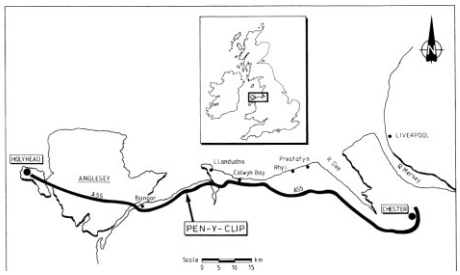
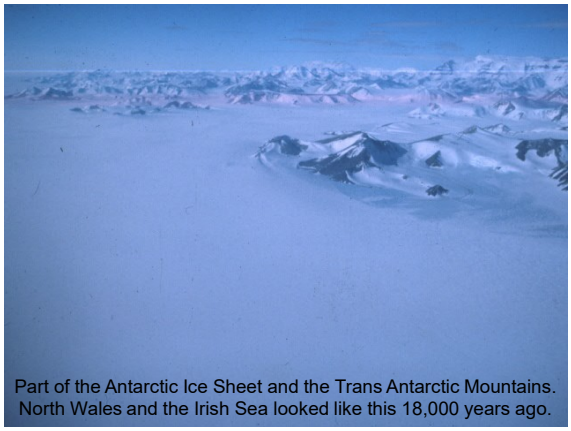
Geology and the A55 North Wales Coast Road

A variety of difficult ground conditions caused many problems during the upgrading of the A55. This talk will explain these problems and how they were overcome.

Frank Nicholson

- £732 million for improvement of 109 km to Menai Bridge
- Well over £1 billion at present day prices (to Menai Bridge)
- Basic upgrade to dual carriage about £1.7 million per km
- Pen-y-Clip £110 million for 1.9km
- Conwy Crossing £227million for 5.8km

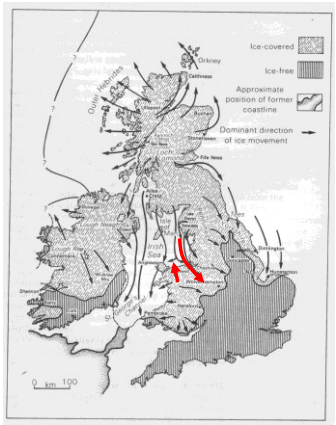




Part of the Antarctic Ice Sheet and the Trans Antarctic Mountains. North Wales and the Irish Sea looked like this 18,000 years ago.

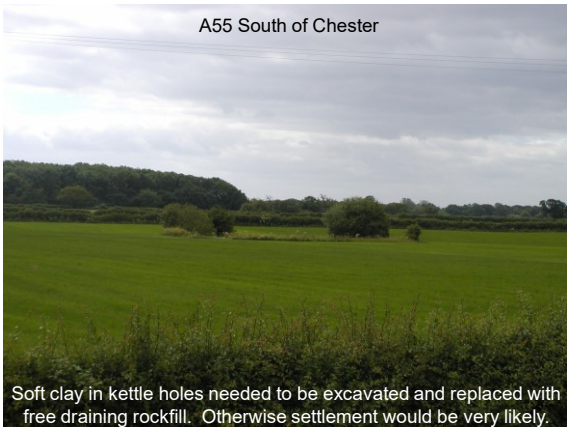
Breida Glacier, Iceland – probably the margin of the ice sheet across Cheshire and the Midlands looked like this.

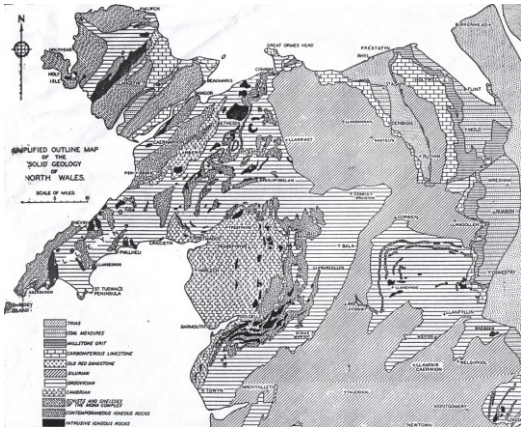
Ice cover and main ice movement directions in the last glaciation.



