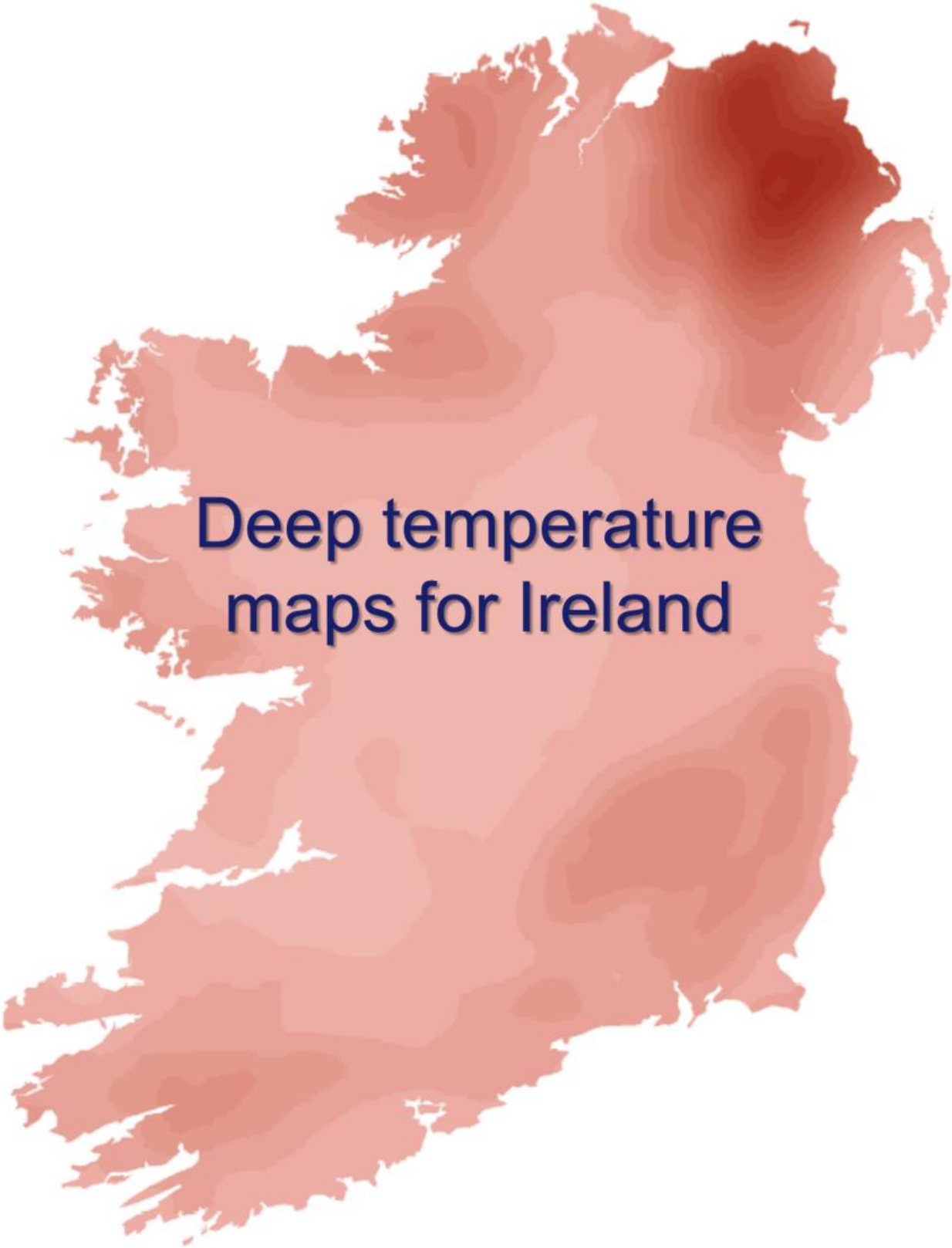
Rialtas na hÉireann
Government of Ireland

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann



Deep temperature maps for Ireland

Groundwater & Geothermal Unit

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Overview

Geological Survey Ireland has produced a new suite of deep temperature maps for onshore Ireland. This short document is designed to present the maps and their metadata (describing how and why the maps were made) to the public. The maps will be available to view and download on Geological Survey Ireland's online viewer in late 2021. The six maps were produced using temperature data provided by the Dublin Institute for Advanced Studies (J. Fullea. *G.O.THERM.3D Providing a 3D Atlas of Temperature in Ireland's Subsurface*, funded by the Irish Research Council and Geological Survey Ireland). The maps represent two dimensional slices through the crust at depths of 2 km, 2.5 km, 3 km, 3.5 km, 4 km and 5 km. Images of the map layers are presented in Appendix A, and the metadata is presented in Appendix B.

