693 are right-handed and one is left-handed. Terrestrial gastropods have more left-handed ones but they are very rare in marine gastropods. The variation is governed by mutations in a particular gene. The Hindu god Vishnu holds a left-handed shell, the Indian conch or chank (*Turbinella pyrum*), nearly all of which are right-handed, the left-handed ones being mutants and held in great value by Hindus.

Neptunia contraria

9. Moa

Moa

This New Zealand bird was first described by Richard Owen (1894-92), the founder of the British Museum (Natural History), from a few broken bones. Subsequently, there have been discoveries of more complete skeletons, eggs, footprints and mummified soft tissues. The last Moa died about 600 years ago and the bird was never seen by Europeans. There were about 12 different species, some in North Island and some in South Island. Moa birds had only one predator, the Haast Eagle, and were hunted to extinction by humans, as shown by the large middens of Moa bones.

10. *Homo heidelbergensis*

Homo Heidelbergensis

"Rhodesia man" as it was once called, was discovered in 1921 in a lead mine in Zambia, and is about 200-300,000 years old. Stone tools were also found but it is not clear by whom they were made. This hominid species also lived in Germany. Howell (1965) showed human evolution in his original "March of progress" diagram, of which there have been numerous parodies. *Homo heidelburgensis* was originally thought to be the ancestor of *Homo neanderthalensis* and *Homo sapiens* at a time when it was believed that there had been a single evolutionary lineage leading to modern man and all new finds represented 'missing links' in this lineage. There is now much more knowledge about hominid evolution, which is a tree rather than a single lineage. Progressive evolution culminating in modern humans at the top of the tree is a poor analogy as all living organisms, not just humans, occupy the tips of branches in the tree.

Conclusion

Fossils chronicle constant and dramatic changes in life on earth through the immensity of geological time. They show times when species developed new ways of living and diversified and other times when they were decimated in mass extinctions. They are important in reconstructing the 4evolutionary tree of life by filling in gaps revealing transitional forms between living groups of organisms.

Report by Dave Brook

From polar bears to deep-sea seeps: a Mesozoic macropalaeontologist in Greenland

Simon Kelly

2 June 2017

At the Home Counties North Regional Group meeting at Affinity Water, Hatfield, 20 people hears Simon Kelly give his talk **From polar bears to deep-sea seeps: a Mesozoic macropalaeontologist**

in Greenland, about his experiences as a macropalaeontologist working iwith field parties from the hydrocarbon industry who do not know fossils.

Simon Kelly is a palaeontologist, specialising in Mesozoic mollusca and biostratigraphy. Graduating from Oxford University in 1971, he studied for a PhD at London University (1977) on bivalves of the Jurassic-Cretaceous boundary in eastern England. Worked at Goldsmith's College for two years before taking up missionary work in the Fens and worked at Cambridge University for 5 years. Apart from a 5-year stint at the British Antarctic Survey he has been self-employed based in Cambridge, working mainly for CASP (formerly the Cambridge Arctic Shelf Programme). He has been on 25 Polar expeditions (Antarctic, Greenland, Svalbard and Canadian Arctic), amongst other areas, and is currently curator of two arctic geological collections. He was awarded the Polar Medal in 2000 and has written more than 60 peer-reviewed publications.

ABSTRACT – *This talk is aimed at a general level, introducing the audience to life as a palaeontologist working under canvas in Arctic conditions with hazards from the intense cold down to -40ºC to visits from Polar Bears. How do we travel and what can we find? What use is a macropalaeontologist to the hydrocarbon industry of the North Atlantic? What is CASP? Why Greenland? The talk will present a guide through some of the biota which we find in the Triassic, Jurassic and Cretaceous rocks, from mighty air-breathing dinosaurs to giant methane-dependent deep-sea molluscs, and show how we can use them to understand changing environments. And what do we use for a clock? - a geological one that is. How do we get a resolution of under half a million years?*

