New insights into North Sea tunnel valley infill and genesis from high-resolution 3D seismic data

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1. Study summary

Motivation:

The infill of valleys carved by water flowing beneath glaciers (tunnel valleys) can help to understand past and present subglacial drainage systems.

Problem:

Previously, the resolution of conventional 3D seismic data in the North Sea has been too low to conduct fine-scale investigations of tunnel valley infill, whilst borehole studies are limited by low spatial coverage.

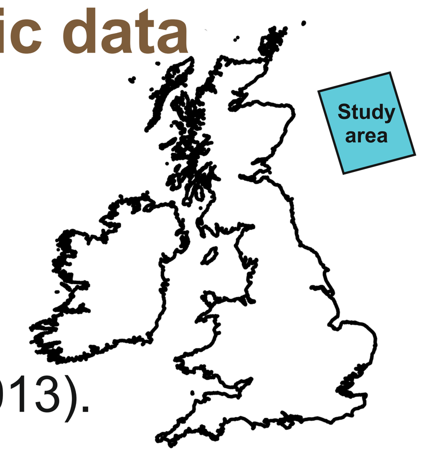
Goal:

Use novel high-resolution 3D seismic data, set in the regional context of conventional 3D seismic data, to gain new insights into the infill of tunnel valleys in the central North Sea.

Preliminary findings:

- Glacial landforms are found buried within the tunnel valleys.
- The presence of landforms suggests that the tunnel valleys were not entirely filled immediately after formation, and were later reoccupied by grounded ice.
- 10 tunnel valley generations identified where 6 were previously mapped.
- Of these, generations 2, 3, 4, 5 and 7 contain glacial landforms.

2. What's new? High-resolution 3D seismic data

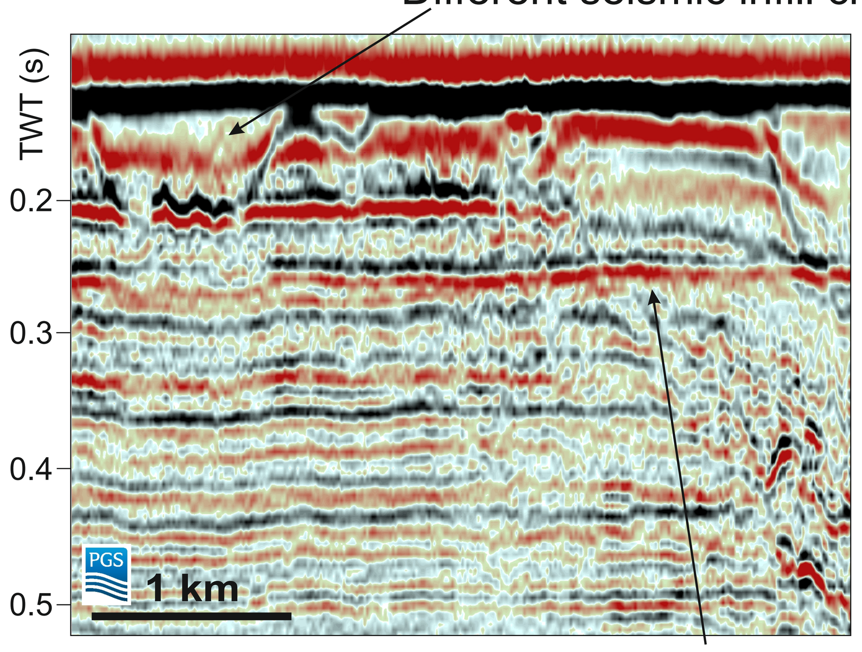


We use high-resolution (HR) 3D seismic data (6.25 m horizontal resolution, ~2 m vertical resolution) acquired by the geohazard assessment industry (Games, 2012).

