Imaging the temperature beneath Ireland and Britain using massive, broadband surface-wave datasets and petrological inversion

Emma L. Chambers, Raffaele Bonadio, Sergei Lebedev, Javier Fullea, Duygu Kiyan, Christopher Bean, Brian O'Reilly, and Patrick Meere

Email:
echambers@cp.dias.ie

De-risking Ireland's Geothermal energy potential

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Why are we interested in the subsurface temperature in Britain and Ireland?

THE IRISH TIMES

Mon, Apr 19, 2021

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Geothermal energy could be new heat source for Ireland, reports show

Heat from beneath Earth's surface could be used in buildings, while decarbonising heat sector

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Southampton celebrates 25 years of geothermal District Energy Scheme

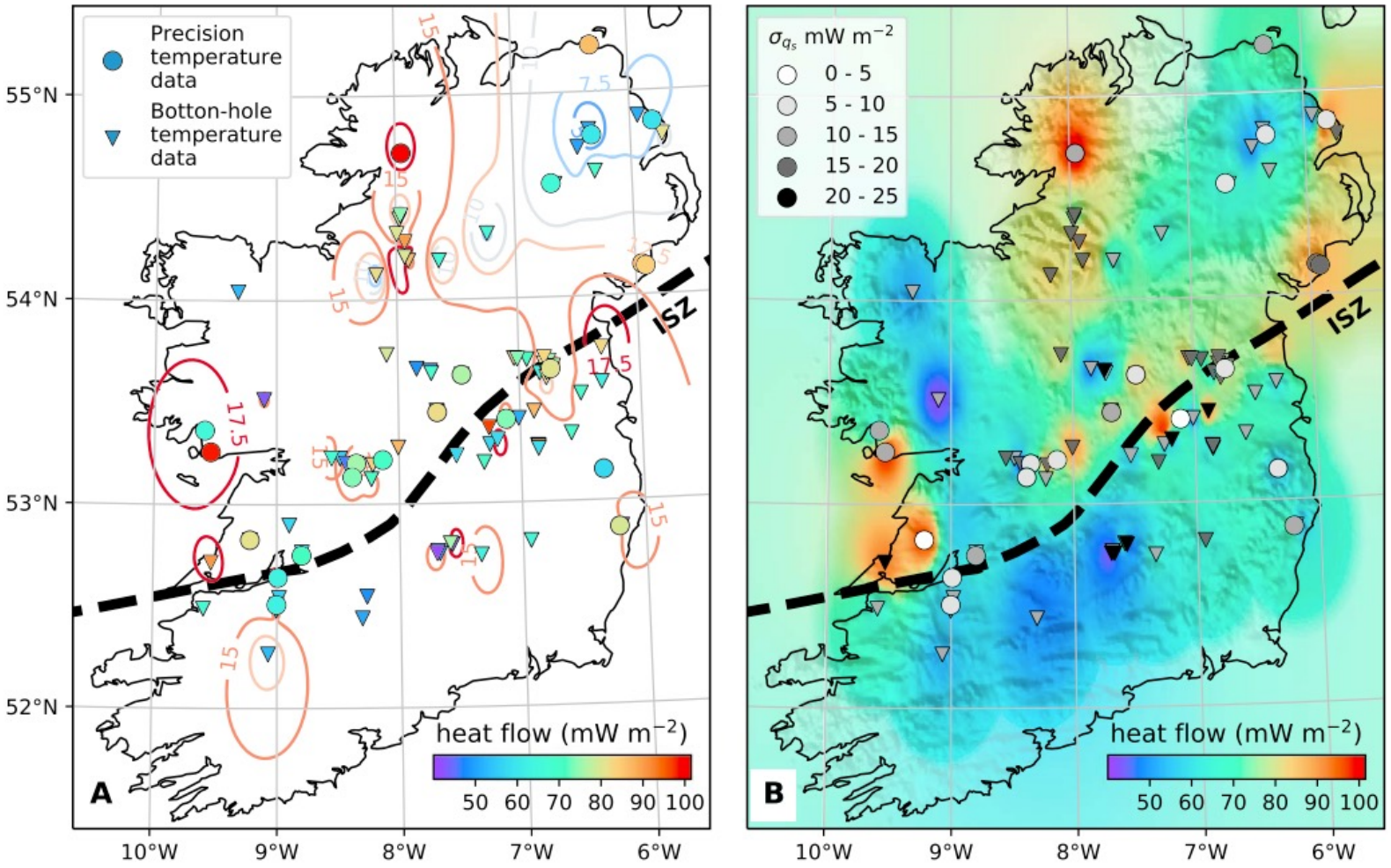
How can we map the geothermal gradient?

