Home Counties North Regional Group

Newsletter - Issue No. 2 - July 2014

WELCOME to this second edition of the Newsletter of the Home Counties North Regional Group. It is pleasing to report the successful first year following our re-birth.

Meetings have been well attended and enjoyed by all those who came along. We have also managed to get around the region, with meetings in Hatfield, Hemel Hempstead, Milton Keynes, Towcester and at the Geological Society. The programme has been varied and we hope to maintain that variety in the future.

Around 40 members attended the Annual General Meeting on 22 April, when the Chair reported on events throughout the year, the Treasurer reported on our financial position and many thanks were given to Officer Catherine Everett who is standing down from the Group temporarily due to work/family commitments and whose tireless contribution to the Group has been invaluable.

The new Committee was elected at the AGM. The Chair was approached afterwards by 2 members expressing an interest in serving on the Committee. As a result, Susan Gann has been co-opted onto the Committee and the other member will be co-opted in due course. Since there have been no other additions since the last Newsletter, we present below only the photographs of those elected and refer you to Issue No. 1 for details on individual members of the Committee. We will give details of co-opted members in the next Newsletter. While this Newsletter was being prepared, the Chair resigned due to the pressure of work and the position is currently vacant.

Meet Your Committee

Officers

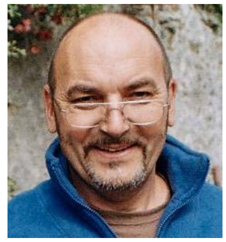
Chair – Vacant **Treasurer – Louise Cox** **Secretary – Jonathan Vetterlein**

Ordinary Members

David Brook

Alistair Dewar

Seamus Lefroy-Brooks



Jessica Macdonald

John Wong

Charlotte Murray

Sarah Smart

Ex-Officio Members

David Jones is a member of Council, Vice-President Regional Groups and former Chair of the Southern Wales Regional Group.

Other members of Council within the region are also ex-officio members of the Committee.

Meetings of the Home Counties North Regional Group

1. The rocky road as geological adviser to the Chiltern Society

27 November 2013

Ivinghoe Beacon, high point of the Chilterns

At the Home Counties North Regional Group meeting at Affinity Water in Hatfield, more than 40 people heard Haydon Bailey (Director, Network Stratigraphic Consulting Ltd. and Geological Adviser to the Chiltern Society) give an extremely interesting talk on the chalk of the Chiltern Hills. The talk covered the formation and characteristics of the chalk before going on to describe a number of locations in the chalk of the Chiltern Hills, where he has provided technical advice and interpretation of the geology.

Chalk is a white semi-lithified carbonate sedimentary rock that formed in the Late Cretaceous (the age of the chalk in the Chiltern Hills is between 100-84 Ma (Cenomanian – Santonian). It is thought that the white chalk cliffs on the south coast of England were the reason for the earliest recorded name of the Great Britain as 'Albion' which derived from 'Alba' meaning white.

Composition: The vast majority of the rock is biogenic, being composed of plant and animal remains that formed as soft mud on the sea floor. Although some large fossils such as ammonites can be found, most of the components of the chalk (nannoplankton) are very small and are best seen in detail under a microscope with a minimum magnification of x1000. Coccoliths are the dominant constituent in the chalk and are the disaggregated platelets from Coccolithophores (unicellular phytoplanktonic algae); other constituents are foraminifera, bryozoans, molluscs, bivalves, echinoderms, sponge spicules (the source of some of the silica in flint), tiny crystals of calcite (crystallites) and radiolarians.

While chalk, is a rock that is commonly found across many parts of north-west Europe and around the Mediterranean, the conditions that led to its formation are pretty unique in the geological record. The late Cretaceous was a time of elevated global temperatures with very high sea levels. From the study of foraminifera, it has been possible to deduce that the sea temperature was in excess of 17^{o}C at 42^{o}N. The high sea levels resulted in major flooding of continental shelves with open marine conditions over much of what is now north-west Europe and into North Africa. The high sea level meant that there was a much reduced source of clastic sediments to the sea and much clearer water in the oceans (the photic-zone was likely to have extended to 80-120m deep. The lack of sediment and warm sunlit water provided ideal conditions for the growth of the coccolithophores. Even today, species of coccolithophores are the most abundant single-celled organisms in the oceans and blooms of these algae in the North Atlantic, off Newfoundland and off the south coast of Devon and Cornwall, can be seen in satellite images.

Chalk nomenclature: The nomenclature used for the chalk of the Chilterns is based on that developed for the chalk in Sussex. The formerly used terms of Lower, Middle and Upper Chalk have been superseded by the Chalk Group, which is split into the Grey and White Chalk Sub-groups. The boundary between the Grey Chalk and the overlying White Chalk is at the base of the Plenus Marls. Although chalk deposition continued until the end of the Cretaceous in the Chilterns and London Basin area, the youngest chalk is the Seaford Chalk (top not seen), which dates from the mid-Santonian. All of the younger chalk deposits in the Chilterns area were eroded before the deposition of the Palaeogene sediments.

Flints: The abundance of flints decreases down through the sequence. The silica in the flints derives from the re-precipitation of silica sourced from dissolved sponge spicules. The weathered remains of sponge spicules were seen in the excavations along the route of the cut-and-fill tunnel on the Baldock bypass. The residual iron oxide coating of the spicules remained as brown staining. Many flints are in the form of trace fossils, spiral burrow infills such as *Zoophycos*, although it is not known exactly what animal created the burrows. Some scientists have been able to examine these flints in detail by taking large blocks of flint-bearing chalk in hydrochloric acid, which leaves a residue of the flint.

Hardgrounds: A section through the cut and fill Baldock tunnel shows a good example of the hard-ground called the Chalk Rock. These hardgrounds represents a period in time where the sea floor went though repeated cycles of shallow diagenesis and re-exposure. This resulted in extensive burrow systems and mineralisation with glauconite and phosphate. At Kensworth Quarry, it is possible to see large pipes in the Chalk Rock, which gives this bed a very high permeability. The Chalk Rock can be found across the full extent of the Chiltern Hills.