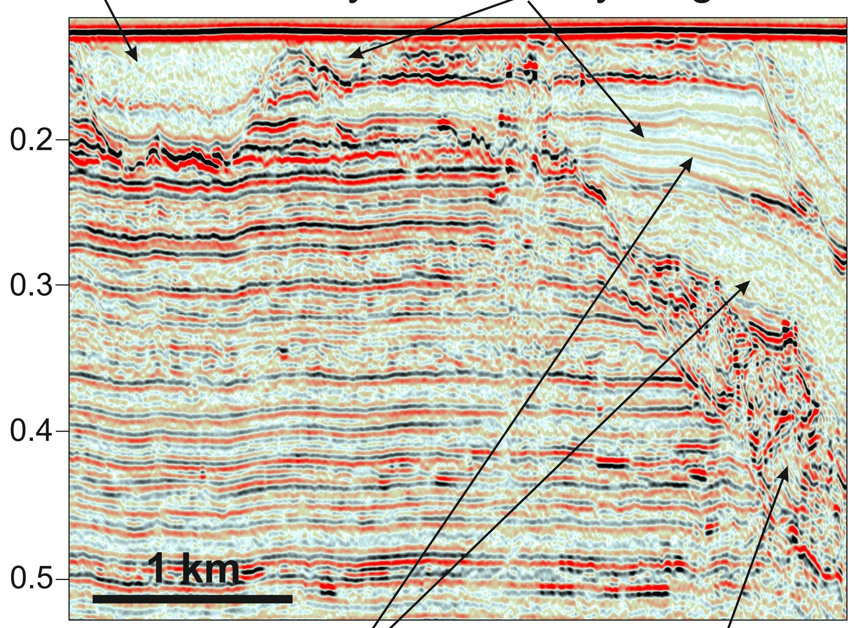
Previous data used to study tunnel valleys = 12.5-100 m horizontal and ~8-16 m vertical resolution (Stewart *et al.*, 2013).

The HR 3D data is coupled to an improved resolution regional 3D seismic survey of the central North Sea (12.5 m horizontal, ~8 m vertical resolution) to provide context and extend our analyses over a broader spatial area.

