British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

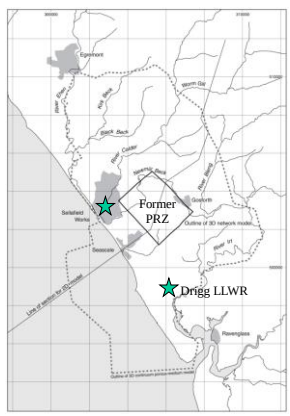
Applied geoscience for our changing Earth

Characterisation of Quaternary deposits in West Cumbria using the concept of domains: A case study

Jon Merritt

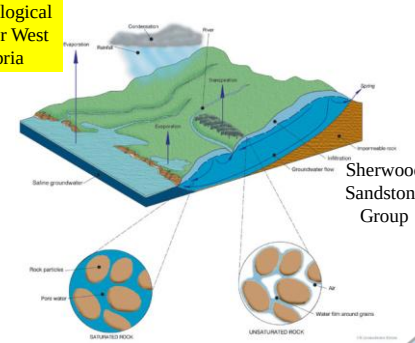
- **Quaternary Characterization Programme**
- **Glaciation of West Cumbria**
- **Development of hydrogeological domains**
- **Recent modelling requirements**
- **Multi-till sequences: The ice-stream legacy in northern England**
- **Conclusions**

The Calder Catchment



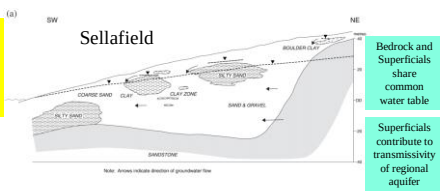
after McMillan et al., 2000. QJEGH, 33, 301-323

Conceptual hydrogeological model for West Cumbria



Sherwood Sandstone Group

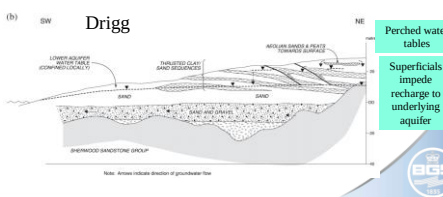
Local hydro-geological profiles



Bedrock and Superficials share common water table

Superficials contribute to transmissivity of regional aquifer

Recharge through Superficials at both sites

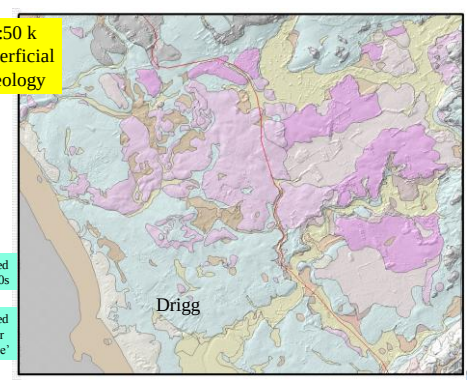


Perched water tables

Superficials impede recharge to underlying aquifer

after McMillan et al., 2000. QJEGH, 33, 301-323

1:50 k Superficial Geology



Mapped in 1920s

Deemed 'fit for purpose'

NEXTMap Britain™ elevation data from Intermap Technologies.

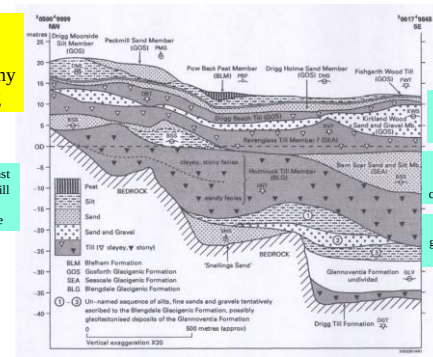
NIREX Quaternary Characterization Programme 1993-97

25 boreholes
57 trial pits
27 sections
targetted mapping
geophysics
and much more

