OSL dating of Late Pleistocene raised shorelines in northwest Scotland

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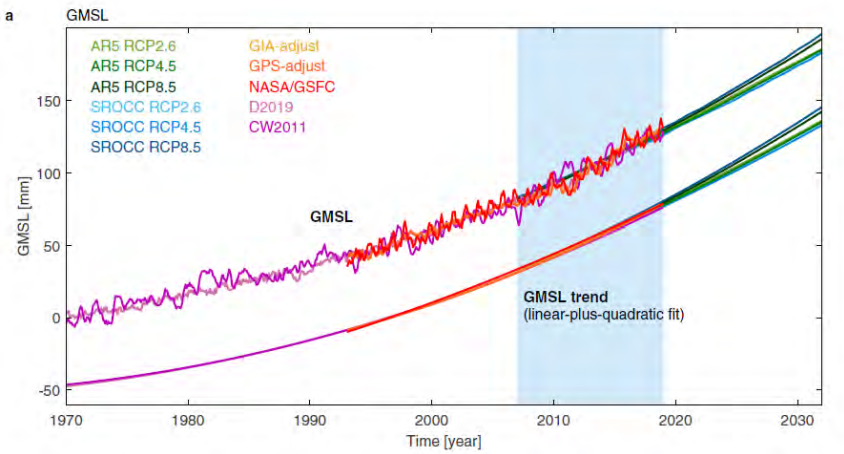
Outline

- Why are we studying raised shorelines in Scotland?
- Field sites
- OSL procedures
- First results

Interactions between ice sheet and sea levels

Sea levels are rising at an accelerating rate

- Wang et al. (2021) – 4.0 mm/yr
- Projected to be 15 mm/yr at the end of the century (Oppenheimer et al, 2019)



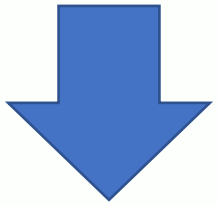
Wang et al., 2021

- Possibility of 2 m more within the next 100 years due to runaway marine ice sheet retreat of Greenland and Antarctic ice sheets (Siegert et al., 2020; Post et al., 2019)

- Models for the West Antarctic Ice Sheet indicate that the runaway marine ice sheet retreat could be stabilized by GIA and sea level feedback

- The mantle under the West Antarctic Ice Sheet is weak and sensitive to loading and unloading
- Topography and mantle are different for the East Antarctic Ice Sheet and Greenland
- This leads to large uncertainties in predictions of sea level rise!

How do mantle rheology and topography influence stabilization of ice sheets?



Use an analogous setting that is already completely deglaciated: British-Irish Ice Sheet

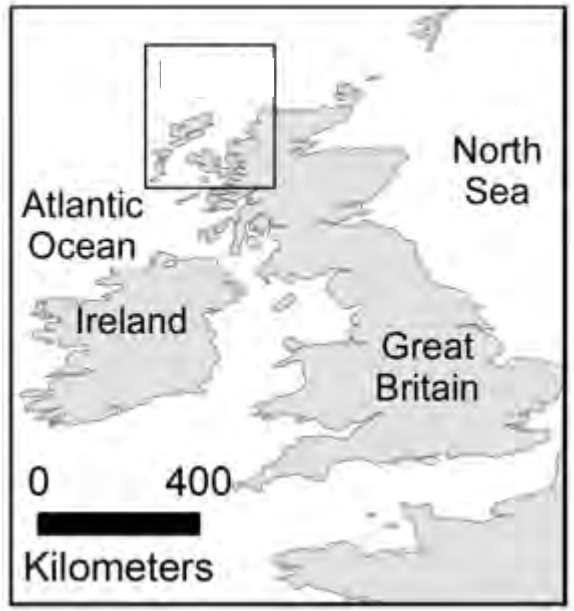
The British-Irish Ice Sheet as Analog

- At the last glacial maximum (LGM) the BIIS connected with the Fennoscandian Ice Sheet

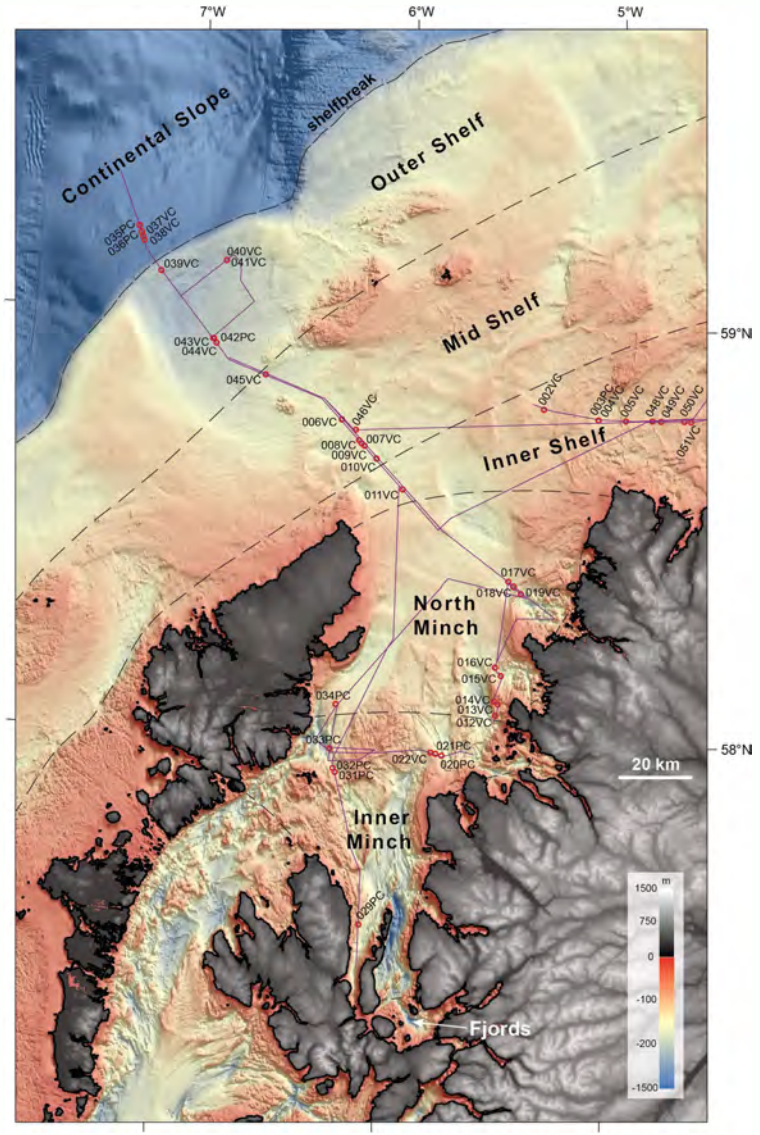
- Several ice streams drained along its margins

