Geological Survey Ireland

Tellus geochemical survey: shallow topsoil multi-element maps for the northern half of Ireland

October 2020

Rialtas na hÉireann
Government of Ireland

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

Document Information

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Reviewed by	Date	Comment

Approved By	Date	Comment
		Geological Survey Ireland

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1.0	07 October 2020		MAB, VG
2.0	15 April 2021	Minor corrections to the text and legends of Ca and Cd maps.	MAB, VG
2.1	21 December 2021	Missing reference to SGS, Canada was corrected.	MAB, VG

Table of Contents

Executive summary

This publication presents interpolated maps of geochemical data for shallow topsoil samples across the northern half of Ireland and Northern Ireland. Samples were collected between 2004 and 2019, as part of the Tellus geochemical survey projects of Geological Survey Ireland and the Geological Survey of Northern Ireland (Figure 1).

The maps presented here represent almost 17,000 sites covering the northern half of Ireland, an area of just over 50,000 km^2. Together they represent a wide variety of geological domains in Ireland (Figure 2).

Each sample was prepared and chemically measured by a number of techniques. Laboratory tests comprise: soil pH (CaCl2); loss-on-ignition at 450°C and multi-element partial extract analyses of major, minor and trace elements by ICP following *aqua regia* digestion. ICP (*aqua regia*) analyses were conducted by SGS, Canada, and ALS Minerals Ltd., Ireland.

Acknowledgements

Geological Survey Ireland and the Tellus geochemistry team gratefully acknowledge the efforts of all project partners, contractors and especially field samplers, and the kind co-operation of all landowners and stakeholders.

This publication is published with the approval of the Director, Geological Survey Ireland.

1. Introduction

1.1. Sample collection and analysis

Soil samples were collected from 6,862 sites in Northern Ireland in 2004 – 2006 for the original Tellus survey, conducted by the Geological Survey of Northern Ireland (GSNI). In Ireland, 9,921 sites were sampled between 2011 and 2019 as part of Geological Survey Ireland's (GSI) Tellus programme (Figure 1). In Northern Ireland soil samples were taken at a density of one sample per 2 km^2, with sites typically located in the northwestern and southeastern quadrants of the 2 x 2 km grid square. In Ireland regional samples have been collected at a sampling density of one sample per 4 km^2, i.e. one sample per 2 x 2 km grid square. Periurban samples around Dublin and Galway were collected at a sampling density of one sample per 1 km^2, i.e. four samples per 2 km x 2 km grid square.

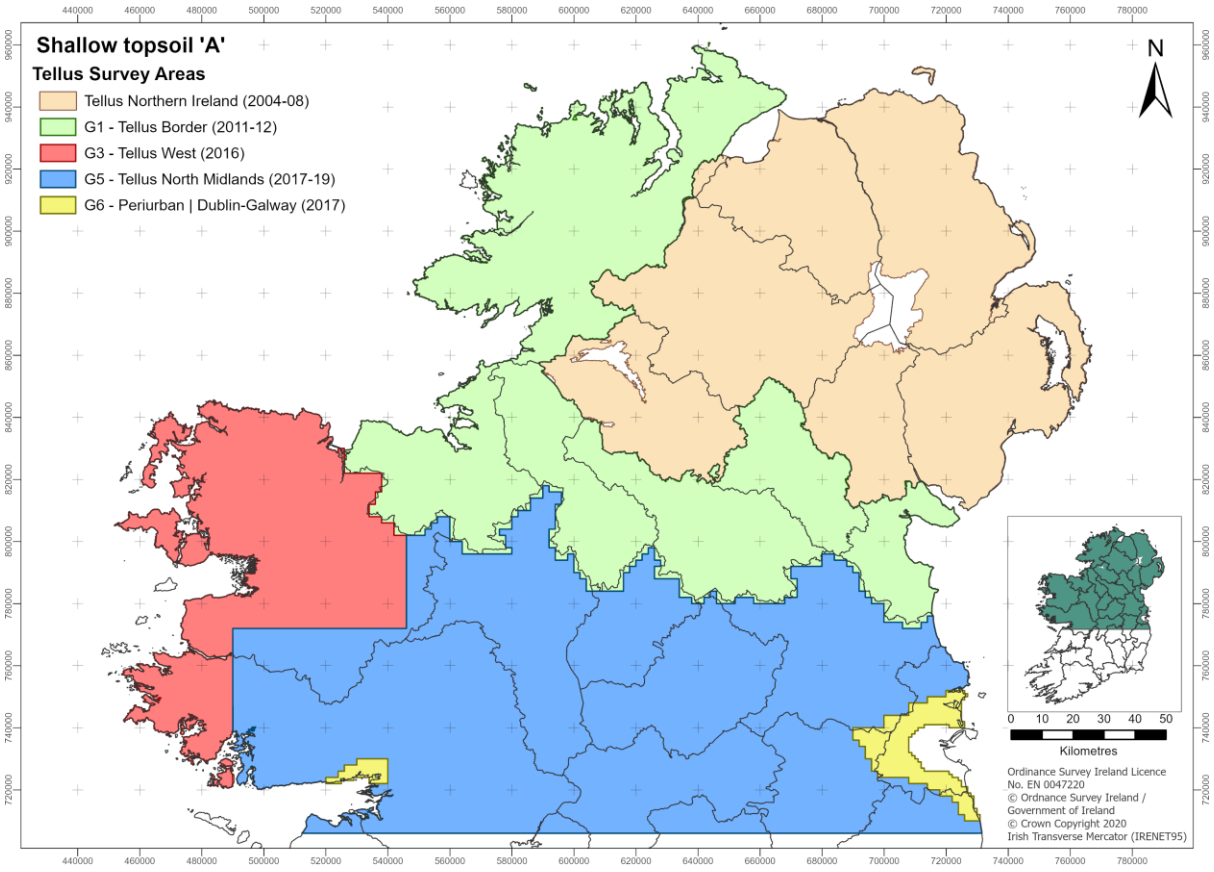


Figure 1: Shallow topsoil 'A' survey areas, completed by the Geological Survey of Northern Ireland Tellus Survey and Geological Survey Ireland's Tellus Programme (2011 and 2019).

Two soil samples were taken at each site using an auger, a shallow topsoil from a depth interval of 0.05-0.20 m (designated 'A soil) and a deeper topsoil from 0.35-0.50 m (designated 'S'). Samples were analysed for pH, loss-on-ignition (LOI) and over 50 inorganic major and trace elements, using a

variety of techniques. Sampling methodology, sample preparation, analysis and quality control measures are fully described in Young and Donald (2013), Knights *et al*. (2020) and Szpak *et al*. (2020). All data are freely available from GSNI (www2.bgs.ac.uk/gsni/tellus/data_licensing/index.html) and GSI (https://www.gsi.ie/en-ie/programmes-and-projects/tellus/Pages/Data-and-Maps.aspx).

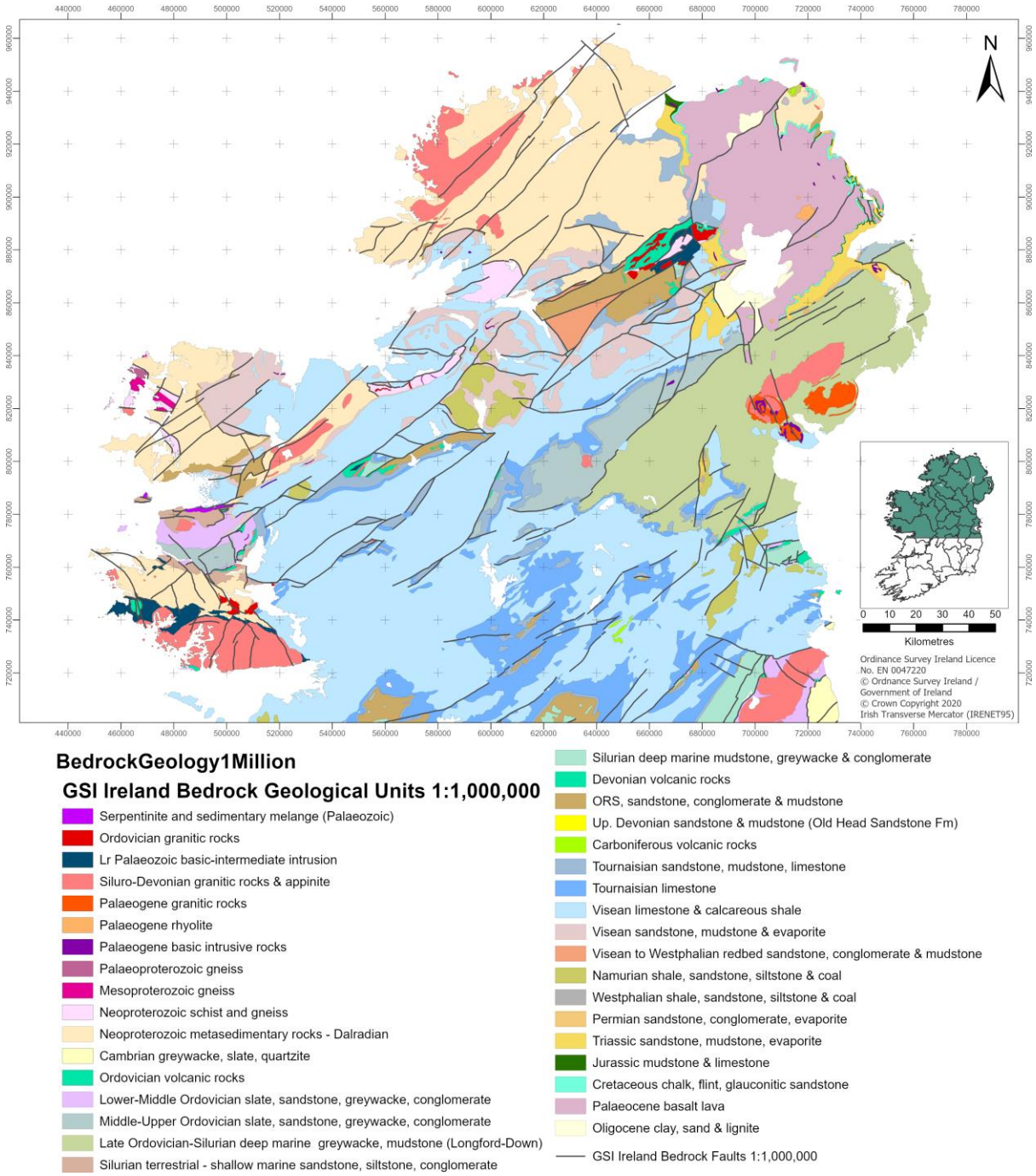


Figure 2: Bedrock Geology of Ireland (scale: 1:1,000,000).

1.2. Data processing and map production

The maps presented here illustrate the geochemistry of 'A' soil samples, as analysed for pH ($CaCl_2$), for LOI at 450°C and for inorganic elements analysed by ICP-MS/AES following acid digestion in *aqua regia*. Data for Northern Ireland were processed as described by Young and Donald (2013). GSI data have not been conditioned. No levelling of the data collected over different years or analysed by different laboratories has been undertaken. The lack of levelling means that discernible survey boundary effects may be observed for some elements but, in general, the maps provide a good regional-scale representation of geochemical variation in the northern half of Ireland, having regard to the limits of the analytical method. Digestion of samples with *aqua regia* achieves only a partial extraction for most elements, especially those in less soluble minerals such as oxides and many silicates, so the true soil concentrations of many elements reported here are understated. The observed spatial distributions of elements thus reflect not only the bulk composition of the soil samples but also the ease of extraction of elements.

The greater density of soil samples in Northern Ireland and in the Dublin and Galway periurban areas can lead to skewing of the statistics on which the map classes are based, affecting the distribution of values for some elements across the region. In order to create a more even and representative spread of sample points, for these areas the average concentration value was calculated for each 2 km x 2 km grid cell, so that the interpolated maps are based on the same 1-per-4 km^2 sample density across the entire region.

The interpolation method employed to produce the maps was Inverse Distance Weighting (IDW), with a cell size of 250 m and a standard circular search radius of 2,000 m. The maps are presented with linework from the GSI 1:1,000,000 Bedrock Geology map (Figure 2).