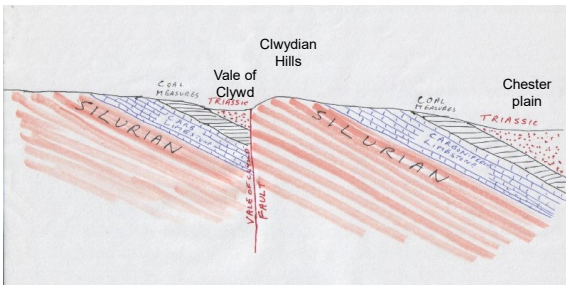
Ice blocks part buried in sediment after a flood caused by minor volcanic activity under an ice sheet. These would form very small "kettle holes". Southern Iceland

Kettle holes developing in fresh glacio-fluvial deposits. South Iceland





The Vale of Clwyd Fault causes a repetition of the succession Silurian to Triassic along the NE Wales coast.



West of Chester – Coal Measures with a deep cutting and other construction.

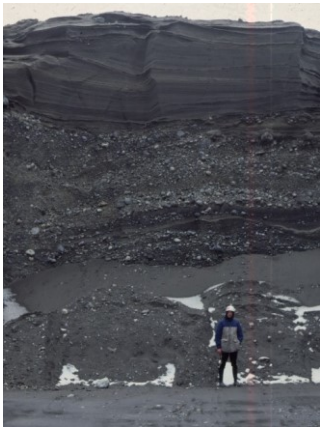
To investigate and remediate the old coal workings needed:

- 3000 drill holes totalling 60 km of drilling (at £100 plus per metre?)
- 12000 tonnes of cementiferous grout was injected to stabilise the voids
- Total cost £32 million for 11.2 km (completed 1984)

Haydock Opencast Site

Void migrating upwards in Opencast face – potential serious subsidence.

Opencast coal was extracted here to 30m – backfill carefully compacted.



Glacio fluvial sands and gravels (photo central Ireland).

Where there are substantial glacio fluvial sands and gravels under the A55 – no special problems.

Unusual for the A55 !

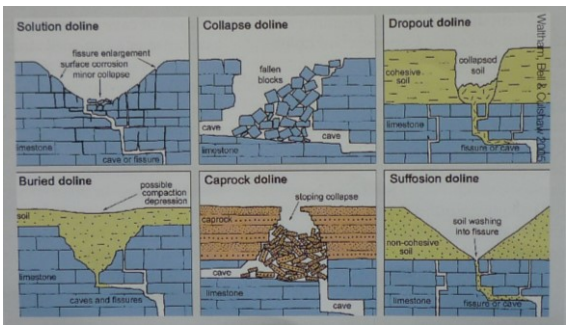
Extensive mineral workings near Holywell. Lead-zinc veins in Carboniferous Limestone.

Capped mine shaft.

- 36% of Holywell Bypass in Carboniferous Limestone was affected by old workings in mineral veins.
- 34 mineshafts capped as part of the road works.
- Also 10 reinforced concrete rafts needed to stabilise the upgraded carriageway.

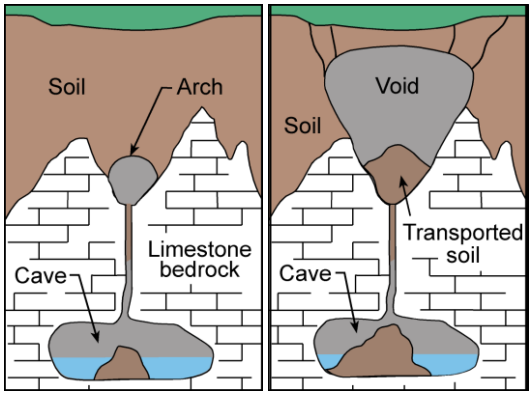
Further West (near Travellers Inn) glacial deposits, mainly till, overlying limestone.