Hughes et al., 2016

Minch Ice Stream (MIS)



- Between Outer Hebrides and the NW Scotland mainland
- Size comparable to ice streams in Antarctica and Greenland
- Similar rheology and topography
- Start of retreat ~30 ka
- Rapid and final retreat ~17 ka



Bradwell et al., 2021

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JQS Journal of Quaternary Science QRA Quaternary Research Association

Pattern, style and timing of British–Irish Ice Sheet advance and retreat over the last 45 000 years: evidence from NW Scotland and the adjacent continental shelf

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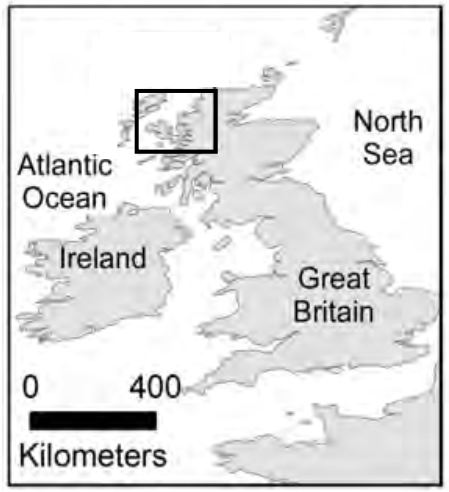
Our work:

provide age constraints on raised shorelines

additional input for existing GIA models

Field sites: September 2022

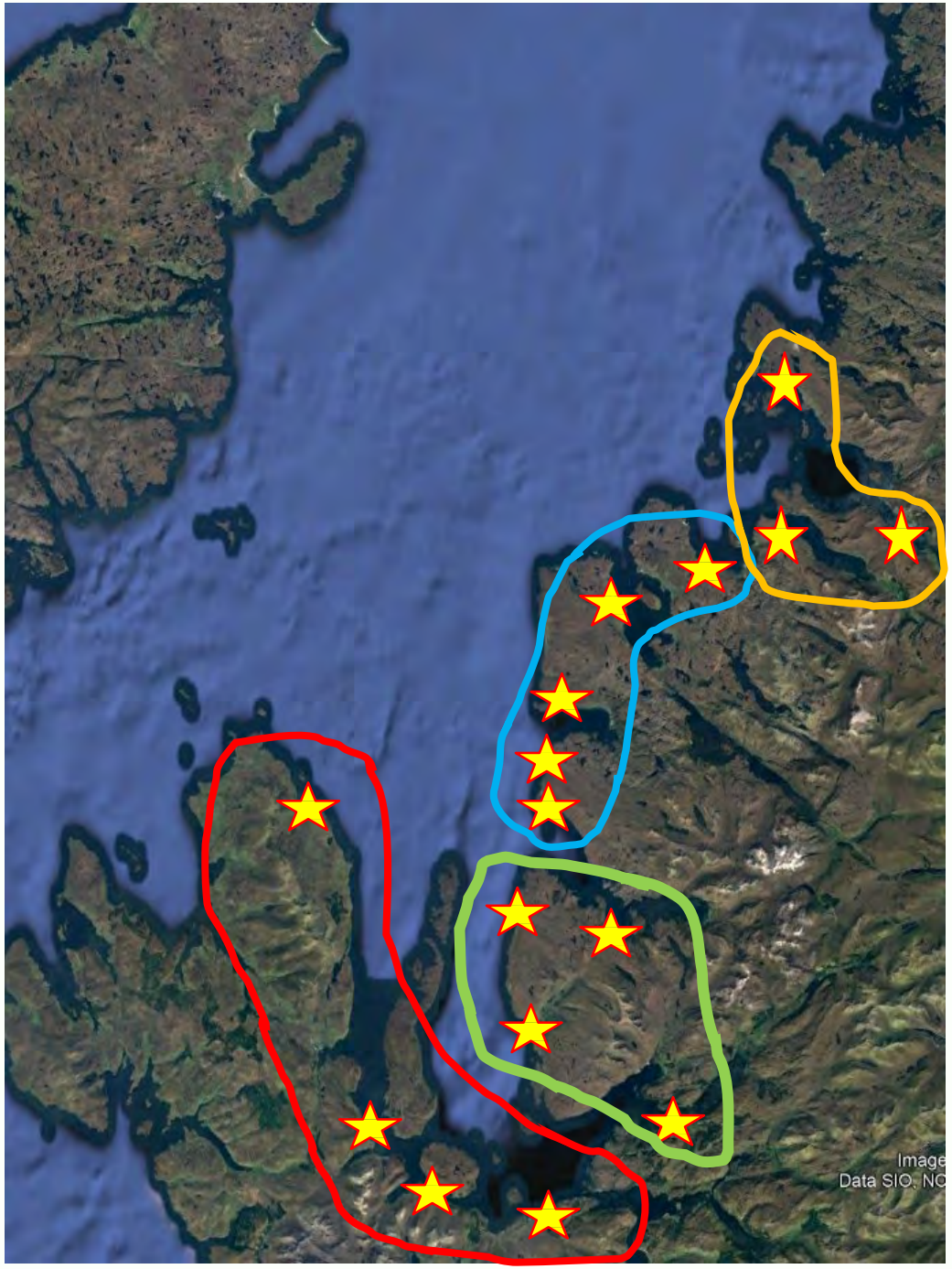


Collected 40+ samples

from 4 General Areas

- Skye
- Applecross
- Gairloch
- Ullapool

Samples were collected with tubes or under a tarp

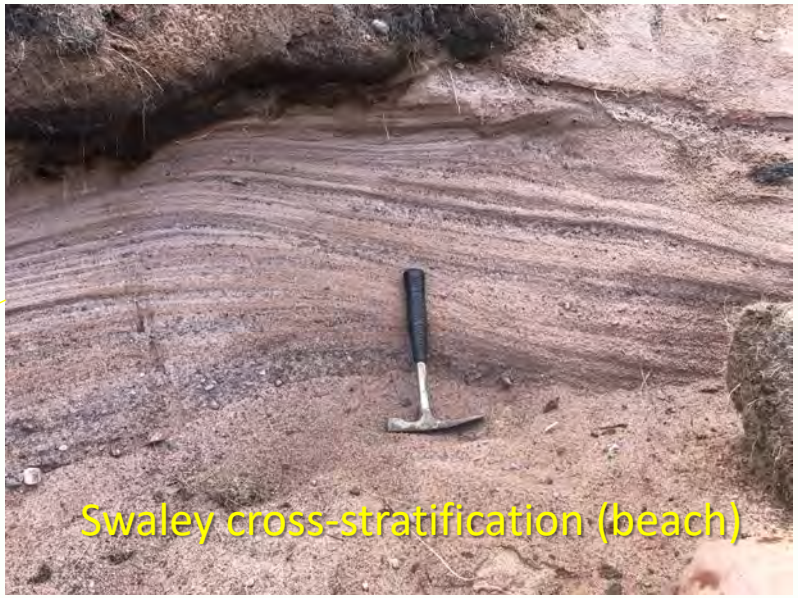


Applecross Heritage Center Site (AP22-02)

Cuiag Delta (AP22-11)

Topset surface of Uplifted Delta

South Erradale (GA22-01)



Slaggen Bay

- Pre-LGM?
  - Near 40-m?

Methods

- Standard procedures for extraction of coarse grain quartz, etching with HF

- Risø TL/OSL-DA-20 reader
- Hoya U-340 filters (290-370 nm)
- built-in $^{90}Sr/^{90}Y$ beta source, dose rate ~100 mGy/s
- blue LEDs (470 nm), 82 mW/cm^2
- IR at 875±80 nm, 124 mW/cm^2
- 2 mm aliquots