1.3. References

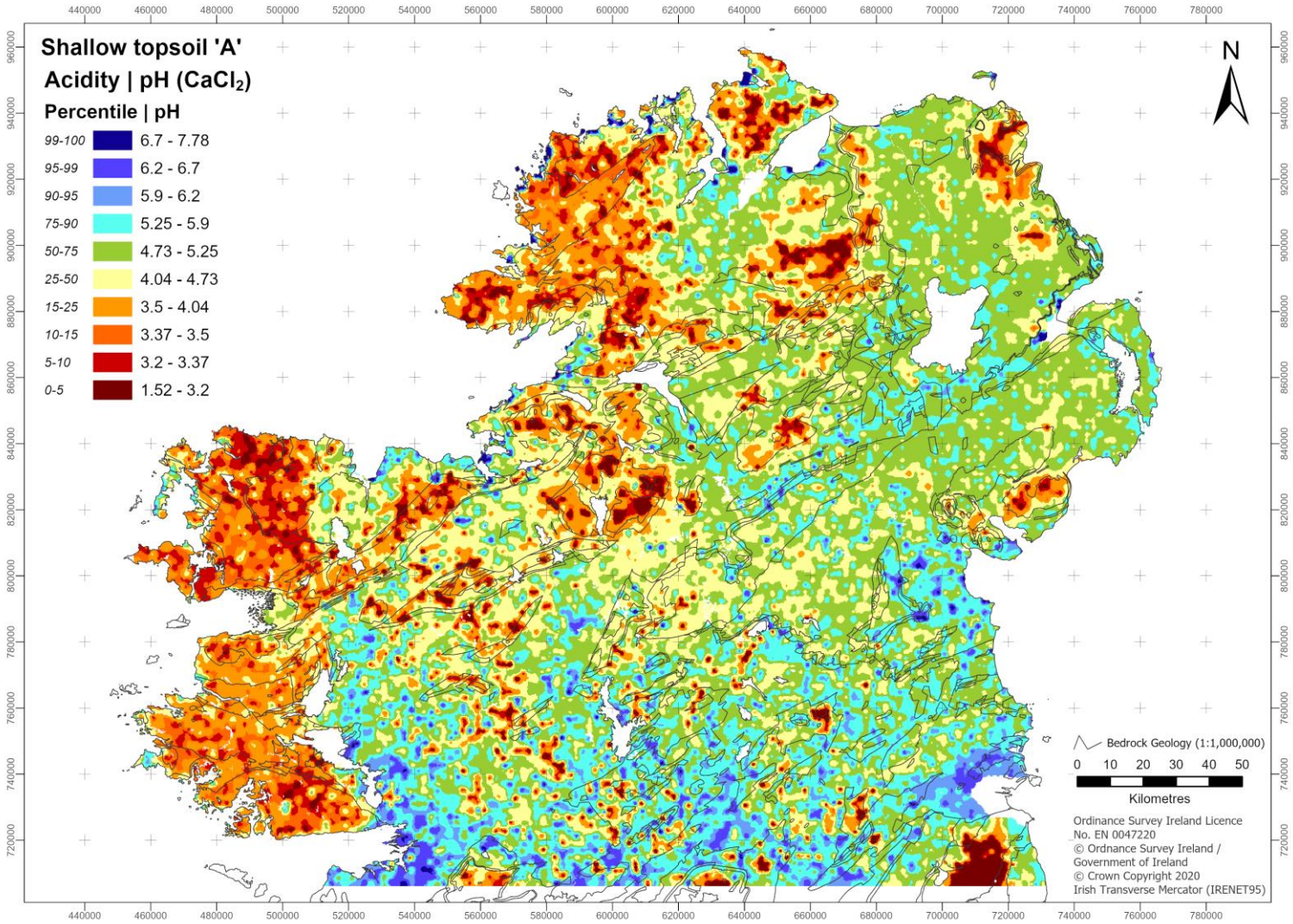
Knights, K.V., Szpak, M., Mather, J. and Collins, L. (2020). Tellus geochemical survey: shallow topsoil data from the border and west of Ireland. Geological Survey Ireland, March 2020

Szpak, M., Gallagher, V., Mather, J. and Knights, K.V. (2020). Tellus geochemical survey: shallow topsoil data from the midlands of Ireland. Geological Survey Ireland, October 2020

Young, M.E. and Donald, A.W. (eds.) (2013). A guide to the Tellus data. Geological Survey of Northern Ireland, Belfast.

2. ‘A’ shallow soil maps

2.1. Soil pH


Shallow topsoil 'A'
Acidity | pH ($CaCl_2$)
Percentile | pH
99-100 6.7 - 7.78
95-99 6.2 - 6.7
90-95 5.9 - 6.2
75-90 5.25 - 5.9
50-75 4.73 - 5.25
25-50 4.04 - 4.73
15-25 3.5 - 4.04
10-15 3.37 - 3.5
5-10 3.2 - 3.37
0-5 1.52 - 3.2
N
Bedrock Geology (1:1,000,000)
0 10 20 30 40 50
Kilometres
Ordinance Survey Ireland Licence No. EN 0047220
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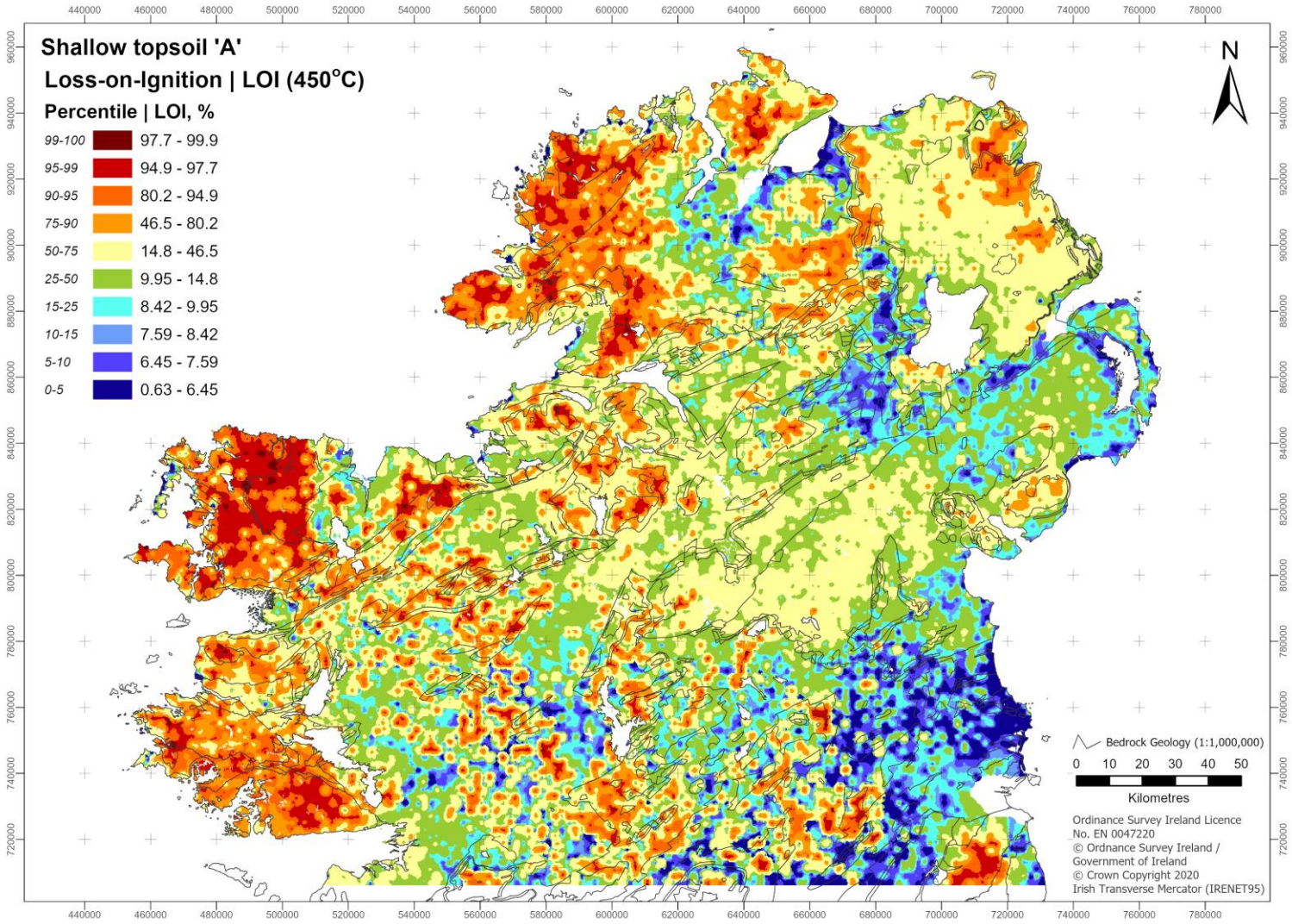
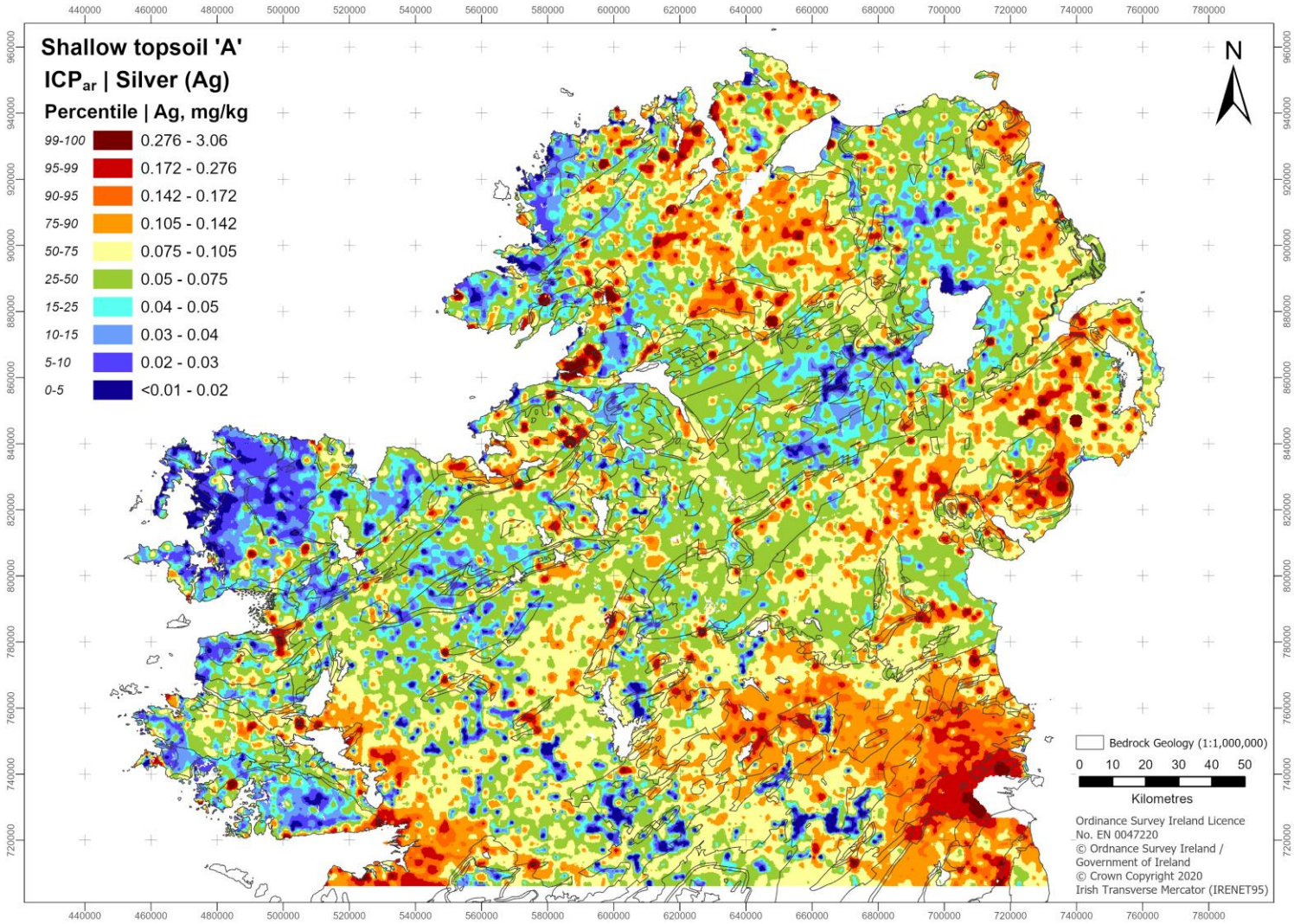
© Crown Copyright 2020
Irish Transverse Mercator (IRENET95)
440000 460000 480000 500000 520000 540000 560000 580000 600000 620000 640000 660000 680000 700000 720000 740000 760000 780000
960000 940000 920000 900000 880000 860000 840000 820000 800000 780000 760000 740000 720000

