Quaternary Newsletter
Report
QRA Quaternary Research Association

# JOINT QRA ENGINEERING GROUP AND GLACIAL LANDSYSTEMS WORKING GROUP (GLWG) FIELD TRAINING COURSE TO NORTH WALES: 27TH-30TH OCTOBER 2022.

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North Wales signified a point of confluence between ice originating from the Irish Sea and Snowdonia. Sediment exposures found along Welsh coastlines are, therefore, commonly glacial in origin, and sometimes superimposed by periglacial processes. Consequently, North Wales provided the ideal location for a first joint QRA Engineering Group and Glacial Landsystems Working Group (GLWG) field training course. This meeting focused on training participants in the sedimentology, engineering geology, and geohazard significance of glacial and periglacial sediments. The trip was based at the Conway Centre on Anglesey, and convened by **Dave Evans (Durham)**, **Paul Fish (Jacobs)**, **Julian Murton (Sussex)**, **Emrys Phillips (BGS)**, and **Simon Price (Arup)**, with support for evening talks from **Helen Reeves (Jacobs)** and **Dave Roberts (Durham)**. The event was attended by 44 people, with 70% of these from an industry background.

**Thursday 27th October**

We convened on the Thursday evening and began with introductions to the weekend, showcasing the wide range of attendee backgrounds present. It was great to see the event was supported by past and present chairs of the Engineering Group of the Geological Society (EGGS), and a former president of the Geological Society. We were all very much looking forward to learning from one another over the following days. In preparation for field excursions the next day, **Dave Evans** and **Julian Murton** provided the first round of evening presentations. Themes included how the term till means different things to different people and has *been* a source of much confusion to all. **Julian Murton** elaborated on the concept of the *Last Periglacial Maximum* and explained how features resulting from this period have the potential to cause problems for engineering geologists. These themes were regular points of field discussion over the following days.

**Friday 28th October**

The first stop was the classic Dinas Dinlle cliffs near Caernarfon. **Dave Evans** introduced the site (Fig. 1), which sits at a confluence between ice originating from the Irish Sea and nearby Welsh Ice Cap. The exposure comprises a composite moraine, produced ice-marginally. In section, primary sedimentation varies between bedded gravels and sands, which have been glaciotectonised to produce a stacked sequence. **Emrys Phillips** showed the importance of logging exposures at both the macro- and micro-scale (Fig. 1) and explained that reverse and normal faults and folds could all be seen on site and, in thin sections. The site was a perfect illustration of the potential complexity of glacial sediments associated with moraines. This complexity needs to be considered when developing conceptual models or interpreting ground investigation data to produce engineering geological models. Crucially, Dinas Dinlle provided a brief coffee (and chips) stop, we then moved on to the next site of the Friday, Aberdaron.

The second site of the day was Aberdaron near the western tip of the Llŷn Peninsula. The group were treated to scenic stroll to the far side of the beach (Fig. 2), where **Julian Murton** drew attention to a sequence of sediments that have has been interpreted as a periglacial slope deposit (Fig. 3A-B) preserved in a topographic basin below a variety of glacial sediments. **Cristina Balaban** questioned the possibility of brecciated bedrock being sourced


**Figure 1.** Dinas Dinlle near Caernarfon, North Wales. [A-B] Overviews of Dinas Dinlle, a glaciotectonite within a composite moraine. [C] Emrys Phillips discussing micro-structures present within thin sections from Dinas Dinlle *(Photo Credits: Ethan Lee, Craig Parry, Cristina Balaban)*.

locally from subglacial plucking, but **Julian** argued the thickness of the deposit (~10 m high), angularity of the clasts, and downward dip of the clinoforms all point to a 'head' deposit. In a borehole, these periglacial sediments could be mistakenly interpreted as weathered bedrock, a glaciotectonite, or a result of careless drilling, meaning engineering rockhead could be hard to define.

A short way down the beach, and **Dave Evans** introduced the layer-cake stratigraphy of glacial sediment (Fig. 3C-D), which comprises stratified and massive diamictons with intervening fine-grained laminated and gravel lithofacies deposited by the Irish Sea Ice Stream. Previously, the stratified diamictons were interpreted as melt-out tills, but are now thought to represent debris flow fans, which were subsequently deformed during ice-margin oscillations. The differences between pseudolaminations resulting from glaciotectonism, and laminated fluvial deposits were discussed. It was stressed that multiple hypotheses based on conceptual ground models should be considered when developing engineering geological models.

After a scenic coastal drive under the October twilight, the party arrived at Porth Neigwl, near Abersoch. **Dave Evans** discussed stratified diamictons with subtle evidence for low strain signatures of glaciotectonism that invalidated earlier interpretations of the sequence as a debris-rich ice melt-out or glaciolacustrine origin. For the geomorphology enthusiasts, **Dave Evans** showed a LiDAR image of the site that showed enigmatic sinuous ridges extending across low coastal marshes and asked if the features had a glacial origin or resulted from periglacial frost heave.