- high resolution Ge gamma spectrometer

OSL properties: Applecross AP22-02

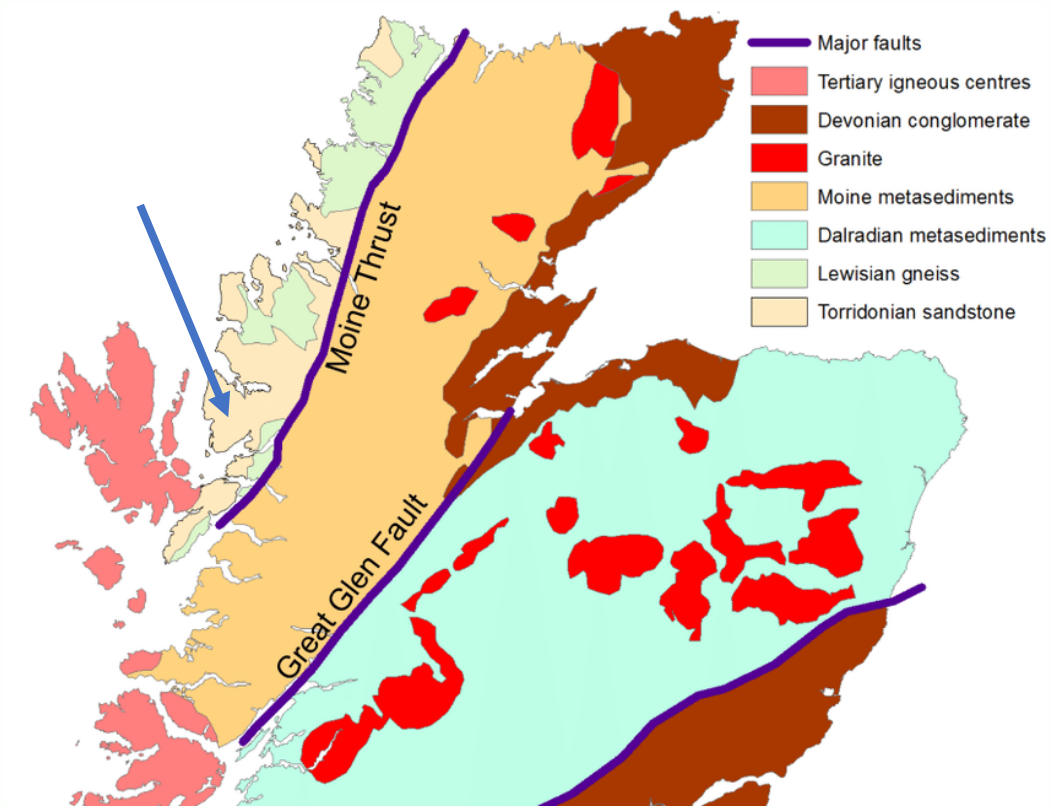
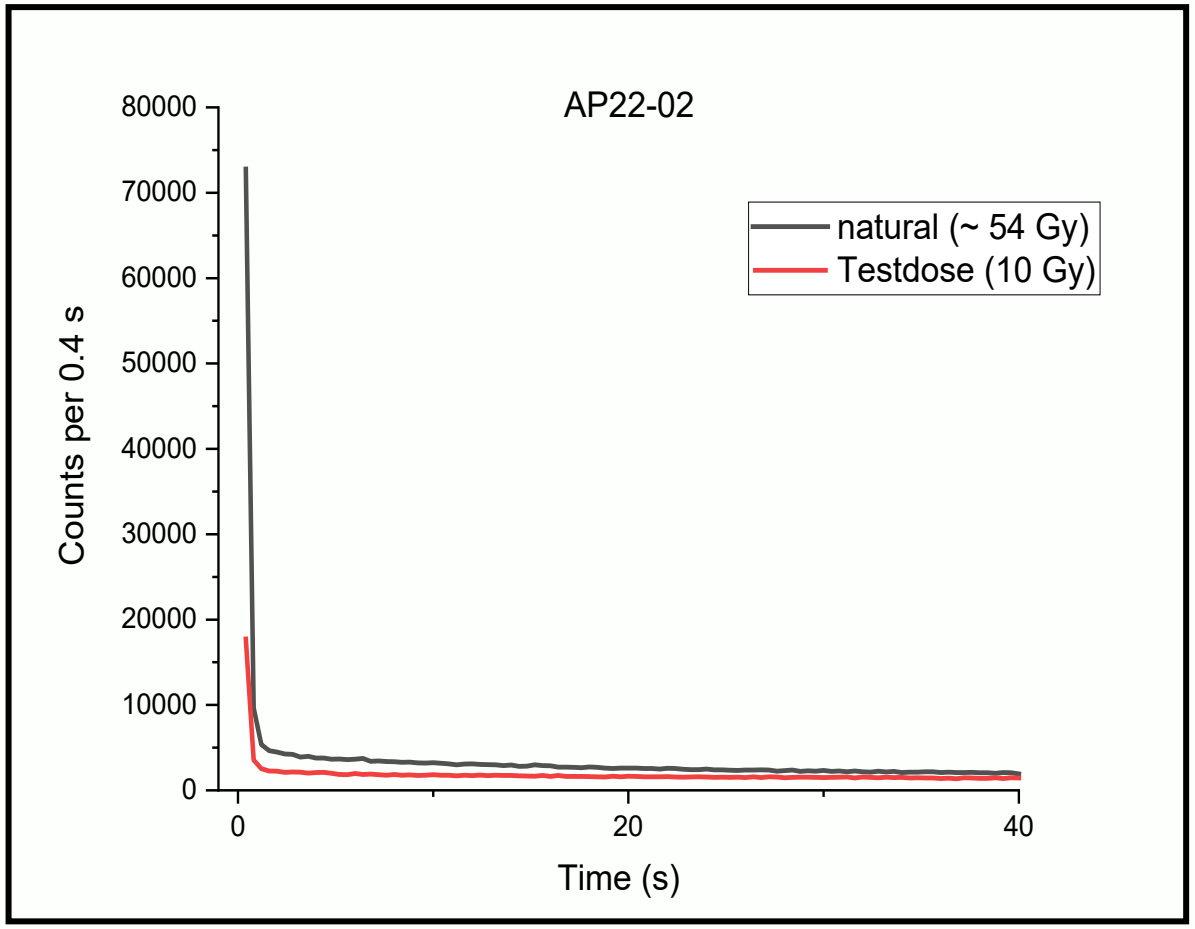
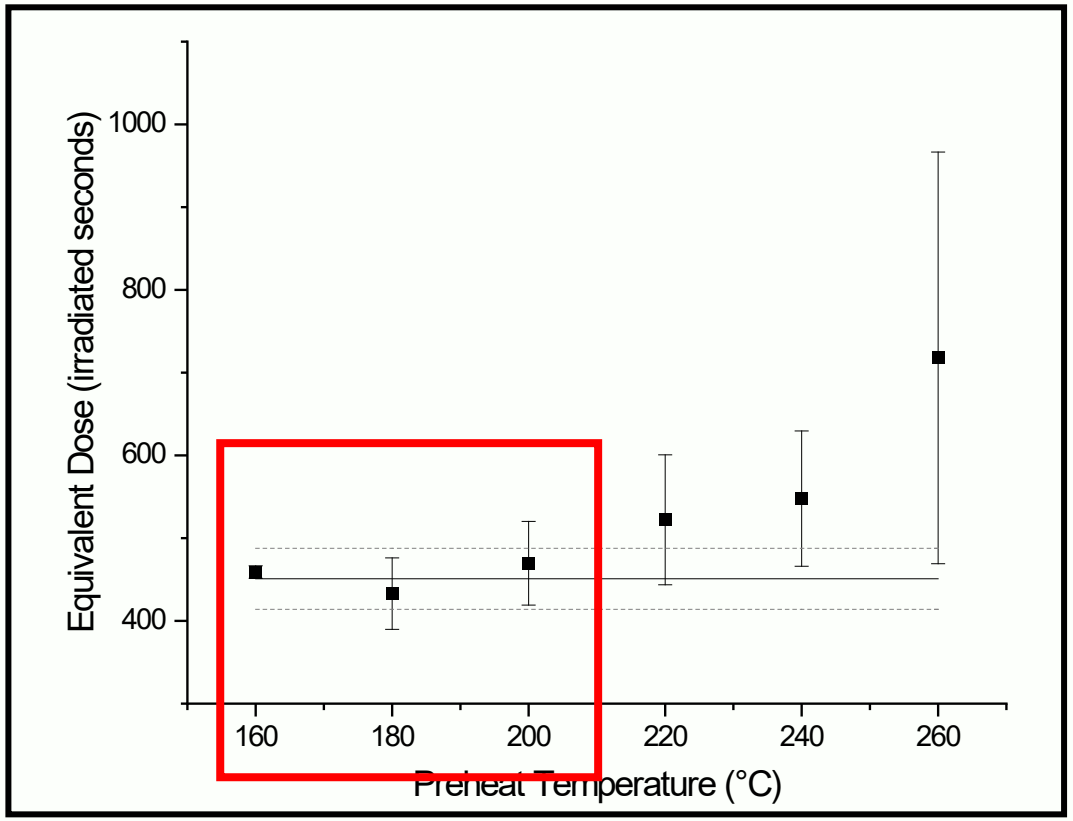