<u>Directly</u>

- Boreholes

<u>Indirectly</u>

- Seismic imaging
- Geophysical-Petrological inversion
- Magnetotellurics

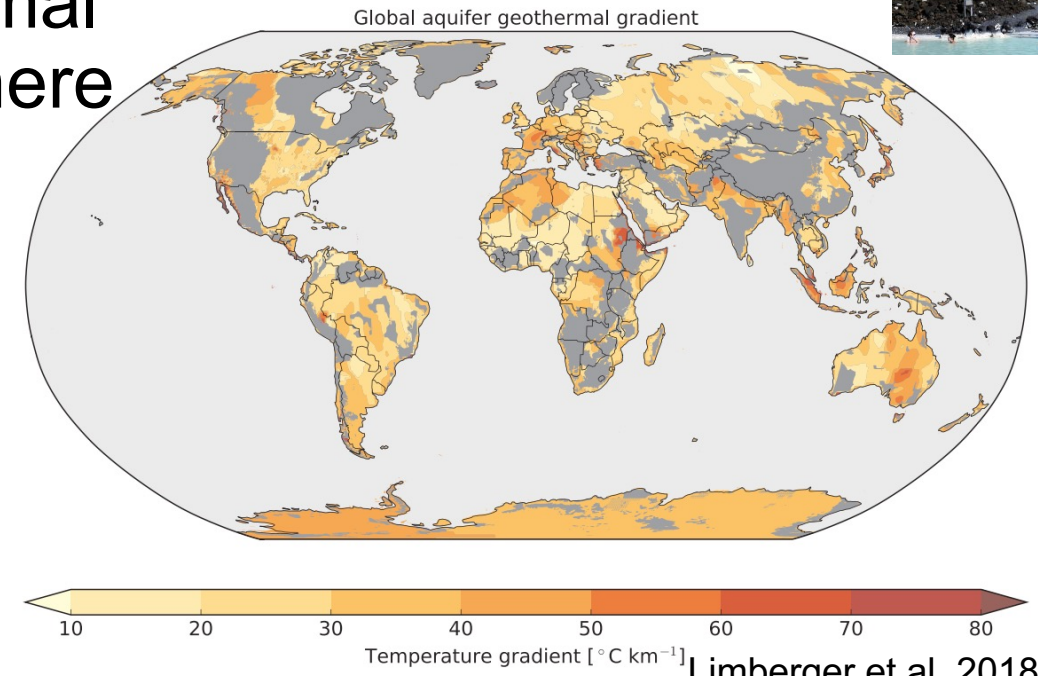


Mather et al. 2018

Lithospheric vs Crustal model for Geothermal

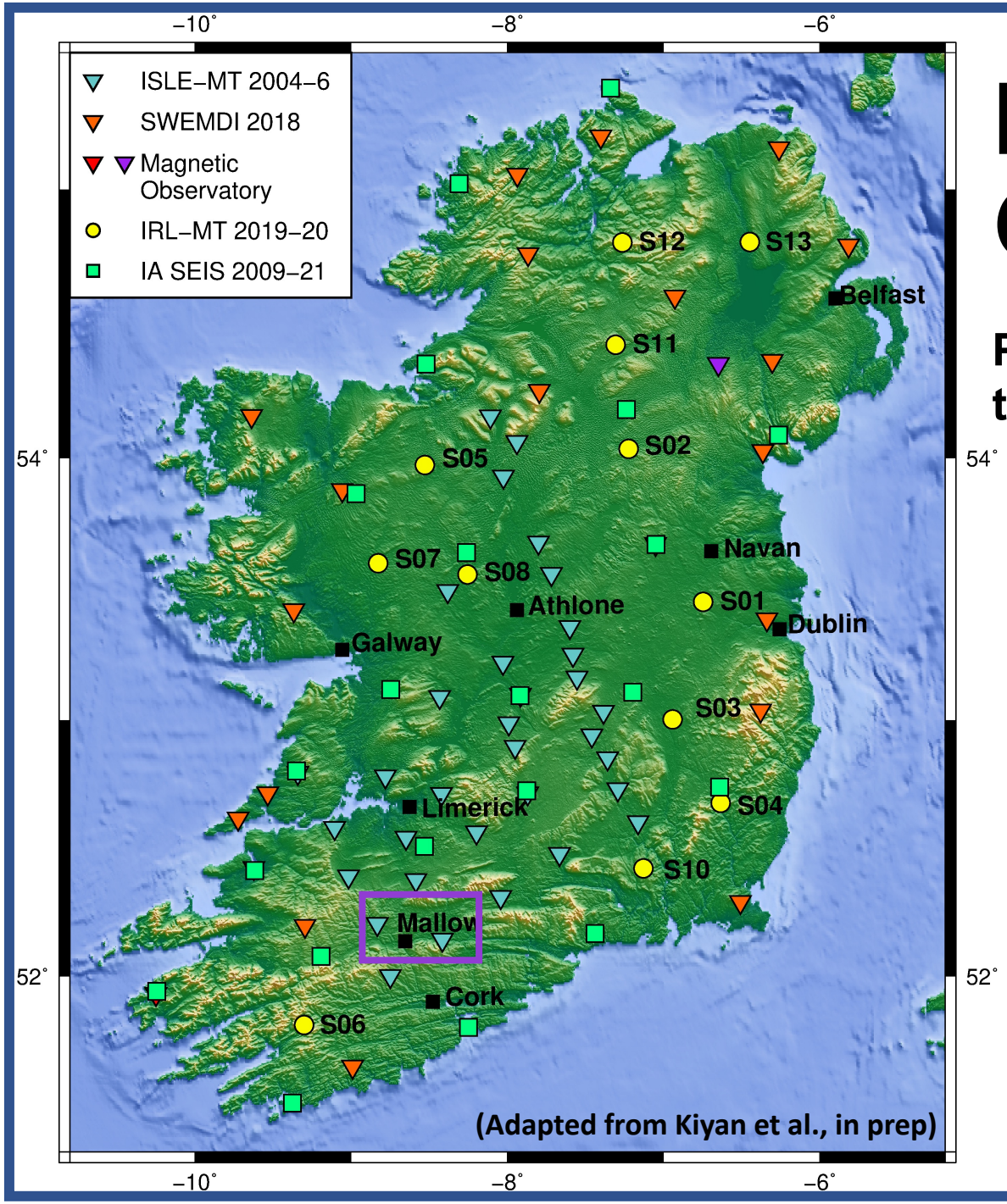
- Surface heat flow arising from 2 main sources
  - Crust - Mantle
- Earth's temperature rises from the surface to the core.
- Can have geothermal heat almost anywhere in the world
- Low enthalpy geothermal most efficient in heating systems