Marl Seams: There are many marl seams in the chalk, with the number increasing in abundance down through the succession. Just below the Chalk Rock is the Southerham marl which can be directly correlated to the same marl in the chalk near Lewes in Sussex. Comparing the geochemical signatures of these marls shows that they were formed from volcanic tuffs erupted from the early opening of the Atlantic Ocean. These marls are laterally extensive and can be traced across the southern North Sea area into Germany.

Middle Chalk marl seams from Royston

Fault across Southerham Marl, Baldock by-pass tunnel

Structure of the chalk: The published BGS maps of the Chiltern Hills show very few faults and give the impression of an area with a simple structure. However, there are many locations where faults are present and their under-reporting is due to their presence only being identified when recorded in quarries and road/railway cuttings. In Kensworth quarry (near Dunstable) for example, the section through the chalk is highly faulted. En-echelon faults and related joints at the top of the sequence created the conditions that led to the formation of an extensive number of solution pipes that have been infilled with clay-with-flint deposits.

Chiltern Society: Haydon has been involved as the Geological Adviser for the Chiltern Society over the last five years and he has been called upon to give advice and make assessments on a number of developments and issues relating to the geology and hydrogeology of the chalk.

In the River Misbourne catchment, the river usually runs dry along the middle part of its course. Aside from potential impacts from the abstraction of groundwater affecting the height of the water table, there is a very close relationship between the properties of the bedrock geology and where the river tends to flow. In the upper reaches of the catchment, the course of the Misbourne is on the New Pit Chalk Formation, which contains many marly beds. Consequently the river normally flows at the surface there. Where the river then flows over the Lewes Nodular Chalk, which is more permeable and with pipes in Chalk Rock, the riverbed is usually dry.

The pre-Anglian ice age course of the proto-River Thames flowed perpendicularly across what is now the course of the River Misbourne on its way to the sea via the vale of St. Albans. During the Anglian ice age there was a peri-glacial lake in the Rickmansworth area, which subsequently overflowed down spillways into the Colne Valley. The underlying chalk was therefore also affected by glacial and peri-glacial activity in addition to the impact from the flow of the River Thames and this has also contributed to creating conditions that are ideal for flow in the chalk aquifer.

High Speed 2: The Chiltern Society is not against HS2 in principal, but objects to the proposed route. The engineering and tunnelling may seem simple, but in many places it will be passing below the water table in chalk below the Lewes Chalk. Haydon reviewed the borehole records along the route of the tunnel and in a borehole at Chalfont St. Giles found that in a location where the tunnel crown will be 22m below ground level the depth to the top of competent chalk was 16m giving only 6m of competent rock above the tunnel. With the deep zone of weathering and the jointing and fracturing in the chalk there is potential for collapse. Haydon's report for the Chiltern Society identified a number of potential impacts of HS2 including; damage to the aquifer; pollution of the aquifer; long-term damage to the valley including total loss of the Misbourne river and ground collapse.

In May 2013 the Draft Environmental Statement was published. The route alignment had been changed, with the line now running further to the west of Amersham and avoiding some of the critical water sources in the Misbourne valley, but it will still run within 175m of an Affinity Water public water supply abstraction, and close to the location of the existing borehole record which has only 6m of competent rock above the tunnel. There was also a glaring error in Section 8.4 of the draft statement which showed the Gault and Greensand as overlying the chalk! This was fortunately corrected prior to the formal submission of the Environmental Statement.

Report by Jonathan Vetterlein

2. The engineering geology of chalk: a total rock approach – Part 2

21 January 2014

At the Home Counties North Regional Group meeting at the Geological Society, 90 people heard Professor Rory Mortimore talk on: **The engineering geology of chalk: a total rock approach – Part 2**, a partial reprise and further development of his 2010 Glossop Lecture, the final thought of which was of the need for an appreciation of the possible significant impact of an apparently insignificant geological feature. In view of the amount of construction in chalk in south-east England, this was a very topical subject.

Trying to make sense of the Chalk has entailed involvement in a large number of constrcution projects from Yorkshire to the south coast and more recently into the North Sea with offshore wind farms. Ground investigations at Mundford, Norfolk, had set the standard for description and classification of chalk for engineering (Ward, Burland and Gallois, 1968) and introduced the Mundford weathering grades. These grades were applied and tested at the nearby Grimes Graves Neolithic flint mines in Norfolk, where the speaker was engaged on engineering aspects of tunnelling, which he then compared to the flint mines at Maastricht in the Netherlands. He also worked on the A26 Lewes tunnel and other schemes and found there was no easy way to link the geology between schemes in engineering.

He thus established the need for a framework for chalk investigations. He also undertook parallel research with Bernard Pomerol of Paris University between 1977 and 2002, and on the geology of UK chalk with Chris Wood of BGS 1976-2014. A key part of the work involved following through construction projects with students and industry-supported PhDs 1975-2013. Knowledge of the engineering geology of chalk was further developed through the 1989 Chalk symposium at Brighton, work by CIRIA 1993-2002 and the Glossop paper published in QJEGH in 2012. More recently there has been work on applying chalk geology and engineering geology to coastal cliff collapse and groundwater flooding.

Lessons from engineering projects

Road projects for the A26 Lewes tunnel, the A27 Brighton by-pass and the M3 at Winchester have allowed assessment of the impact of lithology, fracture style and fracture aperture on engineering behaviour of the Chalk.

The A26 Cuilfail tunnel at Lewes is a 700m-long tunnel through a hill with stress relief towards the river, resulting in loosening of the rock mass. A pilot adit 20m long was excavated and gave considerable insight into the rock mass to aid interpretation of material from boreholes. Open (>200mm) widely to very widely spaced (>600mm) fractures were observed in massive hard chalk. At the time only the Mundford scale was available for weathering and it could not be readily applied. There was no apparent relationship between fracture apertures, block size and fracture frequency.

There were slickensided clay-smeared polished faults sub-parallel to the tunnel drive, which were recognised by displaced marl seams and flint bands. At the beginning, a relatively simple support system was specified with the road-header cutting an annulus, into which a steel arch was placed with grout-filled hessian bags behind and then cut the face and bench. Output averaged 1m of tunnel advance per 8-hour shift.

