A GEOCHEMICAL APPROACH TO UNRAVELLING ICE SHEET HISTORY USING BOTH TELLUS AND TELLUS BORDER SOIL GEOCHEMICAL DATA

Michael Dempster[1], Paul Dunlop[1]

[1]*School of Environmental Sciences, University of Ulster, Cromore Road, Coleraine, Co. Londonderry, BT52 1SA*

(dempster-m1@email.ulster.ac.uk, p.dunlop@ulster.ac.uk)

1. INTRODUCTION

Using geochemistry to establish the provenance of subglacial sediment (till) represents a novel approach to investigating regional ice flow patterns in Ireland. The north of Ireland has a diverse geology and a complex glacial history (Figs.1 & 2) that offer the potential to identify subglacial transport across lithological boundaries.

Till and soil geochemistry are closley linked (Dempster et al., 2013). In this study we use the geochemistry of the Tellus Border and Tellus soil samples as a proxy for till geochemistry to determine the bedrock parent material for the till. This can be used to identify the degree and direction of subglacial transport which can therefore inform understanding of ice bed processes and subglacial bedform generation.

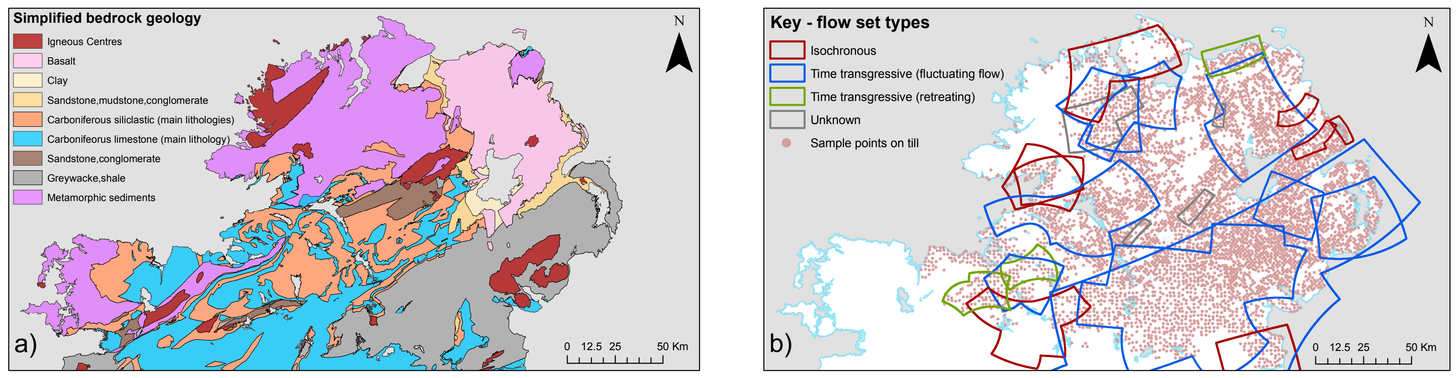

Figure 1. a) Simplified solid geology of the north of Ireland b) Drumlin flow sets wholly or partly in the Tellus Border and Tellus survey area (after Greenwood and Clark, 2009). There are four types of flow set in the region representing different glaciological contexts (isochronous, time transgressive (fluctuating flow), time transgressive (retreating) and unknown).

2. METHOD

Principal component analysis (PCA) has been applied to between 23 and 27 elements for a total of 5729 soil samples that occur on till in the study area, both at regional scale and in targeted areas based on drumlin flow sets (Fig.1b).

PCA assigns each element a loading value which is used to calculate scores for each sample point. It follows that if a sample point is dominated by high loading elements it will have a high score, and if low loading elements are dominant it will return a low score. Sample point scores are therefore representative of groups of elements that can be linked to bedrock source areas. The scores are mapped to assess the degree and direction of subglacial transport.

SAMPLE SELECTION
Samples from areas of till superficial geology

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DATA PREPARATION
Organic soils removed, element selection, normalisation

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PCA
Element loading, element groups and sample point score determination

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IMPORT INTO GIS
Spatial distribution of element groups used to determine till provenance and transport direction.