2.2. Loss-on-Ignition (LOI)



2.3. Silver (Ag)


Shallow topsoil 'A'
ICP$_{ar}$ | Silver (Ag)
Percentile | Ag, mg/kg
99-100 0.276 - 3.06
95-99 0.172 - 0.276
90-95 0.142 - 0.172
75-90 0.105 - 0.142
50-75 0.075 - 0.105
25-50 0.05 - 0.075
15-25 0.04 - 0.05
10-15 0.03 - 0.04
5-10 0.02 - 0.03
0-5 <0.01 - 0.02
N
Bedrock Geology (1:1,000,000)
0 10 20 30 40 50
Kilometres
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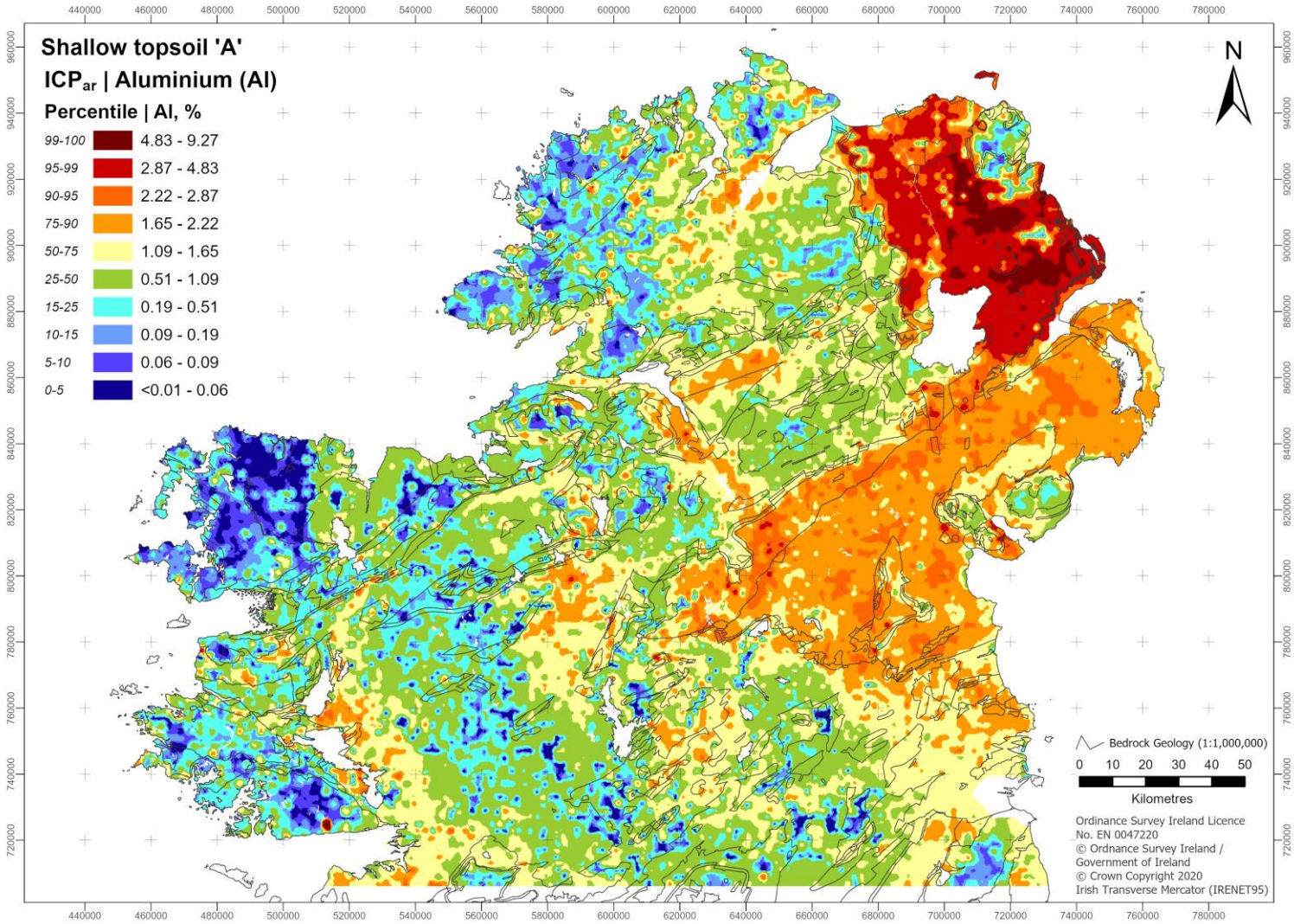
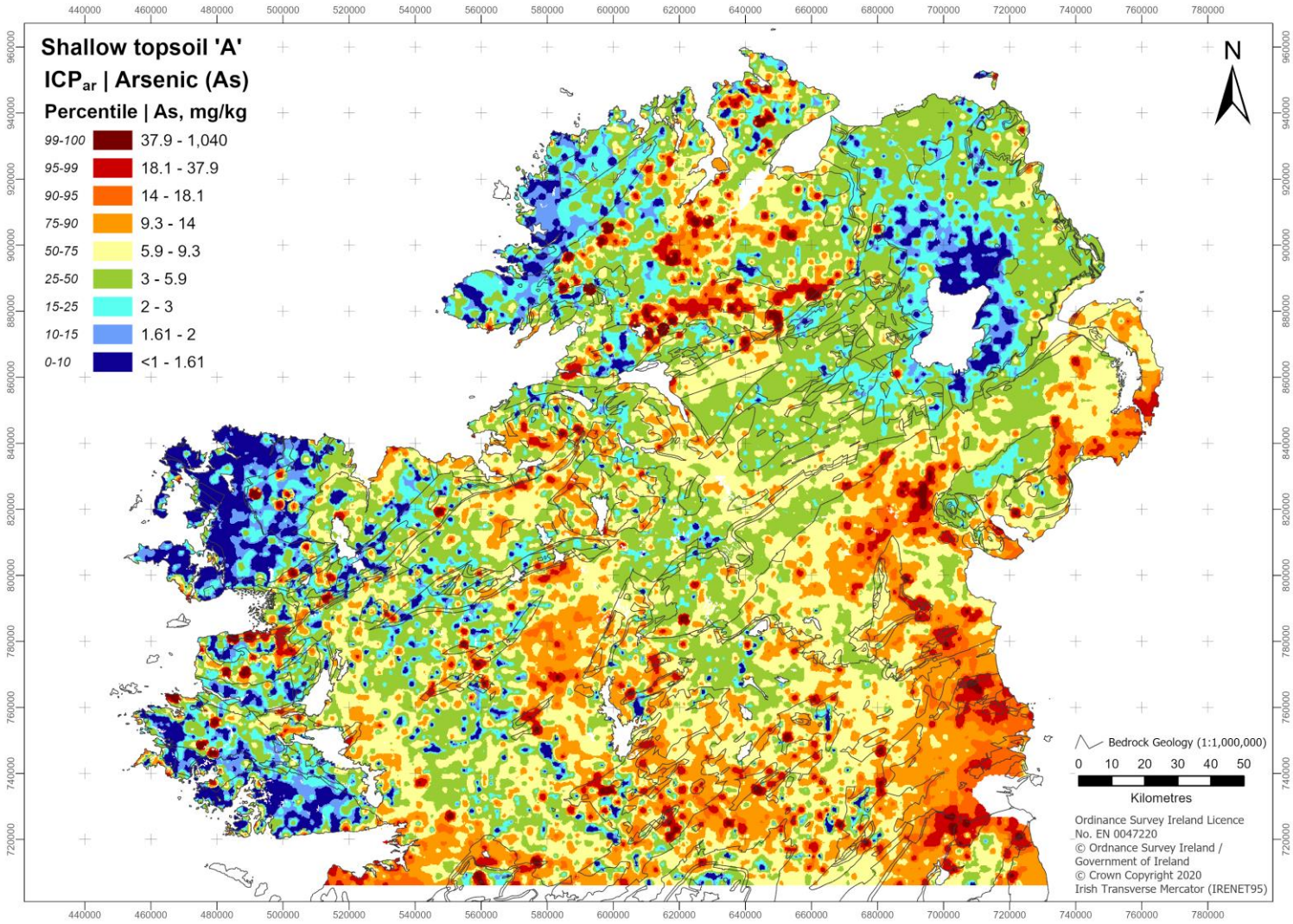
Irish Transverse Mercator (IRENET95)
440000 460000 480000 500000 520000 540000 560000 580000 600000 620000 640000 660000 680000 700000 720000 740000 760000 780000
960000 940000 920000 900000 880000 860000 840000 820000 800000 780000 760000 740000 720000

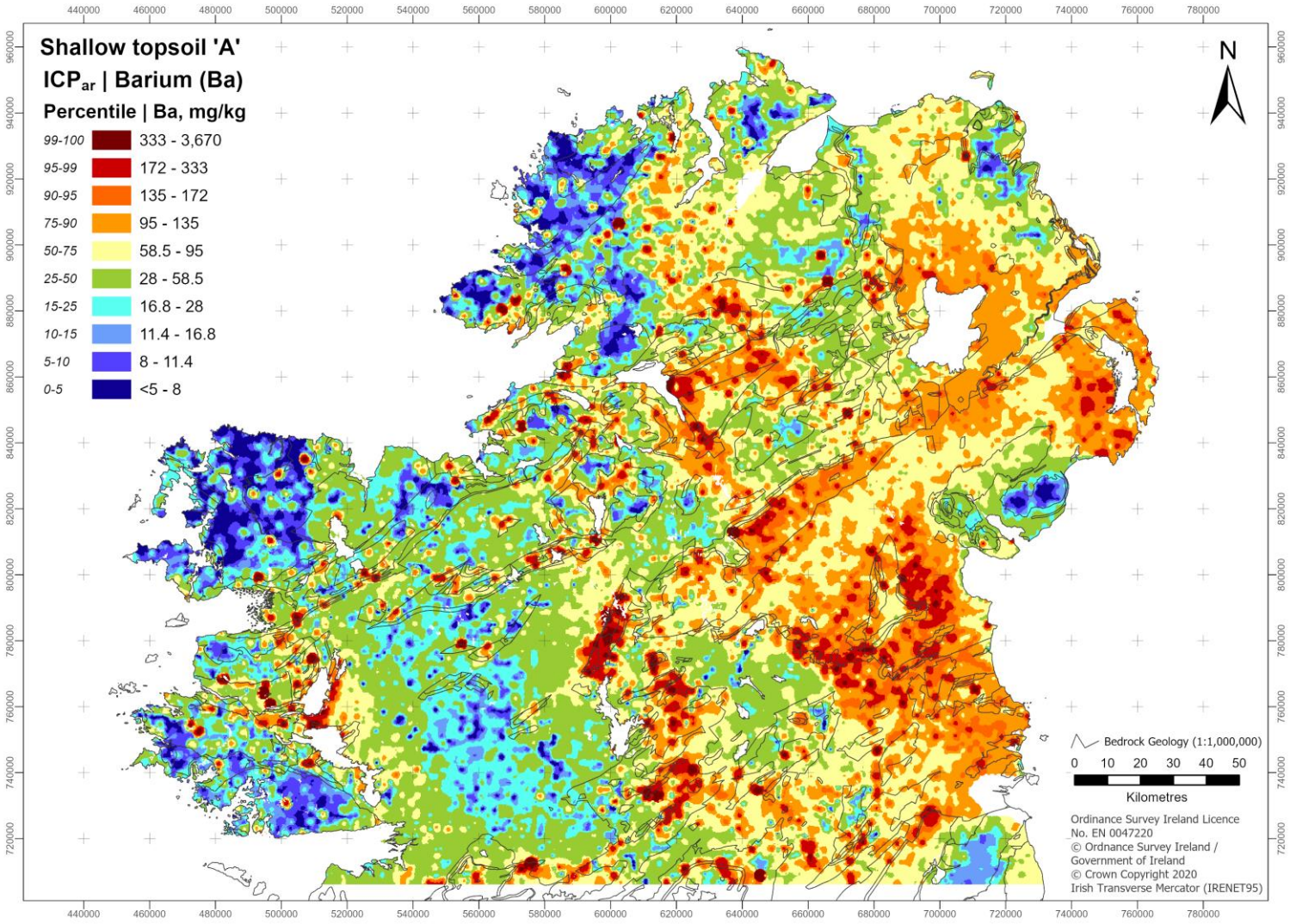
2.4. Aluminium (Al)



2.5. Arsenic (As)



2.6. Barium (Ba)


Shallow topsoil 'A'
ICP$_{ar}$ | Barium (Ba)
Percentile | Ba, mg/kg
99-100 333 - 3,670
95-99 172 - 333
90-95 135 - 172
75-90 95 - 135
50-75 58.5 - 95
25-50 28 - 58.5
15-25 16.8 - 28
10-15 11.4 - 16.8
5-10 8 - 11.4
0-5 <5 - 8
N
Bedrock Geology (1:1,000,000)
0 10 20 30 40 50
Kilometres
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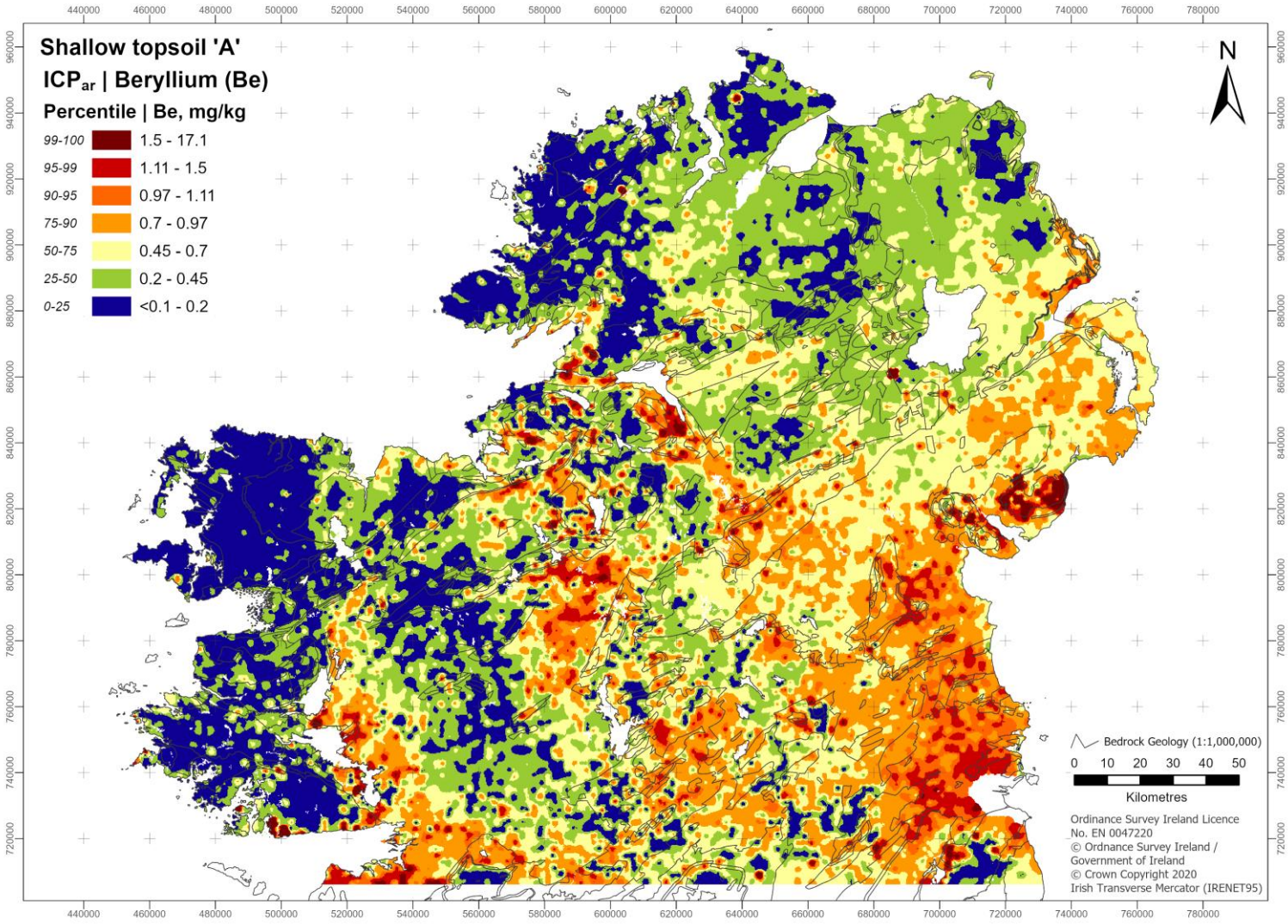
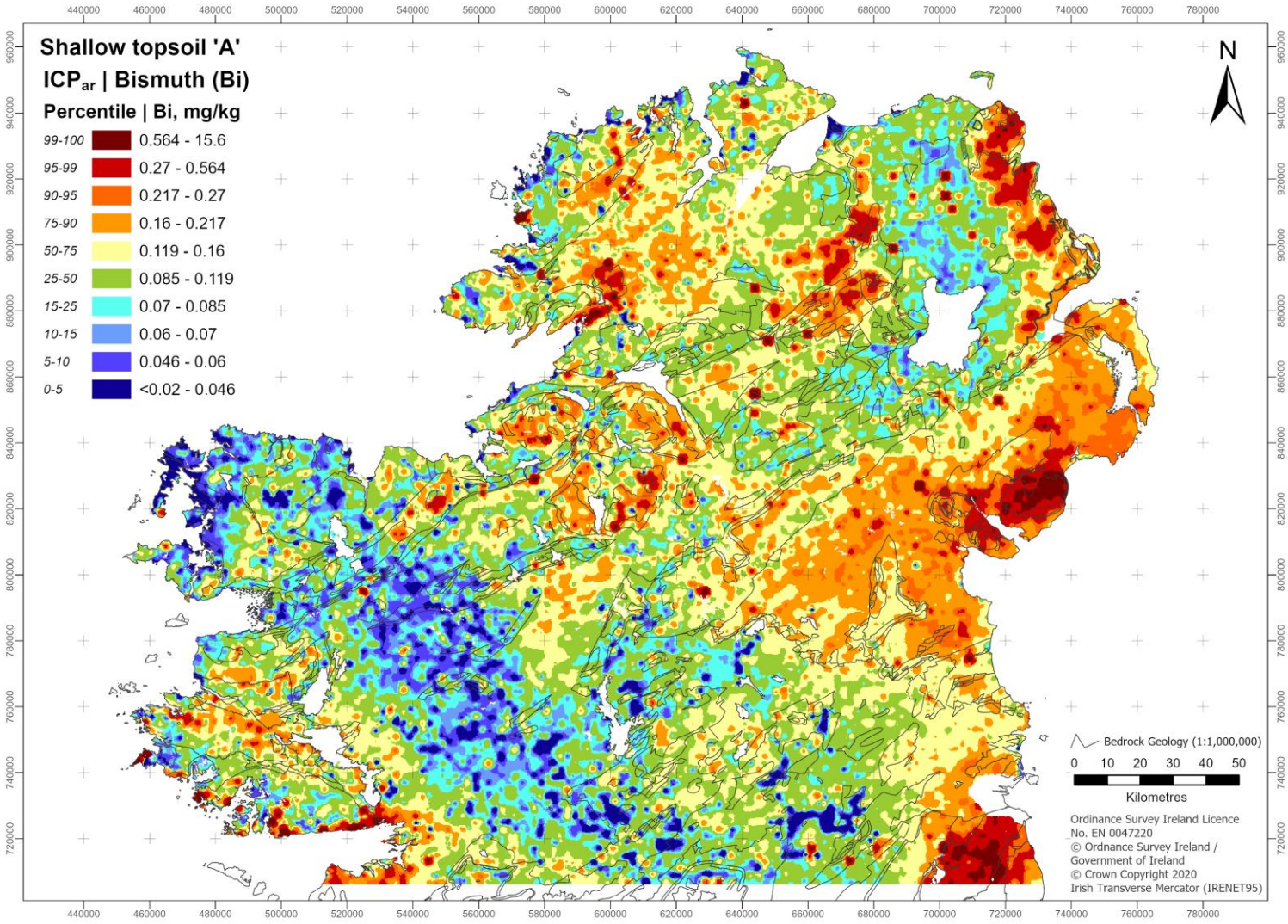
Irish Transverse Mercator (IRENET95)
440000 460000 480000 500000 520000 540000 560000 580000 600000 620000 640000 660000 680000 700000 720000 740000 760000 780000
960000 940000 920000 900000 880000 860000 840000 820000 800000 780000 760000 740000 720000

