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‘Unlocking the geothermal energy potential of old sedimentary systems: Linking reservoir quality, geomechanics and flow.’

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1.0 INTRODUCTION

Hot Sedimentary Aquifer [HSA] systems present an opportunity to harness geothermal energy in areas where traditional hydrothermal heat sources are not available. The Midland Valley of Scotland [MVS] which is home to the major cities of Edinburgh and Glasgow, and approximately 3.5 million people hosts a promising HSA. Despite having a firm technical foundation to develop HSAs, there are still fundamental questions remaining related to the interplay of reservoir quality and hydro-mechanical properties, particularly in diagenetically complex sedimentary sequences, like that in the MVS (Brereton et al., 1988; Kearsey et al., 2024; Ballantyne, 2024). Using the Upper Devonian/ Carboniferous clastic strata of the MVS, this work sets out to answer three key questions:

- To what extent is the depositional facies driving the petrophysical properties of the strata?
- To what extent is the strata diagenetically altered, and what effect does this have on reservoir quality?
- What is the reservoir quality and flow potential of the strata at depths suitable for attaining economic geothermal temperatures?

2.0 METHODOLOGY

To date, this work has utilised traditional sedimentological logging, facies analysis, and preliminary petrographical and petrophysical analysis:

- Three sedimentary logs were taken in the Kinnesswood Formation at locations in the Pentland Hills (southwest of Edinburgh). Each facies was sampled for thin-sections and porosity testing.
- Eleven thin-sections were impregnated with blue -dye to highlight porosity and assessed for their mineralogical contents.
- Eleven samples were measured for their bulk density. Porosity was calculated assuming a grain density of 2.68g/cm^2 based on the mineralogy.

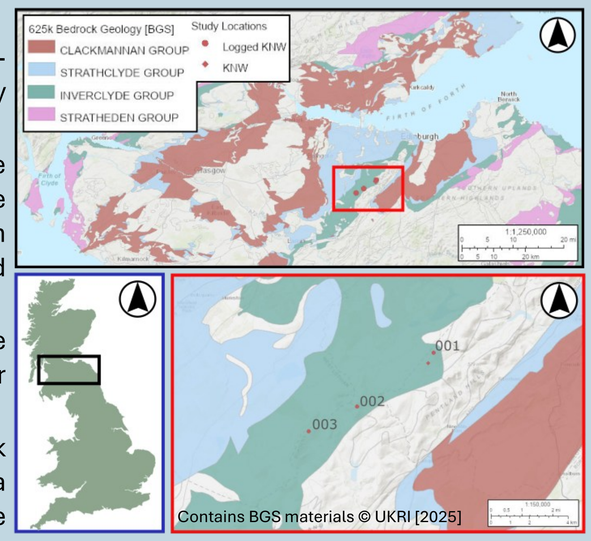
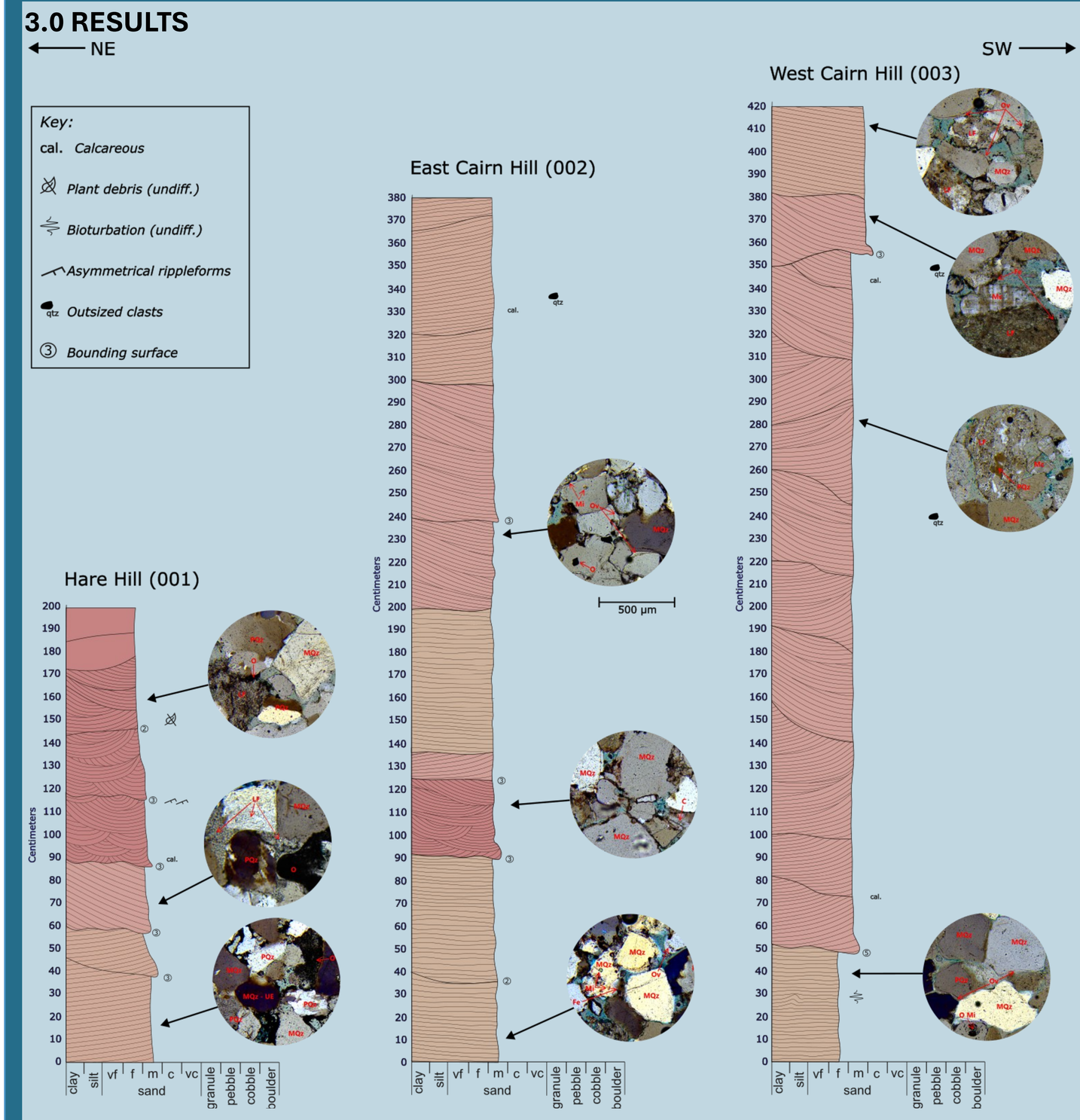