CASP

Casp was founded as the Cambridge Arctic shelf Programme by the ate Brian Harland. He first went to Svalbard in 1935 and following many subsequent visits, he published The geology of Svalbard as *Geological Society Memoir* No 17 in 1997. CASP has been a geological education charity since 1975. It is attached to Cambridge University but not funded by it. Indeed it pays the university for the use of its facilities and is funded by the hydrocarbons industry. It specialises in fieldwork in remote areas and is currently working on the Barents shelf, Greenland, Arctic Canada, the Caspian and Black Seas, Ethiopia, Siberia and the Russian Arctic. With its wider sphere of activities, it dropped the longer title but retained CASP, as it was well known by that name. It has also worked ion Argentina, Brazil and other areas.

Why Greenland?

Remembering that Svalbard used to be further north and the North Atlantic has only ben open since the Cretaceous, the Norwegian shelf hydrocarbon basins were once closer to Greenland than to Norway and there are very few Mesozoic rocks exposed in Norway. The rocks and topography are similar in many ways to Skye.

In the field there is evidence of ancient Inuit life, though the settlement at Scoresbysund was only started in the 1950s. In 15 expeditions to Greenland, the speaker has only met native Greenlanders on 3 or 4 days, though they do meet the Danish military Sirius Patrol, which monitors the national park area.

Fieldwork in spring involves the use of skidoos, with travel in convoys and roped up in crevassed areas. In summer they are taken to field sites by twin otter, helicopter or rubber dinghy. Wildlife includes birds such as ptarmigan, musk ox and seals, which only the Inuit are allowed to hunt and they have come across caribou antlers, even though the last reindeer were hunted out 200 years ago. Polar bears are a particular hazard and field parties do gun training every year but fortunately have never had to fire the guns.


C

ASP collections have over 37,000 specimens including belemnites, bivalves and huge quantities of mud for microfossils – palynology, micropalaeontology, geochemistry etc.

Mesozoic rocks

Triassic rocks are all marine in the early Triassic, with ammonoids and bivalves such as *Halobia* and *Dromella*. From the mid-Triassic on, the rocks are fluviolacustrine with superb dinosaur trackways, lacustrine biota and late Triassic macrofloras directly comparable to offshore deposits for sedimentation and provenance studies.

The area was an arm of the Arctic Ocean closing in the proto-Atlantic and there is lots of interesting sedimentology, such as halite pseudomorphs. Lacustrine stromatolites are present and stromatolite-encrsted logs and tree stumps as well as *Holo metabous* insect larvae. The stratigraphy of the James Land basin has now been revised and it matches that of the mid-Norway area.

The **Rhaetic** has a good leaf flora with *Lepidopteris attanis* and *Thaumatopteris schenk.*

Jurassic rocks (200 to 145Ma) are much more marine and all stages are represented, a useful comparison since in onshore Scotland and Norway the Jurassic is limited. There is much to compare with Svalbard.

The typical structure is a series of fairly steep north/south faults dipping into the sea and there are traces of oi; at the top of some of these structures. Greenland is not an oil province but it is key to the offshore succession.

There are a series of non-marine/shallow marine/deepening cycles. Shallow-water sandstones have trigonid bivalves, which became almost extinct at the end of the Cretaceous with only a few species now found around Australia. There are phosphates reminiscent of the Cambridg coprolites (of Cretaceous age) but the bulk are phosphatised concretions rather than coprolites, which were minealised in the slow sedimentation rates. *Trigonia hemisphaerica* (early Bajocian) gives the earliest mid-Jurassic date in Greenland. Higher up ammonites become common such as *Cranocephalites pompeckji*, often heavily mineralised with barites.

There are 86 ammonite horizons in the mid- to late Jurassic, epresenting 281,000 years per division, 35 palynomorph biozones at 691,000 years per division and 25 microfossil biozones ar 968,000 years per division. Integrated stratigraphy allows very refined dating of the rocks.