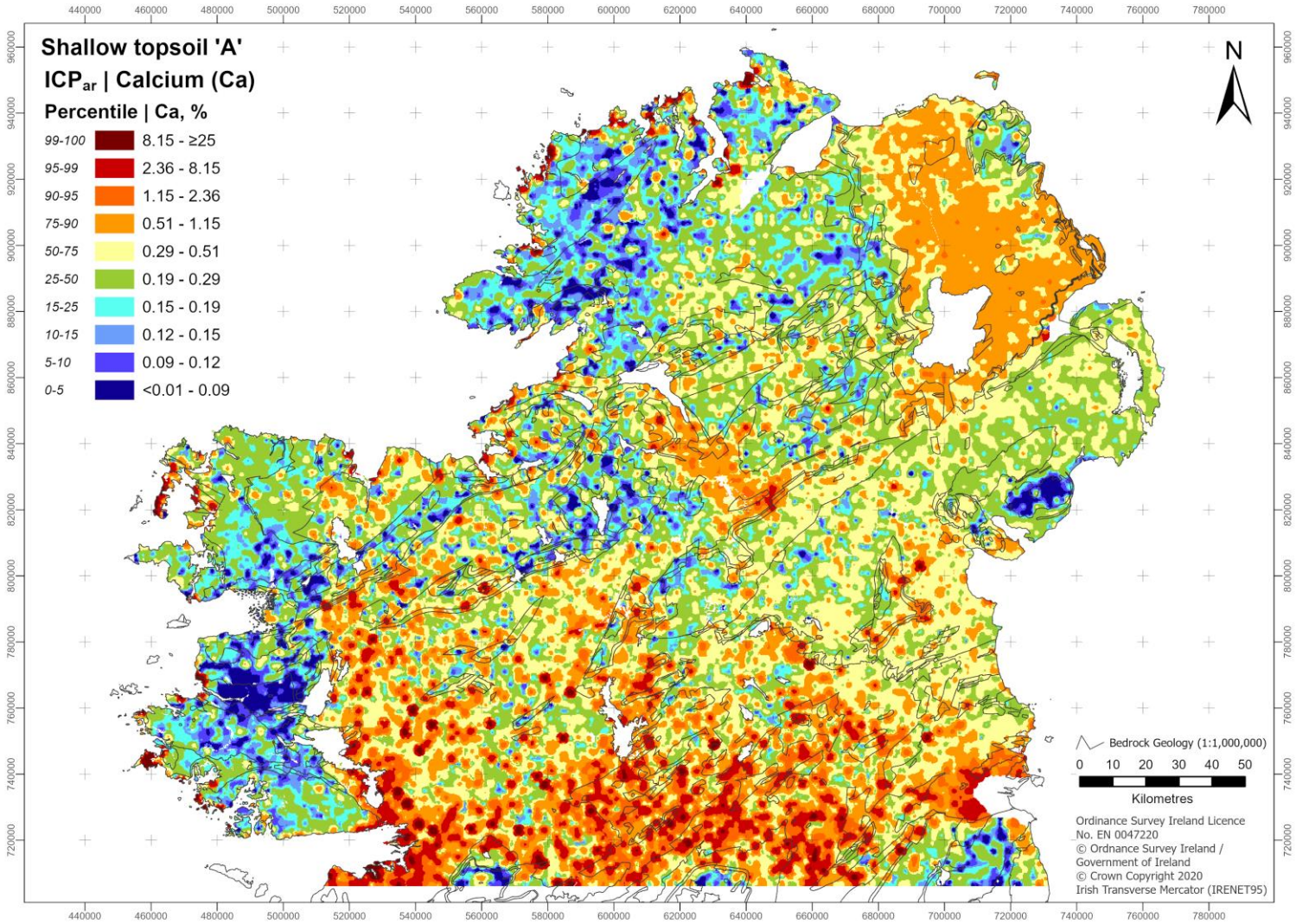
2.7. Beryllium (Be)



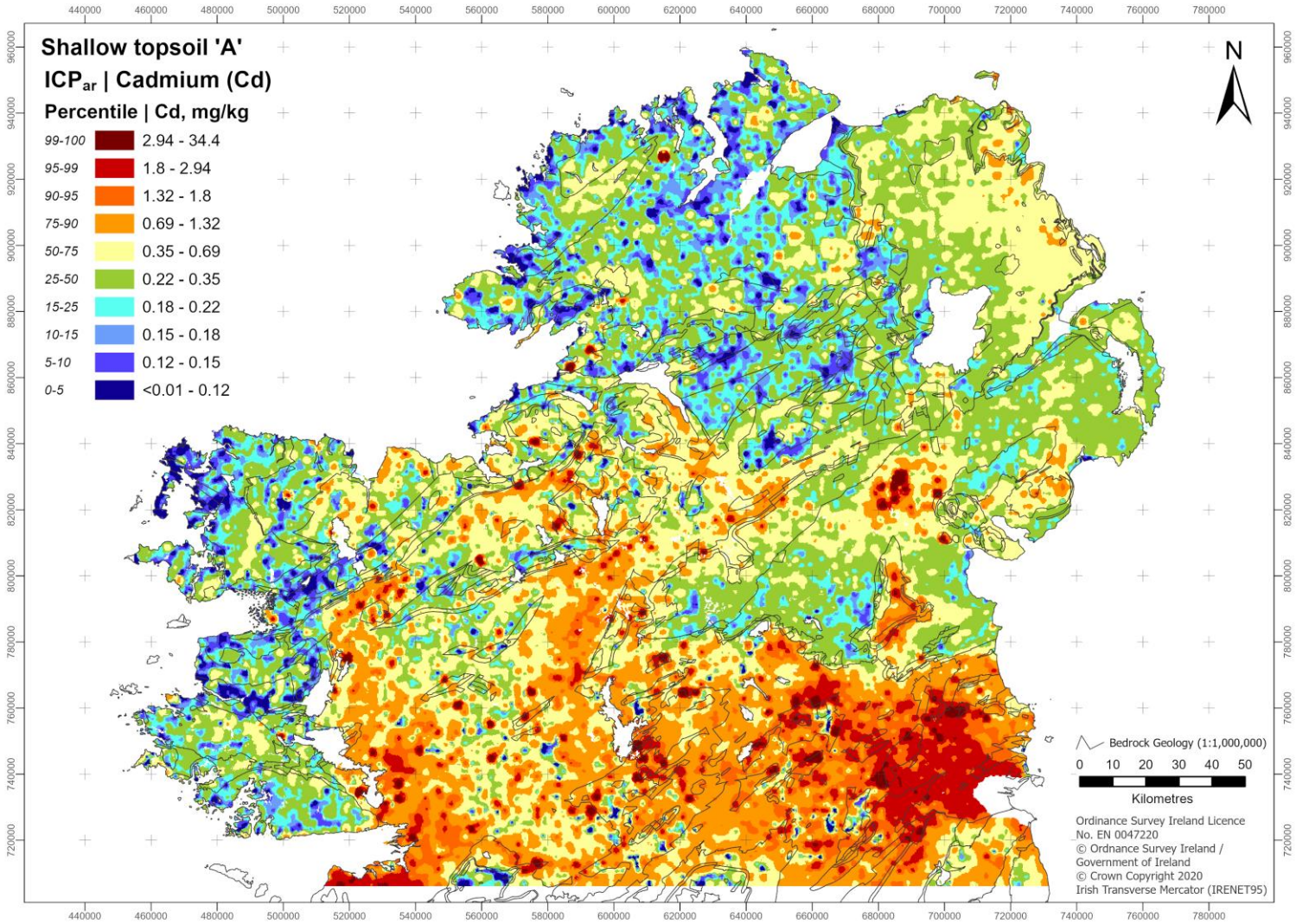
2.8. Bismuth (Bi)



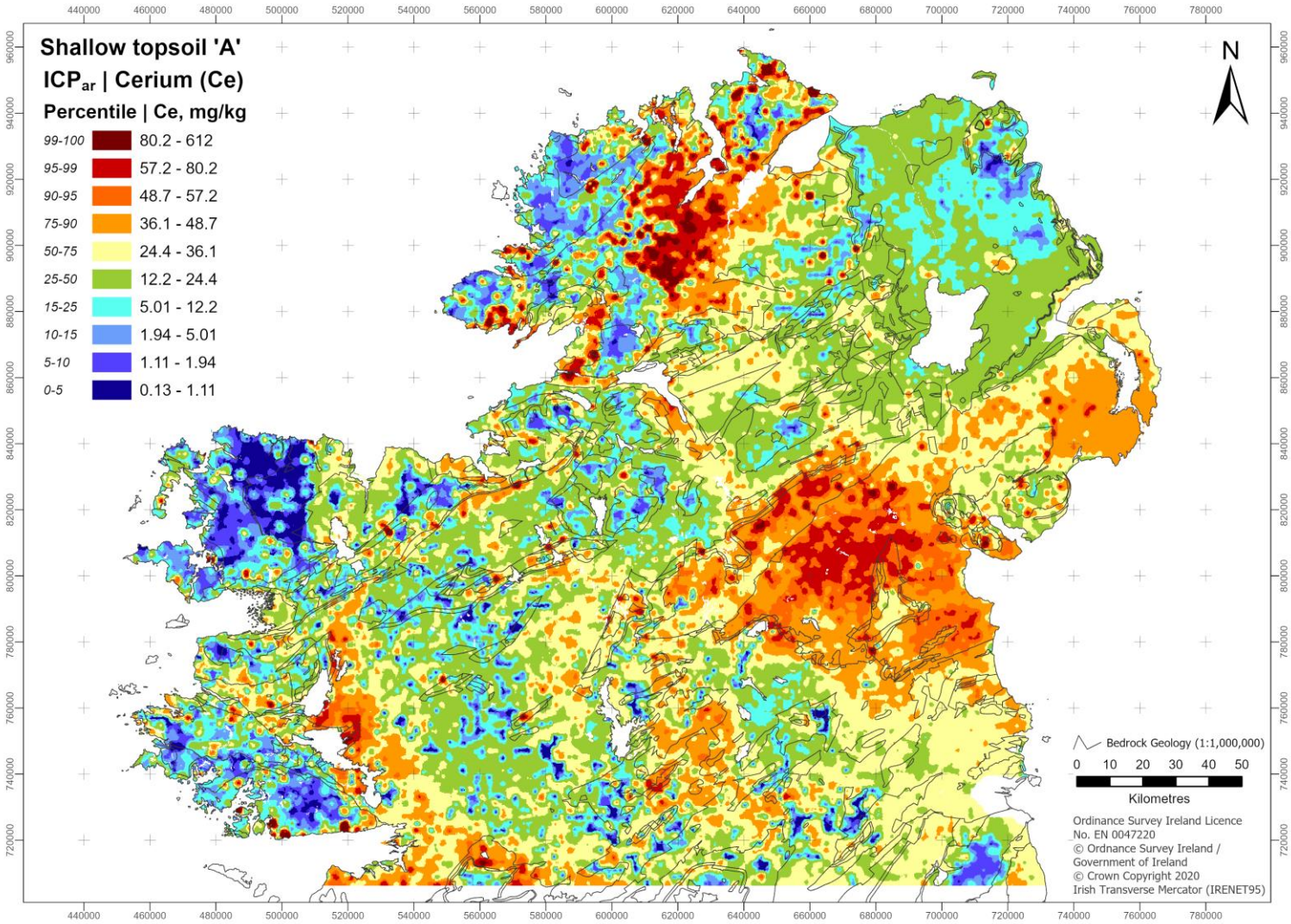
2.9. Calcium (Ca)