Conventional 3D seismic data



High-resolution 3D seismic data



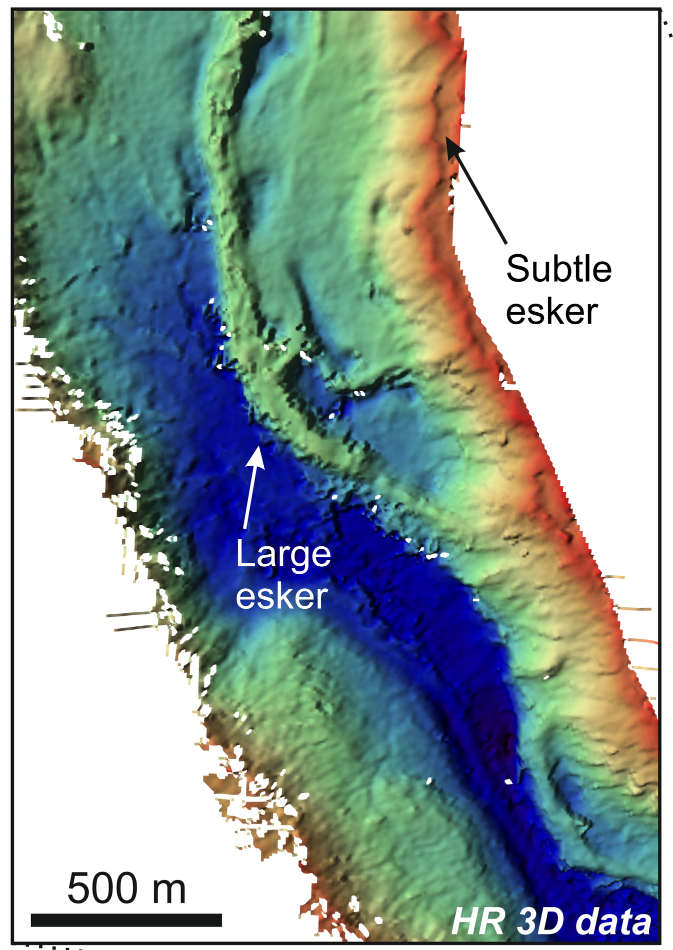
TWT = two-way travel time in seconds

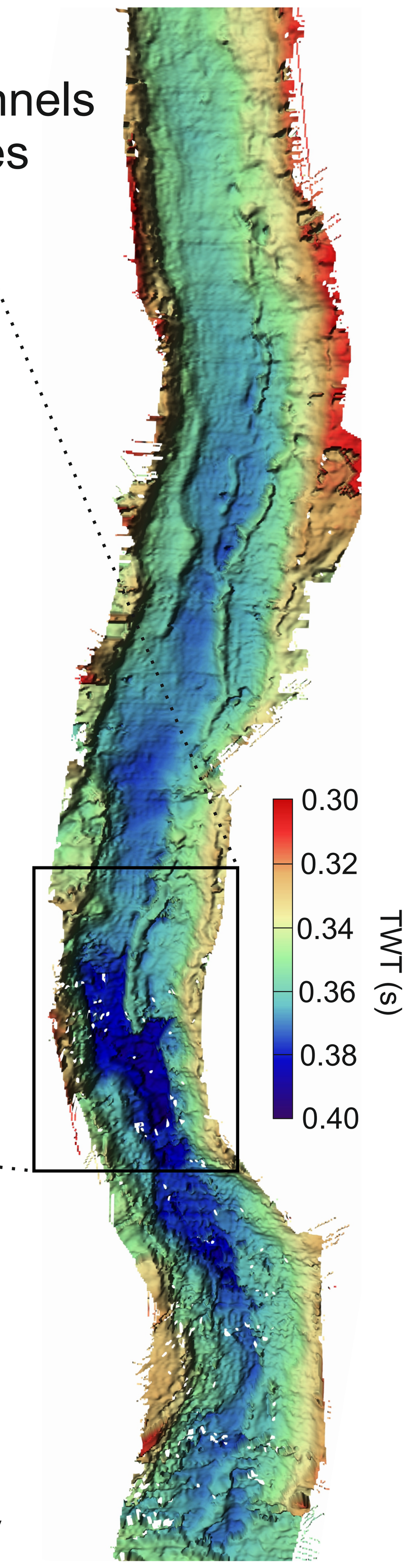
3. Glacial landforms buried within tunnel valley infill

HR 3D seismic data permits imaging of glacial landforms buried inside some tunnel valleys that were previously difficult to resolve, including:

- Eskers
- Crevasse squeeze ridges
- Kettle hole topography
- Moraines
- Braided meltwater channels
- Glaciotectonic structures