The maps have been prepared as part of Geological Survey Ireland's National Geothermal Database project. Geological Survey Ireland provides geological advice and information to support the understanding of Ireland's geothermal resources, the development of Irish geothermal energy policy and the growth of the Irish geothermal industry. Geological Survey Ireland, as a division of the Department of the Environment, Climate and Communications (DECC), has published these maps in fulfilment of a commitment under the All of Government Climate Action Plan.

These maps are based upon a probabilistic thermal model of the Irish crust and as such, there is a degree of uncertainty inherent in the dataset (see Mather et al., 2018; Mather & Fullea, 2019). The temperature values mapped here should be viewed as guideline only and not as absolute values. The actual temperature at depth may vary from the temperatures shown in these maps. Nevertheless, the dataset is the most up-to-date and realistic representation of Irish crustal temperatures that is currently available. These maps are an important first step in the development of a fit-for-purpose National Geothermal Database.

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References

B. Mather, T. Farrell, J.Fullea, Probabilistic Surface Heat Flow Estimates Assimilating Paleoclimate History: New Implications for the Thermochemical Structure of Ireland Article, 2018 Journal of Geophysical Research: Solid Earth 123(12):10,951 - 10,967. DOI: 10.1029/2018JB016555 71

B. Mather and J. Fullea, Constraining the geotherm beneath the British Isles from Bayesian inversion of Curie depth: Integrated modelling of magnetic, geothermal, and seismic data Article, 2019 Solid Earth 10: 839–850. DOI: 10.5194/se-10-839-2019

Appendix A Deep temperature maps

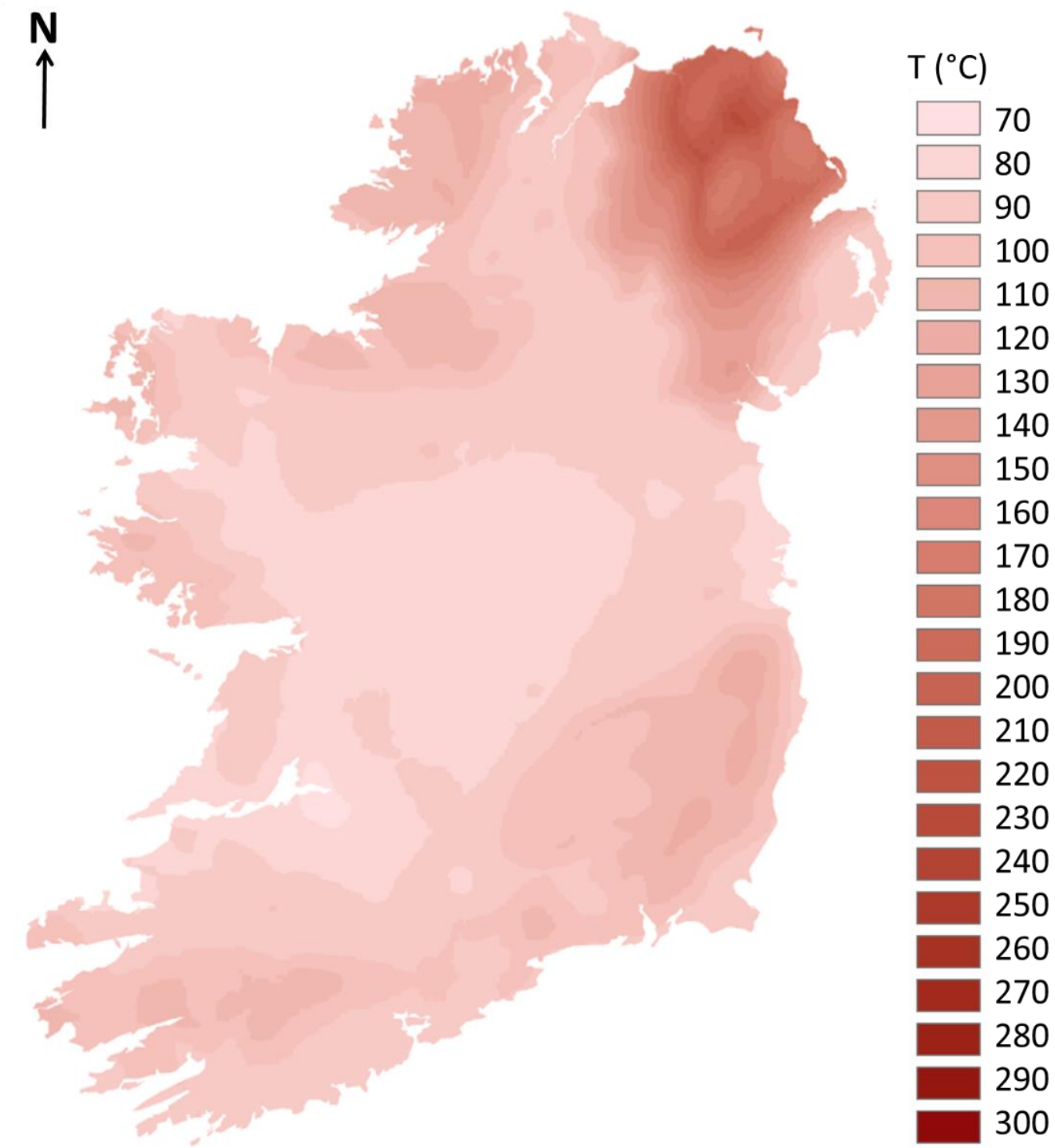

Figure 1 Deep temperature map at 2.0 km. Temperatures in degrees Celsius. Scale approx. 1:2,000,000. Values range from 70°C to 230°C.