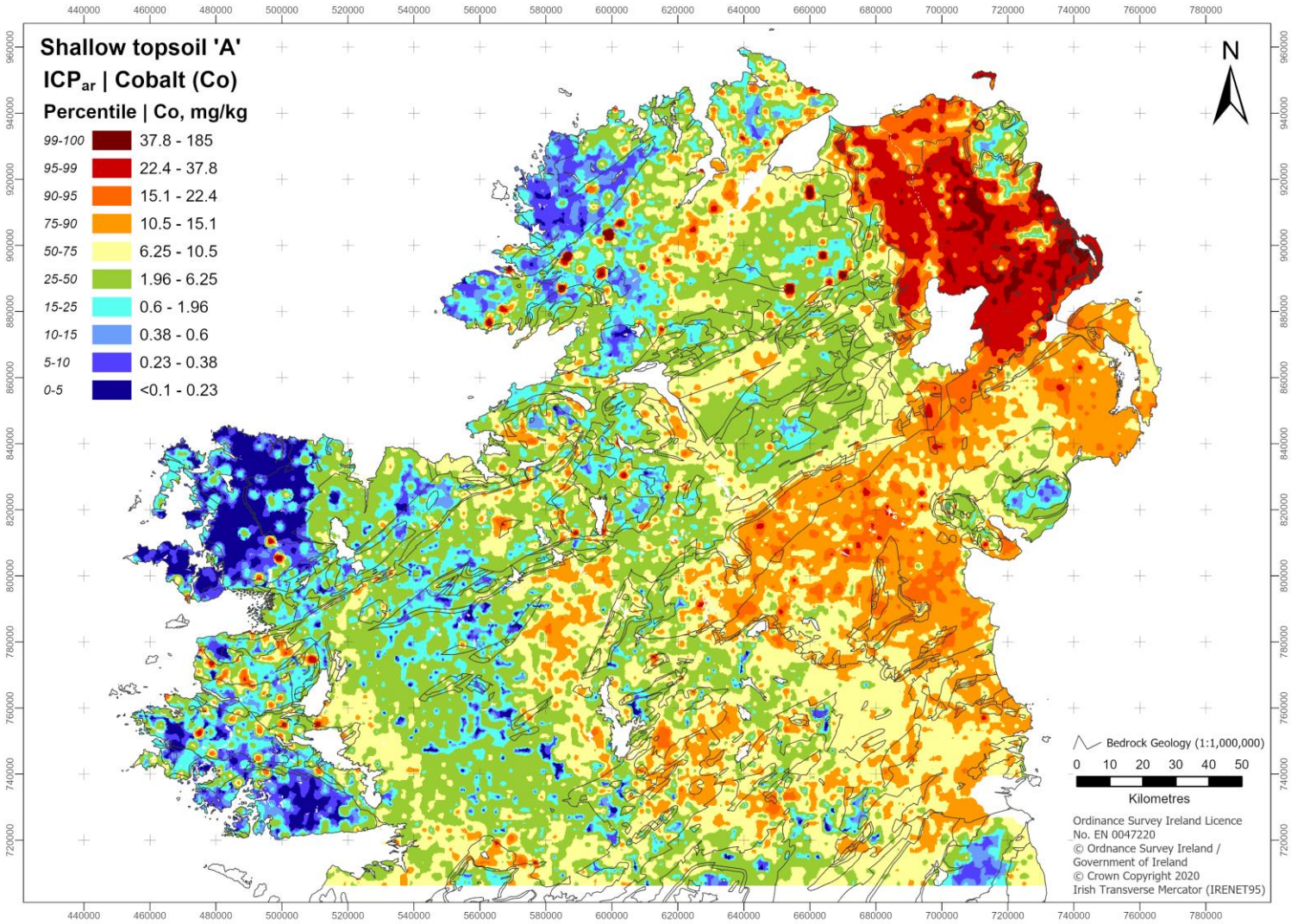
2.10. Cadmium (Cd)



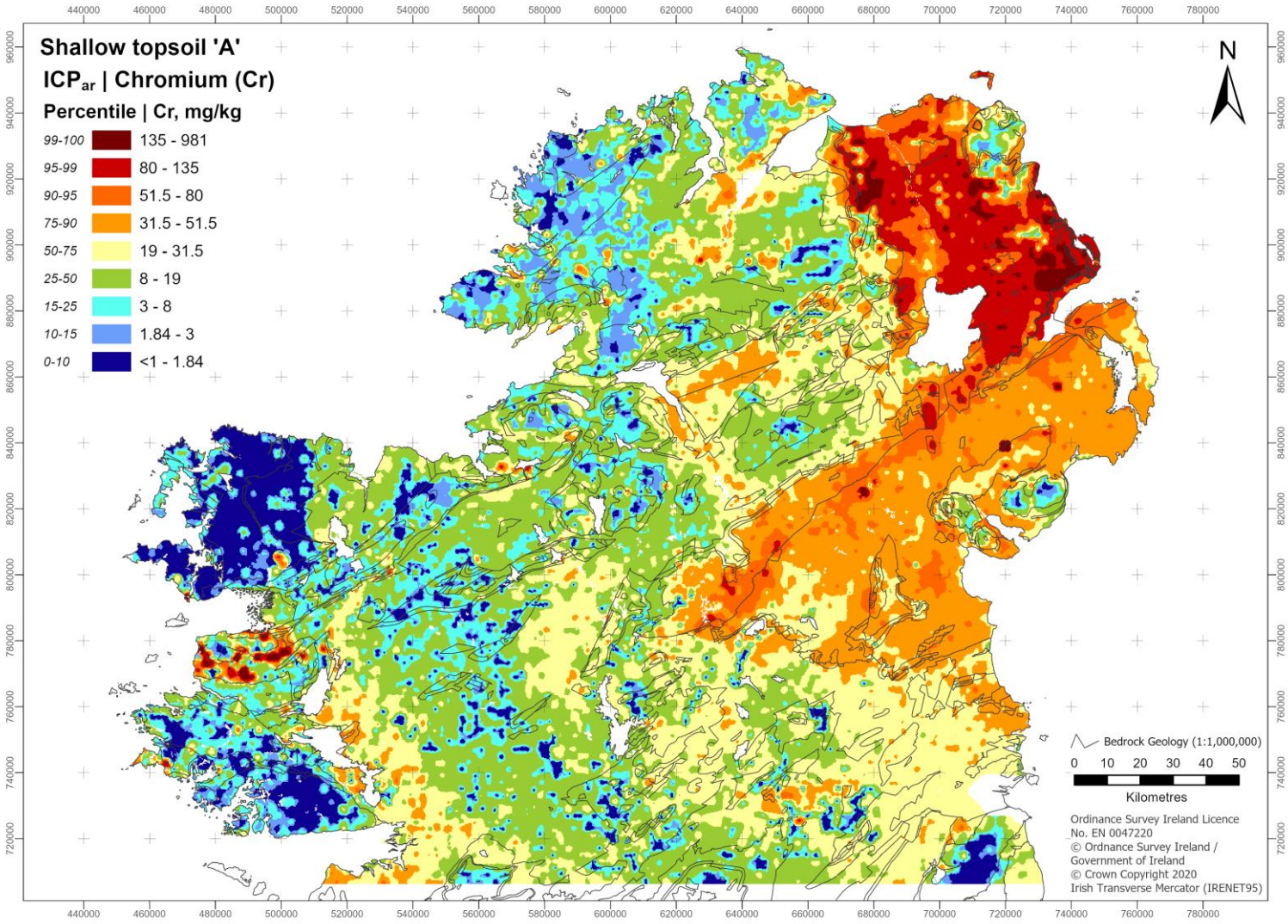
2.11. Cerium (Ce)



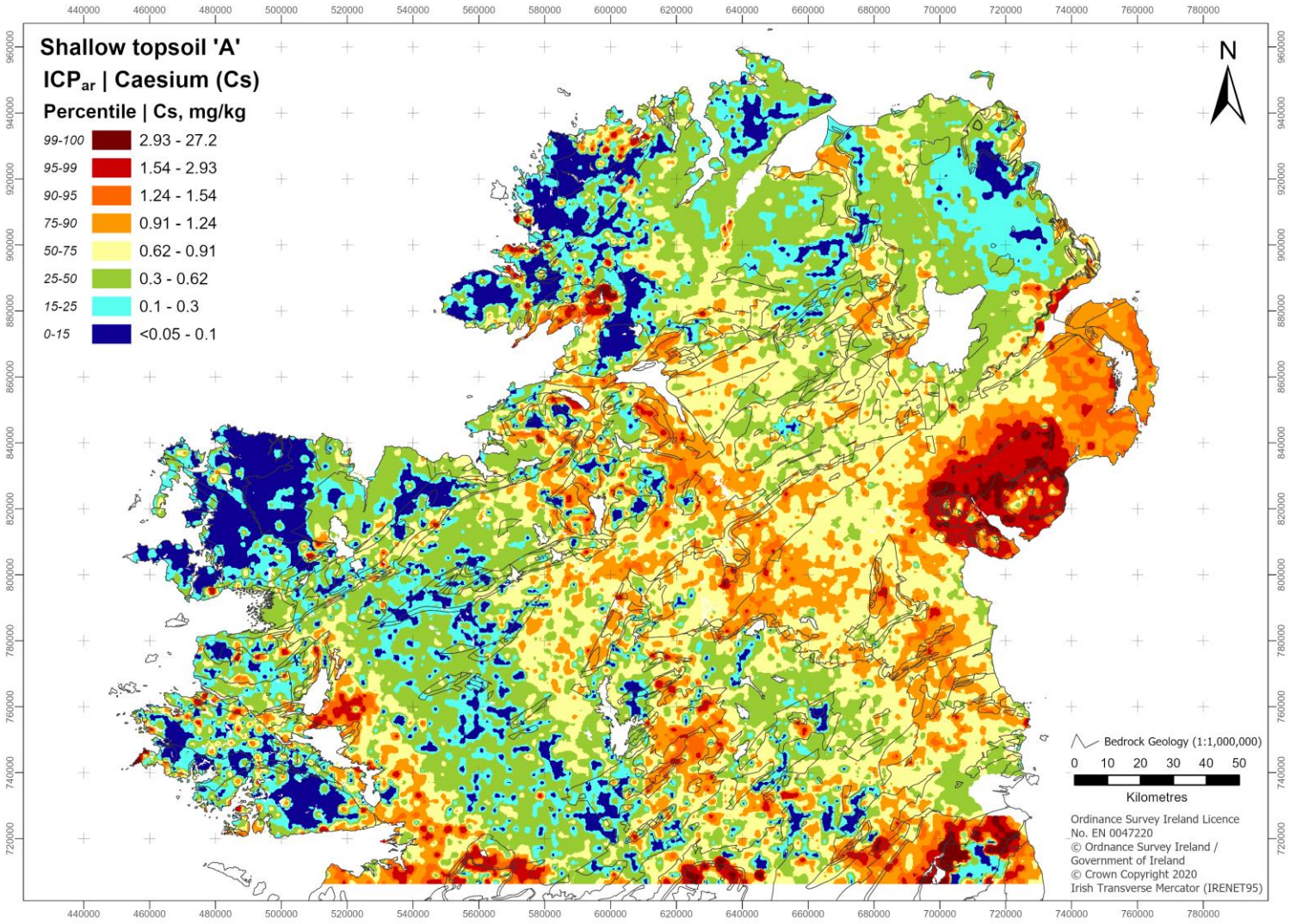
2.12. Cobalt (Co)