Aerial image of an esker in Canada





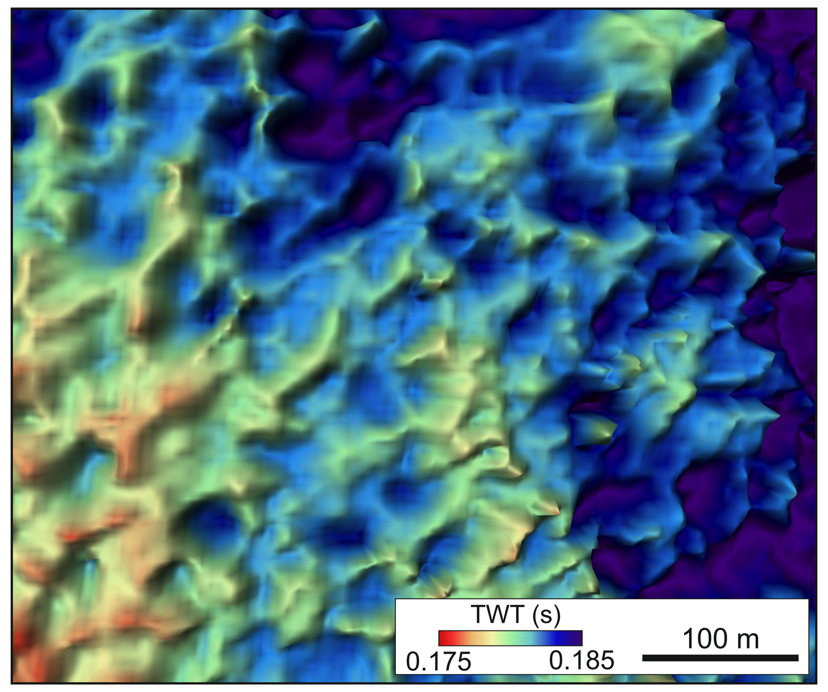
Conventional 3D data

Fragmented esker systems are the most common glacial landform buried inside the tunnel valleys.

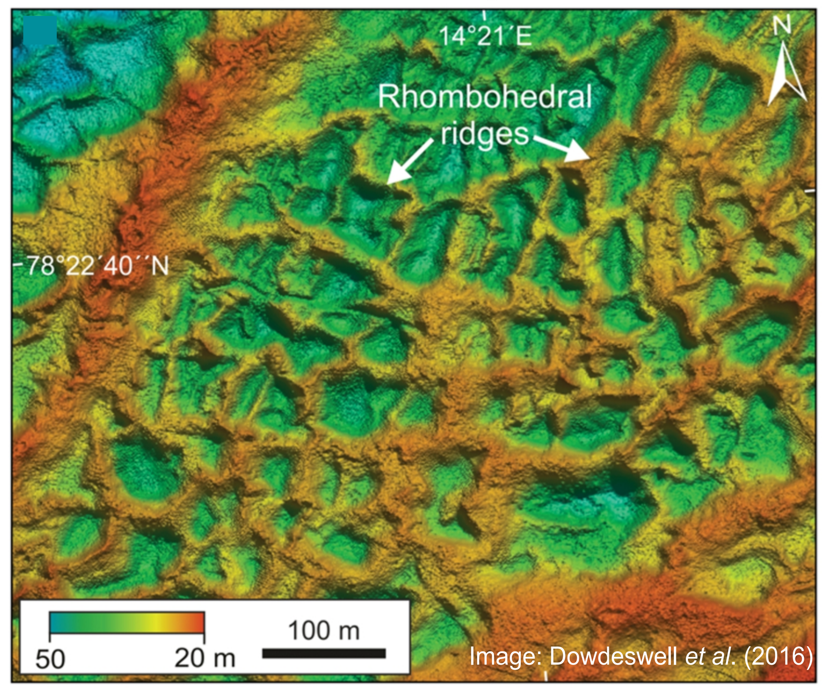
They are 50-150 m wide, ~20 m high and >14 km in length, similar to terrestrial eskers elsewhere.

Their presence implies reoccupation of tunnel valleys by grounded ice and thus non-immediate filling of the valleys.