Figure credit: Alamy



Limberger et al. 2018

Mallow warm spring. From Goodman et al. (2004).

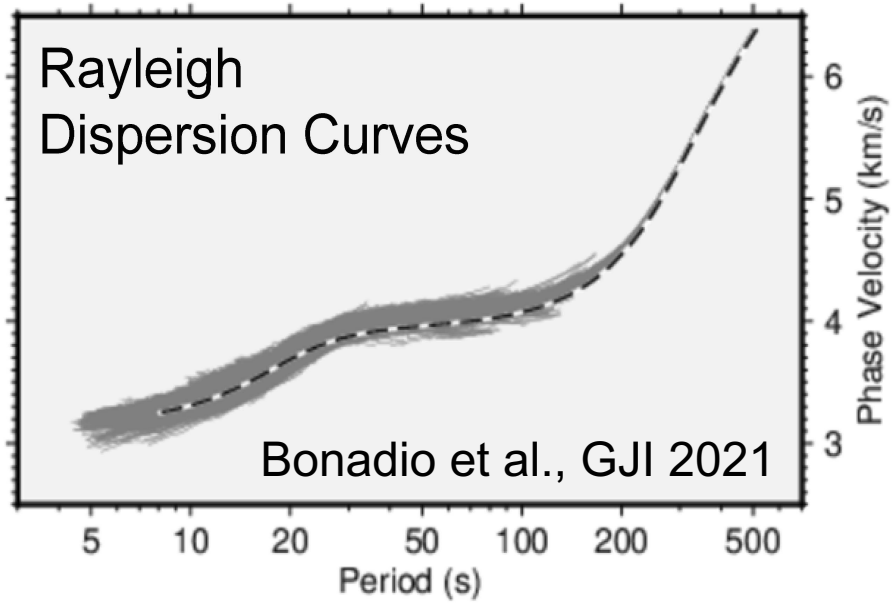


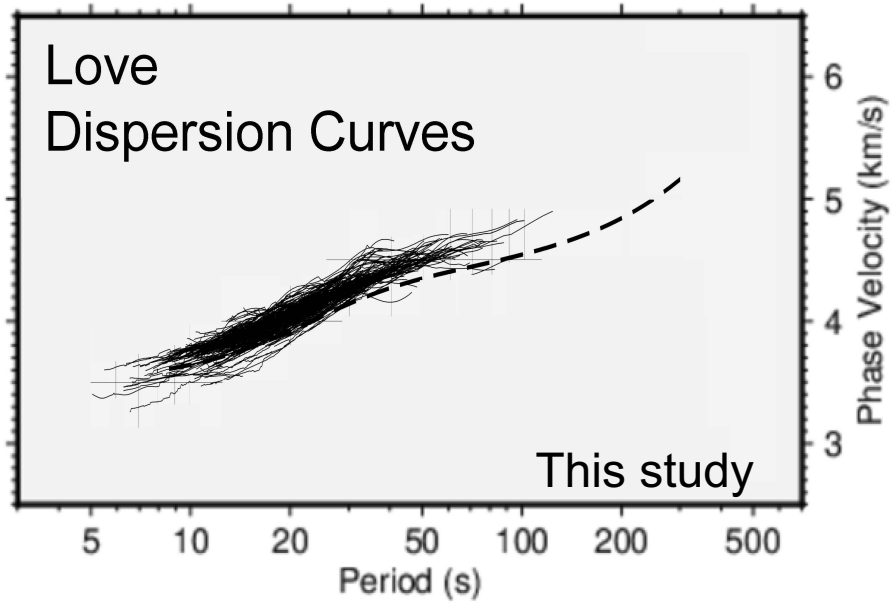
DIG - De-risking Ireland's Geothermal Potential

Primary Objective - De-risk borehole drilling costs to promote geothermal energy.