After dinner, the Friday evening talks began with **Dave Roberts** introducing sedimentological and geomorphological data collected from the North Sea floor, as part of the BRITICE CHRONO project. **Dave** explained the sedimentary signatures used to infer the transition from grounded ice to glaciomarine conditions indicative of ice sheet

**Figure 2.** Joint QRA Engineering and GLWG members making their way to the first exposure at Aberdaron, Llŷn Peninsula (Photo Credit: Craig Parry).


**Figure 3.** The second site of the Friday, Aberdaron. [A-B] Head deposits at Aberdaron. [C-D] Making our way towards the layer-cake stratigraphy at Aberdaron. *(Photo Credits: Craig Parry, Simon Price)*.

retreat, which could then be dated. The application of this new understanding of ice sheet behaviour to the development of ground models for offshore renewable energy projects was discussed.

The second evening talk was delivered by **Helen Reeves**, who discussed the use of different types of ground model in a typical engineering geology project. The presentation highlighted the important role of engineering geologists in the early identification of ground hazards to reduce a project's risk. Inherent in this is understanding glacial and periglacial sediments and geohazards. The use of conceptual models and glacial landsystem models was highlighted as an important first step in predicting ground conditions based on limited site data.

**Saturday 29th October**

After a fantastic first day in the field, we were all very enthusiastic for day two. The first site of the day was the site of Moranedd, near Cricceith (Fig. 4), which is the type-site for North Wales Quaternary stratigraphy. Cricceith shows activity of both the local Welsh Ice Cap and the regional Irish Sea Ice Stream, superimposed by subsequent periglaciation. The lower, shale-rich Cricceith till, deposited by Welsh ice, evidences numerous water escape structures/clastic dykes, interpreted as subglacial hydrofractures. These features are thought to have resulted from the overburden pressure exerted by thesubsequent inundation of the site by Irish Sea Ice, represented by the gravelly and lithologically distinct Llanystumdwy till.

The localised impact of overriding means the geotechnical properties of tills may vary significantly and datasets can only be meaningfully interpreted if the glacial history of a site is understood. **Dave Evans** also discussed the peril of the oversimplification of lithofacies units without consideration of process-form understanding and explained how solifluction deposits with palaeosols that cap the sequence had formerly been interpreted as tills. **Julian Murton** also showed how vertical structures in the palaeosol unit could be interpreted as hydrofractures, unless careful study of vertical orientation of the elongate clasts, which showed they were ice-wedge casts, was not undertaken. **Emrys Phillips** highlighted numerous examples of deformation structures, including folds with clast alignment and pressure shadows (Fig. 4B).

After a (failed) ice cream hunt, a drive down the coast, and a short walk across a railway, we arrived at the second site of the day, Glanllynnau (Fig. 5). Here, **Dave Evans** pointed out that, similar to Criccieth, this site firstly records the activity of the both the Welsh Ice Cap and the Irish Sea Ice Stream, but with the added complexity of preserved ice-dammed lake deposits, resulting in laminated muds; and outwash plains, resulting in glaciofluvial sands and gravels, capping the section. **Dave Roberts** showed that the two competing ice masses did not preserve a simple layer-cake stratigraphy, and instead there is evidence of truncation of the tills by glaciofluvial and glaciolacustrine sediments, and glaciotectonic thickening of the sequence due to proglacial deformation.

Saturday evening talks were given by **Simon Price** and **Emrys Phillips**. Simon discussed geotechnical soil behaviour and emphasised the importance of understanding the stress history associated with segregation ice, glacier ice and groundwater. **Emrys**