Ridges buried inside a tunnel valley



Crevasse squeeze ridges in Svalbard

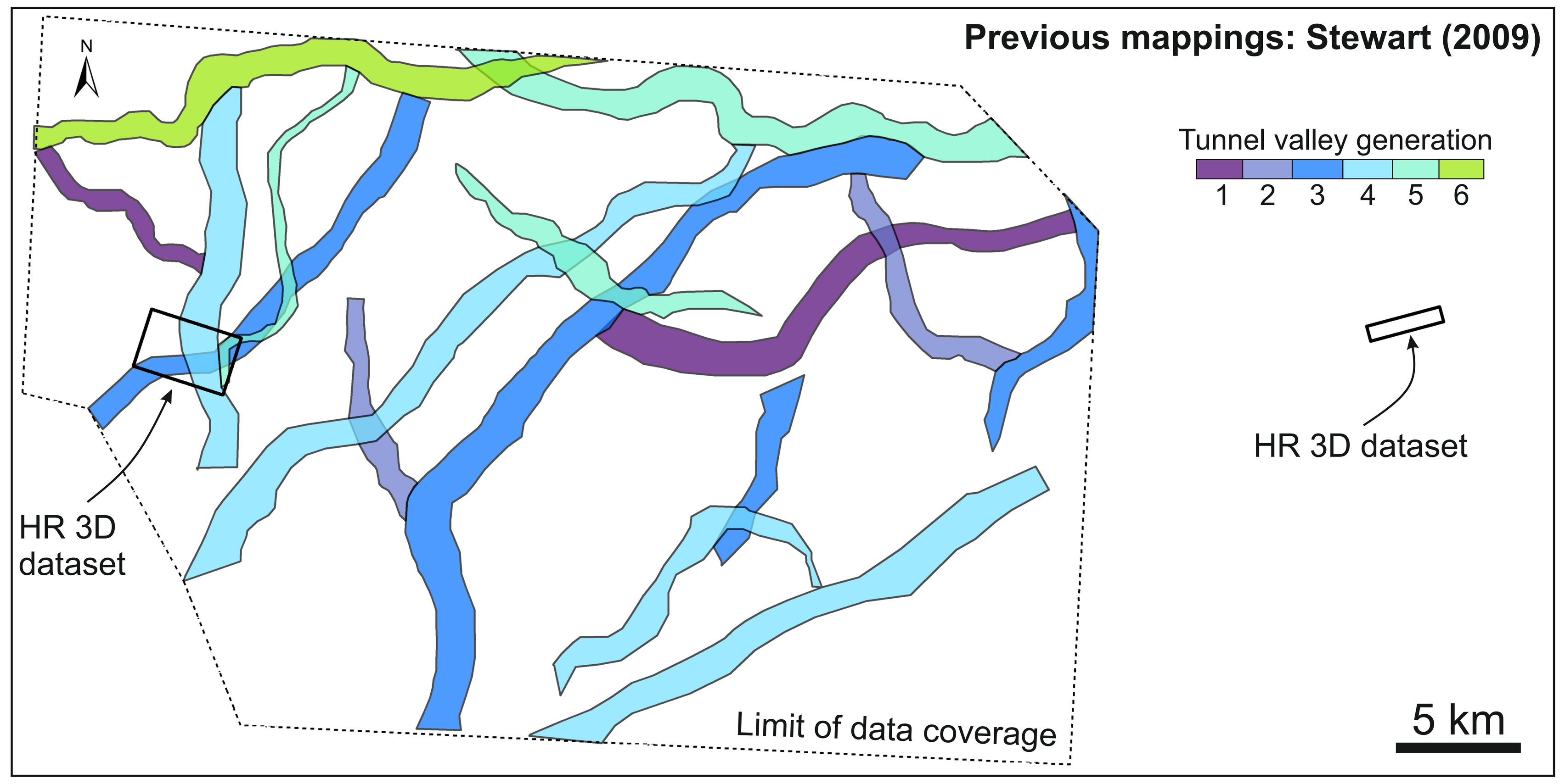


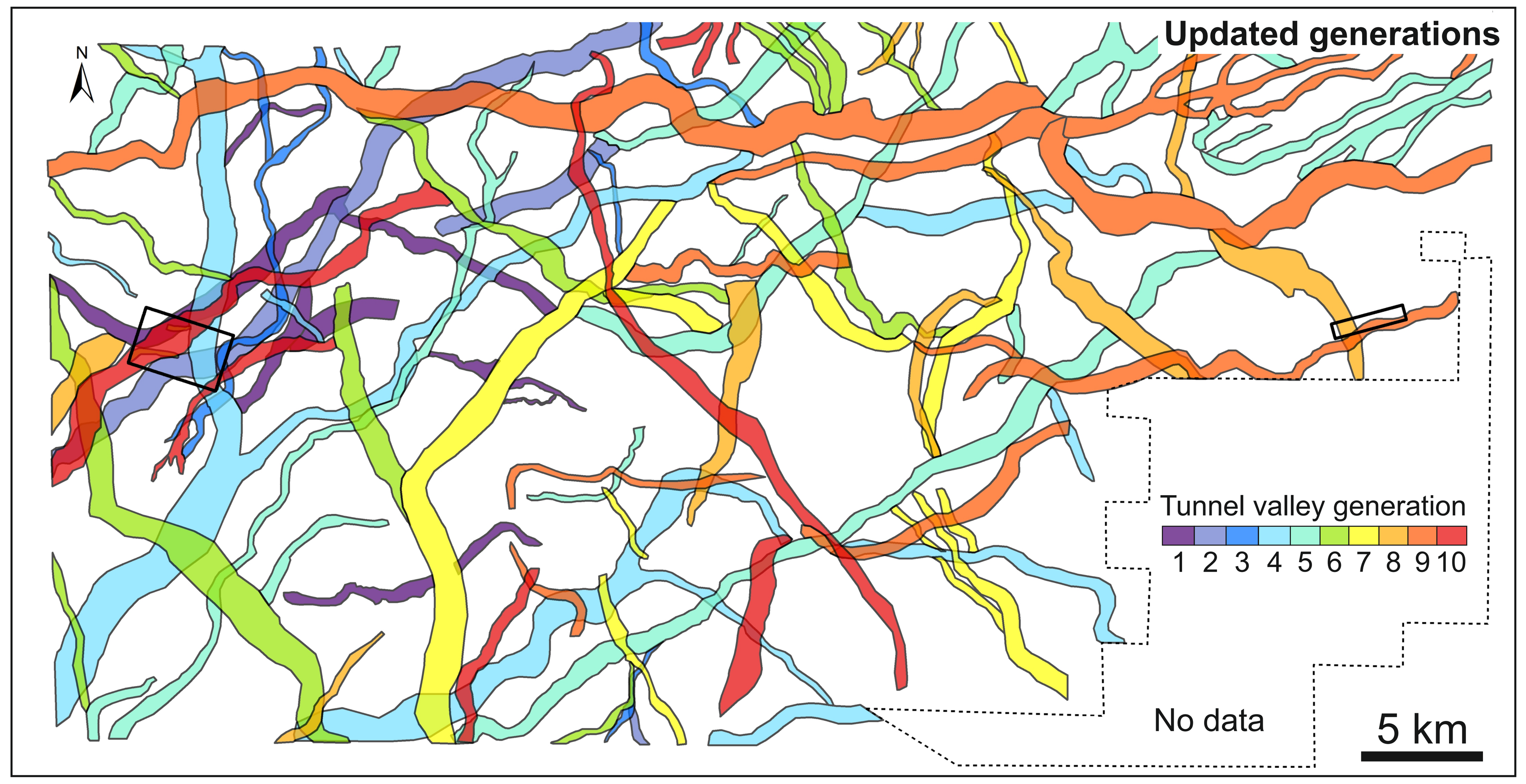
Rhombohedral ridges are buried within one tunnel valley. At ~1-4 m high, 20-250 m long, and with side slopes of ~10°, their size and morphology matches delicate crevasse squeeze ridges formed during glacial surges.