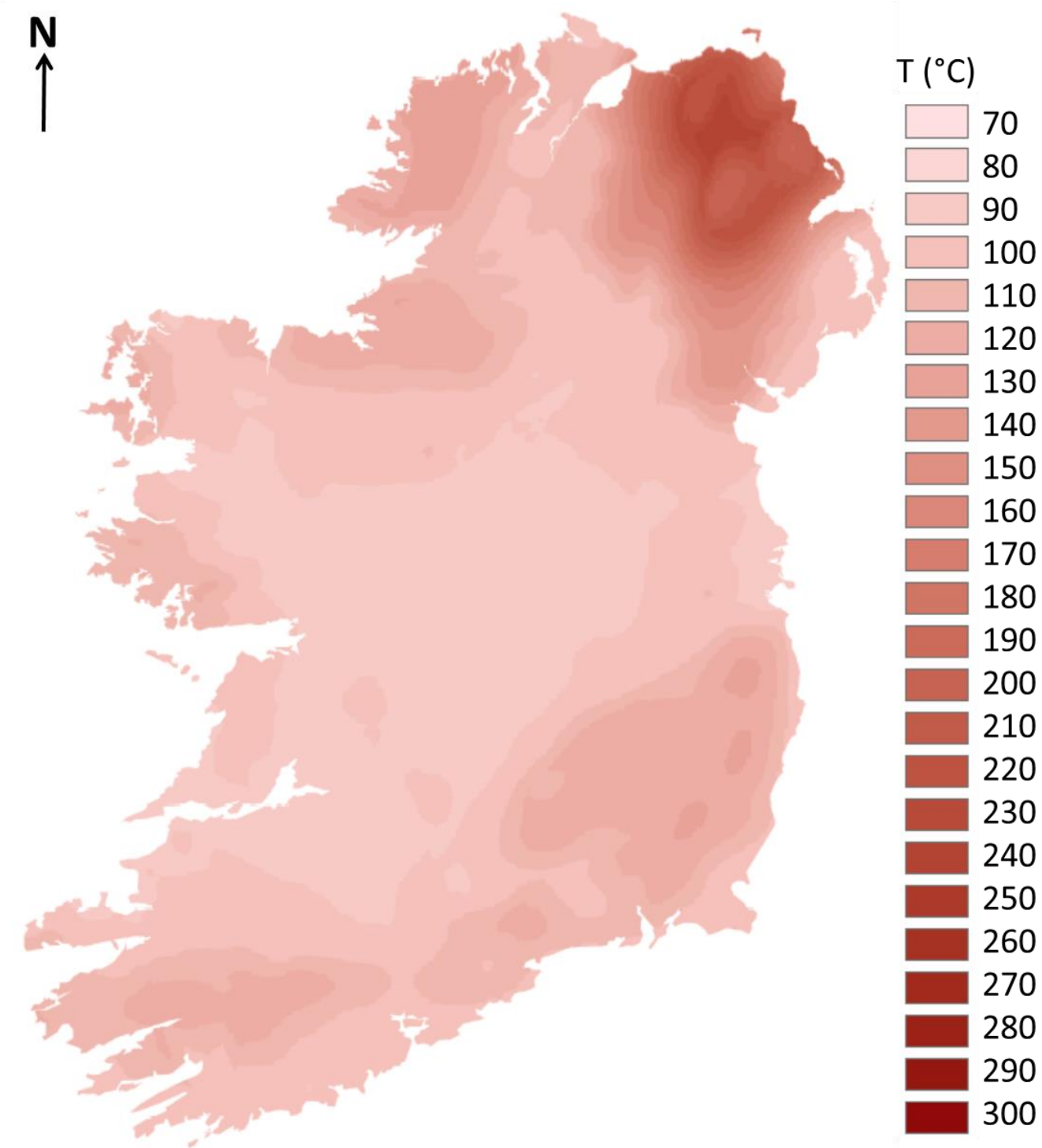

Figure 2 Deep temperature map at 2.5 km. Temperatures in degrees Celsius. Scale approx. 1:2,000,000. Values range from 80°C to 240°C