However, steeply inclined conjugate fractures sub-parallel to the drive combined with marl seams in the roof, caused roof and sidewall failures and eventually the rib spacing was determined by the presence of faults with the planned 2m spacing reduced in areas of loose rock to 1m spacing or less. In one case, 4 adjacent arches came down leading to 50mm of ground settlement 30m above and causing severe damage to 3 houses. Stability during construction was severely impacted. The first 100-150m of the drive had fractures open to 30mm (in one case to over 300mm). Over-break reached 1m in height over $^1/_6$ to $^1/_3$of the circumferential length of the arch and in 2 locations over-break extended up to 3m.

At the north portal, there were slope stability problems with rapid collapses as soon as the faces in the New Pit Chalk were exposed. In contrast, the south portal in Lewes Nodular Chalk was stable. In the earthworks peckers and jacks had to be used to reduce the size o blocks of hard chalk >1m^3 before transport to the fill area. The same horizons were found in the Lewes Nodular Chalk at the M3 in Winchester and at Home Farm, Brighton. Achieving 10% air voids in compacted fill required extra compaction and the addition of water in some cases.

Construction projects illustrated that the impact different lithologies and fracture styles had on engineering was consistent over large areas of southern England. Traditional division of the Chalk into Lower, Middle and Upper masked these engineering variations. A new lithostratigraphy for the Chalk was, therefore, developed mainly in Sussex and, with BGS, was applied to the new geological maps across the country.

A key feature of the road construction projects has been the recording of fractures and the identification of the distinctly different fracture styles in the various units of the chalk. In summary, the fracture style is consistent in each formation, the strike direction is consistent and the dihedral angle between conjugate sets varies between units.

Holywell Nodular Chalk Formation – inclined conjugate fractures

Seaford Chalk Formation – sub-vertical joint sets

Newhaven Chalk Formation – inclined conjugate fractures

European research

From 1997 to 2013 there have been a series of European-funded research programmes (ROCC, Protect, Inform and FLOOD1) involving the University of Brighton with the British, French and Danish Geological Surveys and various local authorities. These programmes sought to determine whether potential cliff failures or potential groundwater floods could be monitored and predicted. For example, monitoring was carried out at Birling Gap every 3 months from September 2001 to January 2003 and at Beachy Head up to 50m behind the cliff. At Birling Gap, in the Seaford Chalk with closely spaced vertical fractures, there was a small cliff collapse and the cliff edge moved significantly. At Mesnil-val, microseismic monitoring and extensometers were installed in 30m deep boreholes to try to detect the cracking as it occurred. Cliff collapse occurred within 3 months of installation. Analysis of the microseismics showed 48 hours warning of the collapse occurring and a similar response was obtained in laboratory tests at INERIS, Nancy.

The outcomes of the cliff instability research included the need to tailor the geophysical techniques to the chalk formation, taking account of lithology, fracture style and the engineering geology context. In formations with mainly vertical joints, azimuth resistivity was useful but it did not work well in formations with conjugate fractures. Acoustic emission worked well in formations with inclined conjugate fractures in tighter rock. Traditional land survey techniques provided the best control on sites in France, southern England and Denmark. The fragmentation of the collapse was related to formation and mapping formations properly enabled better prediction of the likely scale of failures. Stratigraphical integrity was retained in collapses, suggesting a circular mechanism driving the base of the cliff outwards. It was also found that breaking wave energy on the wave-cut platform was transmitting to the cliff face.

Research has also looked at water-weakening of the chalk and particularly the effects of salt water. It is noticeable that inland quarry faces unaffected by salt-water differ in frequency and type of failure from coastal cliff faces. The effect of salt water on weakening the chalk is also a critical issue in North Sea oil reservoirs.

Apparently insignificant karst features and iron staining

On the A27 Brighton by-pass through Great Wood, karstic bedding planes were identified. These had sheet flint at the base with tubular karst above and could be traced back to cross-bedded sands in a former underground river system. The only field exposure where a similar situation was found was in the coastal cliffs at Dieppe where huge sediment-filled surface dissolution features fed water and sediment downwards into fractures terminating 65-70 m below along an almost continuous flint band, the Seven Sisters Flint Band, at the base of the cliffs.

An underground river system of caves and tubular karst had developed along the flint band with some sedimentary infill. The Dieppe example provided an analogue for the A27 Great Wood cuttings. Tubular karst, often in soft weak chalk and millimetre or centimetre thin sheet flints are often broken up in borehole cores so may not be recognised as such. On the A27 Great Wood to Ditchling road cuttings up to 30% of the available volume of chalk for construction in the fill areas had been dissolved. The only clue was the tubular karst.

Tubular karst structures developed above a sheet flint band in the Chalk.

It is essential that iron-staining is highlighted on core logs.

During ground investigation for a tunnel in east London, only one horizon in one borehole in the suite showed iron staining. This provided the only clue to an area that was very different in terms of groundwater flow and ground stability when the tunnel went through. Borehole caliper logs indicated a fracture zone at this horizon and fluid logs (temperature) suggested that water flow at this level.

The main lessons learned relate to the significance of stratigraphy for engineering, the impact of fault zones, block sizes, conflict with the Mundford scale, the significance of karst features and iron stains and the potential value of geophysical borehole logs.

Impact of lateral changes in lithology

On the Brighton by-pass, the Newhaven Chalk varied dramatically between the eastern and western ends of the scheme in limestone/marl content and fracture style. Such variation was shown to relate to where chalk formed on the sea-bed in relation to tectonic structure. Section loss, including loss of marl, was related to 'growing' anticlinal highs on the sea-bed. Seismic records indicated that such anticlinal highs were formed over reverse faults deep beneath the Chalk that were moving during the period of Chalk deposition. This example from the Newhaven Chalk along the A27 Brighton Bypass was used to explain similar lateral variation leading to loss of marl and increase in brittle, fractured limestone on an offshore anticline met during construction of the Channel Tunnel.

The attenuated section of Chalk Marl with increased limestone was where the wet zone at km 21was encountered in the Channel tunnel. At the Southwick twin-bore tunnel on the A27 Brighton by-pass cross-hole seismic sections were shot. It was found that hard, high-velocity layers in the chalk caused dust which filled the tunnel, while soft, lower-velocity beds were balling up on the roadheader tines and conveyor. During excavation of the Benfield cutting, the same hard, high velocity layer of chalk was so tight and hard that a ripper and large face-shovels could not break-out the 'massive' beds by attempting to break into the cutting from the top downwards. Changing the method of working to break-in from the valley-sides did work. This emphasised the need to match the excavation technique to the geology.