Figure 2.1. The locations of outcrops, and the sedimentary logs seen in Figure 3.1.

3.0 RESULTS



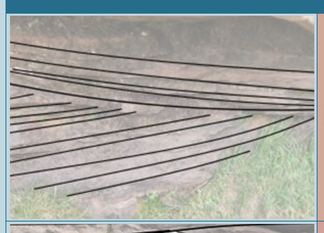
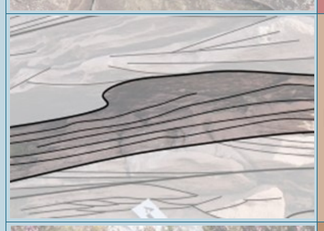
Facies Code		Structures	Interpretation	Average Porosity
	Laxb	Planar low-angle crossbedded	Subaqueous lateral accretion of migrating straight-crested dune-forms in the Lower Flow Regime.	16.05%
	Xb	Planar crossbedded	Subaqueous down-stream accretion of a Newtonian flow deposit and migration of straight-crested dune-forms.	15.31%
	Txb	Trough crossbedded	Subaqueous down-stream accretion of a Newtonian flow deposit and migration of sinuous dune-forms under uni-directional flow.	16.51%
	Pb	Parallel bedded	Subaqueous down-stream accretion of Upper Flow Regime plane bed deposition under uni-directional flow.	13.29%
	Cs	Structureless-nodular	Subaqueous down-stream accretion of a non-Newtonian flow deposit under high sediment load conditions. Diagenetic alteration forming calcite-rich nodules.	9.34%

Table 3.1. The individual facies identified as part of this work to date. The colours of the facies code correspond to the colours used in Figure 3.1. Cs facies was seen at a standalone outcrop ~500m southwest of Hare Hill (denoted as point “KNW” on Figure 2.1).

Figure 3.1 [Left] Logs taken at Hare Hill (001) [NT 17111 61869], East Cairn Hill (002) [NT 13064 59181], and West Cairn Hill (003) [NT 10540 57962] through the Kinnesswood Fm. Also shown are the annotated images of thin-sections sampled from the outcrops. Thin sections imaged at X40 mag. under XPL. Poly-/Mono-crystalline quartz [PQz/MQz], Lithic fragments [LF], Microcline [Mc], Muscovite mica [MM], Biotite [B], Opaques [O], Mineral inclusions [Mi], Overgrowths [Ov], Iron-staining/minerals [Fe], Cements [C], Undulose extinction [UE].