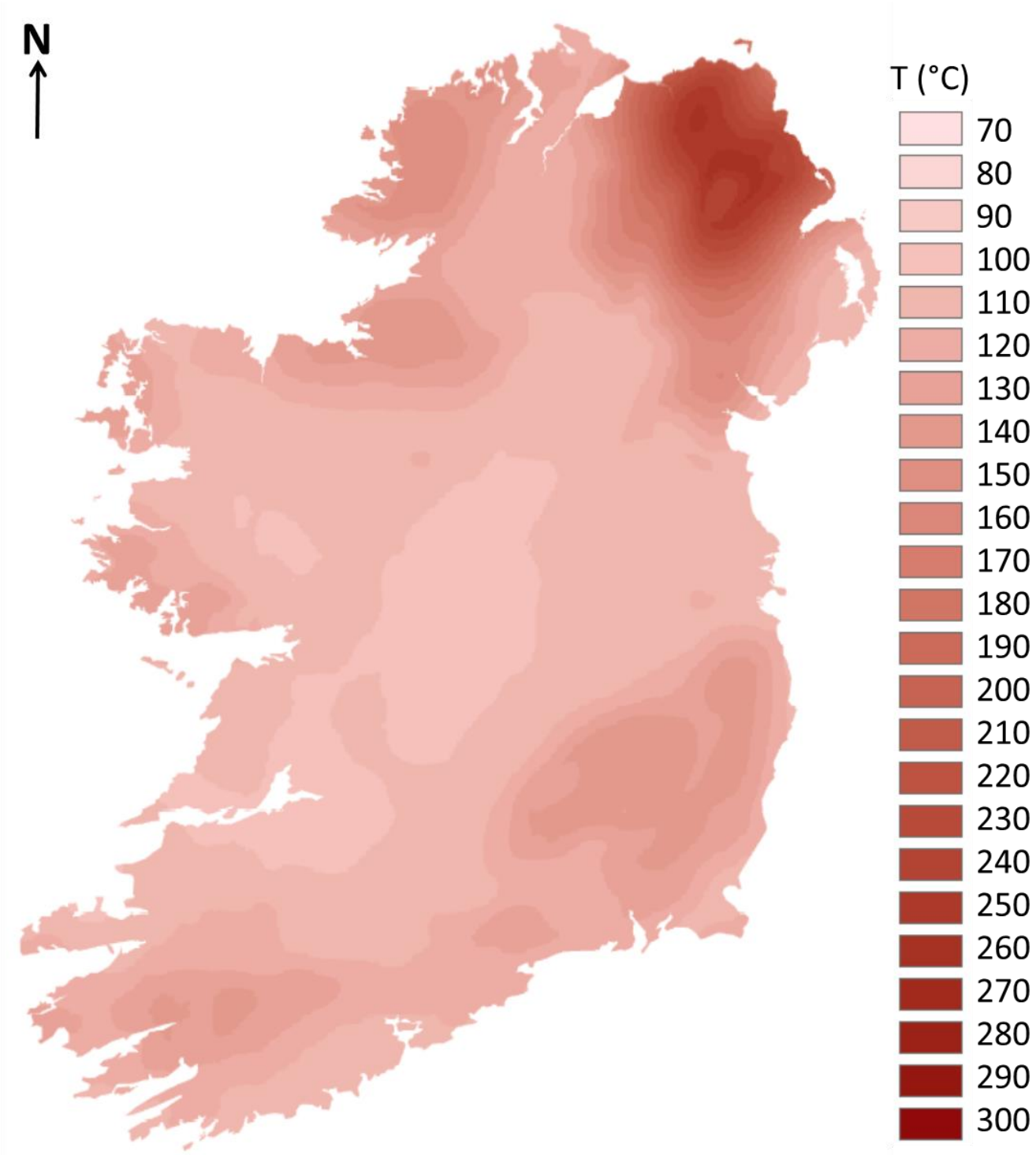

Figure 3 Deep temperature map at 3.0 km. Temperatures in degrees Celsius. Scale approx. 1:2,000,000. Values range from 90°C to 260°C