Key issues in the chalk

We need to be confident about:

- Descriptions and classifications, with fracture aperture a key;
- Lithological features such as marl seams and flint bands; and
- Groundwater flow horizons.

We can improve confidence by:

- Better graphical logs;
- Other techniques such as camera logs;
- Interpretation of core in terms of grade;
- Geophysical logs – e.g. it is possible to identify all the larger flints and marl seams in resistivity logs; and
- Knowing what features to look for including marls, flints, karst and weathering.

Intact dry density is used as a key index property of chalk. However not all engineering behaviour can be related to intact dry density. Hydraulic conductivity, for example, does not correlate with intact dry density or porosity and the question must arise as to whether density is a good measure of how chalk might behave. Hydraulic conductivity is more related to the matrix character (petrology) and the presence of clastic marl and/or plastic marl.

Integrating engineering geology, geophysics and hydrogeology

This is essential to get a picture of:

- groundwater behaviour;
- flow on bedding features;
- mechanism for movement of water in the unsaturated zone; and
- understanding material – fracture interchange.

Conclusion

The development of knowledge of the chalk and its engineering and hydrogeological behaviour has had 2 strands starting in 1974:

1. research developing the geology of chalk; and
2. learning from industrial practice (engineering).

We need to recognise and log all 'insignificant' features before their engineering significance can be recognised. Perhaps we need a logging manual of features!

The research that this work has been based on has benefited from involvement with industry. For example the Flood1 project was supported by data from the CTRL, the Lewes CSO tunnel and the A303 Stonehenge tunnel investigations, which covered a similar stratigraphy and geological structure to the FLOOD 1 experimental sites in the South Downs, Berkshire /Downs and the Somme Basin in France.

Report by Dave Brook

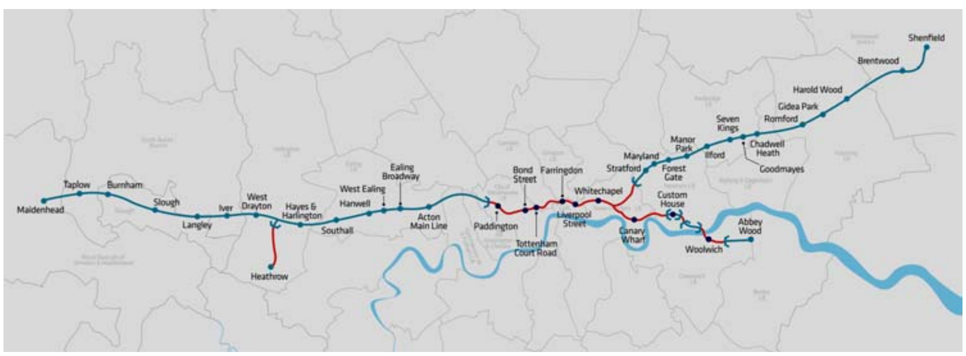
3. Crossrail: geology and engineering

6 March 2014

Crossrail: geology and engineering

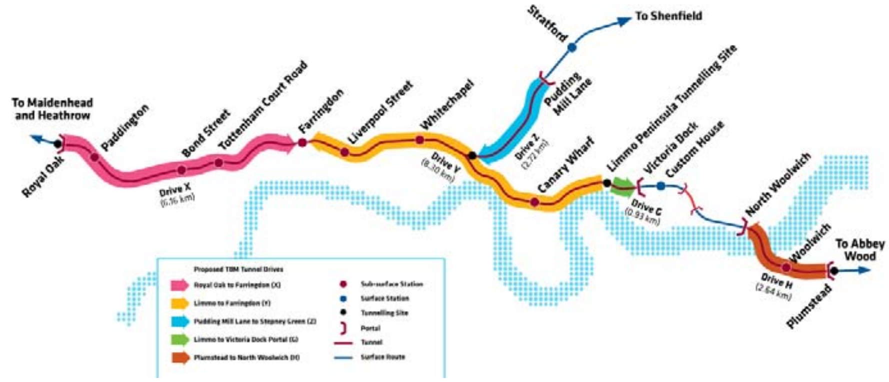
At the Home Counties North Regional Group meeting at Shutlanger Village Hall, 32 people heard **John Davis** of GCG give his talk on **Crossrail: geology and engineering**. John is currently on secondment to the Chief Engineer's Group at Crossrail, where he is responsible for geotechnical matters that arise in the eastern half of the Crossrail project.

Introduction to Crossrail



Europe's largest infrastructure project, stretching from Maidenhead in the west to Shenfield and Abbey Wood in the east, Crossrail will cover over 100km of track including 21km of new sub-surface twin-bore tunnels and 9 new stations in central London.

Construction started at Canary Wharf in May 2009, with the first tunnel boring machine (TBM) for the Royal Oak to Farringdon drive being launched in May 2012. The main civil engineering construction works are planned to complete in 2017. Fit-out of stations and testing will continue afterwards and Crossrail services on the central section are expected to start by late 2018.



Ground conditions

Crossrail have had over 1,000 boreholes drilled and acquired 34,000m of data together with using 650 third-party boreholes and 25,000m of data and a 1,200,000+ line AGS database. The geology comprises Quaternary on London Clay, the Lambeth Group, Thanet Sand and Chalk. The development of this succession has a fundamental bearing on the properties Crossrail are interested in.

The London Basin is traditionally viewed as a simple syncline with an occasional fault. In fact it is a quite complicated shape, with a wavy axis and closes to the west. The rocks were generally deposited at times of high sea levels but periods of low sea-levels mark sedimentary breaks at the top of the Chalk, in the mid-Lambeth hiatus, in the London Clay and the Harwich Formation. For example, the London Clay was eroded and consequently unloaded before deposition of the Quaternary, with a thickness of 200m reduced to 50m in central London and the west and 0-10m south of the Thames. All these rocks were folded in the Alpine orogeny and there are probably multiple faults, eg the Farringdon and Greenwich Faults.

At Farringdon Station, there are 2 ENE-WSW strike-slip faults with a lot of normal faults running roughly N-S between them. At Limmo (the junction of the Rivers Lee and Thames at Bow Creek), there are a series of faulted blocks. The result is that the Harwich Formation can be above the line of the tunnel, in the face or below the invert. The Harwich Formation has small-scale faulting shown in the Oldhaven Member at the Canary Wharf Station Box.