Sea levels were much higher in the mid- to end-Cretaceous. Eastern Greenland has the only complete Cretaceous succession in the Norwegian – Greenland Sea area, with all stages from the Berriasan to Maastrichtian in marine rocks. The rocks are deep marine sandstones and shallow marine sandstones with mudrocks but no Chalk, which does not extend north of the North Sea. There are exposures of the Jurassic/Cretaceous boundary with concretionary horizons and lots of ammonites, eg 9 Buchiid zones such as *Buchia keyerlingi* (Valanginian). Inoceramid bivalves occur higher in the Cretaceous , eg *Sphenoceramus patootensiformis*.Greater precision in dating is obtained with ammonite zoning. Macropalaeontology works alongside palynology, eg of dinoflagellate cysts , eg *Wigginsiella grandstandica*, originally described as early Cretaceous (Albian) but it has Cenomanian ammonites (eg *Schoenbachia varians*) alongside.

The combined stratigraphy makes it stronger and they have now produced a very detailed stratigraphy for the Cretaceous and are able to recalibrate other groups using ammonites and tweak other micropalaeontological successions.

The very southern area around Kangerlussuaq has the layered gabbros of the Skaergaard intrusion but very close are successions of mudstones of Maastrichtian age containing *Diplomoceras* and *Acanthiscaphites tridens*, a zonal indicator in Europe.

Methane seeps

The Chalk does not extend north of the North Sea but there are late Barremian limestones fed by highly calcified tubes located very near fault structures and huge lucinid bivalve shells in great abundance growing around the tubular structures, all of which are of methanogenic calcite. Around these methane seeps a mussel, *Caspiconcha whithami*, up to 2cm thick and 40cm long, is a new genus and species of methane-seep bivalve. The same genus occurs in Japan and California.

Report by Dave Brook

Field meetings

Reports have not yet been received for some of the field trips so to ensure there is a full record I have included the information from the flyers for those for which there is no report. I have slightly edited these to include the number of people attending each trip. Should further reports be received, they will be included in the next issue of this Newsletter.

1 Geology, geomorphology, geoarchaeology and prehistoric history of north-west St Albans, Sandridge and Coleman Green, Hertfordshire.

Led by John Wong FGS

18 March 2016

We assembled at the car park at Verulamium Park on a rather overcast morning, for an excursion to explore various aspects of the geology, archaeology, buildings and history of the area.

Walking downslope to view the valley of the River Ver, in which the park is situated, John noted that the valley was asymmetric, being much steeper on the northern side, due to differential erosion during the last (Devensian) ice age, the period from which the flood plain of the river dated. He explained that the sun shone more strongly on the northern side, melting the layer of permafrost which had formed over the chalk and melt water carrying ground material would flow down the northern side of the valley, eroding it more heavily. The resulting steeper north side had contributed to the strategic location of the area. That had led first to the Iron Age, and subsequently to the Roman, settlements.

Looking over the flood plain, we could see a line of trees marking the present course of the River Ver. This had varied over the course of time, and was much narrower than hitherto, due both to cutting down and to human activities, such as modifying the stream for the use of water mills.

Prior to the Devensian, rivers in the area had tended to follow the dip slope of the chalk to the south-east, or had skirted it to the north.

Two huge tongues of ice during the latter part of the Anglian glaciation had blocked the path of the proto-Thames, which had passed through the Vale of St Albans, then eastward across what is now Hertfordshire, the middle of Essex and the southern North Sea to become a tributary of the Rhine. The ice dams resulted in the diversion of the Thames to approximately its present path, and the River Ver, which now drains the area, has a southerly course and joins the River Colne.

John produced a series of Ordnance Survey maps of different dates, which showed both the development of the City in modern times and the gradual discovery of archaeological sites. This had culminated in the excavations in the Park carried out in the 1930s by Sir Mortimer Wheeler and his wife Tessa, which had revolutionised the understanding of Roman Verulamium.