Nirex Science Report S/97/002

BGS litho-stratigraphy at Drigg

Great contrast in types of till and provenance



Thin pebbly clays

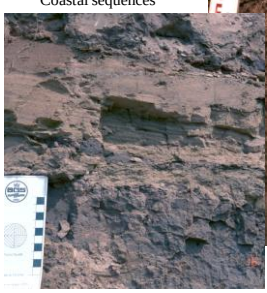
Sand-filled channels

Dense gravelly tills

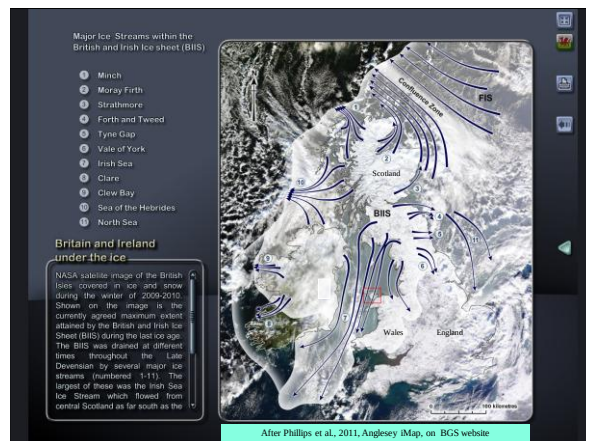
From BGS Technical Report WA/99/80

Contrasting tills in West Cumbria

Coastal sequences

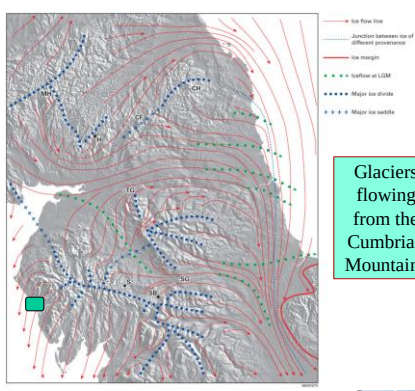


Inland tills



After Phillips et al., 2011, Anglesey iMap, on BGS website

Last Glacial Maximum 28-22 ka BP

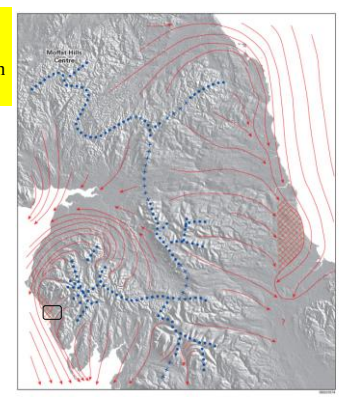


Glaciers flowing from the Cumbrian Mountains

From British Regional Geology of Northern England, 5th Edition, BGS, 2010

After major glacial reorganisation c.18 ka BP

Followed by glacial re-advances

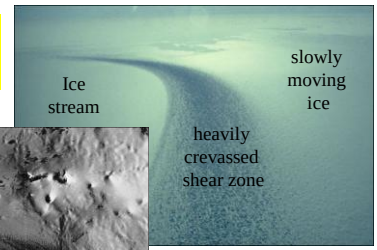


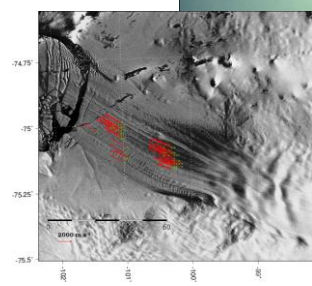
Irish Sea Ice Stream impinges into West Cumbria

From British Regional Geology of Northern England, 5th Edition, BGS, 2010

Ice Streams

Ice Streams



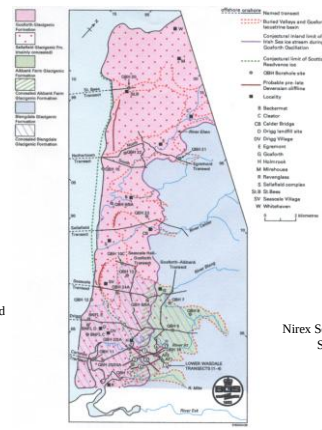


West Antarctic Ice Stream D

Velocities: c. 0.4 – 4.0 km per year

West Cumbria during the Gosforth Oscillation

Litho-stratigraphy of West Cumbria

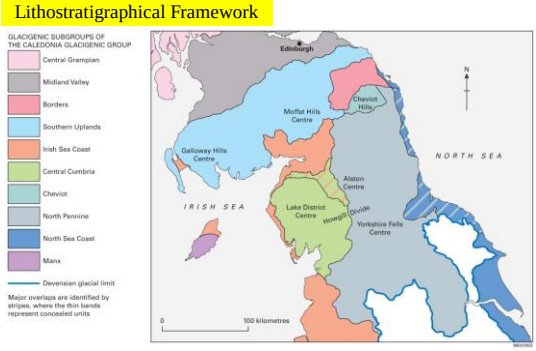


Shear zone at landward margin of ice stream?