Found 50 sinkholes in an area of 35 ha. From 1m to 15m diameter.



Different types of doline (Farrant & Cooper, B.G.S. Geoscientist 2014)

["Dropout doline" also described as "Cover subsidence sinkhole"]



More likely if the road works increase seepage into the ground!

A range of **geophyical methods** used:
Seismic refraction showed voids and surficial material depth.
Microgravity - 4 sites with either voids or deep depressions.
Ground penetrating radar was not successful.

341 probe **drillholes** on a 10m grid (7643m total).
Rockhead varied 2.8m to 34m.
In limestone bedrock 17 apparent voids were found.
These were drilled larger & CCTV used. No large voids were found.
11 “conventional” boreholes & 8 trial pits were also made. One small void (0.5m diam) found just above bedrock in a trial pit.

Found poor correspondence between geophysical methods and direct observations.
e.g. only 1 gravity low & 3 seismic anomalies corresponded with apparent voids found in drill holes.

The rockhead diameter of sinkholes probably being less than 1m means that investigation is very difficult.

On balance the investigations indicated only minor solution enlarged joints.
However surficial material was excavated from each identified sinkhole, which was then backfilled on strong geotextile webbing.
Even so some remedial work has been needed since the road opened.

Ruallt, East slope of Vale of Clywd Pre split blasting

During construction a large wedge failure occurred – stabilised by cable anchors & rock bolts.

Rock bolts, shotcrete and catch fence.

Safety bench and catch fence.

Dee valley/St Asaph bypass – limited problems.

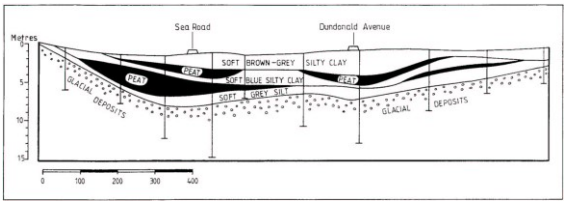
Bodelwyddan Bypass – No problems on till plain over limestone.

Abergele bypass ground conditions

Peat is unstable material – compacts and oxidises (especially if drained). The variable soft clays also give problems.

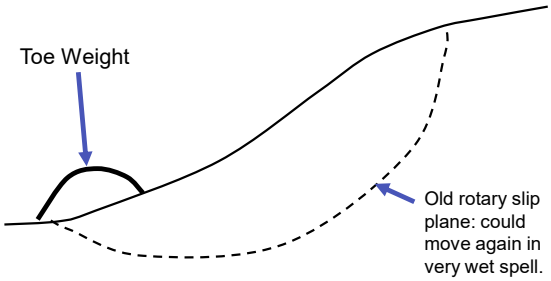
All this material needs excavation and replacement.

Not done thoroughly enough and some remedial work needed!



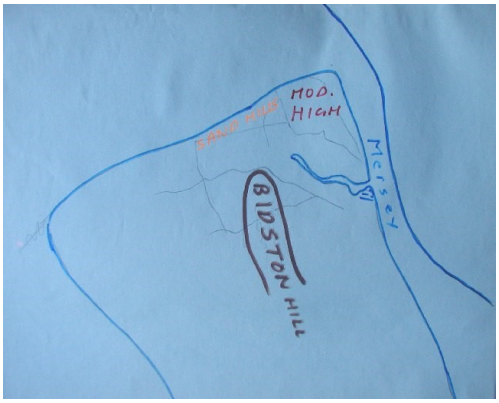
Just East of Old Colwyn – old complex landslips in glacial till over limestone.