3. RESULTS

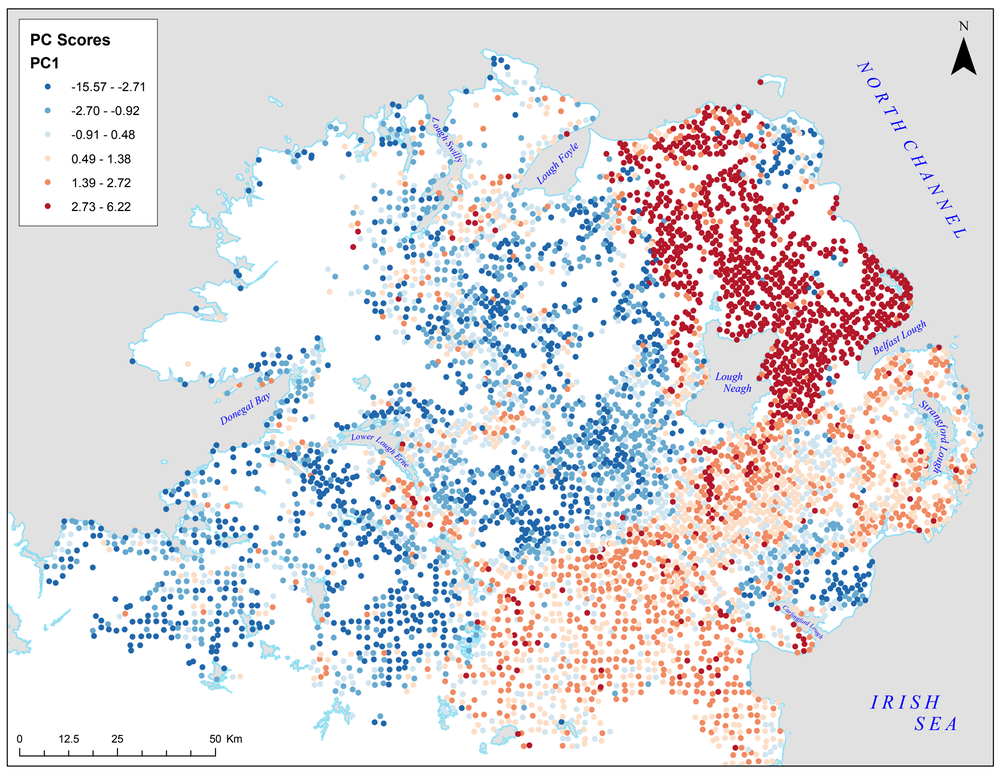

Figure 3. Score distribution for PC1, regional analysis. The scores show a distinct pattern closely linked to local bedrock geology.

Regional analysis

Figure 3 shows PC1 score distribution for the combined Tellus Border and Tellus samples. The region is broadly split into two with high scores (orange-red) found predominantly in the east and low scores (light-dark blue) predominantly in the west. Element loading is presented in Figure 4.

The distribution of high scoring areas in particular shows a very strong relationship to bedrock boundaries, following the outcrop of the Antrim Lava Group (basalt) and Down-Longford Terrane (greywacke and shale) (see Fig.1a). The igneous centres that intrude the greywacke and shale can be identified by low scores over their extent, which also continue southward onto the country rock. The strong link to bedrock can also observed at flow set scale (Fig.5) where a linear group of high scores is closely associated with a specific group of the Down-Longford Terrane. High scores in Figure 5 represent the element group Sr, V, CaO, Sc, Ni and Cr.

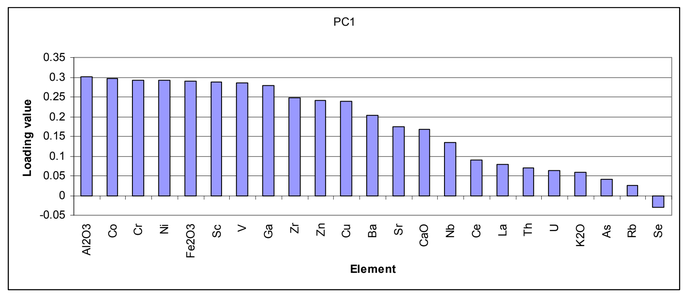

Figure 4. Element loading plot for PC1, regional analysis. These are used to calculated the PC scores shown in Fig.3.

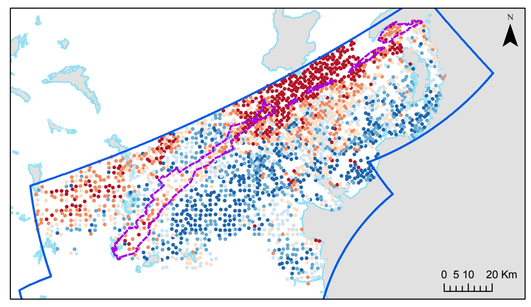

Figure 5. A linear area of high scores (PC2) follow the outcrop of the Gilnahirk Group/Red Island Formation (dashed line).