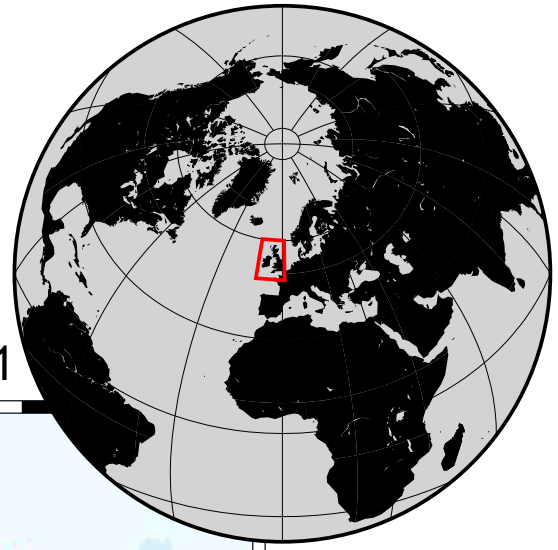
- **Creation of a reliable geothermal resource map of Ireland**
- **Determine the regional geothermal gradient** in Ireland
- Investigate the **thermo-chemical crustal structure** and **secondary fracture porosity within the Upper Devonian Munster Basin**
- Identify and **assess the available low-enthalpy geothermal resources at reservoir scale in the Munster Basin**