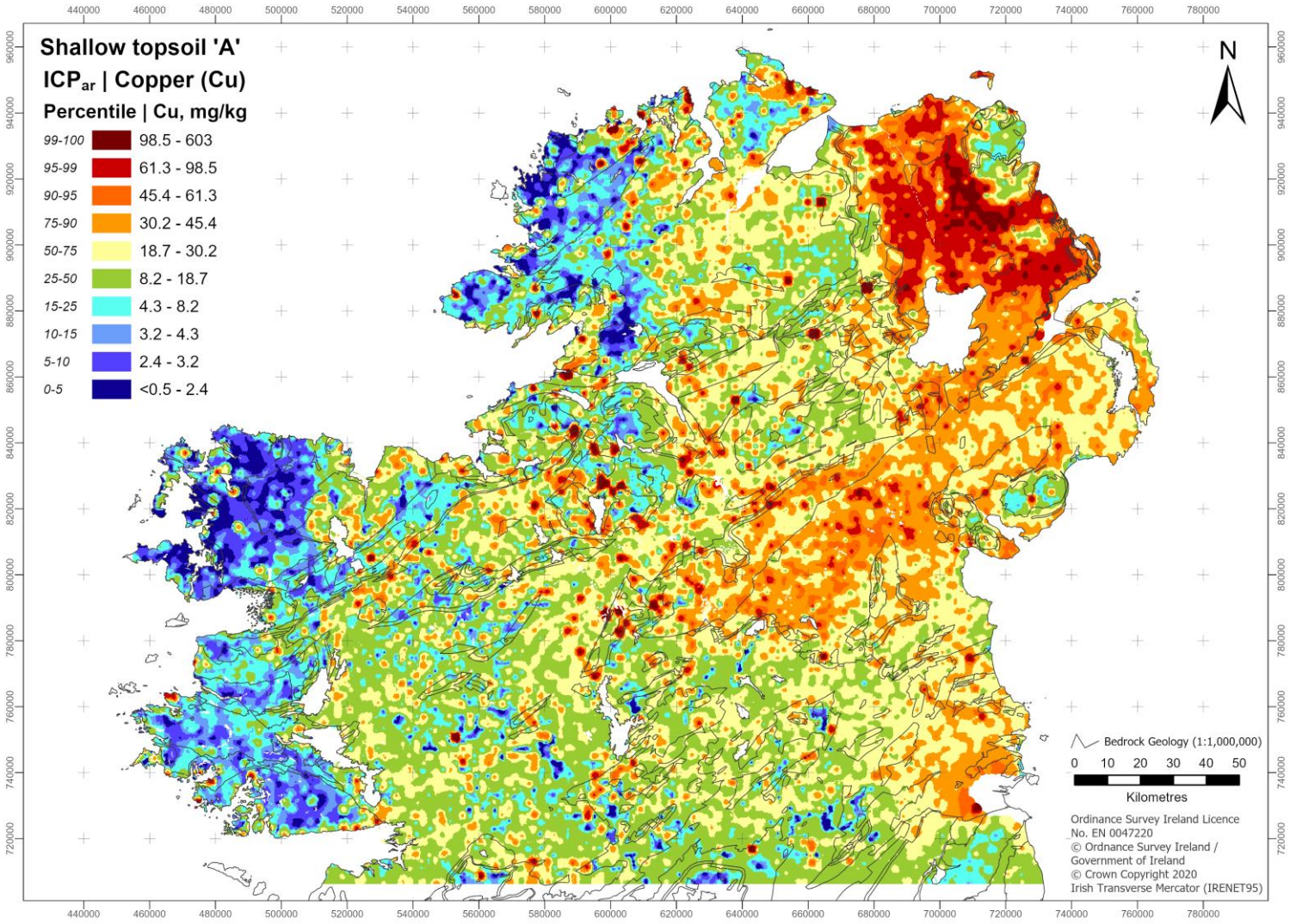
2.13. Chromium (Cr)



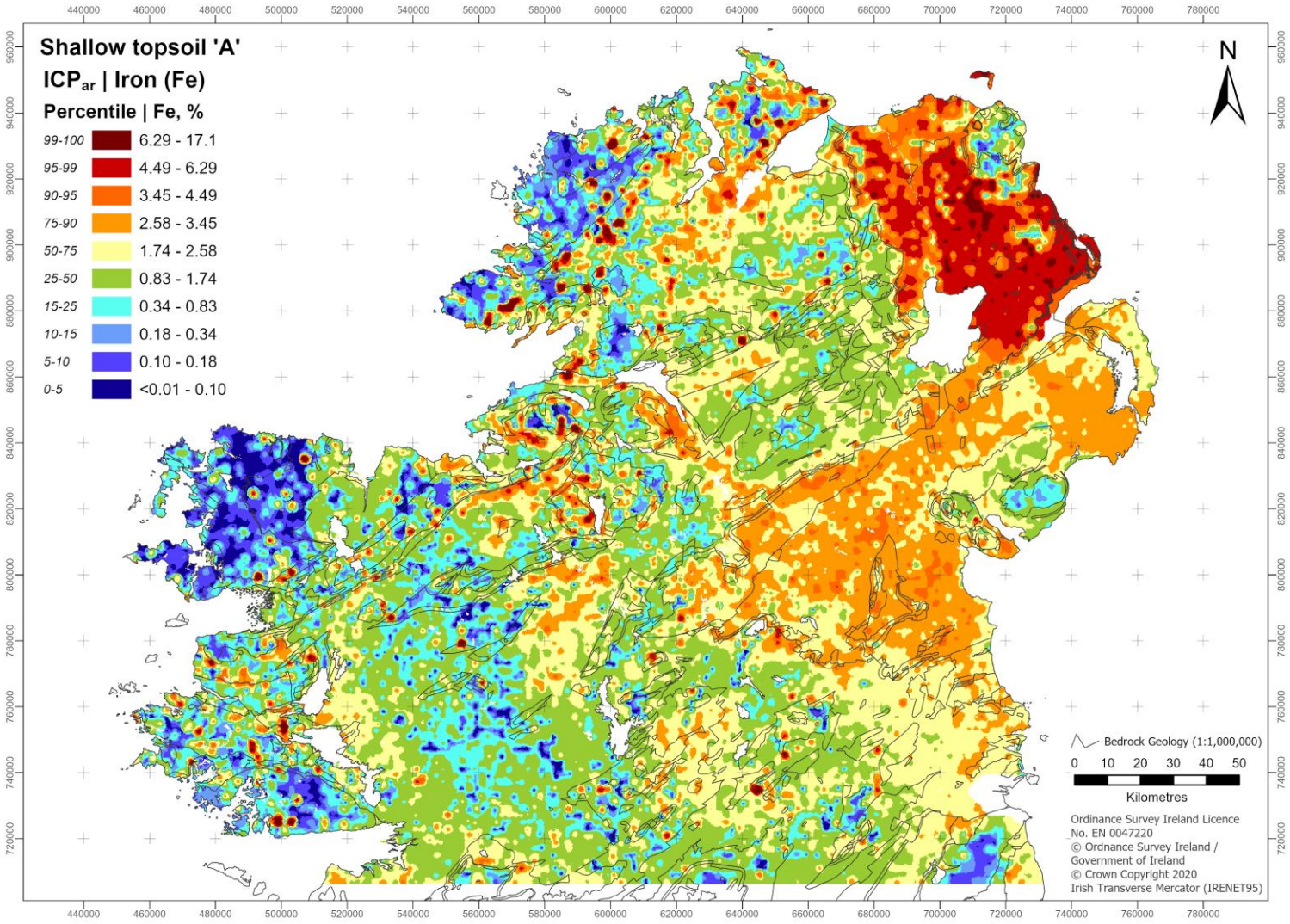
2.14. Caesium (Cs)



2.15. Copper (Cu)



2.16. Iron (Fe)


Shallow topsoil 'A'
ICP$_{ar}$ | Iron (Fe)
Percentile | Fe, %
99-100 6.29 - 17.1
95-99 4.49 - 6.29
90-95 3.45 - 4.49
75-90 2.58 - 3.45
50-75 1.74 - 2.58
25-50 0.83 - 1.74
15-25 0.34 - 0.83
10-15 0.18 - 0.34
5-10 0.10 - 0.18
0-5 <0.01 - 0.10
N
Bedrock Geology (1:1,000,000)
0 10 20 30 40 50
Kilometres
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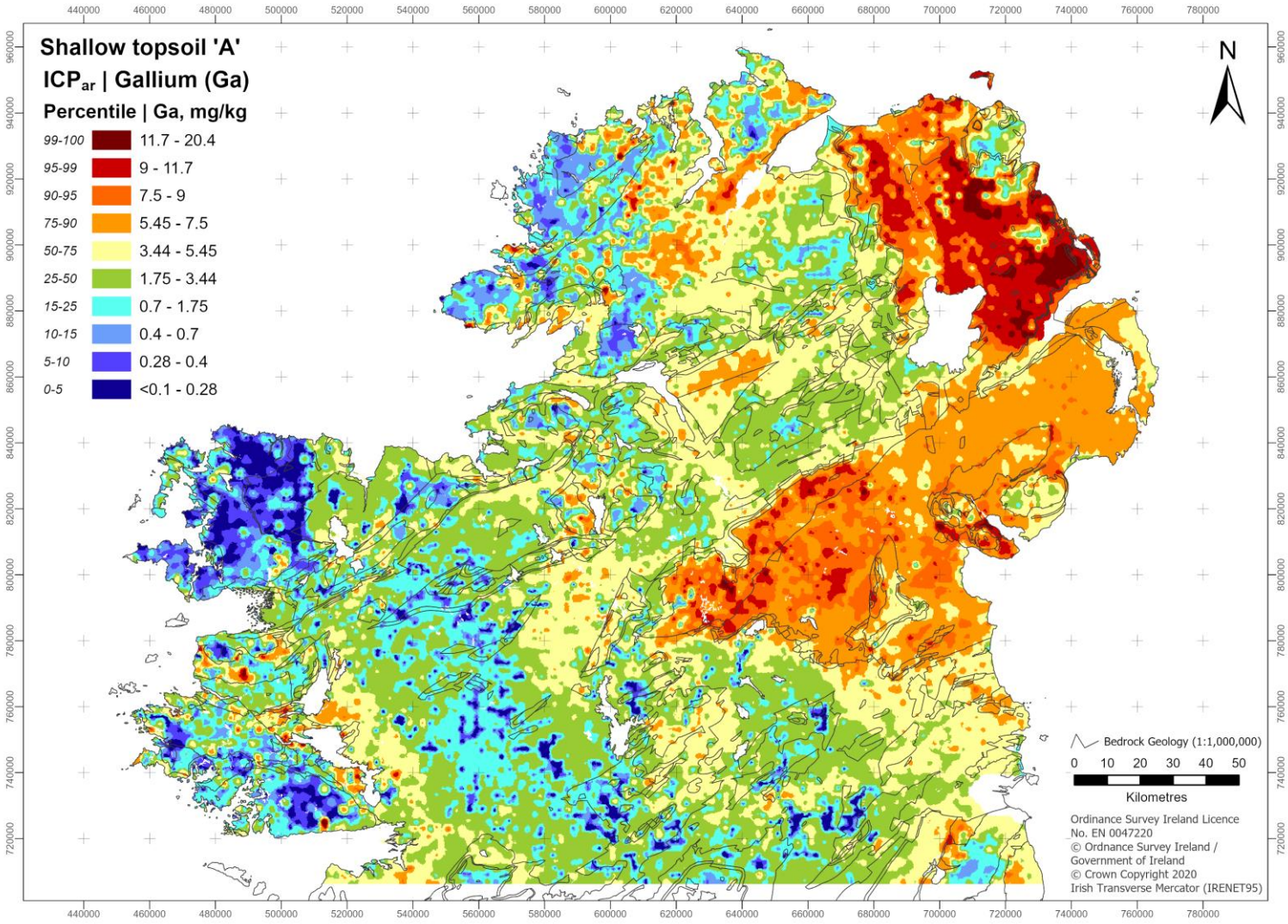
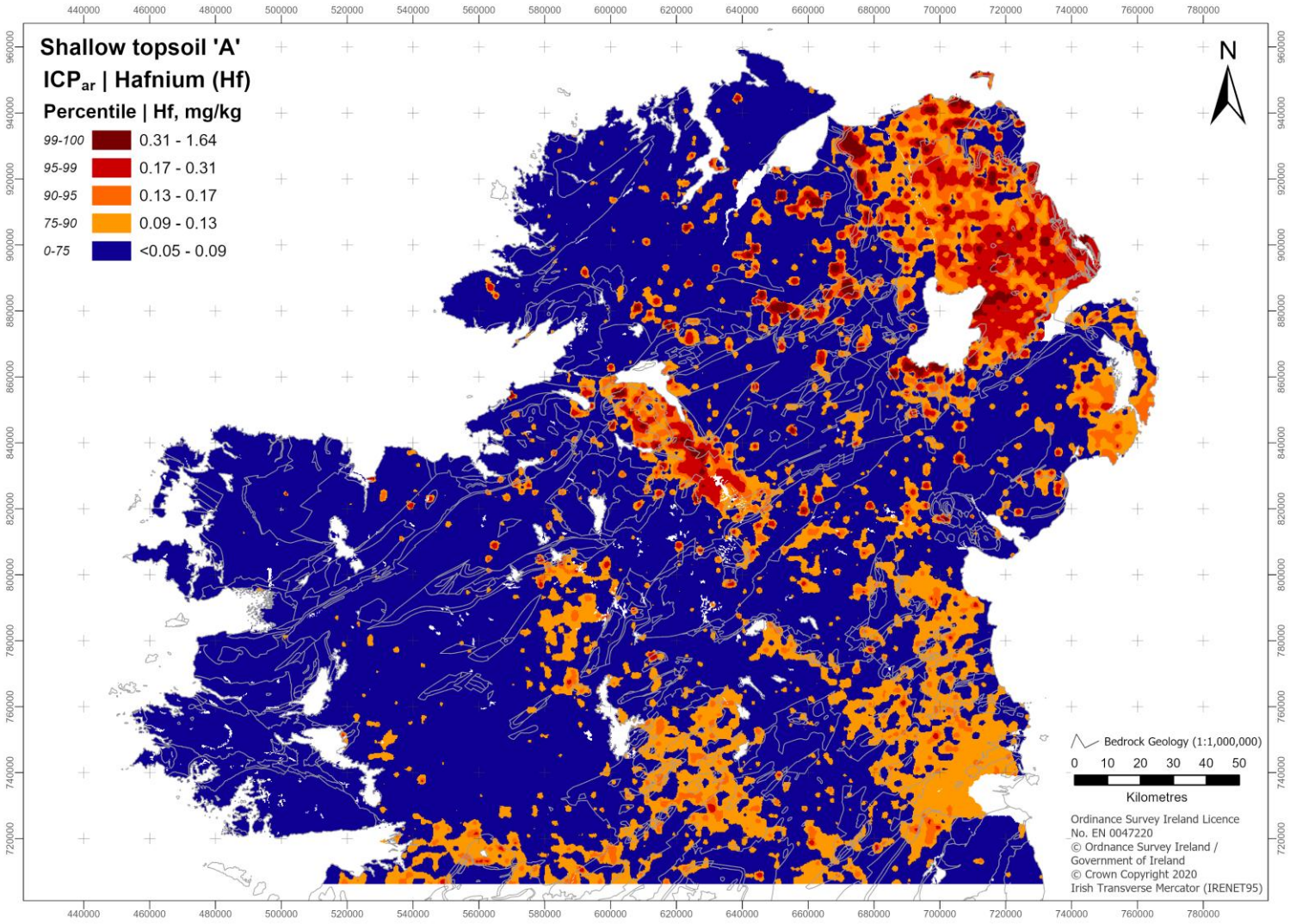
960000 940000 920000 900000 880000 860000 840000 820000 800000 780000 760000 740000 720000