Evidence of subglacial transport

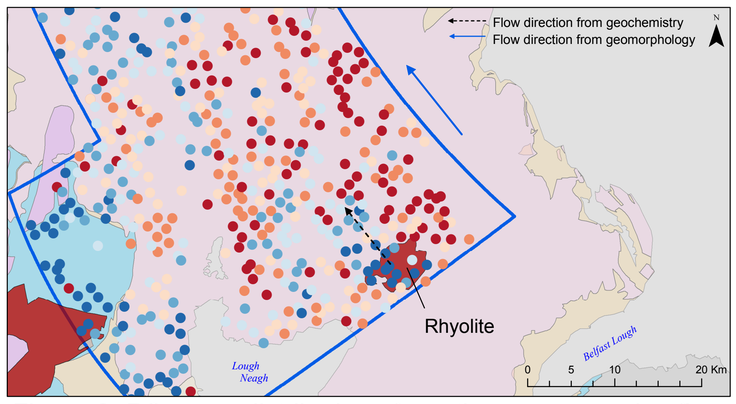

Figure 6. PC score distributions for a time transgressive flow set in the north-east of the study area.

Figure 6 shows the PC2 score distribution for a time transgressive (fluctuating flow) drumlin flow set in the north-east of the study area. Subglacial bedform morphology indicates general ice flow direction to the north-west. Bedrock in the flow set area is dominated by basalt with a rhyolite body situated in the south-east. Lowest scores (blue) are associated with the elements Rb, Th, Ce and La and can be seen extending from the rhyolite to the west and also approximately 8 km to the north-west, in alignment with the ice flow direction indicated by bedform morphology.

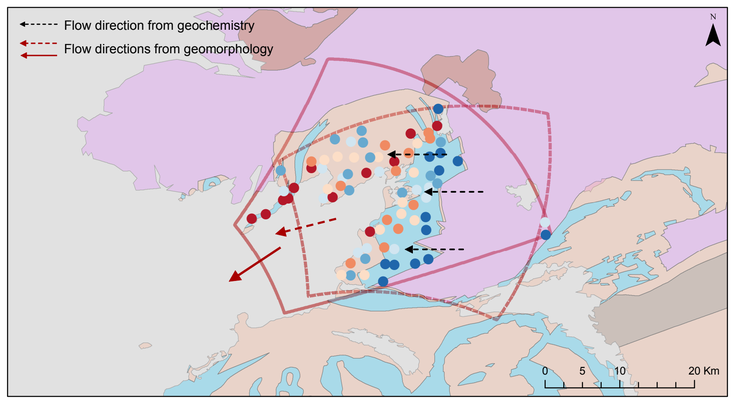

Figure 7. PC score distributions for two cross cutting isochronous flow sets in south Donegal.

Figure 7 shows PC4 score distribution for two cross cutting isochronous flow sets in Donegal. Bedform morphology indicates general ice flow directions to the south-west and south south-west. Siliclastic lithologies outcrop to the north-west and limestones to the south-east with psammite and pelite in the surrounding area. High scores (orange-red) represent Sr and CaO and low scores (blue) V and Ce. Low scores are observed on limestone and high scores on siliclastic sediments, indicating transport of material approximately 5km west, in general aligment with bedform morphology.

4. SUMMARY

The regional results show a strong geochemical link between till and local bedrock, with rapid geochemical changes observed across lithological boundaries (Fig.3). This link is also observed at flow set scale (Fig.5). Examples of subglacial transport of material up to 8km from its likely source area are presented in Figures 6 & 7.

5. CONCLUSIONS

1. Till in the northern sector of the Irish Ice Sheet is primarily local in origin.

2. Subglacial bedforms in the region therefore also display a primarily local bedrock signature, so have likely formed from in situ or from locally derived till.

3. Transport distances of subglacial material are low, consequently rates of evacuation of debris to the ice margins were also low.

REFERENCES

Dempster, M.; Dunlop, P.; Cooper, M.R.; Scheib, A.J. (2013) Principal component analysis of the geochemistry of soil developed on till in Northern Ireland. *Journal Of Maps*, 9, 373-389.

Greenwood, S.L.; Clark, C.D. (2009) Reconstructing the Irish Ice Sheet 2: a geomorphically-driven model of ice sheet growth, retreat and dynamics. *Quaternary Science Reviews*, 28, 3101-3123.

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