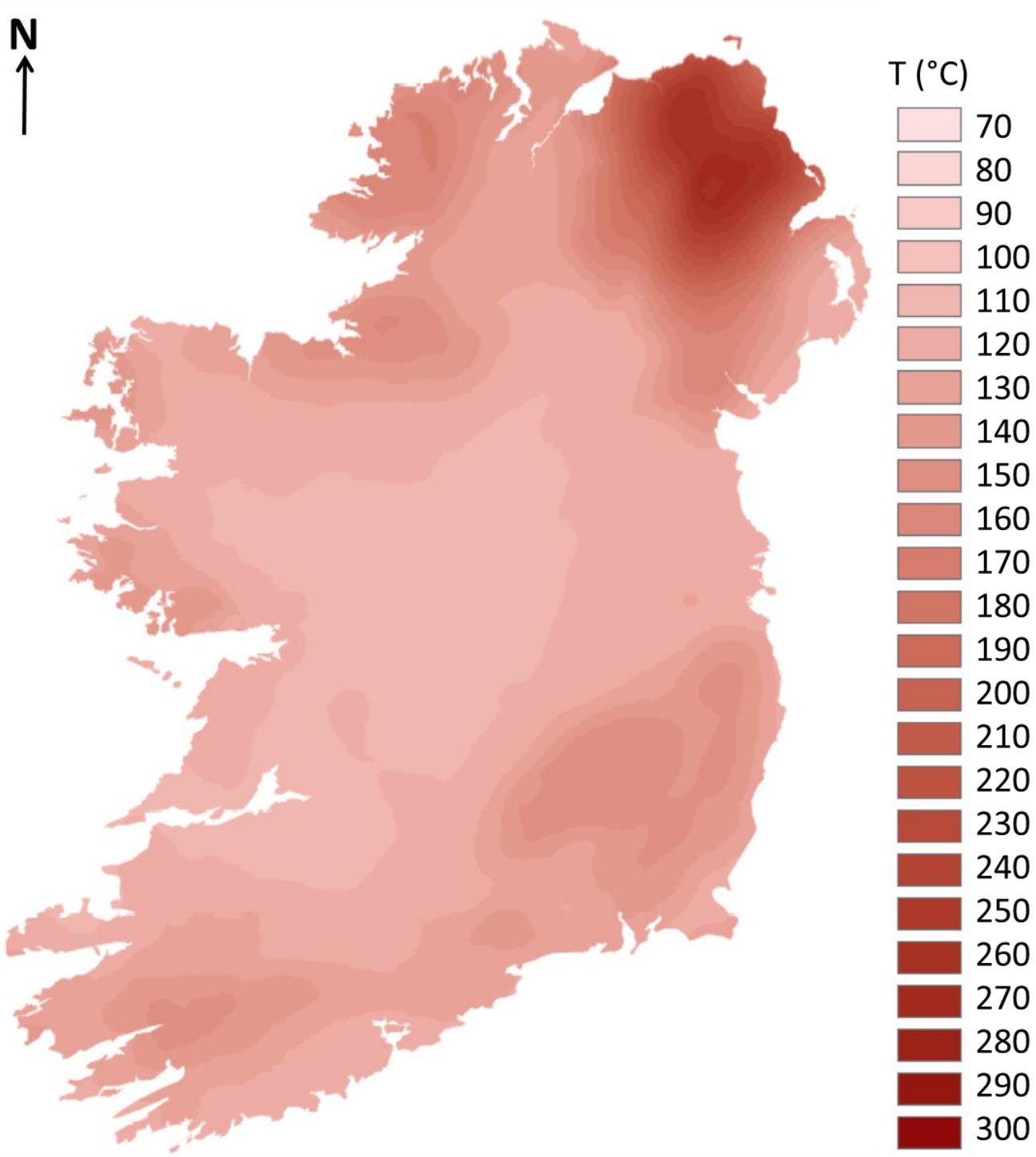

Figure 4 Deep temperature map at 3.5 km. Temperatures in degrees Celsius. Scale approx. 1:2,000,000. Values range from 100°C to 270°C