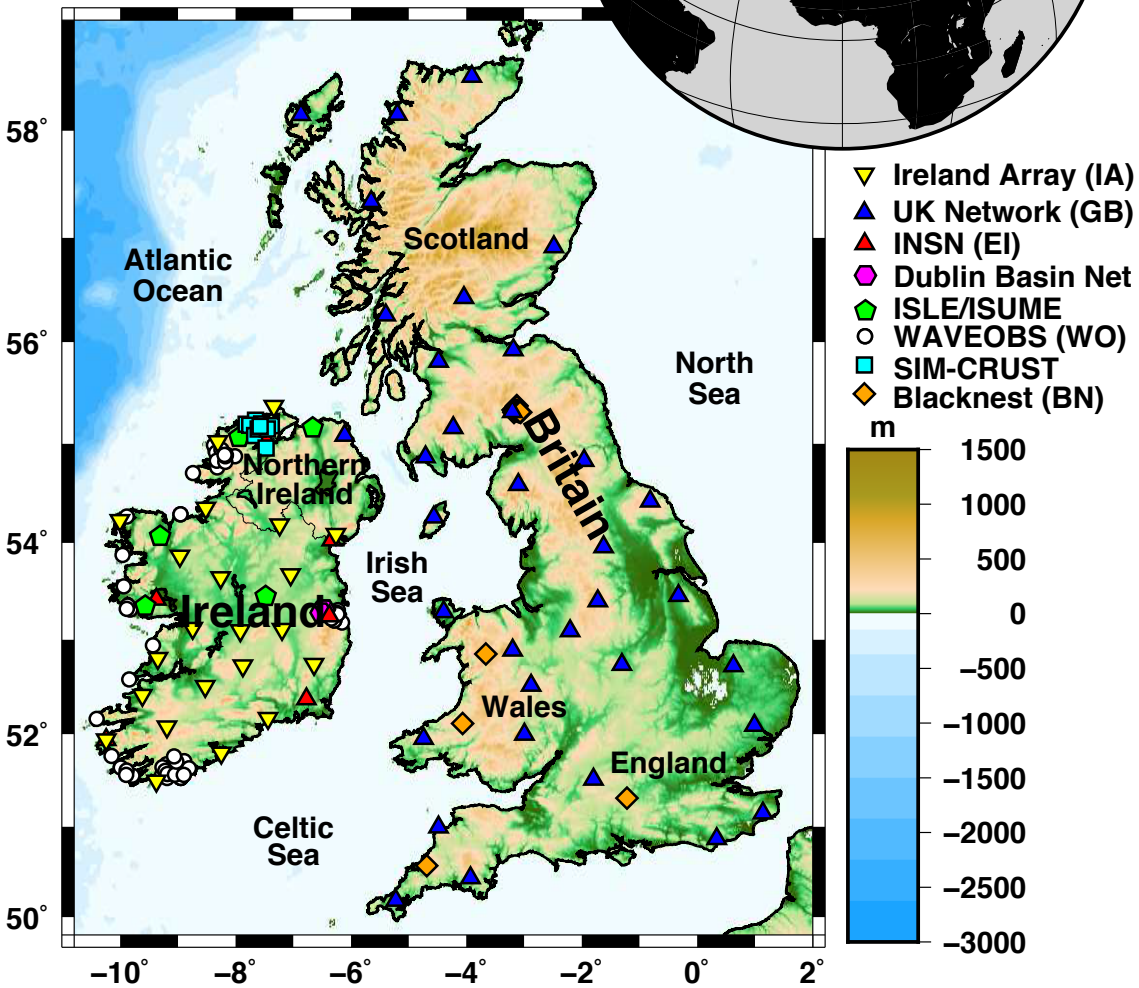
Regional Seismic Tomography



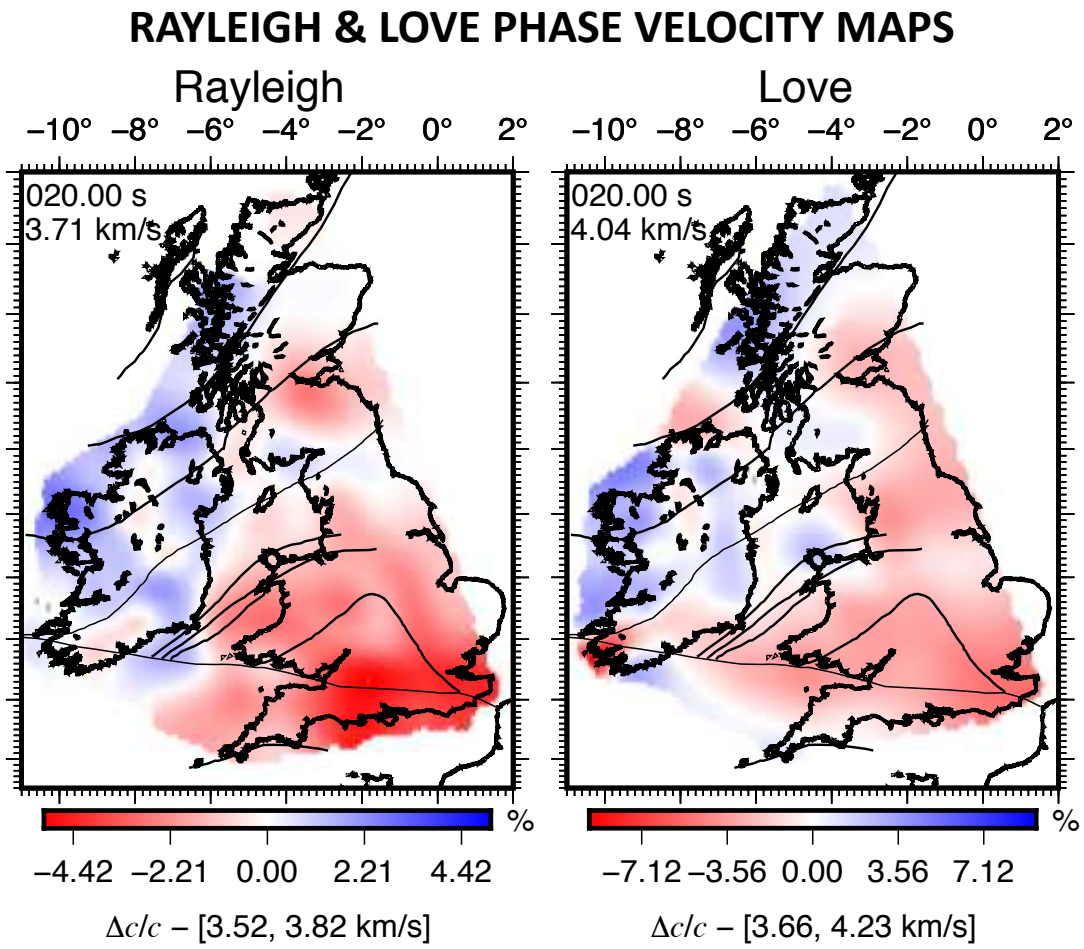


Based on
Bonadio et al., GJI 2021

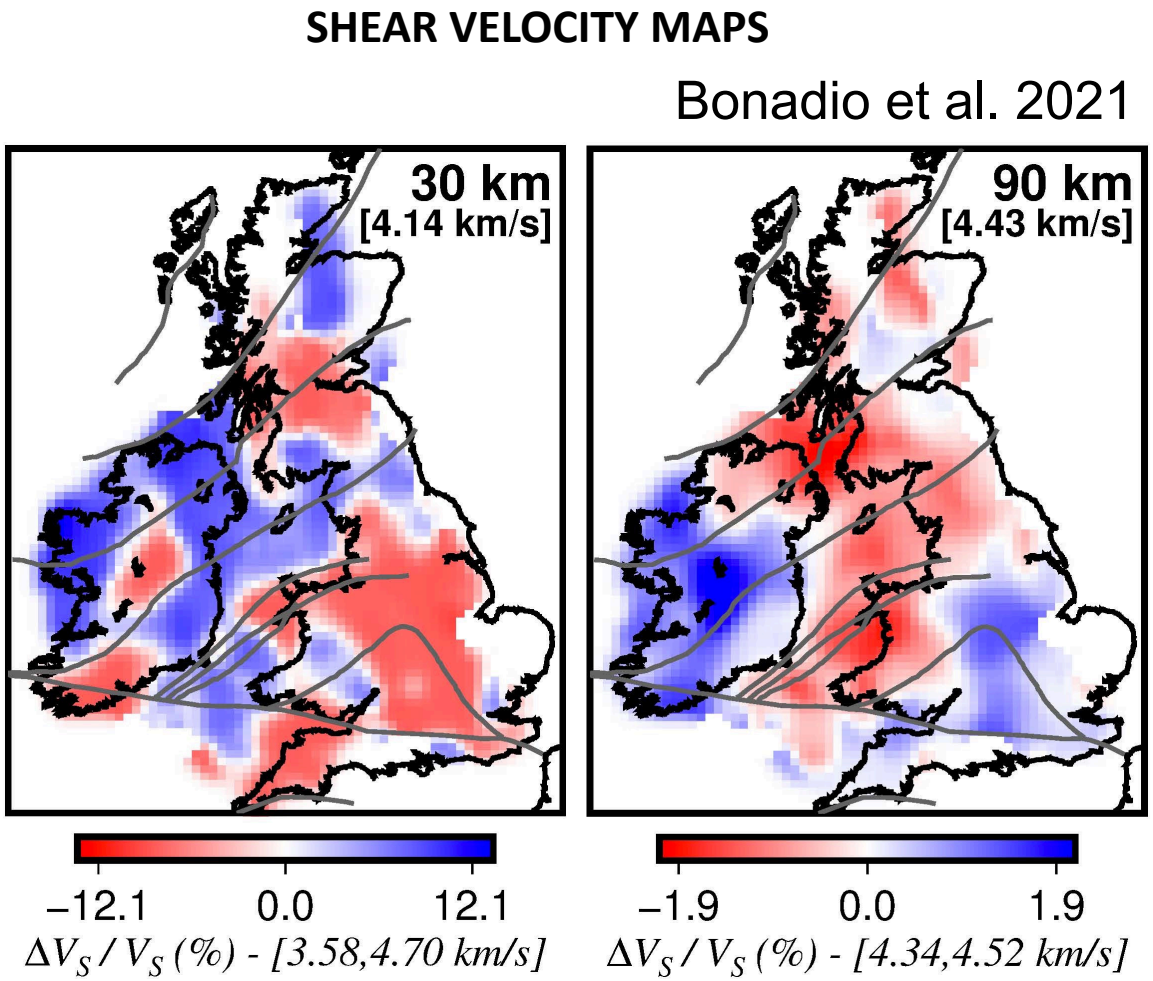




Phase Velocity

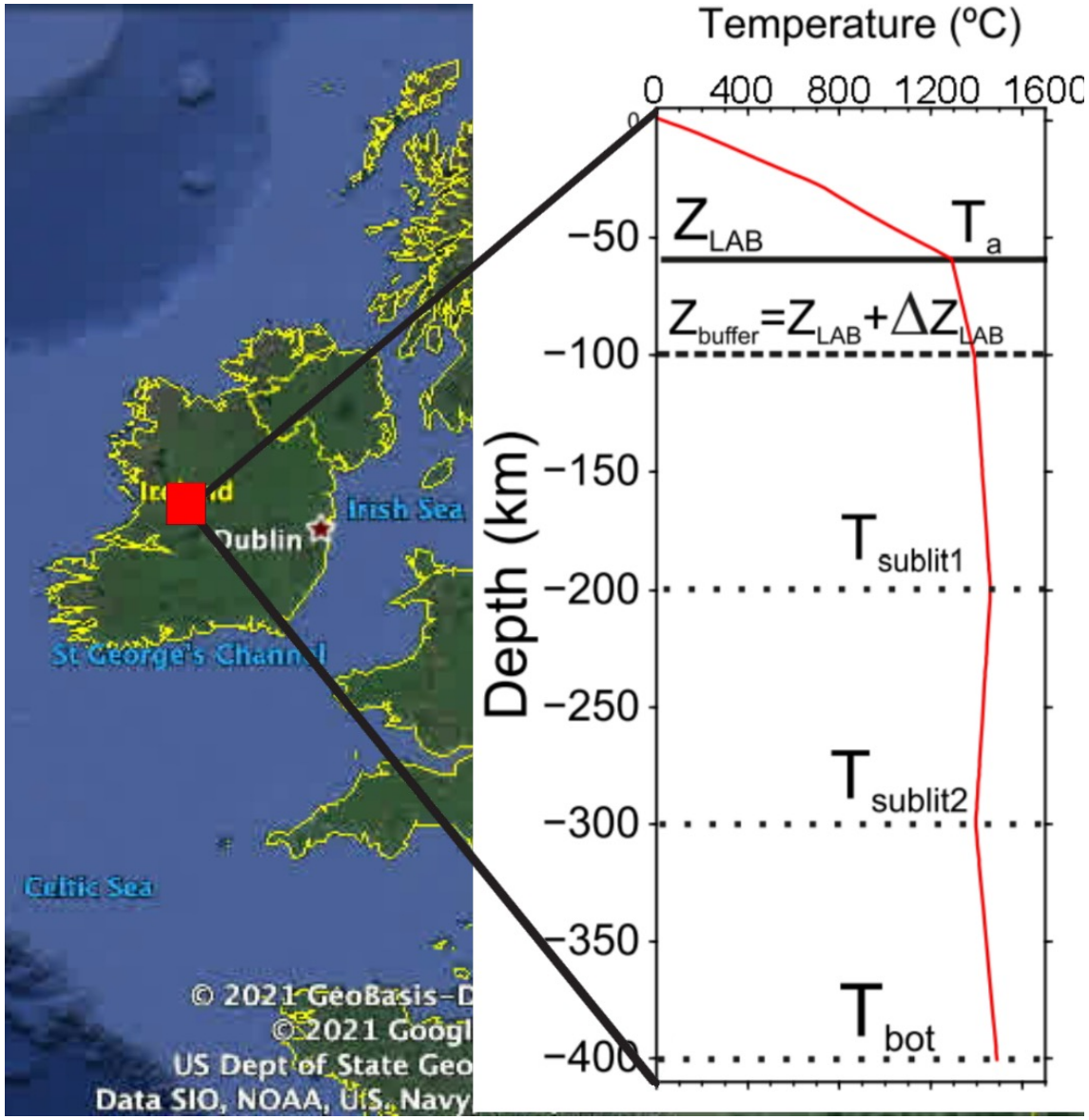


Shear Velocity

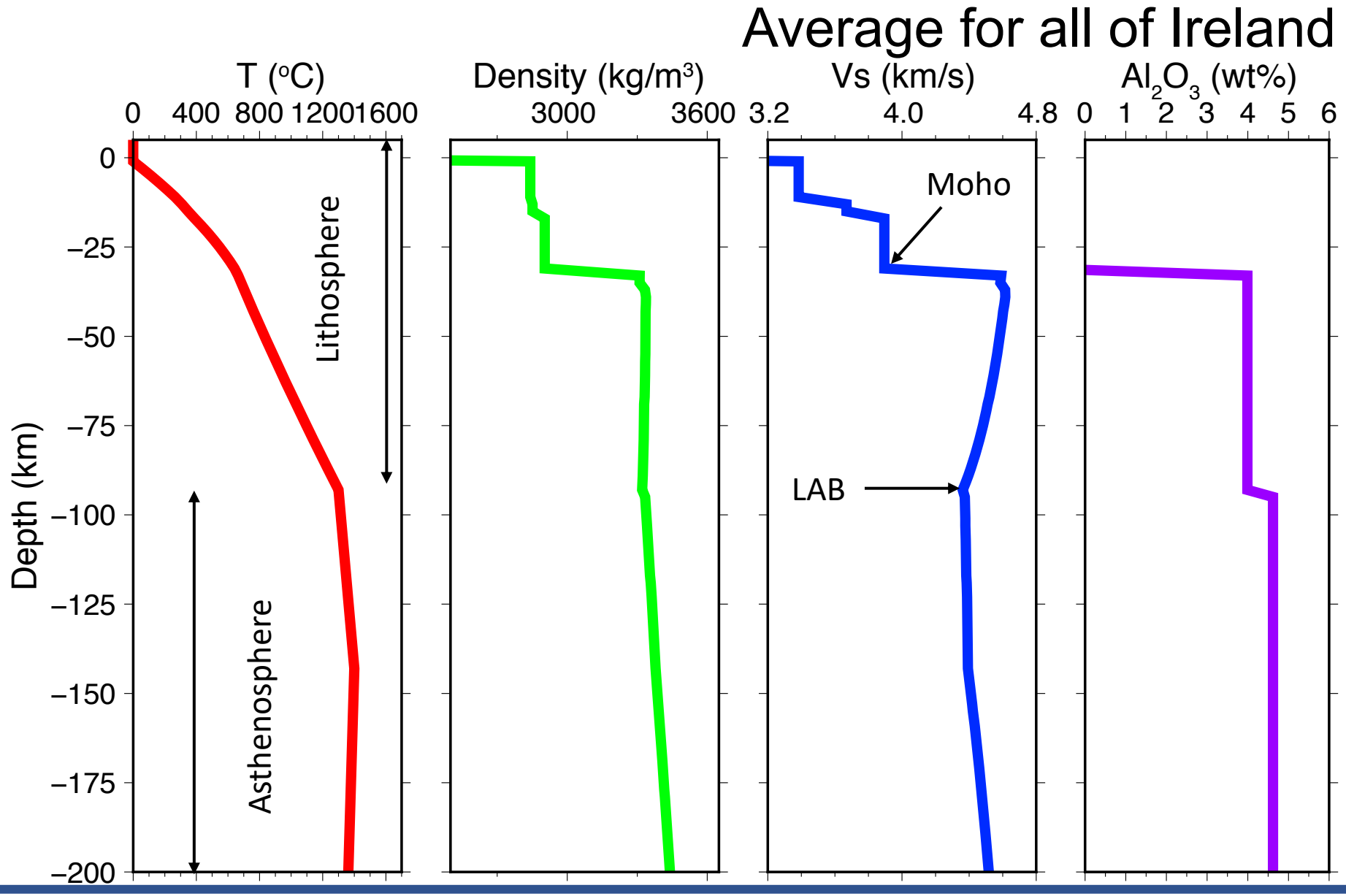


Geophysical-Petrological Inversion