Fig 2.2 from Whitbread 2012

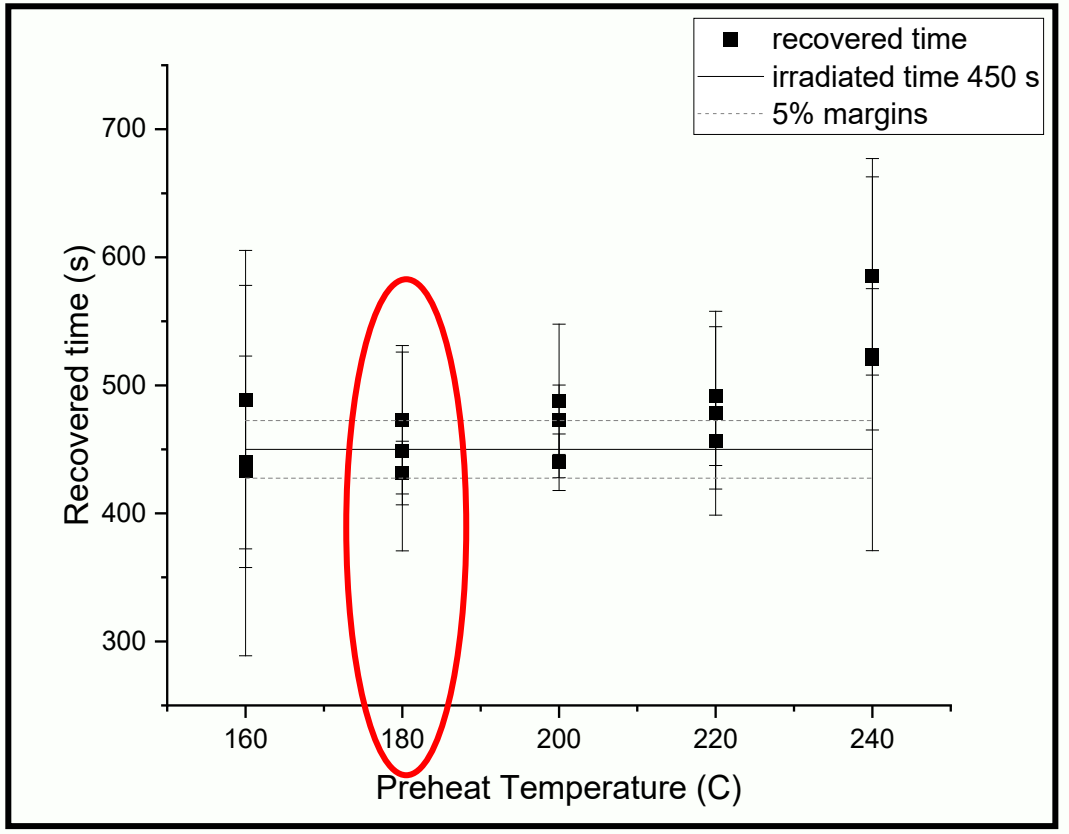


OSL properties: Applecross AP22-02

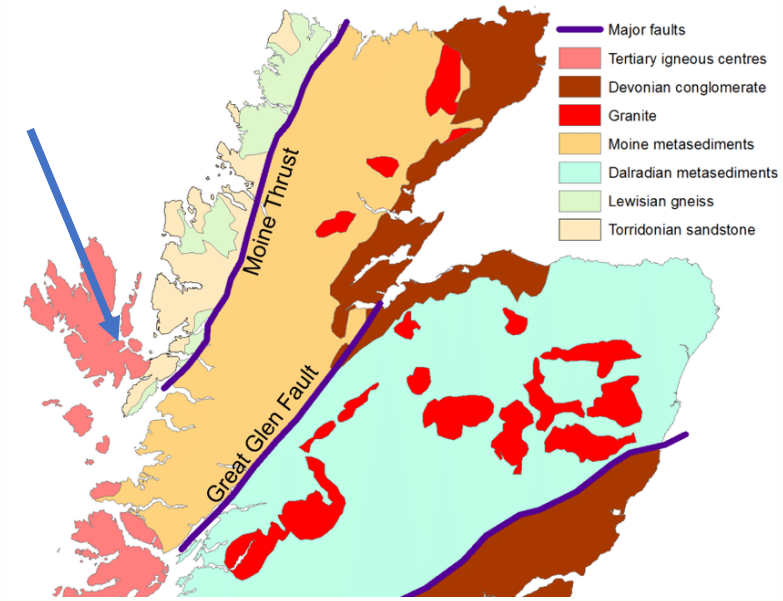
Plateau test



Dose recovery test



OSL properties: Skye KQ22-02



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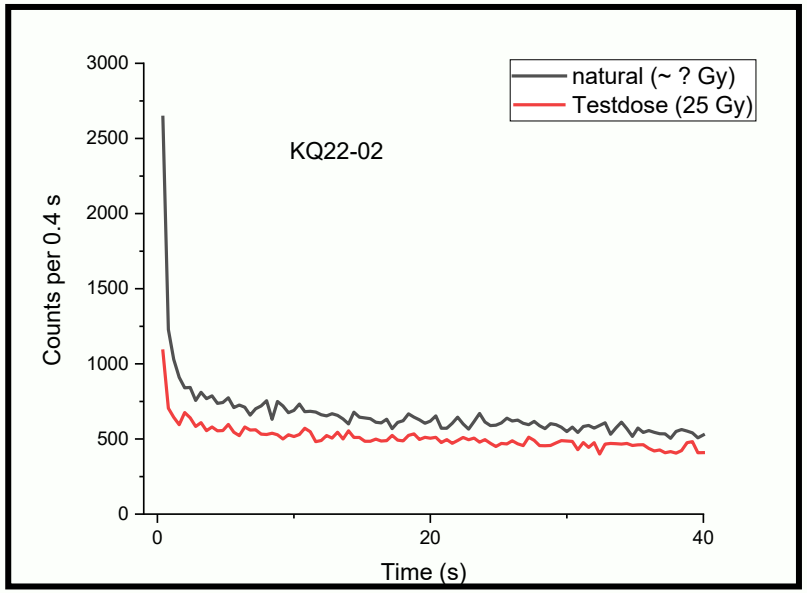
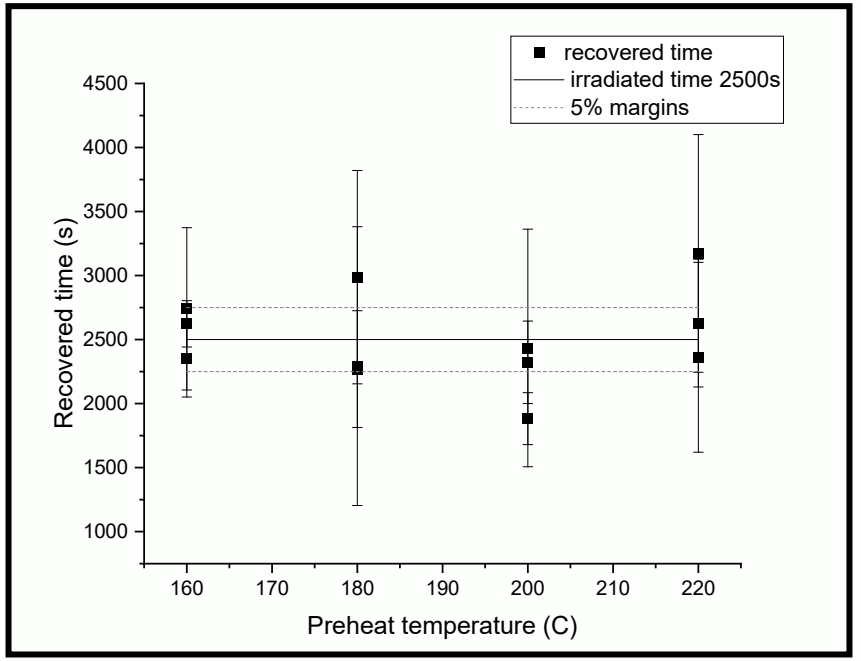




