

From Zircons to Shear Zones: Linking Iona's Gneisses to Britain's Old Crust

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1. Introduction & Definitions

The project's aim is to relate the **Lewisian Gneiss on Iona**, an island on the West coast of Scotland, to the wider Lewisian Gneiss Complex in the NW Scottish Highlands ("Mainland Gneiss") to gain a deeper understanding of lower crustal processes three billion years ago [1]. **Lewisian Gneiss** is an ancient metamorphic rock [2]. **Metamorphic rocks** are created when pre-existing rocks are subject to high pressure and temperature ("are cooked").

To relate the Iona gneiss to the Mainland gneiss, this project investigates a **possible equivalent of the Laxford Shear Zone** on Iona (Figure 1) [3]. A **shear zone** is a zone where blocks of rocks on both sides moved relative to each other, thereby causing deformation. On the mainland, the Laxford shear zone separates a northern block dominated by K-Feldspar-bearing lithologies (pink) from the so called central block that is conspicuously K-Feldspar-absent (white) [4]. An equivalent shear zone may exist on Iona.

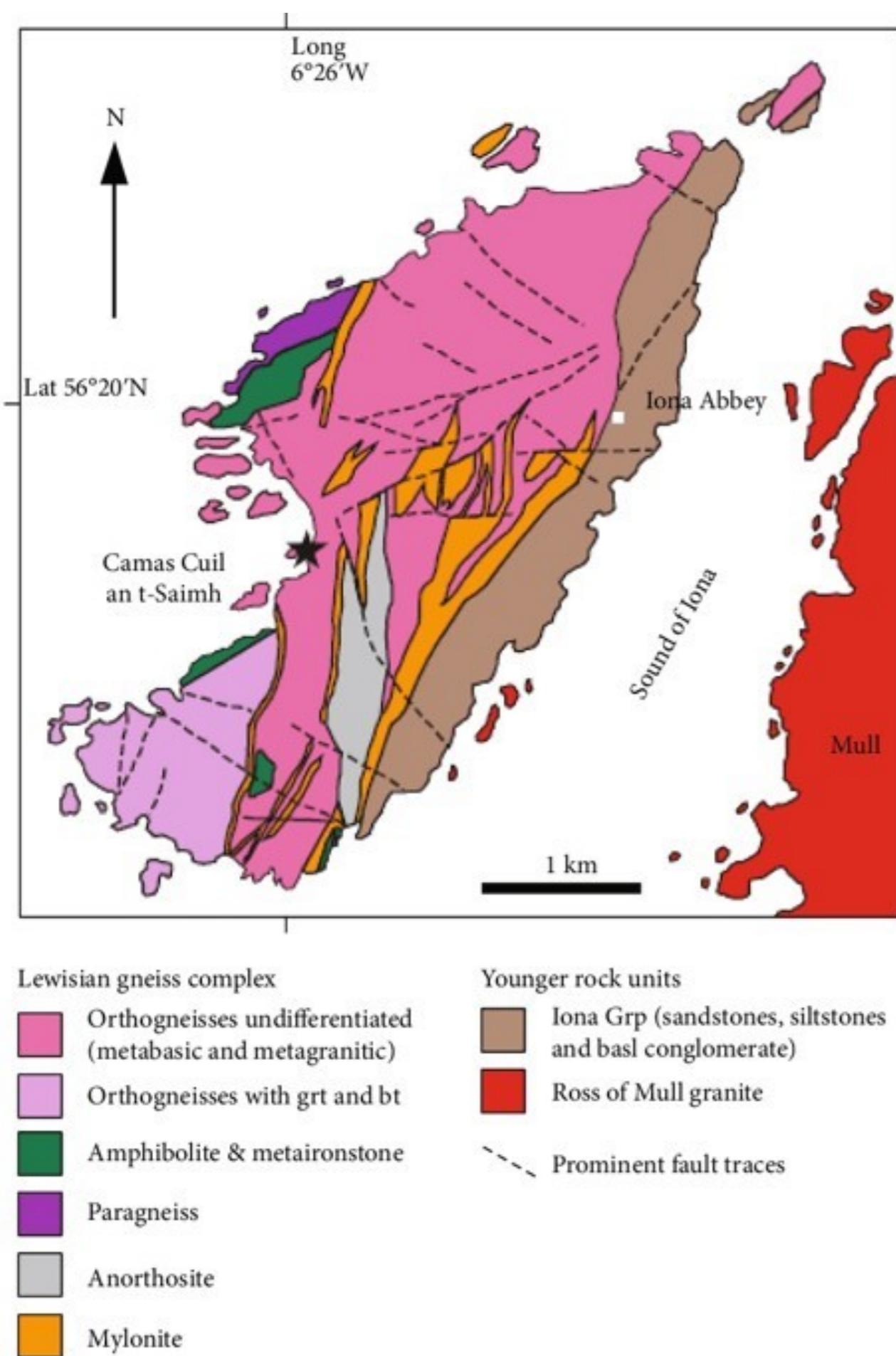


Figure 1: Map of Iona, Showing the Boundary between Orthogneiss with garnit and biotite (light pink) and Undifferentiated Orthogneiss (dark pink). [3]

The three parts of the project's first summer are field-work to collect gneiss samples, an optical comparison of the Laxford Shear Zone and the possible equivalent on Iona, and the separation of the mineral zircon for forthcoming research on an age constraint for Iona gneiss.