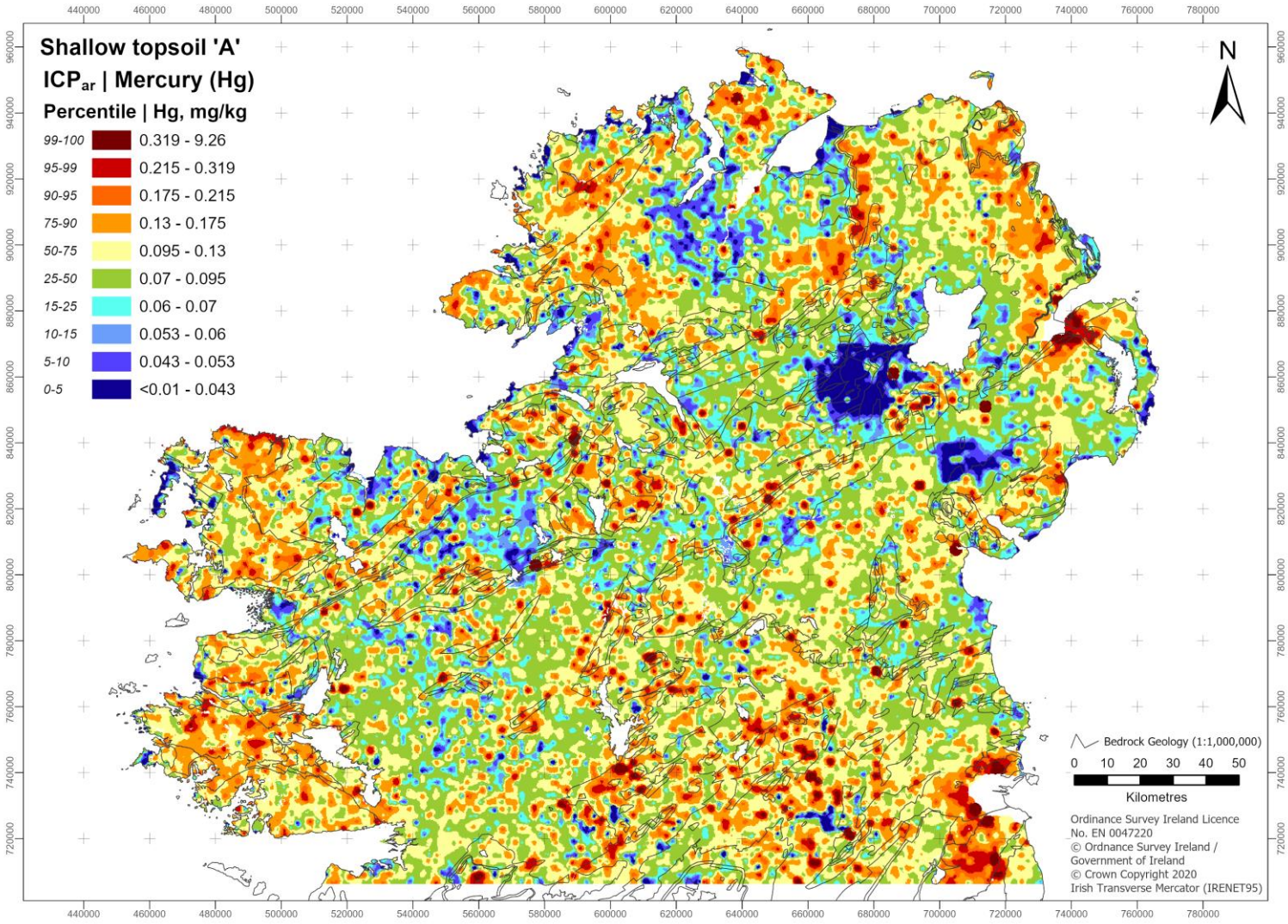
2.17. Gallium (Ga)



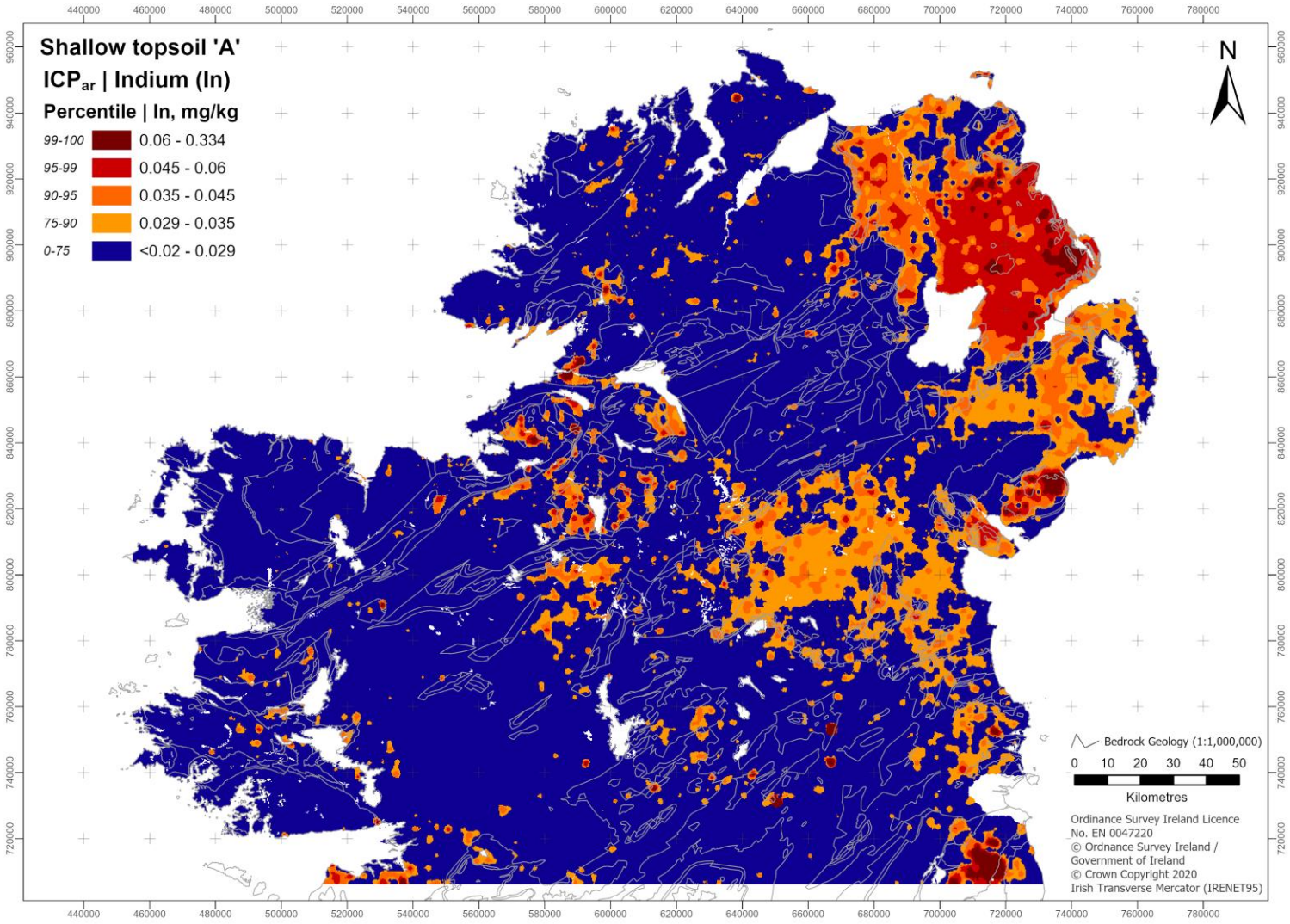
2.18. Hafnium (Hf)



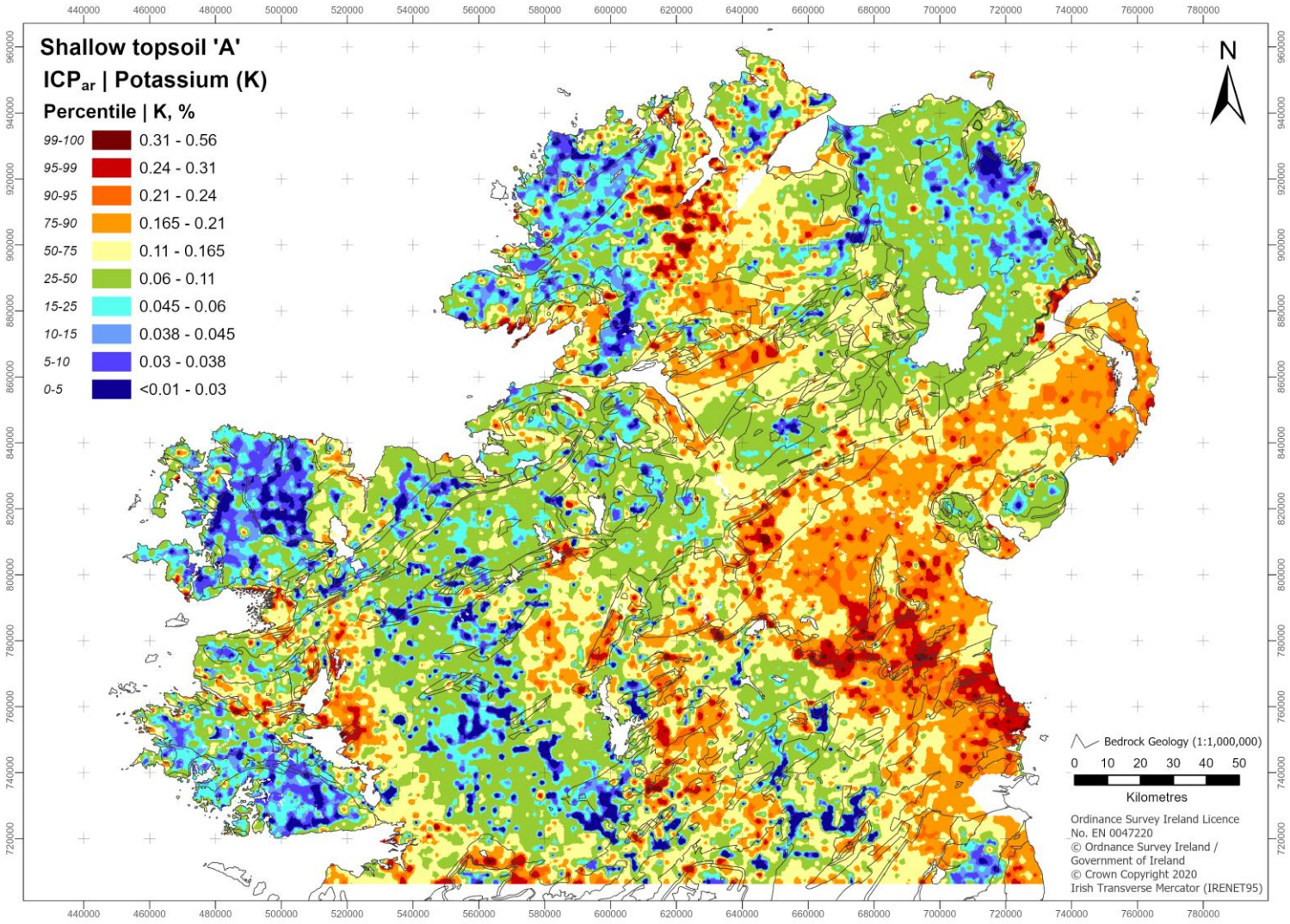
2.19. Mercury (Hg)