The London Clay is a predominantly argillaceous (60%) bioturbated slightly calcareous silty to very silty clay, which is probably the world's most studied material in an engineering sense. It is good for tunnelling through with TBMs. Generally a stiff grey silty clay, it was subject to cyclic marine deposition with 5 main coarsening-upward cycles (A to E) followed by the Claygate Member. Crossrail goes through Zones A and B. The engineering properties are directly related to the sequence and Crossrail boreholes have been subject to detailed high-quality logging. There can be up to 50% sand in the London Clay and macro features include joints, fissures, thin silt and sand laminations and pyrite. Stiffness can be affected by the microstructure, whether it is a relatively open structure, more compacted or very compacted.

The Lambeth Group is difficult because of its variability. 20m or so thick, its lithology, strength and permeability vary both laterally and vertically. Problems also arise from the presence of hard bands and confined groundwater pressures. These are not too much of an issue for TBMs but the Lambeth Group occurs close to the base of several Crossrail stations and shafts. The Group comprises stiff to very stiff clays, clayey sands, sandy clays and gravels ± matrix sand with high permeability and water pressures. There are isolated sand channels 2-100m wide with high permeability and water pressures, a localised presence of gas under pressure and laterally discontinuous sub-units. The mid-Lambeth hiatus at 55.5Ma led to the formation of hard-pans, which are generally discontinuous.

The Chalk is mostly the Seaford Chalk, with flints up to 7.5cm across and clean vertical joint sets. It is generally excellent for tunnelling but there are challenges:

- the presence of flints, which cause excessive wear in the TBM;
- variable clay content causing problems treating TBM slurries;
- localised high-permeability joint systems causing slurry loss;
- variable weathering profile affecting strength and permeability; and
- it is difficult to investigate and characterise.

There is also an abundance of man-made obstructions such as other tunnels.

Drift-filled hollows

Also known as scour features or pingo scars, they can lead to big holes in the top of the Chalk, as at the Thames river crossing at Limmo and the Liverpool Street/Moorgate box. At the Thames/Lee confluence, there is a very deep hollow just off-line from Crossrail, which has about 1m of London Clay separating the gravel and the Chalk. At Liverpool Street/Moorgate the hollow goes down to -40m from +7m and there are signs of slope instability in the side.

These are relict periglacial features formed as a result of faults leading to springs at the surface which froze during ice ages to form an ice-cored permafrost mound (pingo) with mixing of soft sediments when the permafrost melted. In warm periods the pingo collapsed followed by erosion, infill and burial.

Tunnelling strategy

All the tunnelling is by closed-face TBMs, all of which are earth-pressure balance machines except for the Thames crossing, where a slurry machine is used.

Station construction includes top-down box construction and mined stations using sprayed concrete lining, which are accessed from boxes/shafts for ticket halls at either end.

Settlement mitigation

With the abundance of structures above the tunnels which may be sensitive to settlement, particularly differential settlement, the aim is to minimise settlement by use of compensation grouting. In this system a series of drillholes are emplaced before the tunnel passes and settlement is continually monitored. If Settelement approaches a pre-deteremined trigger level then the tube-à-manchettes inject controlled amounts of grout to mitigate against that settlement. This happens in almost real-time, as the settlement is happening.

Report by Dave Brook

4. Chalk mines and solution features in Hertfordshire and the problems they cause

22 April 2014

At the Home Counties North Regional Group meeting at Sir Robert McAlpine Ltd in Hemel Hempstead, 64 people heard Clive Edmonds of Peter Brett Associates LLP (PBA) give his talk on **Chalk mines and solution features in Hertfordshire and the problems they cause** after the

Group's Annual General Meeting. The speaker has spent 25-30 years working on land instability, and PBA now hold databases of natural cavities with >35,000 records, mining cavities with >15,000 records and landslides with >15,000 records.

Natural cavities

Quite a few holes have appeared over the years due to natural cavities. The process is essentially that rain falling through the atmosphere dissolves CO_2 and then picks up biogenic CO_2 from soils and rocks overlying the chalk (the Lambeth Group and superficial deposits) to form a weak carbonic acid that dissolves the chalk. Typical shallow types are:

- sink holes, when the ground collapses, usually due to the collapse of temporary bridging over the dissolution cavity;
- swallow holes where water courses go underground; and
- solution pipes, where solution-widened joints are filled with material washed down from the surface.

Other deeper types include solution-widened joints and tubular karst, where the descending water meets a barrier to flow and moves horizontally rather than vertically. Dissolution is not a quick process and it can taken tens to hundreds of thousands of years.

Principal karst horizons are associated with the Lambeth Group overlying Seaford or Newhaven Chalk. Others are associated with clay-with-flints and where glacio-fluvial terraces overlie chalk. For example, there are a significant number of natural cavities in the chalk where there is under-drainage through glacio-fluvial deposits along the former proto-Thames corridor. Sinkholes are rare where London Clay overlies the Lambeth Group. An interesting example of how deeply solution features can penetrate into the chalk was illustrated at Kensworth quarry in Bedfordshire, where infilled solution pipes had formed at depths of 40-50m below the surface.