John said that the Roman Verulamium had been of much the same size and shape as Londinium (London). Unusually, its theatre had been inside the city to avoid the marshy ground, which was then prevalent in the locality (and which had given rise to the Celtic name from which the Roman name of the city derived).

We passed the Mud Lane Pumping Station, which pumps water from the chalk aquifer beneath, and which together with two other pumping stations provides the main water supply for the modern city. John said that all three together supplied about 20 million litres per day.

We were invited to look over the ground of the floodplain, and saw river gravels laid down by the Ver. John drew our attention to numerous hollows and humps (pingos) formed by freezing and melting processes in a periglacial environment.

We walked along a path to the excavated remains of the Roman Londinium gate and part of the wall. Although depleted by building stone "recycling", its massive construction of Roman bricks (tiles) was still evident. John drew attention to the fact that the infill was not rubble, but solid flint. He pointed to the ditch below the wall and observed that unlike Iron-Age ditches, which tended to be V-shaped, the ditch was of an asymmetric U-shape. It appeared to have been deliberately designed to lure attackers into the ditch, from which they would then find it difficult to escape.

Looking back towards the modern city, John said it lay on the chalk (covered with glacial gravels and boulder clay) and it was possible to see a difference in the steepness of the slope of the hill between the Middle Chalk and the Upper Chalk. The Cathedral lay on a layer of hard ground at the boundary, the Chalk Rock.

We walked back down and alongside a lake that had been constructed in the 1930s. John remarked that the residual clay by the lake was testimony to recent flooding. We passed along a canalised and steepened section of the river, constructed to serve mills, which had a fish ladder to enable the trout to be expected in a chalk stream like the Ver to by-pass the millrace.

We stopped to see a pub, The Old Fighting Cocks, which claimed to be the oldest pub in England, but in fact seemed to be a re-erected medieval pigeon house. We came to St Michael's ford and bridge, Kingsbury, near which was a large block of Hertfordshire Puddingstone, found, we were told, in a Roman fort.

Hertfordshire Puddingstone is a conglomerate of very well rounded flint pebbles cemented into a very hard pale silica matrix. It is thought to result from deposition of silica in solution in the pebbles in a very warm and humid environment.

We then walked up the street, to St Michael's church, situated just by the Verulamium museum complex, passing a Roman sarcophagus en-route. On the way up the street, we had noted kerbstones of sarsen, another type of silcrete, thought to have been formed in a similar way to the puddingstone, but with the silica solution deposited in sand, rather than pebbles.

The church is mainly of flint and recycled Roman tiles, with some blocks of Hertfordshire Puddingstone. Quoins and a small doorway appear to be made of Ham Hill Stone, a Jurassic limestone from Somerset, made from re-worked ooids, with shelly debris and cross-bedding. A curious shallow arch beneath a window in one corner of the church is made from Totternhoe Stone. This comes from near Dunstable and is a silicified chalk from another band of hard ground, this time in the Lower Chalk. Totternhoe stone has an elegant surface, but is better suited to interior work, as it weathers easily outside. There is also stone work of oolitic limestone, Ancaster or similar, from Lincolnshire and a piece of another oolitic limestone which we thought came from Northamptonshire.

We walked back to the car park, and then drove up the ramp into the City, noting the change of slope between the Middle and the Upper Chalk. Turning along the Sandridge Road (a former Roman road), we drove to Coleman Green, where we stopped at the John Bunyan pub for lunch.

The pub is so called, because John Bunyan, who wrote the (decidedly protestant) allegory of the journey of a Christian, *The Pilgrim's Progr*ess (perhaps one of the most influential works of English religious literature), stayed at a nearby cottage when visiting the locality as an itinerant preacher. The cottage is now in ruins, little more being left than an end with the remains of a chimney and fireplace. We crossed over to see it after lunch, passing a roadside exposure of boulder clay on the way.