After Merritt and Auton, 2000, Proceedings of the Yorkshire Geol Soc, 53, 129-154

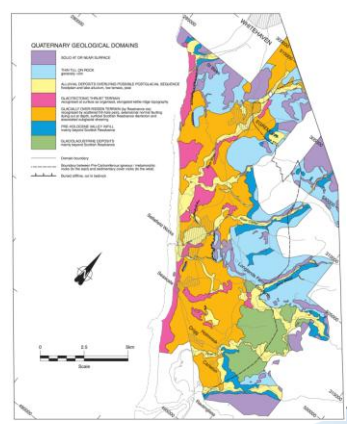
Nirex Science Report S/97/00

Lithostratigraphical Framework



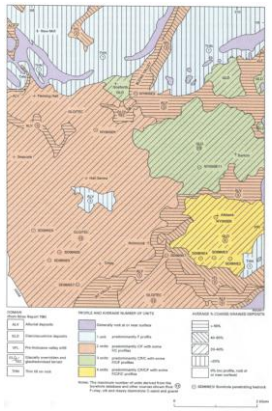
After McMillan, A A, Hamblin, R J O and Merritt, J W. 2010. A lithostratigraphical framework for onshore Quaternary and Neogene(Tertiary) superficial deposits of Great Britain and the Isle of Man. *British Geological Survey Research Report*, RR/10/03.

Quaternary Domains



Nirex Science Report S/97/00

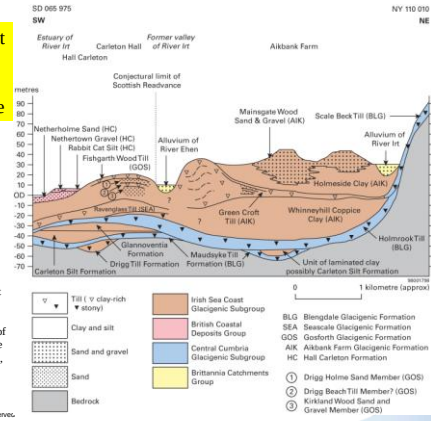
Detailed Profiles in Nether Wasdale



Glaciolacustrine domain

Nirex Science Report S/97/00

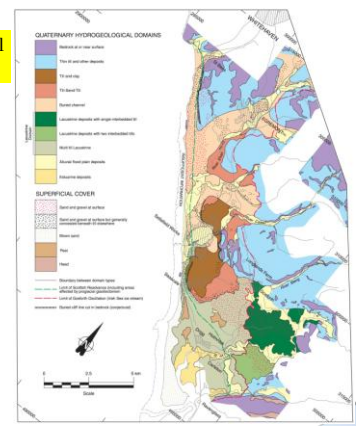
Transect across Nether Wasdale



After Merritt and Auton, 2000, Proceedings of the Yorkshire Geol Soc, 53, 129-154

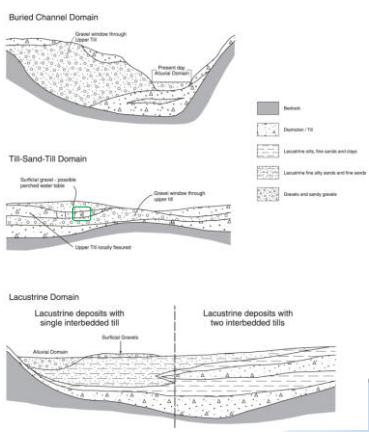
Glacio-lacustrine Domain

Hydrogeological Domains



From McMillan et al., 2000. QJEGH, 33, 301-323

Examples of hydrogeological domains

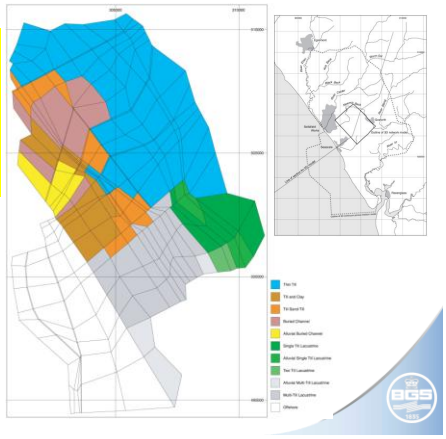


From McMillan et al., 2000. QJEGH, 33, 301-323

Till-Sand-Till Domain

Downward fissure-flow through till layers

Regional groundwater flow model for the Calder catchment based on domains



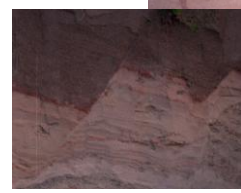
From McMillan et al., 2000. QJEGH, 33, 301-323