Subsidence at Queens Drive, Rickmansworth

Subsidence at Windsor Drive, Hertford

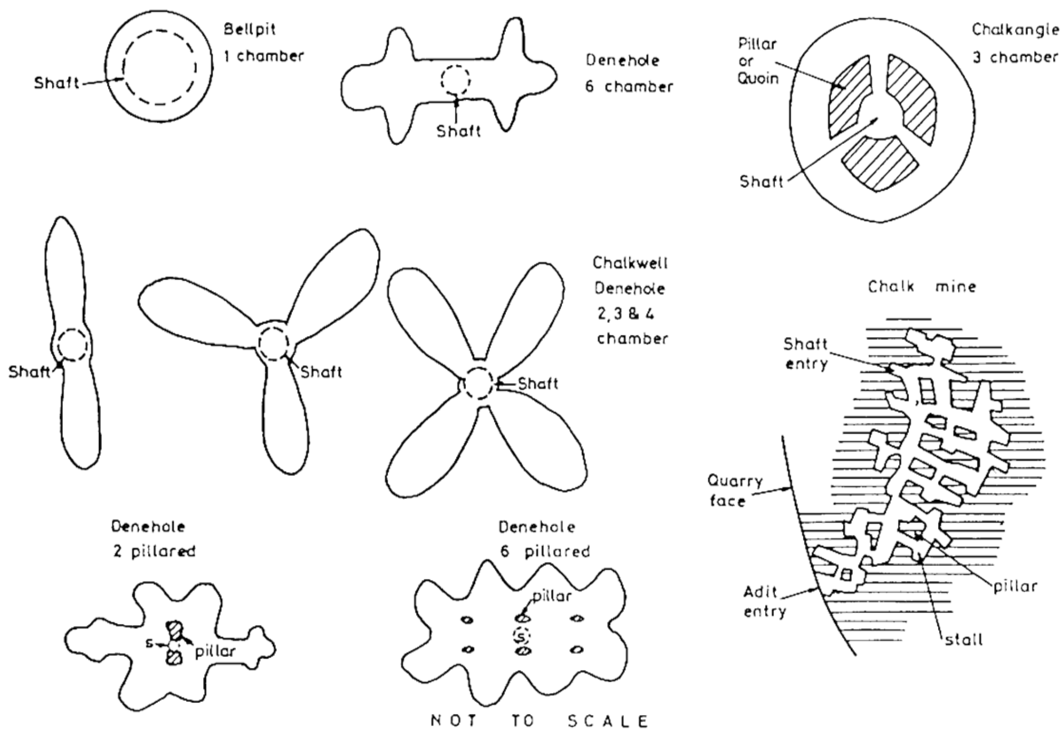
Subsidence at Queens Drive, Rickmansworth, triggered by heavy rain caused a 300mm drop into a sinkhole on the pavement outside a house. At Windsor Drive, Hertford, severe damage was caused to a property which suffered a 250mm drop into a sinkhole 6m across, which was triggered by a leaking sewer.

Modern sinkholes tend to be 1 – 5m across but there are examples of sinkholes 25 – 30m across in grass fields and woods, which are of historical origin. With time, the solution has extended in depth to reach the water table, where flowing groundwater can cause erosion of fines at the base of a solution pipe, producing upward migration of new voids. However, not all surface hollows are sinkholes, as was illustrated by an example near Stevenage.

The PBA database shows significant numbers of natural cavities in Hertfordshire, with concentrations in urban areas (almost certainly because these are the ones that are noticed and therefore recorded). In all chalk nationwide, 12,000 natural cavities are recorded with concentrations on the dip slopes of the Chilterns and the downs of Dorset and Hampshire and the North and South Downs.

Mining cavities

The chalk has various styles of mining, including adits from quarries, bell pits and pillar and stall workings. Bell pits are single-chambered, while deneholes may be 6-chambered and include pillared varieties. Then there are 2- 3- or 4-chamber chalkwells and local variants like chalk angles. Later chalk mines associated with brickworks are generally pillar and stall workings.



Chalk mine styles taken from Edmonds, Higginbottom & Green (1990) Chalk: International Chalk Symposium, Brighton Polytechnic, Thomas Telford

In Hertfordshire, past chalk mining has been for:

- lime burning for agricultural purposes, for application to clay soils to neutralise acidity, enhance drainage and lighten soil texture (late 18th to early 20th centuries);
- production of lime mortar for building purposes;
- production of bricks, tiles and land drainage pipes (bricks made from Lambeth Group clays typically contain up to 25% chalk); and
- the use of chalk to dye, coat and glaze paper.

At Briars Lane, Hatfield, damage was caused when a mine collapse affected the garden and foundations of a house. The hole was backfilled and dynamic probing showed the mine was more extensive. Looking at Hatfield in general, an assessment was made of chalk extraction from quarries and numerous potential areas of mining.

At Highbarns, Hemel Hempstead, PBA involvement started as a subsidence insurance claim when a large void appeared beneath a property, which was backfilled with almost 100m3 foamed concrete. It is important to note that such crownholes can occur in minutes and may present a serious risk to life.

Briars Lane, Hatfield

Highbarns, Hemel Hempstead

Oatridge Gardens, Hemel Hempstead

The most recent event was at Oatridge Gardens, Hemel Hempstead, where a hole 10m across and 6m deep occurred in the garden and the corner of a property on 15 February 2014 and subsequently extended into the middle of the road within 4 days. The hole was backfilled with about 200m^3 of foamed concrete on 21 February. Over 150 dynamic probes around it were carried out around it and PBA also investigated the Wood Land End highway as well. The area is aformer brickworks.

Recorded mine cavities in Hertfordshire tend to be concentrated in urban areas, reflecting the importance of chalk as an additive for brick manufacture.

Conclusions

In order to de-risk land, developers need to know where geohazards occur and how they may impact on a site location.

The options are to carry out an independent search or to search the PBA database, which is based on wide-ranging collection from many sources.

PBA can also do a site-specific hazard probability assessment.

Developers need to demonstrate to local authority planning and building control (and the NHBC) that the ground conditions have been correctly identified and modelled by competent, experienced practitioners (*National panning policy framework guidance*, 2014) and ensure that well considered and robust engineering solutions have been identified and will be implemented as part of the development.

Report by Dave Brook

Field meetings

Discover geology, geoarchaeology and history on a walk in Hertford

21 June 2014

On Saturday 21 June, 13 people met John Wong, the field trip leader, in the St Andrew Mews car park in Hertford, where John handed out colour geology maps among other handouts and explained the local geology using 5 separate layer maps to demonstrate the stratigraphical and spatial relationships of the solid and drift geology. Particular attention was given to the effects of the Anglian glaciation and its impact on the diversion course of the Proto-Thames.

John Wong explains the local geology ***Puddingstone inset in brick wall***

We then examined insets of Hertfordshire Puddingstone in the brick wall alongside the car park before briefly seeing the oldest surviving restored timber-framed domestic building in Hertford, formerly known as the Verger's House, built in the mid-15th century. It is now, somewhat appropriately in use as an antiques shop.