We then drove to see the Devil’s Dyke at nearby Wheathampstead.

This is a scheduled Ancient Monument, lying to the east of the town, a massive ditch about 500m long, 12 m deep, and as much as 40m wide at the top in the middle. It was apparently constructed in the later part of the Iron Age. It seems to have been part of the defensive works for an "oppidum" (town or settlement) of a Belgic tribe. The site of the former settlement lies between the Devil's Dyke and a parallel ditch, known as the "Slad", which runs on its eastern side.

The area was investigated by Sir Mortimer Wheeler in the 1930s. He suggested that the oppidum was the headquarters of the British tribal leader Cassivellaunus, and the site of his defeat by Julius Caesar in 54 BC. However, this would appear to have been more a matter of assumption rather than hard evidence. We walked some way along the ditch, admiring the work which must have gone into its construction, even though it may well have exploited a pre-existing natural valley.

Before we returned to our cars, the writer took the opportunity to mention something regarding our next location, St Leonard's Church, Sandridge.

A site nearby had been the source of one of the largest plumes of contamination to affect an aquifer used for public supply in this country. This had been the subject of a presentation to the Group by Rob Sage of Affinity Water on 5 June 2014 (It was reported in the September 2015 newsletter).

Between the mid-1950s and the early 1980s, a chemical works manufacturing compounds of bromine had operated on the site. During that time, there seem to have been significant leaks of chemicals into the ground. Following the cessation of operations, the site had been sold to a developer for re-development for residential purposes, and is now called St Leonard's Court.

It seems likely that any concerns regarding the chemicals on the site, and the planning condition requiring remediation prior to re-development, related primarily to the protection of the future residents, rather than the underlying chalk aquifer. That might have been because the BGS Hertford sheet shows the site as covered by boulder clay. Indeed, that might also account for the presence there in the first place of the chemical works, which would also have been subject to planning permission. It would also explain the apparent insouciance of the chemical company during operations. Admittedly in the 1950s there was rather less concern about the environmental impacts of industrial activities than would be expected at the present day.

Non-geologists might not have been aware that geological maps rely heavily on inference, given the impossibility of excavating the whole country. It appears that, in fact, the aquifer was only covered at that point by relatively thin interdigitated lenses of clays and gravels, which would have offered comparatively little protection to the aquifer.

The developer carried out some remediation, but unfortunately also removed the buildings and hard standing, to avoid having to pay business rates during a period of delay to the re-development. During that period, there was considerable rain, and this appears to have flushed the remaining chemicals down into the aquifer.

A plume formed down-gradient, from which contaminants were transported fairly rapidly towards the River Lee and boreholes serving consumers in Hertfordshire and North London. Transport seems to have been aided by karstic solution features in the chalk. When early in this century, the relevant water companies started sampling water from the boreholes to test for bromate, a carcinogen, to ensure being able to meet new requirements under the EU Drinking Water Directive, elevated concentrations of bromates and bromides were found and the source was soon identified as the Sandridge site.

Following proceedings under Part IIA of the Environmental Protection Act 1990, a remediation notice requiring further investigation, pumping and treatment to be carried out at their expense had been served on both the chemicals company and the developer.

We moved on to Sandridge and saw St Leonard's Church. This was built in the 12th century, and had its chancel enlarged and rebuilt early in the 15th. However, it fell gradually into a state of disrepair until it was extensively restored and rebuilt in the 1880s. According to a booklet on sale in the church, the architect was William White, a pupil of Sir George Gilbert Scott.

It appears that the original exterior fabric was mainly of flint, with recycled Roman tiles, and a miscellany of other material. By contrast, a zebra-striped oolitic calcarenite, current re-worked with current cross-bedding structures, featured in the newer parts, particularly on the west-facing tower wall.