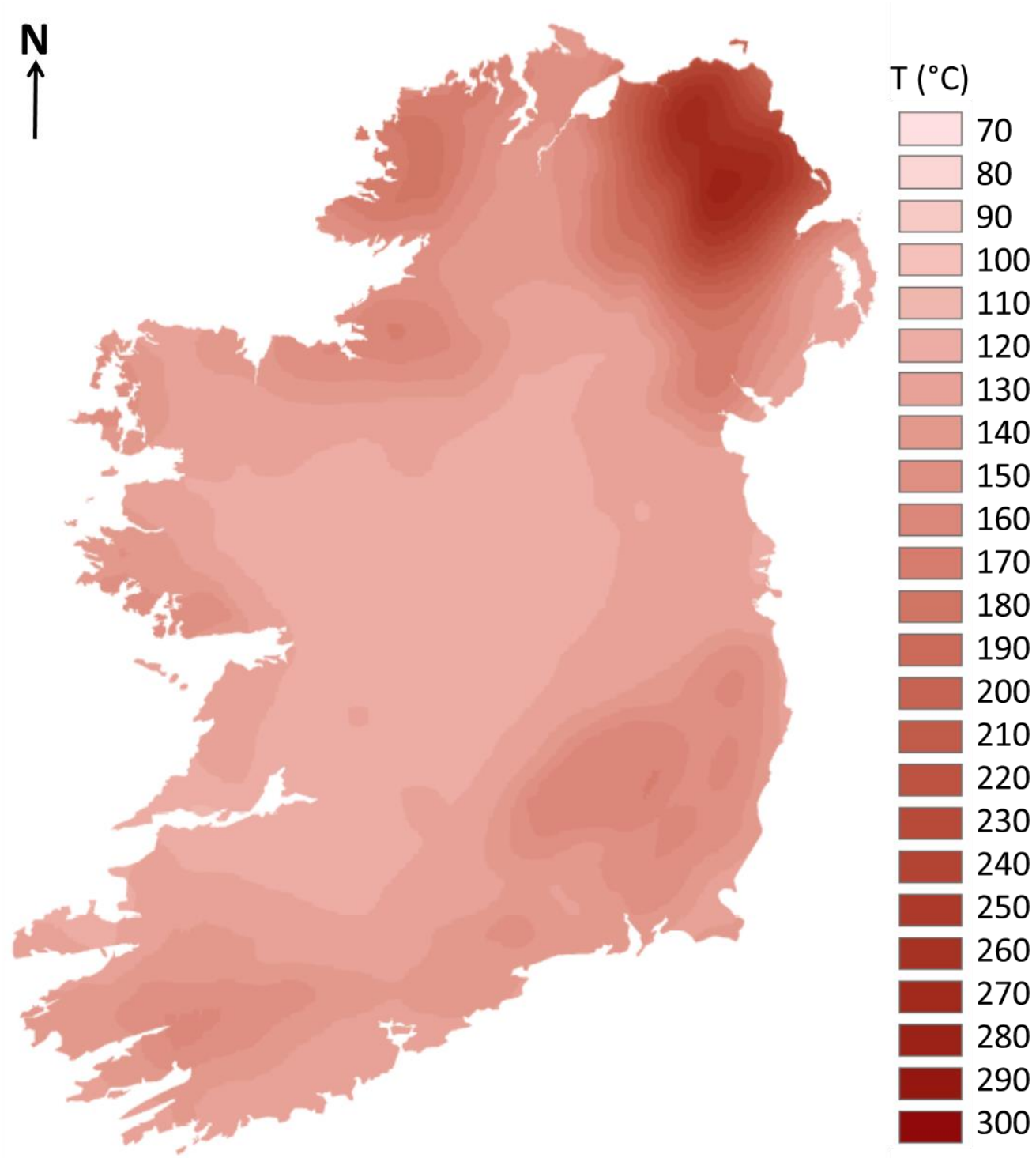

Figure 5 Deep temperature map at 4.0 km. Temperatures in degrees Celsius. Scale approx. 1:2,000,000. Values range from 110°C to 280°C