Puddingstone insets in brick wall alongside car park

Former Verger's House, oldest residential building in Hertford ***The Norman motte, Hertford Castle***

Just along St Andrew Street, we stopped to look at the Wallace House, where Alfred Russell Wallace lived as a child (from 1828 to 1837), being educated at Hertford Grammar School. Wallace was the naturalist, author and scientist who developed a theory of evolution by natural selection contemporaneously with Charles Darwin and was also responsible for the definition of the "Wallace Line" in Indonesia, which separates the Asian from the Australasian fauna.

We then moved on to Hertford Castle, where we viewed the Norman motte, built soon after 1066, and examined the 5-foot thick flint curtain walls of the castle, which contain Roman tiles as well as insets of puddingstone. In the southeast corner of the curtain wall a patch of brickwork can be seen, all that remains of the great angle tower that once rose over the moat and overlooked Hertford. Other points of interest included the postern gate and the inner and outer moats, which are now dry and almost entirely built upon except for the moat garden opened in 1851.

The Postern Gate, Hertford Castle

Roman tiles in curtain wall, Hertford Castle

Puddingstone at the Postern Gate, Hertford Castle

Granite erratic

Former boundary stone

Between the two moats is an 18th century ice house built of bricks beneath a mound, which was once part of the causeway between the two moats. On the inner bailey behind the 15th century Gatehouse stands a stone commemorating the first general synod of the English church, held here in 673AD, a boulder of granite (presumably an erratic) found at Ware in about 1901, which was presented to Hertford Corporation in 1923, and a pebble stone (sarsen), which marked the ancient borough boundary of Hertford in 1621.

Also in the castle grounds is a large lump of puddingstone, described as Hertfordshire's best known claim to geological fame, presented to Hertford by the East Herts Geology Club on behalf of the farmer who found it at the cost of a broken plough. There we met up with Bryan Lovell, a former President of the Geological Society, who was taking a break from the preparations for celebrating his golden wedding by telling us more about puddingstone.

Bryan Lovell talks about Puddingstone

Puddingstone presented to Hertford by EHGC

Bryan explained the work he had done with Jane Tubb of the East Herts Geology Club. Puddingstone is beach gravel that has silica cement which is harder than the flint so it often fractures across pebbles rather than around them. It occurs in lumps and is often turned up by farmers when ploughing. He told us of the local farmer who had insisted when a new road was built that the puddingstone that was excavated was not used in the sub-base of the road but was delivered to her farm and she now has a wonderful collection of puddingstone. He also told of the finding of the probable ancient quarry site where the Romans had extracted puddingstone for the quern stones used to grind corn. A search in the Paris Basin, where puddingstone of a slightly younger age occurs, has found a similar Roman quarry site.

Home Counties North Regional Group party with Bryan Lovell at Hertford Castle

Puddingstone finds in Hertfordshire are consistently at an elevation of 90m AOD and a BGS borehole had also intersected puddingstone at 90m, so there has been a relative change of sea level of 90m since the deposition of the gravel. The rocks beneath were of the Upnor Formation and Bryan was convinced that the occurrences were from the Lambeth Group at 55M years, coincident with the Palaeocene – Eocene Thermal Maximum, when temperatures were much higher than today. Silicification on the scale that occurs in the puddingstone requires high temperatures and alkaline water since silica is only soluble in these conditions. Indeed, isotope work suggests that it may need temperatures as high as 80^{o}C. While this may seem high, it is of note that silicification occurs today in parts of Australia, where air temperatures may reach as high as 40-50^{o}C, so higher temperatures in groundwater are feasible. Bryan also considered that the sarsen stones (cemented sandstones, which often remain after the erosion of surrounding softer non-cemented sandstones) found elsewhere in southern England were of the same mid-Lambeth age and that there was a complete range of silica-cemented material ranging from coarse beach gravels to much finer sands.

After thanking Bryan for his contribution the party moved on to the Hertford Museum, which has an interesting display on puddingstone, including examples of Roman quern stones and Pleistocene mammalian fossils and Palaeolithic and Mesolithic tools. It also has a selection of mineral specimens and puddingstone for sale at reasonable prices.

Puddingstone display in Hertford Museum

After a very pleasant lunch at the Old Barge public house on the bank of the River Lea on Folly Island at the head of the canal, we continued the walk around Hertford, being joined at this stage by 2 late arrivals. The first stop was to see more Alfred Russell Wallace commemorative material, which was installed in 2013 to celebrate the centenary of his death – the mural painted by members of the Courtyard Arts Centre and the memorial on the pavement in Bircherley Green Centre which John told us most people walked over without really noticing it.

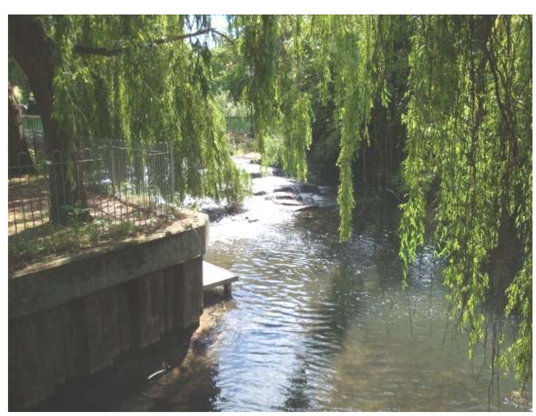
Alfred Russell Wallace mural and memorial, Bircherley Green Centre

At Salisbury Square, there is a modern style sculpture fountain erected in 1994 called 'Confluence', which represents the four rivers that flow into Hertford.

Other places of interest included

- the Adams' Malting near Folly Island;
- the oldest purpose-built Quaker meeting house in the world, a Grade 2 listed building, which was once visited by William Penn, who established Pennsylvania;
- the Jacobean-fronted Corn Exchange, built of Portland Stone;
- the Georgian Shire Hall, which was used for the filming of *Pride and prejudice*
- Parliament Square, named to commemorate the time of the Black Death, when Parliament moved out of London and met in Hertford Castle. The War Memorial at Parliament Square, unveiled in 1921, is of Portland Stone from the same quarry as the Cenotaph in Whitehall;
- the Seed Warehouse, which stores some of Hertford Museum's collections and a Roman corn dryer found locally;
- the remaining building of what was once Christ Hospital Girls' School, which has two coloured figures above the gates, dressed in the traditional uniforms for boys. The school's buildings at Greyfriars in London were damaged by the Great Fire of 1666 and 50 children were sent to Hertford and other children to Ware. In 1902, boys moved to new school buildings at Horsham in Sussex and girls only were educated in Hertford until the Girls' School joined Boys' School in Horsham in 1985. In 1906, Hertford School became Christ Hospital Girls' School; and
- the interesting pargetting on buildings on Fore Street, including the Salisbury Arms public house, where the pargetting is in the form of a vine trained along the bressumer on the beam supporting the overhanging of the first storey.