Just East of Old Colwyn



Constructed toe weight embankment needs marine erosion protection

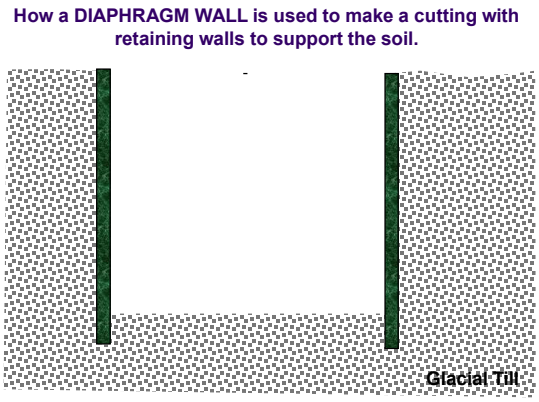
Concrete steps eroded by waves bombarding steps with beach pebbles..



Breakwater designed to be submerged and absorb wave energy.

New Brighton Link Wall 1985 & 2009
Demonstrates effectiveness of breakwaters!

Retaining wall in Colwyn Bypass.



Frame for making a diagphragm wall.

The trench walls need support as they are dug.

The trench is filled with bentonite (a clay with special properties - thixotropic).

The side support is withdrawn.

Concrete is pumped in, displacing the bentonite.

Iron reinforcement is added.

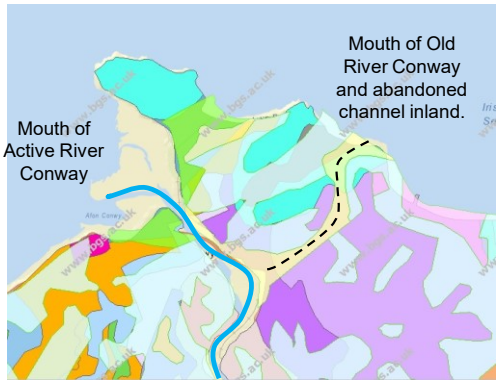
Diaphragm wall before final covering, Byker Bypass, Newcastle.

Retaining wall in Colwyn Bypass, with decorative concrete finish.

Great Orme – Llandudno
ANCIENT copper Mines – Bronze Age (best example anywhere)
Reused in Roman times
And again 1692 to end of 19th Century.

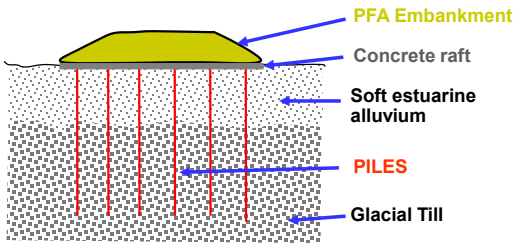
Carboniferous Limestone
With mineral veins – copper (probably plus a little of other minerals e.g. silver, even a trace of gold)
Calcite is the “gangue” mineral.

Lead-Zinc is much commoner in Carboniferous Limestone as at Holywell Bypass, but also copper etc sometimes present.



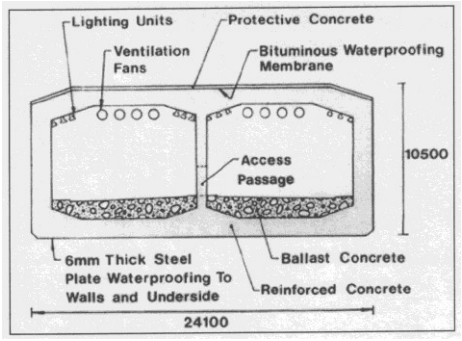
Geology of the Llandudno & Colwyn areas.

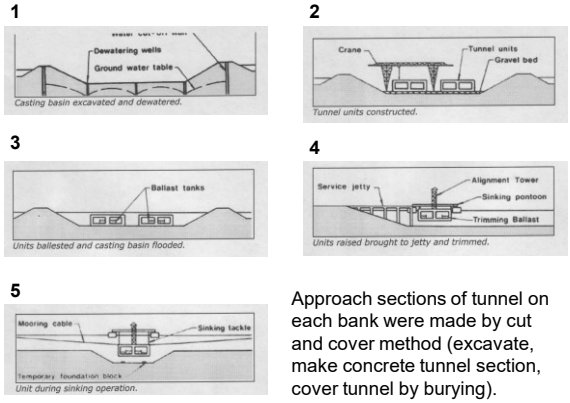
Lightweight pulverised fuel ash embankment on soft alluvium of old River Conwy