Nirex Science Report, S/97/012

The Ice Stream Legacy

Glacially Over-ridden Domain

Till-Sand-Till Domain



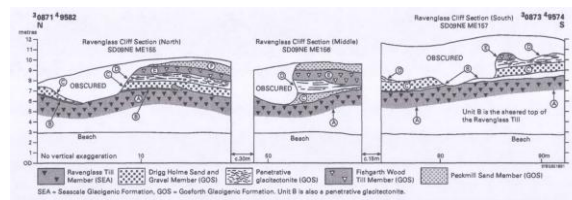
Subglacial attenuation and microfaulting

The Ice Stream Legacy

Glacitectonic Trust Domain

Glacially Over-ridden Domain

The Ice Stream Legacy



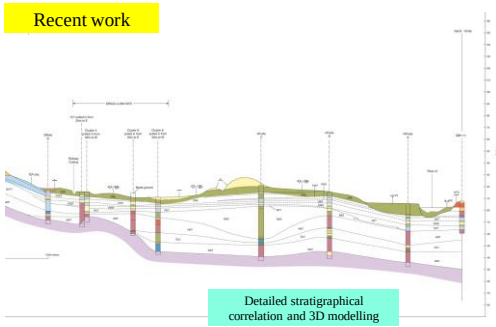
After Merritt and Auton, 2000, Proceedings of the Yorkshire Geol Soc, 53, 129-154

Tills are thin, but laterally extensive

Lenses of sand and gravel (channel-fills)

Partition of groundwater flow

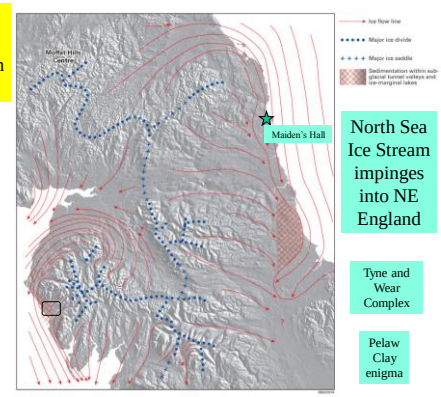
Recent work



Detailed stratigraphical correlation and 3D modelling

After major glacial reorganisation c.18 ka BP

Ice Stream legacy



North Sea Ice Stream impinges into NE England

Tyne and Wear Complex

Pelaw Clay enigma

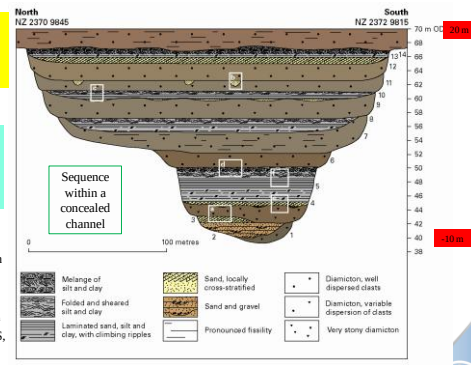
From British Regional Geology of Northern England, 5th Edition, BGS, 2010