4.0 DISCUSSION

Based on a qualitative analysis of thin-sections, the Kinnesswood Formation is a quartz-arenite with less than five percent lithic fragments and other minerals. It may contain a larger percentage of lithic fragments some areas, but generally there is little change in mineralogy spatially or across facies. The dominant components include poly– and mono-crystalline quartz with small inclusions, and lithic fragments. Most grains have a dark iron-staining around the edges. In thin-section the KNW appears somewhat porous, but where present the pore throats are narrow due to quartz overgrowths or other cements. This suggests permeability may be low, and that an understanding of the diagenetic effects (including fracturing) may be important to the assessment of the geothermal system.

Porosity values calculated were within the usual range - from four to twenty-percent - for the Kinnesswood Formation (Brereton et al., 1988; Kearsey et al., 2024).

5.0 CONCLUSIONS AND FURTHER WORK

Preliminary results indicate a heterogenic sedimentological setting with low levels of porosity in the Kinnesswood Formation exposed in the Pentland Hills. Going forward the study area/stratigraphy will be expanded to assess more of the Upper Devonian/ Carboniferous strata of the MVS. Depositional models of the strata will be developed, and a petrographic and petrophysical analysis. An understanding of the diagenetic affects in the MVS will be key to develop a burial history: observations made from outcrop and samples can be translated to the subsurface accounting for effects of loading, compaction, pressure changes and other diagenetic effects - such as fracturing. These results will be used to inform numerical models for reservoir quality and fluid flow in the subsurface, and burial history scenarios in order to model the temperature and stress, and ultimately a diagenetic paragenesis.

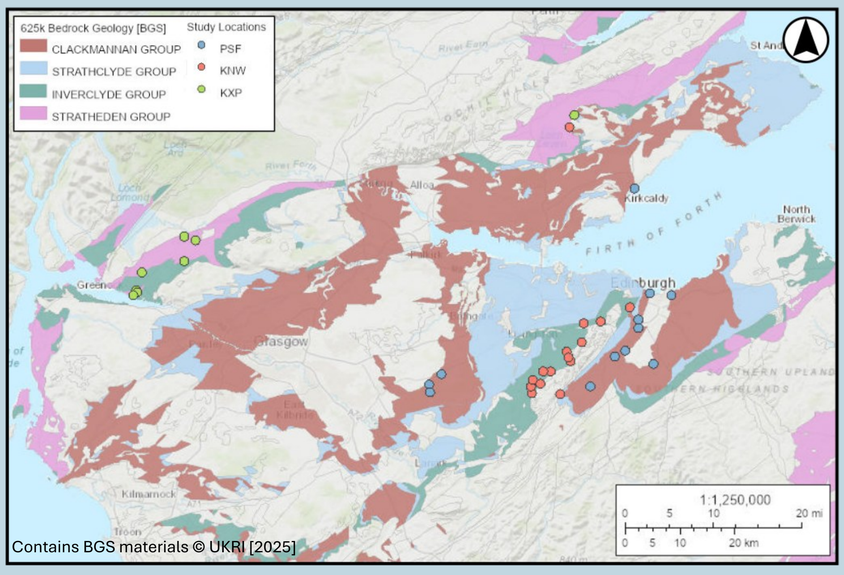


Figure 5.1. The prospective study locations of the Passage Formation [PSF], Kinnesswood Fm. [KNW], and Knox Pulpit Fm. [KXP].

Expand Study Area → Architectural Elements → Depositional Model → Petrographic Analysis → Petrophysical Analysis → Diagenetic Analysis → Numerical Modelling

Acknowledgements

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REFERENCES

Ballantyne, C. (2024) ‘Investigating variations in reservoir quality of the Kinnesswood Formation for geothermal energy applications in the Central Belt of Scotland’, MSc, Heriot-Watt University.

Brereton, R., Browne, M. A. E., Cripps, A. C., Gebski, J. S., Bird, M., Halley, D. N. and McMillan, A. A. (1988) *Glenrothes Borehole: Geological Well Completion Record*, Investigation of the Geothermal Potential of the UK, British Geological Survey.

Kearsey, T. I., Receveur, M. and Monoghan, A. A. (2024) *Modelled hot sedimentary aquifer geothermal potential of Upper Devonian strata in the Midland Valley of Scotland*, British Geological Survey Open Report.