Equivalent dose: CAM

Sample	grain size (µm)	n measured	n used	Dose (Gy)			Overdisp. (%)
TB22-02	90-125	38	22	172	±	13	16
AP22-02	150-180	42	36	49.6	±	2.7	9.2
AP22-08	90-125	83	24	52.6	±	4.1	24
AP22-11	180-212	26	26	48.0	±	2.8	8
AP22-12	90-125	38	35	64.0	±	3.6	11
					±		
GA22-01	125-150	29	28	55.1	±	3.2	8
GA22-13	150-180	29	28	139.1	±	8.9	18
GA22-14	180-212	41	35	132.9	±	8.5	20
					±		
UL22-01	90-150	42	20	84.1	±	7.1	19

Dose rates

- High resolution gamma spectrometry; conversion factors by Guérin et al. (2011).
- Grains were etched to remove contribution by alpha-radiation
- Cosmic Dose rate: Prescott and Hutton (1994).

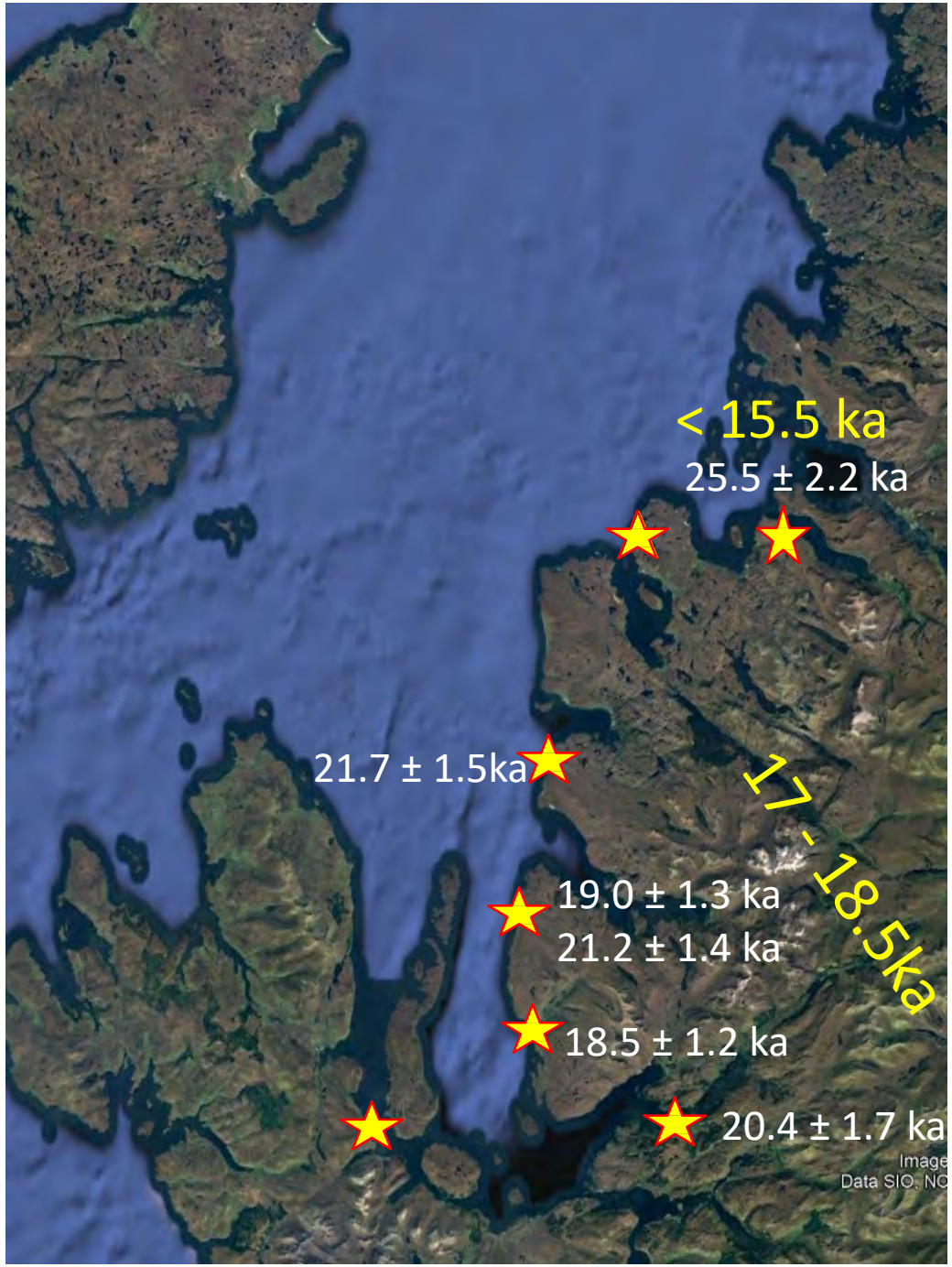
- Th: 3-5 ppm, K~ 2%
- ^{234}Th (92 keV) 1.5-2ppm
- U (^{214}Bi and ^{214}Pb): 0.5-1.5 ppm

radioactive disequilibrium (beach environment; could be leaching of ^{226}Ra or intake of ^{234}Th)