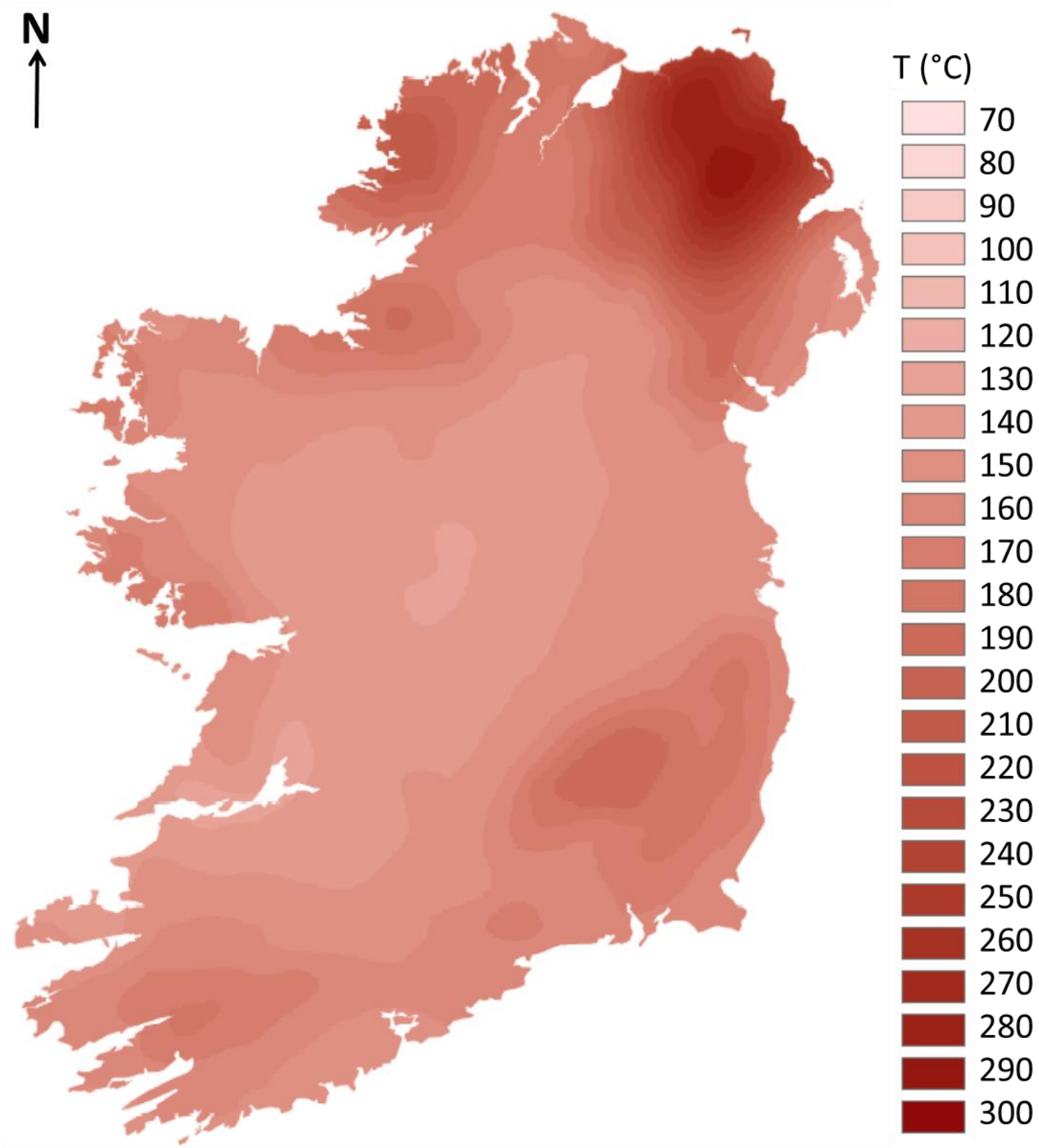

Figure 6 Deep temperature map at 5.0 km. Temperatures in degrees Celsius. Scale approx. 1:2,000,000. Values range from 120°C to 300°C

Appendix B Metadata

This section provides an example of the metadata pertaining to the new maps. Geological Survey Ireland metadata was compiled in a pro-forma for each of the six map layers in Appendix A. The 2.5 km layer is used as an example here. The metadata is written in plain English and describes where the data comes from and how the maps were made.

	Guideline | Example
Official Title	Concise Name, scale (if suitable), extent, projection(abbrev) datum(abbrev) (if suitable), Raster format(GRID or TIFF)(if applicable)
Input your metadata Official Title here	Deep temperature 45m at 2.5 km depth Ireland (ROI/NI) ITM GRID
Purpose	Who is your data useful to and why with an example. **Plain English. Use the readability tests.** **Flesch** **Gunning Fog**
Input your metadata Purpose here	The purpose of this map is to show how hot the Earth is at a depth of 2.5 km below sea level in Ireland. The Earth's natural heat can be used as a source of renewable energy called geothermal energy. Geothermal energy can be used to heat homes and offices. Sometimes geothermal energy can be used to make electricity. Geothermal energy is always available. It will still produce clean energy when the wind isn't blowing, and the sun isn't shining. It also uses a small amount of land. Geothermal energy is a very secure and low carbon energy source. How much heat or electricity you can get from geothermal energy depends on how hot the rocks beneath the ground are. The temperatures of the rocks change with depth and depend on what part of the country you are in. The purpose of this map is to show where the rocks beneath the surface are relatively hotter or colder at a certain depth. Where temperatures are higher, more geothermal energy can be produced. These maps will help the development of geothermal energy projects in Ireland by helping scientists find the places with the best resources. These maps may also be used in other scientific studies of the Earth's crust.
eAbstract	Description of your dataset. **Rules:** Plain English. Must use readability tests. Aim to be understood by a teenager. Avoid jargon. Use simple short words. Explain abbreviations. Explain scientific/geological terms. Guidelines **Plain English. Use the readability tests.** **Flesch** **Gunning Fog**
Input your metadata abstract here	The 'Deep temperature map (2.5 km)' shows the estimated temperature in degrees Celsius at a depth of 2.5 kilometres below sea level for the island of Ireland onshore. The deep temperature data forms a continuous grid of spatial data. This is a raster dataset. Raster data is another name for gridded data. Raster data stores information in pixels (grid cells). Each raster grid makes up a matrix of cells (or pixels) organised into rows and columns. The data has a