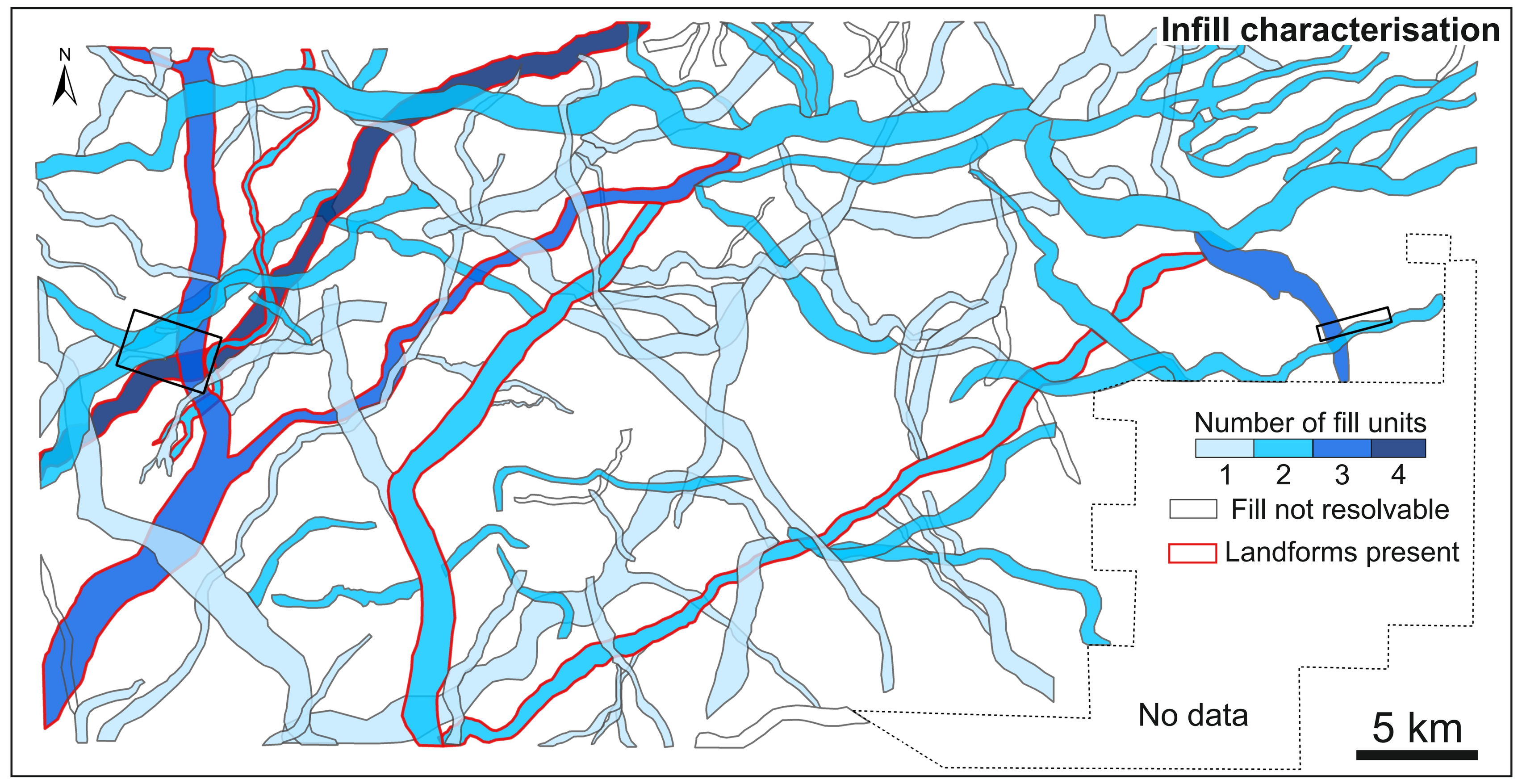
The ridges imply reworking of tunnel valley sediments by grounded ice, whilst their preservation shows that ice stagnated inside the tunnel valley.

4. Infill of different tunnel valley generations

Improved regional seismic data allows 10 cross-cutting tunnel valley generations to be identified compared to 6 previously (Stewart, 2009); this allows the HR 3D landforms to be placed into the context of generations.







Generations 2,3,4,5,7 contain glacial landforms, indicating reoccupation.

3-4 fill units are visible in HR 3D data compared to 1-2 in conventional data.

Future work will focus on examining the infill character of each generation.

References

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Acknowledgements

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