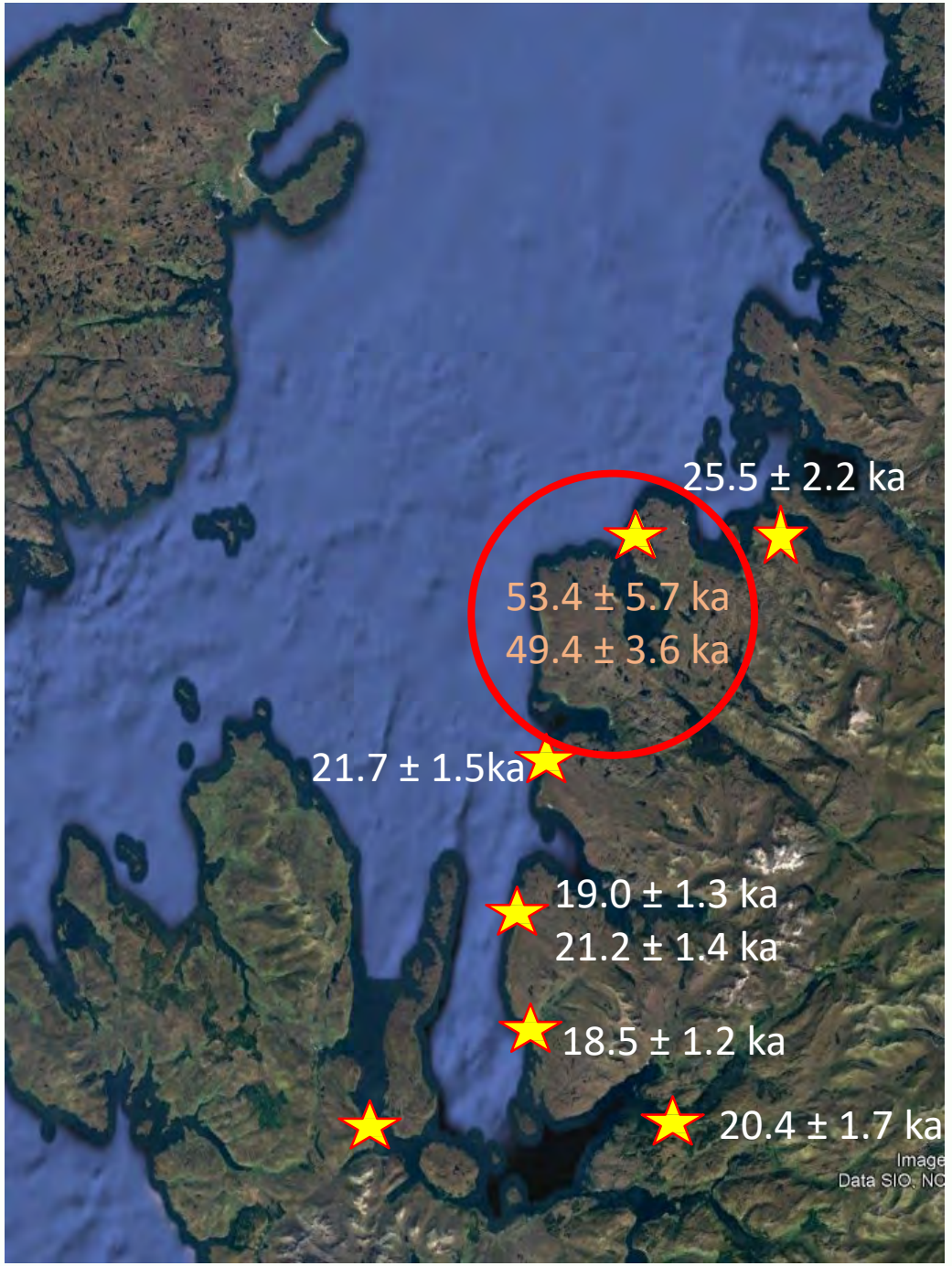
- Dose rates 2-3 Gy/ka

Ages

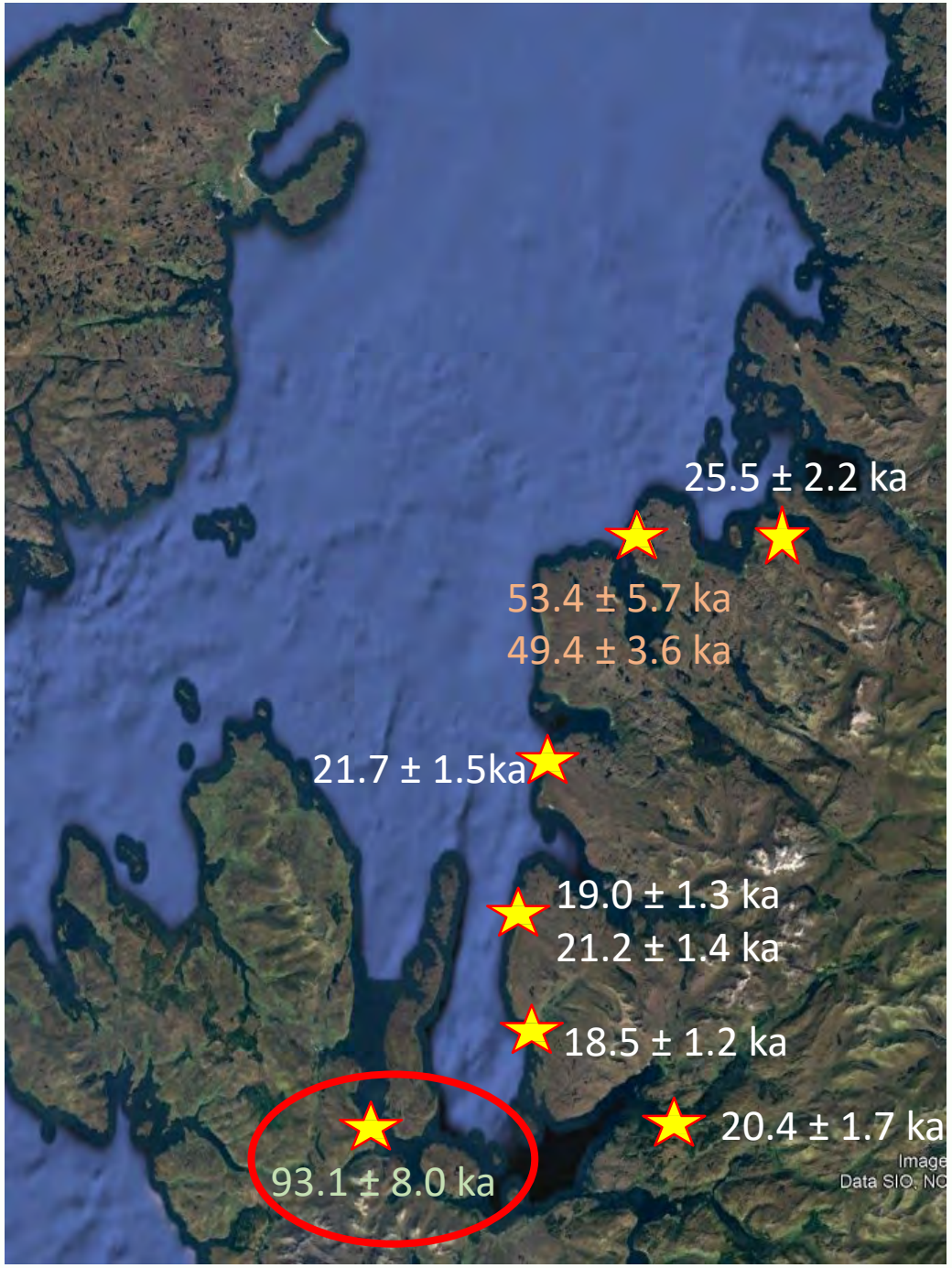
Expected ages (Bradwell et al. 2019, 2021) in yellow