CONWAY TUNNEL

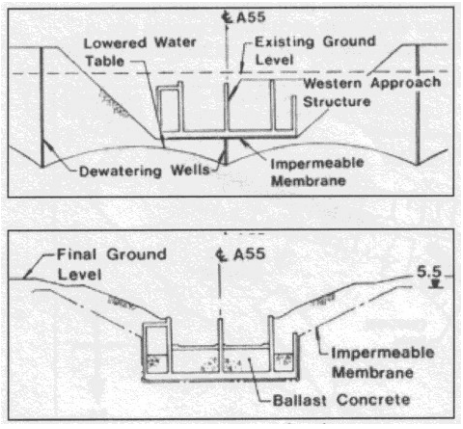
Immersed tube tunnel - 6 x 118m sections





Approach sections of tunnel on each bank were made by cut and cover method (excavate, make concrete tunnel section, cover tunnel by burying).

Conway Tunnel West Portal



Problems with soft alluvium
near the banks of the River Conwy

Excavate and replace with free draining rockfill, but not reasonable for deeper deposits.

For deeper deposits:

Improve rate of water escape by using “BAND DRAINS” = vertical plastic drains cased in fine mesh geotextile.

45,000 band drains were installed. (≈ 500km of drains)

With 10 to 15m of alluvium the ground usually settled about 2m after the embankment was constructed.

Conwy Crossing £227million for 5.8km = tunnel **plus** difficult approaches both sides.

Penmaenbach Tunnel

Large volumes of old scree and other unstable materials excavated.

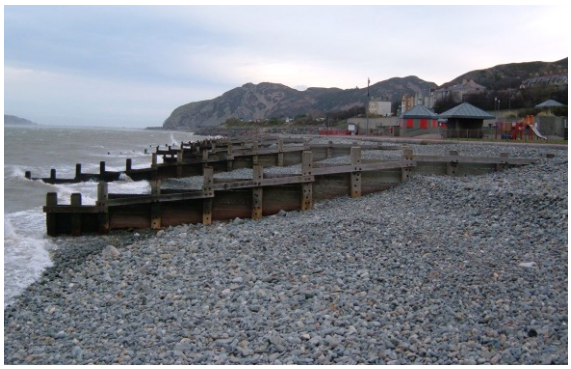
Ring of rock anchors to form a pretensioned arch before tunneling.

Cracked tunnel lining was covered over a few years ago

but that was only a “cosmetic” cover of the main structural lining.