- Use a joint geophysical-petrological inversion (Fullea et al. 2021).
- Input:
  - Phase velocity
  - Surface Heat Flow
  - Elevation
- Inversion Output:
  - Temperature
  - Composition
  - Density
  - Shear velocity



Geophysical-Petrological Inversion

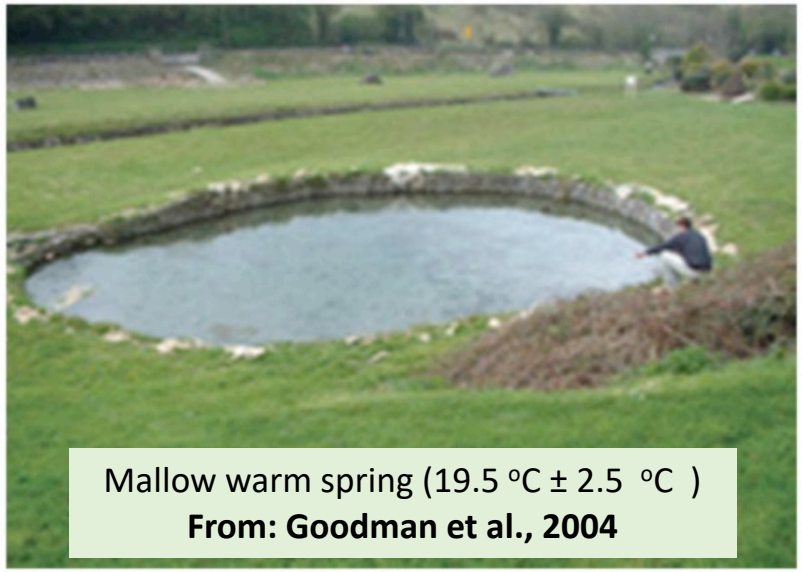


Results

- Massive, new Rayleigh and Love surface wave datasets.
- New insights into the lithospheric structure (Bonadio et al. GJI 2021).
- Isotropic average shear-wave velocities related to temperature and composition
- Isotropic average shear-wave velocities, related to temperature and composition
- Multi-Parameter models of Ireland from the petrological inversion
- Inversion framework that can also incorporate MT, ambient noise data and other datasets.