	grid cell size of 45 metres. This means that each cell (pixel) represents an area of 45 metres squared. This temperature dataset was created by researchers at the Dublin Institute for Advanced Studies. They used a mixture of data types to make a mathematical model of the Earth beneath Ireland. This mathematical model is based on the theory of probability, and can provide more than one answer. This means that the temperature values made from this model are uncertain. The actual temperature at a depth of 2.5 kilometres may vary from what is shown in this map. The cause and amount of uncertainty in the mathematical model is described in the following publications: B. Mather, T. Farrell, J.Fullea, Probabilistic Surface Heat Flow Estimates Assimilating Paleoclimate History: New Implications for the Thermochemical Structure of Ireland Article, 2018 Journal of Geophysical Research: Solid Earth 123(12):10,951 - 10,967. DOI: 10.1029/2018JB016555 71 B. Mather and J. Fullea, Constraining the geotherm beneath the British Isles from Bayesian inversion of Curie depth: Integrated modelling of magnetic, geothermal, and seismic data Article, 2019 Solid Earth 10: 839–850. DOI: 10.5194/se-10-839-2019 Temperature data was extracted from the mathematical model as points. Each point has an x and y coordinate, and a temperature value. The data was then converted into gridded data to create the temperature map.
Dataset creation	How was the dataset created? Go through the whole process from start to finish. Data sources – list external data sources, specify which base maps used Data collection – what equipment was used Software – list all software used include any tools or extensions used Was the data reprojected? From what projection? List any data quality checks carried out.
Input your metadata data creation here	The temperature dataset used to make this map was created by researchers at the Dublin Institute for Advanced Studies. They used a mixture of data types to make a mathematical model of the Earth beneath Ireland. Borehole temperature data was collected in the 1980's and published in the following papers: Barton et al. (1989); Brock (1989); Brock & Barton (1984); and Wheildon et al. (1985). This data was corrected for the temperature effects of past ice ages and re-mapped by Mather et al. (2018). There are no actual temperature measurements available at depths greater than 2,000 metres. Temperature information was also estimated from measurements of the Earth's magnetic and electrical properties. These are called geophysical measurements. The geophysical data used for this map comes from the global EMAG2 dataset (Meyer et al., 2017). The corrected temperatures were combined with geophysical measurements in a probabilistic mathematical model (Mather & Fullea, 2019). This means that the model is based on the theory of probability and can provide more than one answer. This means that the temperature values made from this model are uncertain. This model predicts what the temperature might be where there are no measurements. Temperature data were extracted from the mathematical model as points. The model was loaded into QGIS, which is a software package used for making maps, and subjected to an ITM projection. The estimated temperature at 2.5 km beneath sea level was extracted from the model to make a 2D raster map. This deep temperature map was exported to another software package called ArcGIS and colour coded at intervals of 10 degrees Celsius. A legend was created.

	Credits B. Mather, T. Farrell, J.Fullea, Probabilistic Surface Heat Flow Estimates Assimilating Paleoclimate History: New Implications for the Thermochemical Structure of Ireland Article, 2018 Journal of Geophysical Research: Solid Earth 123(12):10,951 - 10,967. DOI: 10.1029/2018JB016555 71 B. Mather and J. Fullea, 2019 Constraining the geotherm beneath the British Isles from Bayesian inversion of Curie depth: Integrated modelling of magnetic, geothermal, and seismic data Article, 2019 Solid Earth 10: 839–850. DOI: 10.5194/se-10-839-2019Barton, K. J., Brock, A., & Sides, A. (1989). Preliminary results from temperature, heat flow and heat production studies in Ireland. In K. Louwrier, E. Staroste, J. D. Garnish, & V. Karkoulias (Eds.), European geothermal update, Proceedings of the Fourth International Seminar on the Results of EC Geothermal Energy Research (pp. 551–559). Florence: Kluwer Academic Publishers. Brock, A. (1989). Heat flow measurements in Ireland. Tectonophysics, 164(2-4), 231–236. https://doi.org/1016/0040-1951(89)90016-4 Brock, A., & Barton, K. J. (1984). Equilibrium temperature and heat flow density measurements in Ireland (Tech. Rep.) Galway, Ireland: University College Galway Brock, A., & Barton, K. J. (1984). Equilibrium temperature and heat flow density measurements in Ireland (Tech. Rep.) Galway, Ireland: University College Galway Meyer, B., Saltus, R., & Chulliat, A. 2017: EMAG2v3: Earth Magnetic Anomaly Grid (2-arc-minute resolution). Version 3. NOAA National Centers for Environmental Information. DOI: 10.7289/V5H70CVX Wheildon, J., Gebski, J. S., & Thomas-Betts, A. (1985). Further investigations of the U.K. heat flow field (1981–1984) (Tech. Rep.). Keyworth, Nottingham: British Geological Survey. Dr. Sarah Blake, Senior Geologist, Groundwater & Geothermal Unit, GSI 2018-Present Mr. Rory Dunphy, Geothermal Consultant, Groundwater & Geothermal Unit, GSI 2021-Present Dr. Joan Campanyà, Geophysical Consultant, Groundwater & Geothermal Unit, GSI 2017 - Present Mr. Shane Carey, GIS developer and Data Manager Consultant, GSI 2011-Present	
Time Period	Start date when data was first collected. End date of when data last collected	2016-12-12
Input your metadata start date here	31/01/2020	
Input your metadata finish date here	22/06/2020	