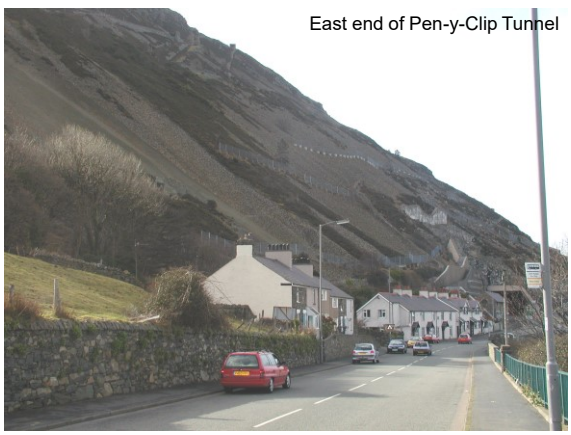
Penmaenmawr Bypass

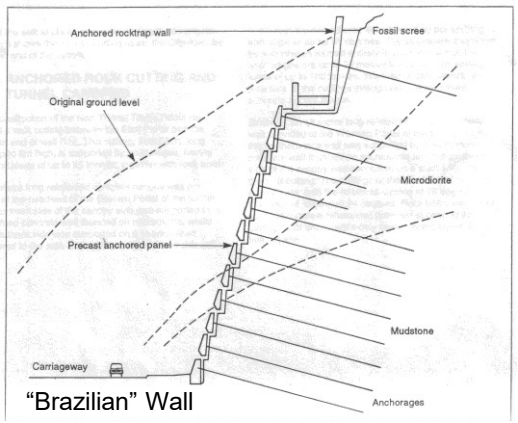
Penmaenmawr Promenade



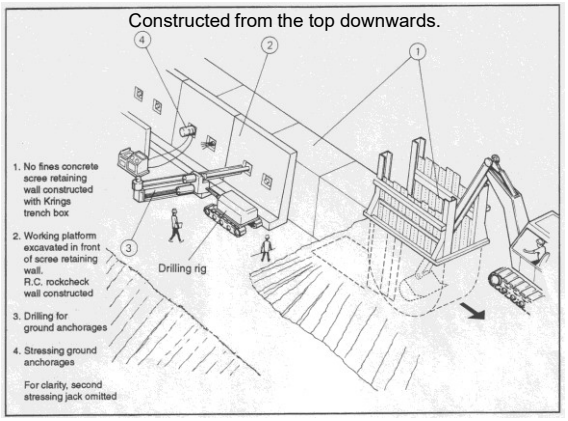
Armour stone imported from Ireland & Sweden. The local quarries were unable to supply enough in the timespan.

East end of Pen-y-Clip Tunnel



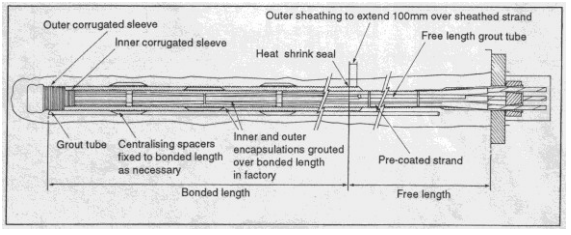


"Brazilian" Wall

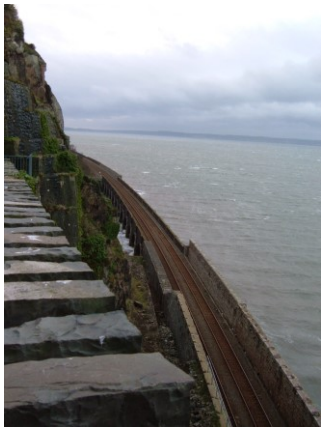


West end - 35 m high.

Ground anchors: 3 to12.5m grouted and up to 25m long (inner half grouted in, outer half free in drilled hole).



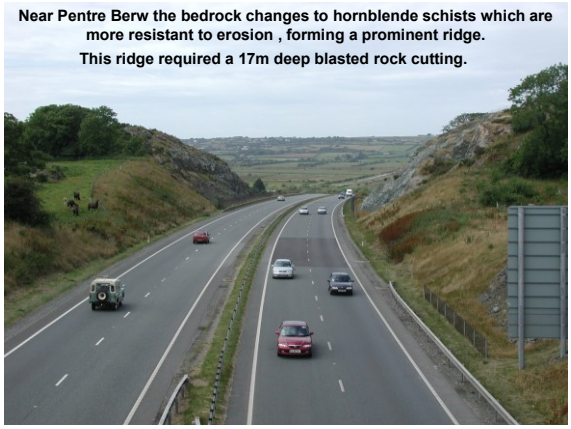
2000 ground anchors were needed at Pen y Clip.



Railway on masonry arches alongside old Pen-y-Clip Tunnel route.

Llanfairfechan Bypass – alluvial silts & clays +/- peats & till, often waterlogged. Excavate & replace with gravel. Or concrete slab with piles where more peat.

- Bangor Bypass. Shallow till over Ordovician siltstone & mudstone. Extensive cuttings needed. Local slate waste used for road base & slate for bridge abutment cladding.
- Similar problems continue beyond Pont Britannia to Holyhead, where Mona Complex schists are prominent. The schists are susceptible to deep weathering. In places salt marsh etc causes problems. At Malltraeth Marsh (salt marsh) the road is constructed on a high embankment.



Penmaenmawr Bypass

Thank you for your attention.