Grade 2 listed Quaker meeting house, Railway Street



The River Lea weir

A brief stroll past the weirs on the River Lea, which mark the limit of navigation took us back to the car park, where thanks were expressed to John for organising and leading the walk.

Report by Dave Brook

Behind the scenes palaeontology workshops at Burymead Museum Resource Centre, Hitchin

5 July & 15 July 2014

Two "hands-on" palaeontology workshops organized and led by John Wong took place at the Burymead Museum Resource Centre in Hitchin in July. Participants included HCNRG members and others, with about 8 people attending each session. The Resource Centre is part of Hitchin Museum but it is located in an industrial estate away from the Museum site. It holds about 10,000 natural history specimens, including many rocks, fossils and minerals (the entire collection of Hitchin Museum and Letchworth Museum).

Each session began with a short introductory talk by Ros Allwood, the Cultural Services Manager of the Museum Resource Centre. This included information about the current museum closure in preparation for its relocation to Hitchin Town Hall, which is scheduled for completion in 2015. Progress reports are available on the Museum's blog: http://www.northhertsmuseum.org. Following the introductory talk, attendees had the opportunity to handle, study and photograph invertebrate and vertebrate fossil specimens, many of which have not yet been on display to the public.

The first workshop (Saturday 5 July) focused on fossils from the Bajocian, Bathonian and Callovian of the Middle Jurassic and the Oxfordian of the Upper Jurassic. Some fossils from other Jurassic stages were also examined. Specimens included marine reptile material and participants learned how to differentiate ichthyosaur from plesiosaur vertebrae, how to estimate the length of an ichthyosaur from a single centrum and how to work out which part of the axial skeleton the centrum came from (neck, trunk, tail). Although the emphasis was upon Jurassic fossils, the session ended with an examination of *Mammuthus* and *Palaeoloxodon* remains (mostly tusks and teeth) from the Pleistocene.

John Wong talking about ichthyosaur vertebrae

Pleistocene elephant tooth

The second workshop (Tuesday 15 July) focused on post-Jurassic fossils, predominantly from the Cretaceous Chalk. There were many beautiful specimens of echinoids, sponges, bivalves and brachiopods as well as fish remains (including the distinctive teeth of *Ptychodus*, a genus of shellcrushing shark). Some disappointment was expressed that basic information about specimens (such as provenance data) was often lacking from the museum catalogue. Without such data the scientific value of the specimens is greatly diminished, although they are obviously useful for instructional and educational purposes.

Tooth of the hybodontiform shark, Ptychodus from the Cretaceous Chalk

Sternotaxis planus, a zonal echinoid of the Cretaceous Chalk

Workshop participants varied in the level of their familiarity with palaeontology, from interested amateurs to those with professional expertise. However, all enjoyed the opportunity to view these collections and will have come away having learned something new – if only the need to ensure that specimens are correctly identified labelled and catalogued! We are grateful to John Wong, Ros Allwood and the Hitchin Museum for facilitating these workshops and allowing us access to these interesting collections.

Report by Paul Garner

Future Programme of the Home Counties North Regional Group

Your Committee are currently working to further develop the programme of events for 2014, which will be of interest to members of the group. We will continue to vary the venues between Hemel Hempstead, Hatfield, Milton Keynes and the Geological Society.

Field meetings

During the summer we expect to run a number of field trips in each of the counties in the region and John Wong is putting together a varied programme.

On Saturday 2 August we have another full day field trip on **Geology, sedimentology and archaeology of Harrold-Odell Country Park and guided walk in Harrold Village**, when John will explain the local geology and the Park Ranger will give a guided tour of the Country Park to see the glacial landforms, river terraces and post-glacial river features with, after lunch, a guided walk of Harrold village led by John.

On Sunday 9 September, John will lead a full-day field trip on **Pre-Anglian Stanmore Gravel on the roof of Barnet Plateau in the London Borough of Barnet.** This field trip will examine the stratigraphy of the Stanmore Gravel within the Borough, and discuss how the geology of the Stanmore Gravel dictates the Quaternary palaeogeography as well as the present day geomorphology, the 20th Century human geography, the evidence of pre-history human dwellings, and the site where the 1471 Battle of Barnet changed the course of British history.

Evening meetings

On Tuesday 16 September, we have our now annual double event curry night at Sir Robert McAlpine in Hemel Hempstead featuring an Antarctic evening with talks by Helen Nattrass of Sir Robert McAlpine on **3 weeks in the Scotia Arc: a snapshot field trip in Antarctica,** covering her recent visit to Antarctica with the Geological Society of America and Dave Brook on **A geologist in Antarctica: reflections after 50 years,** in which he will reminisce on what it was like there as a BAS geologist 50 years ago (actually 49 but who's counting).

On Thursday 23 October, Jackie Skipper of GCG will be entertaining us at Sir Roberet McAlpine in Hemel Hempstead on **Sediments, sequence stratigraphy and material behaviour: why the Lambeth Group presents a challenge**.

On Wednesday 27 November, Tom Hose of GeoConservationUK will be talking on ***Bathers, Walkers and Travellers: the Origins of British Geological Fieldwork*** in the Gass Lecture Theatre at the Open University, Milton Keynes.

Other events

We are also hoping to run both the:

- **Schools Geology Challenge** for those schools in the region that teach courses in geology; and
- **Early Career Geologists Award.**

The winners of these events in the region will go through to the national finals at the Geological Society next year.

Your Committee, most of whom have full-time jobs and put in a great deal of effort on a voluntary basis, will continue to develop events to meet the needs of the Group and will up-date the programme on the website and keep you informed on what is happening.

Thanks are due to the speakers (who again provide their services on a voluntary basis) for presenting their talks, particularly to those who have confirmed that the reports in this Newsletter represent a reasonable summary of what they said and provided appropriate illustrations, and to those members of the Committee who have organised individual evening and field meetings and reported on them.

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