Multi-till sequences in NE England

From British Regional Geology of Northern England, 5th Edition, BGS, 2010

Ice Stream Legacy

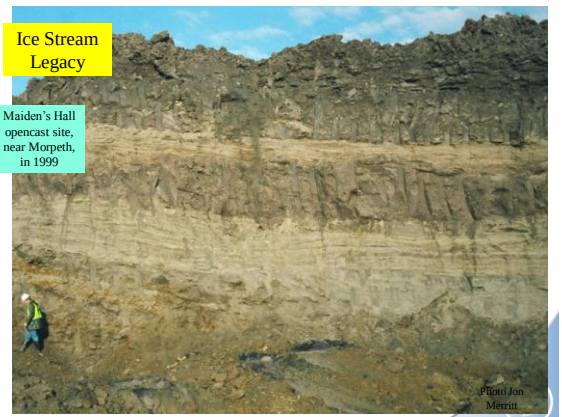
Maiden's Hall opencast site, Morpeth



From British Regional Geology of Northern England, 5th Edition, BGS, 2010

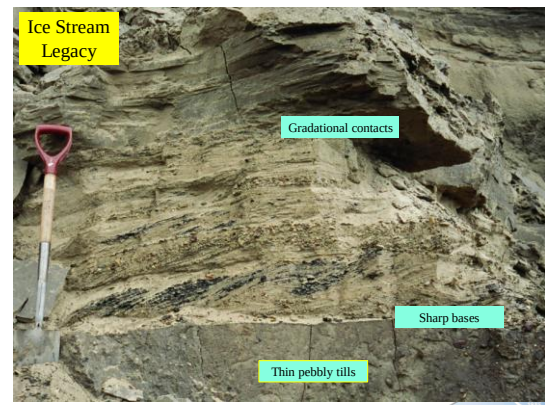
Ice Stream Legacy

Maiden's Hall opencast site, near Morpeth, in 1999



After British Regional Geology of Northern England, 5th Edition, BGS, 2010

Ice Stream Legacy



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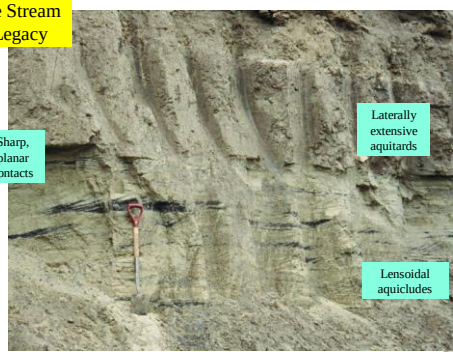
Ice Stream Legacy



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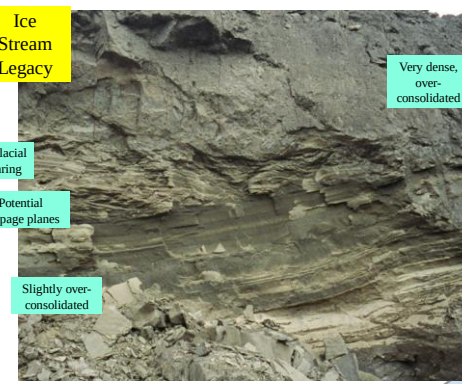
Ice Stream Legacy



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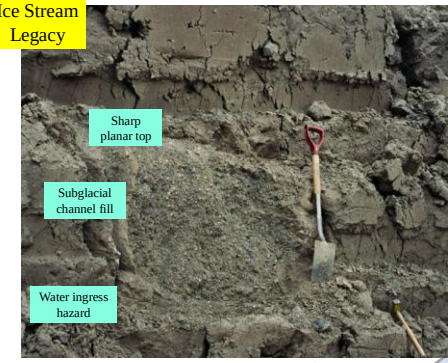
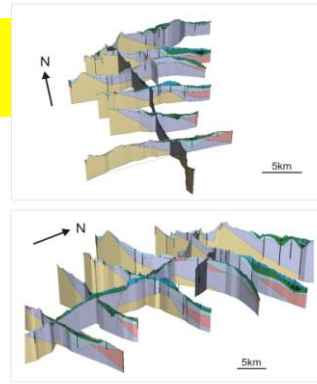
Ice Stream Legacy

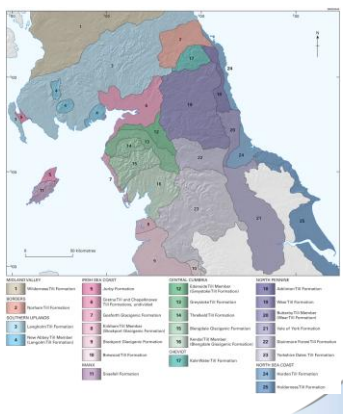


After British Regional Geology of Northern England, 5th Edition, BGS, 2010

BGS GSi3D modelling in County Durham



Towards a subdivision of tills



After McMillan, Hamblin, and Merritt, 2010. A lithostratigraphical framework for onshore …superficial deposits of Great Britain… BGS Research Report RR/10/03.

Fewer, more informative logs in site investigations please!

When is gravel really a till?

A best guess is better than nothing

Comparison of borehole core and logs following BS 5930, Drigg.

Moderate reddish brown (10R 4/6) silty fine to medium grained SAND and fine to coarse subrounded to angular GRAVEL/COBBLES with some coarse to very coarse sand.

Fine to coarse rounded to angular GRAVEL with some pale reddish brown (10R 5/4) to moderate reddish brown (10R 4/6) fine to medium sand matrix (washed out) and occasional coarse sand. 35.90-35.94m fine to medium sand.

From 'Guidelines, protocols and Standards to Quaternary mapping in the United Kingdom', BGS, in press.

Employ Quaternary geologists in site investigations

BGS image P666392

Conclusions

- Domains approach useful for regional hydrogeological modelling of Superficials
- Detailed 3D lithostratigraphical knowledge still required to underpin modern high-resolution hydrogeological models
- Former ice streams have left a distinct legacy of particular importance to engineering geologists and hydrogeologists
- More informative site investigation logs required
- Desirable to consult Quaternary geologists at all stages of site investigations