Inside, we saw Norman pillars and arches of sawn Totternhoe stone, and a late 12th century font carved with interlaced arches and topped with a saw-tooth pattern. At the entrance to the chancel, there is an open stone screen with an arch of Roman tiles. These were apparently uncovered by William White from layers of plaster. He also filled the space between the arch and the roof with wooden tracery and a representation of the crucifixion, in line with the theological tastes of his day in the area, which had now moved somewhat away from Protestantism.

At the entrance to the churchyard is a lych-gate, built as a war memorial in the 1920s. This structure is apparently a listed building in its own right.

We then bade farewell to some of our company. The remainder returned to St Albans, where we visited the excavated remains of the Roman Theatre, and saw floodplain gravel, and more Hertfordshire Puddingstone, before parting to make our way home.

Report by Richard Trounson

2. River Thames Intertidal Foreshore Walks:

Geology, geomorphology, sedimentology and geoarchaeology of the lower Thames foreshores at Southwark and Fulham, London.

Led by John Wong FGS

10 April 2016

Meet by the glass Millennium obelisk near the Millennium footbridge on the north bank of the River Thames.

John will give an introductory talk on the geology and the geomorphology of the Thames flood plain covering:

- the current upstream migration of the tidal head of the Thames estuary;
- the historic transgression and regression events in the Thames shown by archaeological evidence and intertidal sediment records;
- the submerged forest;
- the nearby 'lost' rivers of London (Thames tributaries now hidden beneath urban development); and
- the Roman choice of the site for Londinium (City of London) which was dictated by the local geology.

John will also explain the Port of London Authority foreshore metal detection/digging regulations and permits.

At low tide, we will go onto the intertidal shingle beach along the South Bank in Southwark. Beach walkers are generally interested in the intertidal marine life or archaeological finds such as Roman and Medieval pottery, Tudor and Stuart bricks and tiles, Georgian clay pipes, Victorian ceramics and glassware, remains of domestic animal teeth and bones, ship nails and timber, with the occasional prehistoric flint tools. Along with the archaeological material, we will look at the petrology of the shingles and rubbles and 20th century industrial geological waste. We will examine how geological materials are reworked and redeposited by natural processes and by human activities to give some insights to the solid geology of the Thames catchment area and beyond.

We will see various interesting building stones, for examples Cretaceous tholeiitic basalt, Jurassic Calcarenite, Variscan plutonic igneous rocks, Carboniferous crinoidal limestone, and Archean gabbro over 2 billion years old.

After lunch, we travel to the foreshore near Fulham Palace for another intertidal walk along the north bank of the Thames before the arrival of high tide. There is a plan B if we are unable to reach Fulham while it is still low tide, or we have adverse weather on the day.

3. Lower Cretaceous – Aptian and Albian – and Quaternary of west Mid-Bedfordshire: the Gault Clay Vale, Greensand Ridge and Boulder Clay Hills – Tilsworth/Stanbridge/Eggington/Hockliffe/Battlesden/Tebworth/

Rushmere Country Park and Stockgrove Country Park, Bedfordshire

Led by John Wong FGS

22 May 2016

Meet at the car park of McDonald's restaurant south of Hockliffe village.

John will give an introductory talk on the Lower Cretaceous and Quaternary of the area in this field trip covering:

- landscape characters and land use of the Greensand ridge, Gault Clay vale and boulder clay hills;
- palaeogeography and tectonics of the Late Upper Jurassic and the Cretaceous non-conformity;
- stratigraphy and palaeogeography of the Lower Greensand Formation (known as Woburn Sands in the west of Bedfordshire);
- palaeoenvironment and sedimentology of the Red Sands, Silver Sands and Brown Sands;
- diagenesis of the Woburn Sands and ironstone;
- palaeogeography and petrology of the Gault Clay and the Upper Greensand;
- the Lower Coprolite Bed and the Upper Coprolite Bed;
- economic geology and local quarrying activities;
- geoarchaeology of the Iron Age and Norman hill forts;
- building stones as indicators of proximities to the Woburn Sands and Totternhoe Stone;
- glacial fluvial deposits;
- glacial till and provenance of glacial erratics; and
- buried glacial channels and periglacial geomorphology

In the morning we shall look at the geology, geomorphology and the building stones in and around Tilsworth, Stanbridge, Eggington and Hockliffe.