Ages


25.5 ± 2.2 ka
53.4 ± 5.7 ka
49.4 ± 3.6 ka
21.7 ± 1.5ka
19.0 ± 1.3 ka
21.2 ± 1.4 ka
18.5 ± 1.2 ka
20.4 ± 1.7 ka
Image
Data SIO, NO

Ages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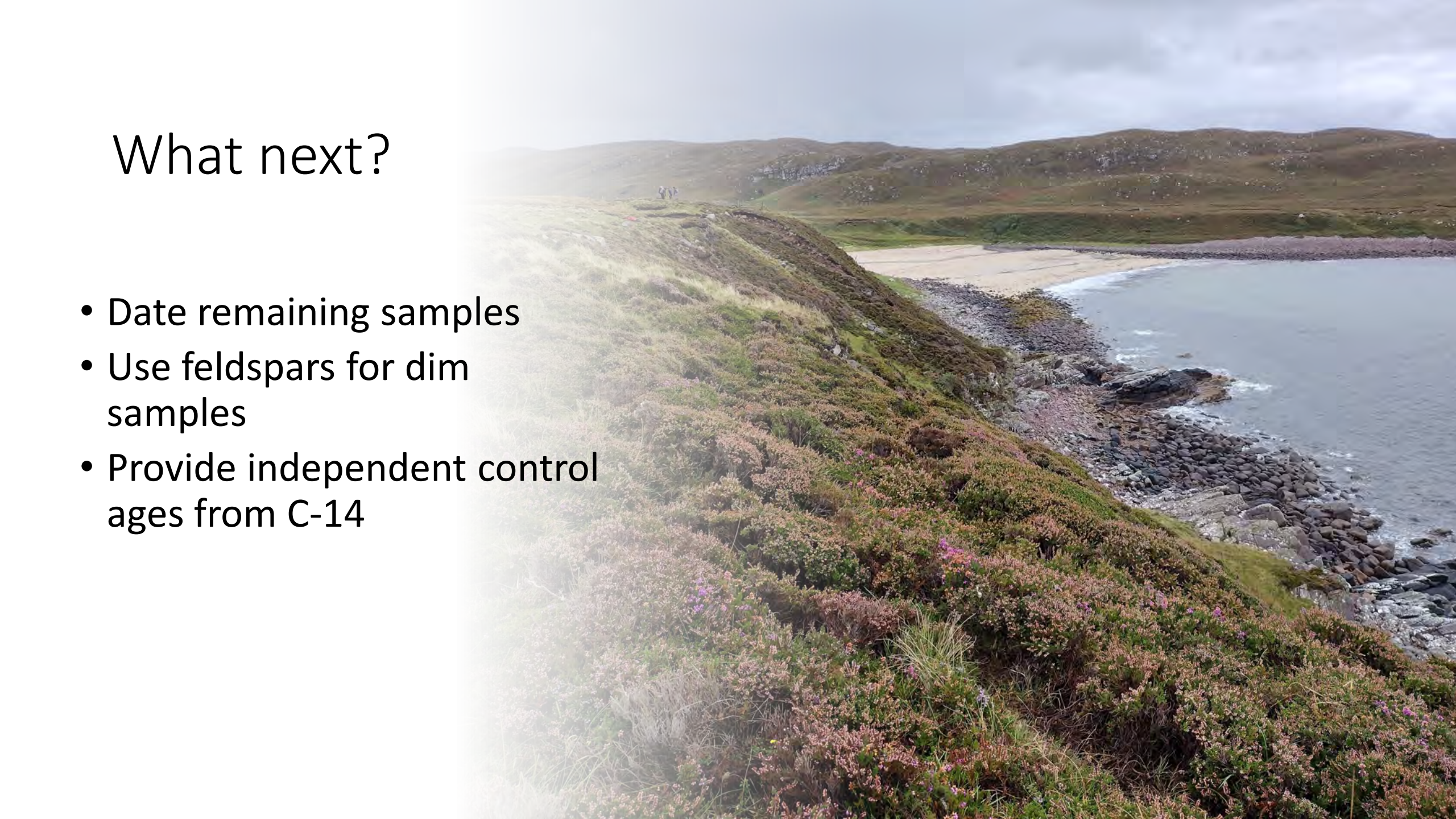
19.0 ± 1.3 ka
21.2 ± 1.4 ka
18.5 ± 1.2 ka
20.4 ± 1.7 ka
93.1 ± 8.0 ka
Image
Data SIO, NO

Conclusions

- 9 out of 40 samples have been dated so far
- Samples in sandstone-dominated areas have good OSL properties
- Ages are slightly older than expected
- There are some surprises: samples from Slaggan Bay fall into the MIS-3 range, one sample from MIS-5c

What next?

- Date remaining samples
- Use feldspars for dim samples
- Provide independent control ages from C-14



Thank you!

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The Braes (TB22-02)

Loggie (UL22-01)