2. Hypothesis

Across fault zones, the distinct blocks of rocks often differ in mineral composition. Furthermore, the rocks typically "dip" (are inclined) at a steeper angle closer to the fault. At the Laxford Shear Zone, the two blocks

of rocks differ as the Northern block is characterised by K-Feldspar rich gneiss (pink) and the Southern block is characterised by K-Feldspar poor gneiss (white) [4]. The colour difference indicates an age difference between the two blocks. If the boundary on South Iona is equivalent to the Laxford Shear Zone, a similar distinction between pink and white gneiss on opposite sites of the fault would be observable.

3. Methodology



Figure 2: Shear Zone on South Iona with Approximated Dips

The research this summer was divided in three major parts: collection of samples, field observations comparing potential shear zones, and the separation of zircons from the sample for dating in the laboratories of the School of Earth Sciences. The dating itself is scheduled for winter 2022/23. The steps completed so far are:

- to examine outcrops of Lewisian Gneiss at the Laxfordian sheen zone (NW Highlands) and on South Iona to familiarise oneself with the different mineral composition and metamorphic features
- to take samples of K-Feldspar-rich (pink) Lewisian gneiss and K-Feldspar-poor (white) Lewisian gneiss at both sides of the Laxfordian sheen zone and on both sides of the hypothesised sheen zone on Iona
- to break samples of pink and white Lewisian gneiss from South Iona using a jaw crusher
- to sieve samples and separate grains of $< 350 \mu\text{m}$
- to use heavy water for density separation
- to subdivide grains with density $> 2.8 \text{ gcm}^{-3}$ by magnetic properties, keep non-magnetic grains
- picking out individual zircon grains for future analysis (has been started)

4. Results and Limitations



Figure 3: Boundary Between White and Pink Gneiss on South Iona

Figure 2 shows that the dip of Lewisian Gneiss on Southern Iona steepens by multiple tens of degrees



Figure 4: Overview of Lewisian Gneiss on South Iona

compared to the baseline state (Figure 4). This together with an observed change in colour between pink K-Feldspar rich gneiss in the NE of Iona and white K-Feldspar poor gneiss in the SW of Iona (Figure 3) provides evidence for the hypothesis that a fault runs through South Iona, which at least appears similar to the Laxford Shear Zone on the mainland. However, it would require quantitative data on the ages of the blocks of rock and of the fault itself to connect this fault to the Laxford Shear Zone.

5. Forthcoming Research

The new geochronology facility will be used to determine ages for two types of Lewisian Gneisses on South Iona. The next steps include:

1. identifying zircon grains under the microscope based on optical properties (sheen, colour, and shape)
2. investigating the zonations in the extracted zircons and identify different growth domains using the state-of-the-art microprobe at St Andrews
3. using U-Pb dating to compare the age of the Iona gneisses to the Scottish mainland Lewisian gneiss

The direct age constraint will allow an insight into a possible link between the Laxford Shear Zone and the fault on South Iona, for which no published age exists.

6. Acknowledgements

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References

- [1] S. R. Miorcevic, A. Copley, and O. M. Weller, "Testing the importance of sagduction: insights from the lewisian gneiss complex of northwest scotland," *Precambrian Research*, vol. 379, p. 106708, 2022.
- [2] C. A. McAteer, J. S. Daly, M. J. Flowerdew, M. J. Whitehouse, and N. M. Monaghan, "Sedimentary provenance, age and possible correlation of the Iona group SW Scotland," *Scottish Journal of Geology*, vol. 50, no. 2, pp. 143–158, 2014.
- [3] T. J. Dempster, A. D. Hollingsworth, E. McIntosh, S. Edgar, J. W. Faithfull, and D. Koehn, "Deformation-induced and reaction-enhanced permeability in metabasic gneisses, Iona, Scotland: controls and scales of retrograde fluid movement," *Geofluids*, vol. 2021, 2021.
- [4] K. Goodenough, Q. Crowley, M. Krabbendam, and S. Parry, "New U-Pb age constraints for the Laxford Shear Zone, NW Scotland: Evidence for tectono-magmatic processes associated with the formation of a paleoproterozoic supercontinent," *Precambrian Research*, vol. 233, pp. 1–19, 2013.
- [5] S. Fischer, A. R. Prave, T. E. Johnson, P. A. Cawood, C. J. Hawkesworth, M. S. Horstwood *et al.*, "Using zircon in mafic migmatites to disentangle complex high-grade gneiss terrains—terranes spotting in the Lewisian complex, NW Scotland," *Precambrian Research*, vol. 355, p. 106074, 2021.