Goals

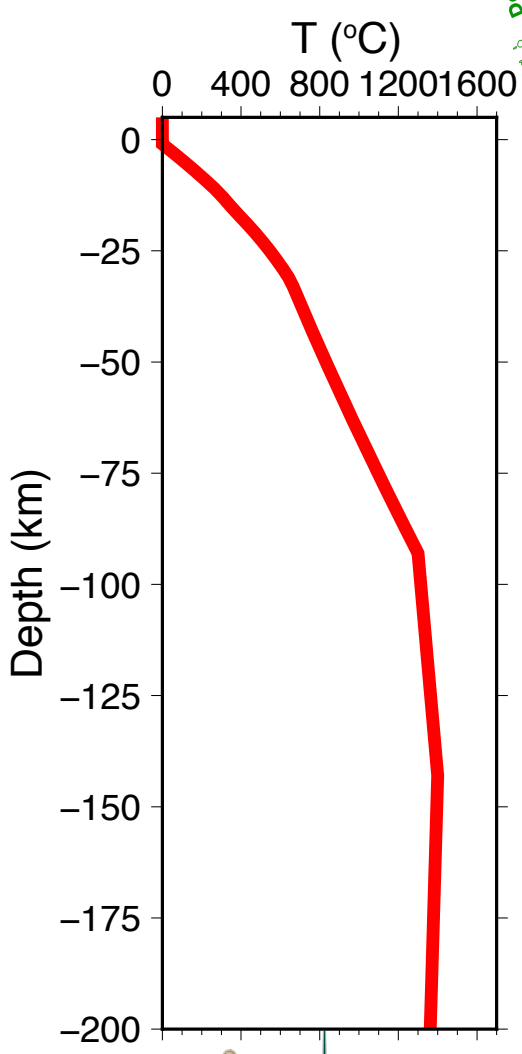
- 3D petrological-geophysical, self-consistent model across Ireland
- Geothermal gradient map
- Identify areas of high heat flow for further geothermal exploration
- Fine-scale MT and seismic surveys in areas of particular interest (Mallow warm springs)



Mallow warm spring (19.5 °C ± 2.5 °C)
From: Goodman et al., 2004

Conclusions

- Low enthalpy geothermal systems can be used at most locations around the world
- Mapping the geothermal gradient requires a lithospheric model, not just a crustal model
- Geophysical-Petrological inversion: combines seismic and other data and outputs temperature, composition, density, seismic velocities
- DIG project: creating a temperature and geothermal resource map of Ireland



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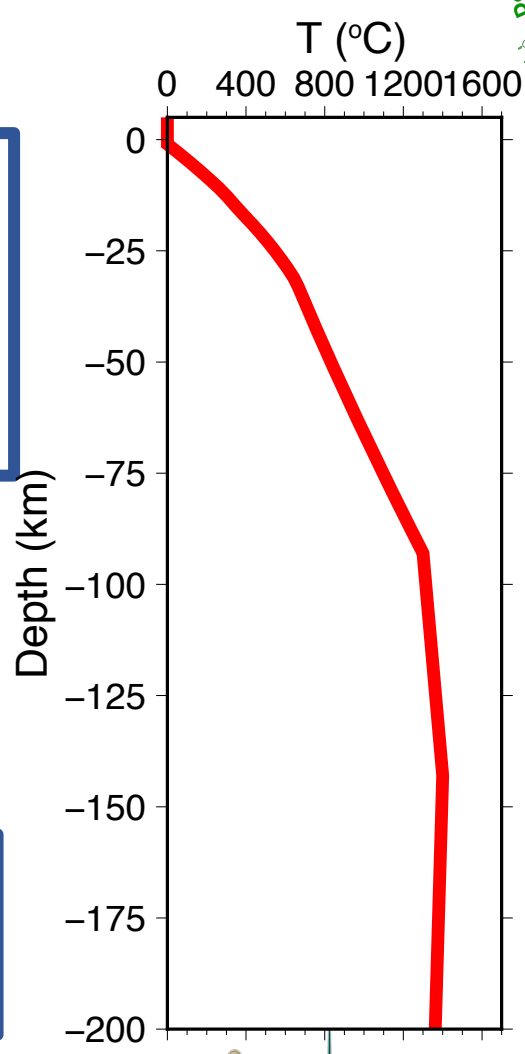
- DIG project: creating a temperature and geothermal resource map of entire Ireland

For the latest updates on the DIG project visit:

www.dig-geothermal.ie



Email: echambers@cp.dias.ie
Twitter: @seismoechambers

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