We then travel to Rushmere Country Park for lunch, look at the Red Sands deposits and discuss the diagenesis history.

In Stockgrove Country Park, we shall examine the fluvio-glacial gravels, the changes in the soil character, the asymmetric cross-section profile of the steep river valley and, also, U-shaped dry valleys. There is a large sundial on top of the hill made of large blocks of rocks from the Lower Greensand Formation, and there is an exhibition on the local geology.

At Battlesden, there is glacial till with glacial erratics from the Palaeozoic provenances and possibly older.

We wrap up this field trip at Tabworth to see the mega periglacial geomorphology and tour around the village.

4. Geological field visit to: Soil Consultants Ltd, High Wycombe, Hellfire Caves and St Lawrence Church, West Wycombe.

Led by John Wong FGS

15 July 2016

This will be a short visit to the offices of **Soil Consultants Ltd,** a ground investigation company that undertakes a large array of projects in London and the Home Counties. It will encompass a short talk on the London Basin deposits, particularly the London Clay, where we will have some samples of deposits to examine looking at the minor differences that tell us where they come from in the stratigraphic sequence and the importance these differences have from a geotechnical perspective.

After our visit to Soil Consultants, we travel to Hellfire Caves (also known as West Wycombe Cave) at Church Lane, West Wycombe HP14 3AH for lunch break before the group visit to the Caves. Hellfire Caves are a network of man-made chalk and flint caverns excavated in the late 18th century with passage over ¼ mile underground past 3 chambers and a large chamber called the Banqueting Hall and then further down over a pool of water called River Styx to the Inner Temple at some 300 feet beneath St. Lawrence Church at the top of the hill. The geology of the bottom 2/3 of the Hellfire Caves network is Turonian New Pit Chalk Formation (non-nodular chalk, with thin marl seams and sporadic flint) and the top 1/3 of the network is Lewes Nodular Chalk Formation (nodular chalk with layers of flint, thin marls and hardgrounds of condensed chalk). John will discuss the different Chalk Provinces within Britain, the periglacial deposits and glacial origin of the topography in the vicinity.

After Hellfire Caves, we have a steep climb up to the top of West Wycombe Hill to see the 18th century St Lawrence Church (also known as Summer Church) and mausoleum in the Chiltern Area of Outstanding Natural Beauty. From the highest public level on the church tower, one can see West London on a clear day. The tower is 80 feet tall, with the golden ball on top of the tower adding another 20 feet to 646 feet (197m) above sea level. We will examine the building stones and the church interior architecture of Middle East influence. If there is time, we can walk northwards ¾ miles further over the hill to see the Bradenham Puddingstone (Buckinghamshire Puddingstone).

Future Programme of the Home Counties North Regional Group

Your Committee continues to develop the programme of events, which, hopefully, will be of interest to members of the group, and will continue to vary the venues. If anyone knows any other venue that would be available and would suit members of the Group then please let your Committee know the details.

Thanks are due to the speakers for presenting their talks and to those who have provided reports on field meetings. I will be handing over production of the Newsletter as I resigned from the Committee in January but I hope to complete reports on the remainder of the 2016 activities and early activities in 2017 a little quicker than I have done to date.

If you have any comments on the content of this Newsletter or suggestions as to events the group should consider holding, please let your Committee know by e-mailing homecountiesnorthregionalgroup@gmail.net and keep checking the website http://www.geolsoc.org.uk/hcnrg.

Dave Brook

Newsletter Editor