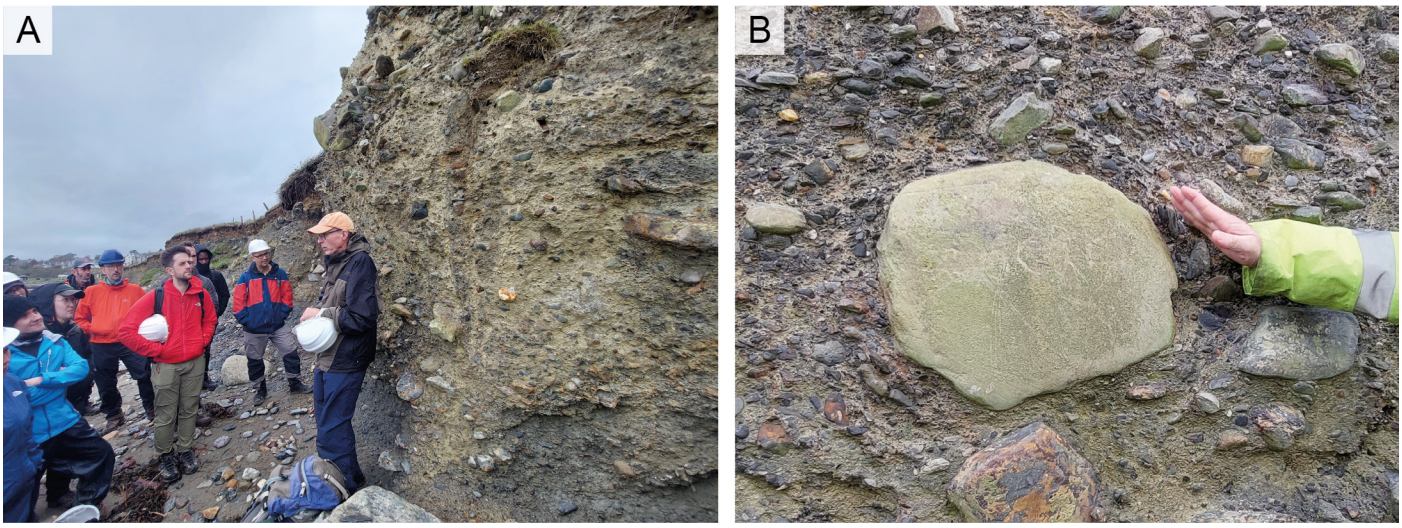


**Figure 4.** Cricceith (Moranedd). [A] Julian Murton discussing periglacial structures. [B] Emrys Phillips discussing subglacial deformation structures *(Photo credits: Cristina Balaban)*.


**Figure 5.** [A] Section at Glanllynnau, dissected by a fault. [B] Dave Evans explaining the history of Glanllynnau. [C] Classic soft sediment deformation in glaciolacustrine sediments at Glanllynnau *(Photo credits: Ethan Lee, Ben Stoker, Emma Cooper)*.

**Figure 6.** Checking out some cores from the North Sea courtesy of Dave Roberts *(Photo Credit: Cristina Balaban)*.

**Phillips** then introduced the group to thin section petrography and explained that all macro-scale field techniques could be undertaken with thin sections: particle size shape and lithology, clast microfabric, rotational or planar deformation, and faults, folds, and pressure shadows. In engineering geology settings, which often lack substantive exposures, thin sections from borehole records are a powerful tool for characterising sediment properties.

Finally, **Dave Roberts** presented us with some cores from the North Sea floor (Fig. 6), which were extracted as part of the BRITICE-CHRONO project, as introduced the previous evening. The cores contain sediments ranging from massive diamictons interpreted as tills to laminated muds interpreted as glaciolacustrine sediments, recording the retreat of the North Sea Lobe over Dogger Bank.

**Sunday 30th October**

The final day brought us to our finale, a drumlin section at Cemlyn Bay on Anglesey, near the Wylfa nuclear power station. **Emrys Phillips** introduced us to a landscape of bedrock and till-cored drumlins and showed that recent BGS mapping indicated this glacial landscape was preserved on the bed of the Irish Sea. Dave Evans described the stratified nature of the exposed drumlin core (Fig. 7) and explained that drumlins can inherit pre-existing sedimentology. Just when people's minds were turning to the trip home, someone asked "so how do drumlins form?". The subsequent discussions highlighted that the engineering properties of tills in drumlins will be different to adjacent tills (and there is no straight answer).

The trip concluded with views of drumlins (Fig. 7C) and a good feeling about the importance of understanding glacial and periglacial geology in engineering projects.

**A Reflection on post-PhD Careers**

The five glacial geology PhD students had a chance to understand how their skills are valued in industry, which often appears only to recruit engineering geology students. Many Physical Geography courses


**Figure 7.** Cemlyn Bay, Anglesey. [A] A drumlin section at Cemlyn Bay, with Emrys Phillips providing a site overview. [B] The group making their way up the drumlin. [C] Overview of local drumlins *(Photo Credits: Cristina Balaban, Ben Stoker)*.

do not highlight opportunities in applied geoscience careers, yet skills in geomorphology and Quaternary geology are directly translatable into engineering geology. Field meetings run by the QRA Engineering Group, and the Engineering Group of the Geological Society (EGGS) provide informal networking events allowing all geoscience students to learn something new and understand career opportunities in industry.

**Acknowledgements**

Thanks to the QRA Engineering Group, GLWG and EGGS for organising and supporting an insightful and successful field course. Thanks must go out to trip organisers, contributors, and participants (Fig. 8) for a thoroughly engaging few days in the field, and to all those who contributed to the new field guide. We thank Paul Fish for useful comments that improved the quality of this report. We are all looking forward to the next meeting.

**Figure 8.** Group photo on top of the drumlin at Cemlyn Bay, Anglesey.