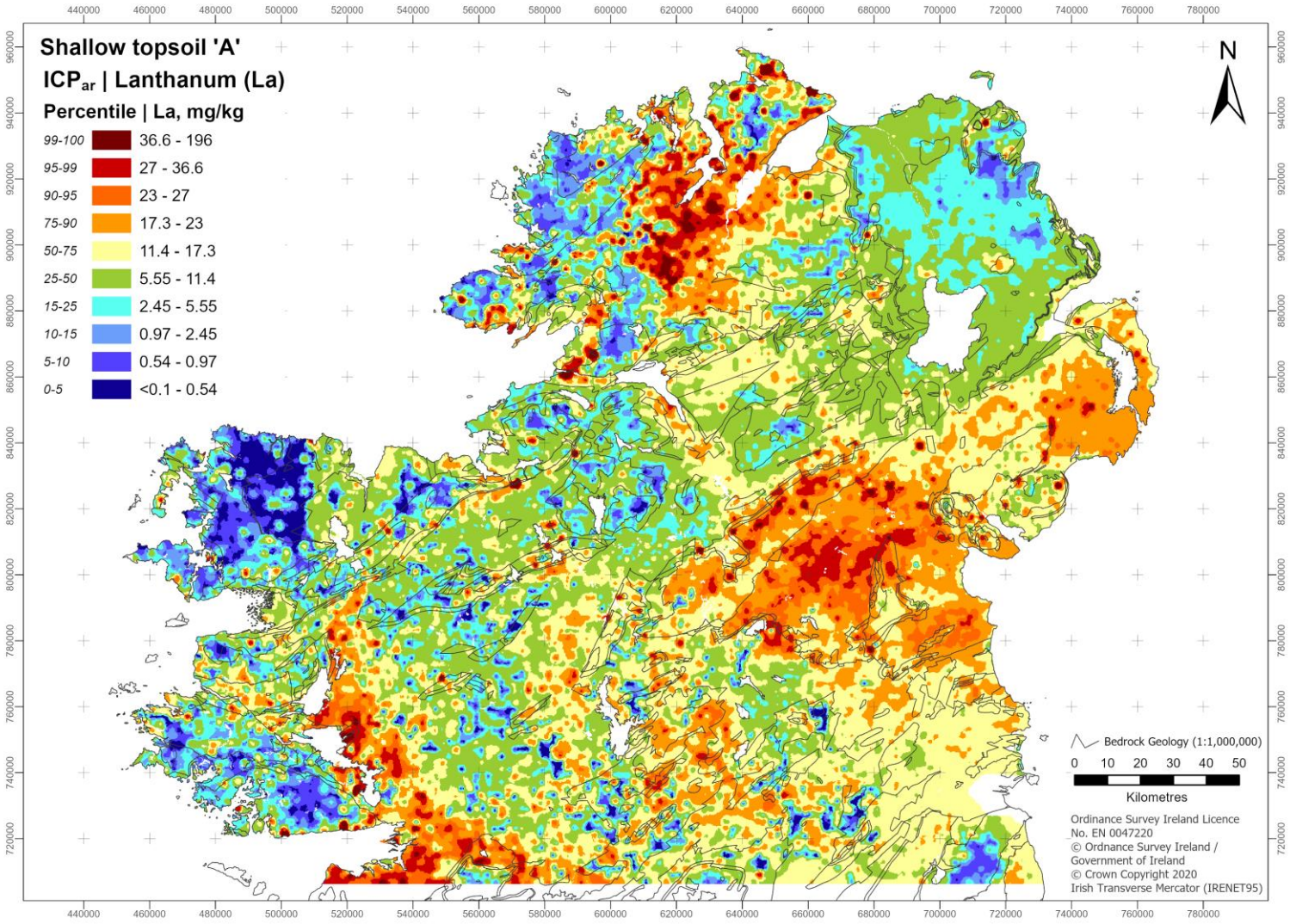
2.20. Indium (In)



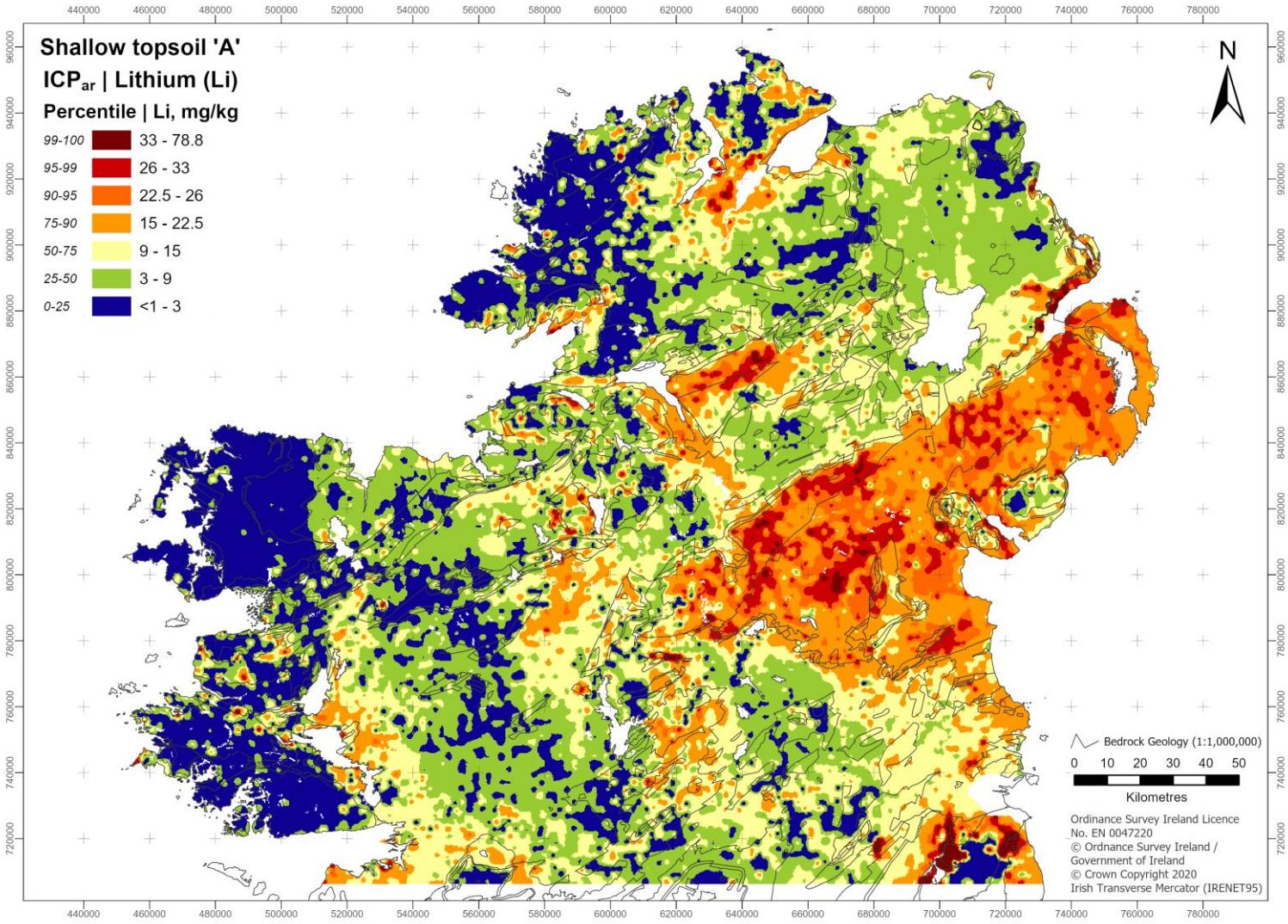
2.21. Potassium (K)



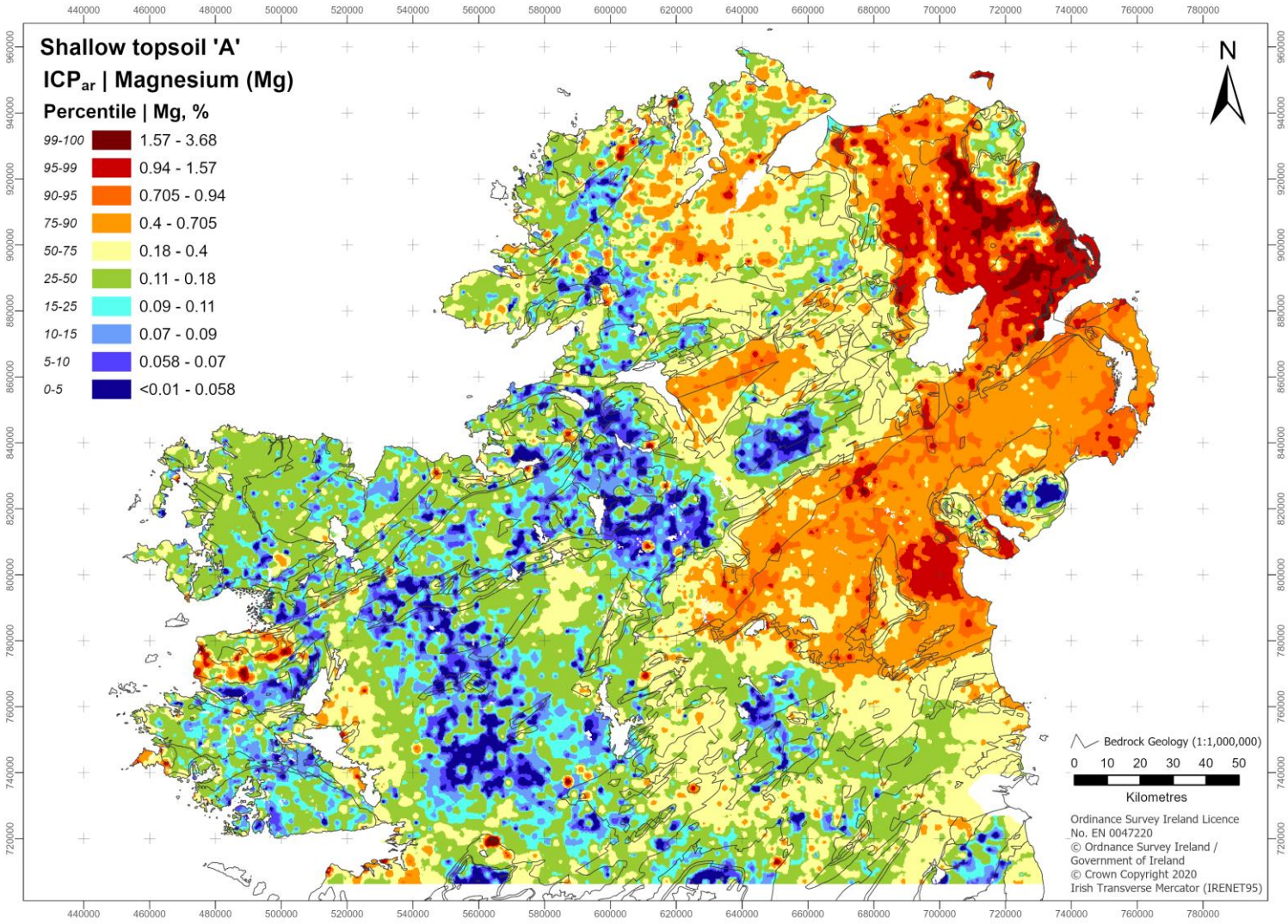
2.22. Lanthanum (La)



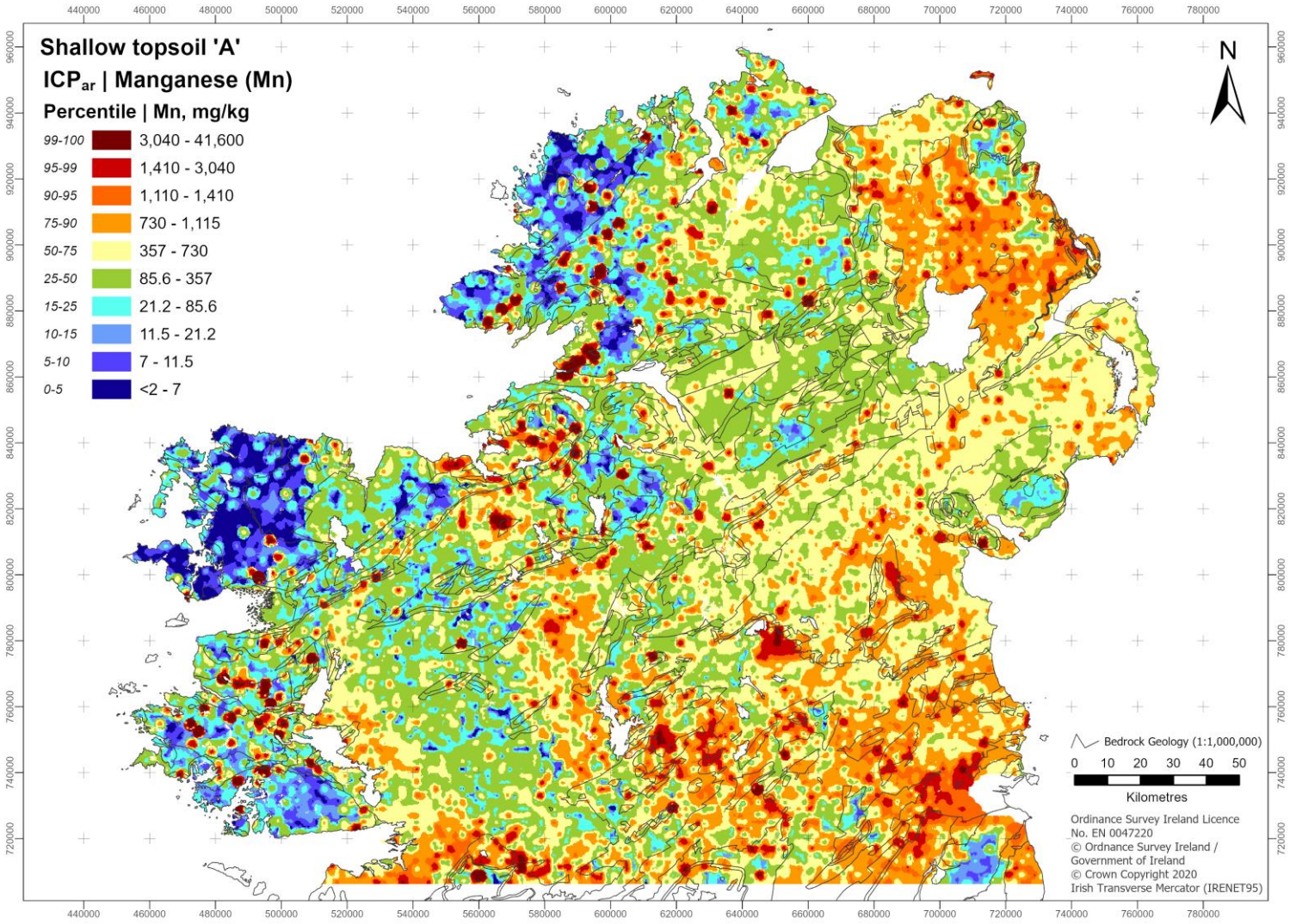
2.23. Lithium (Li)



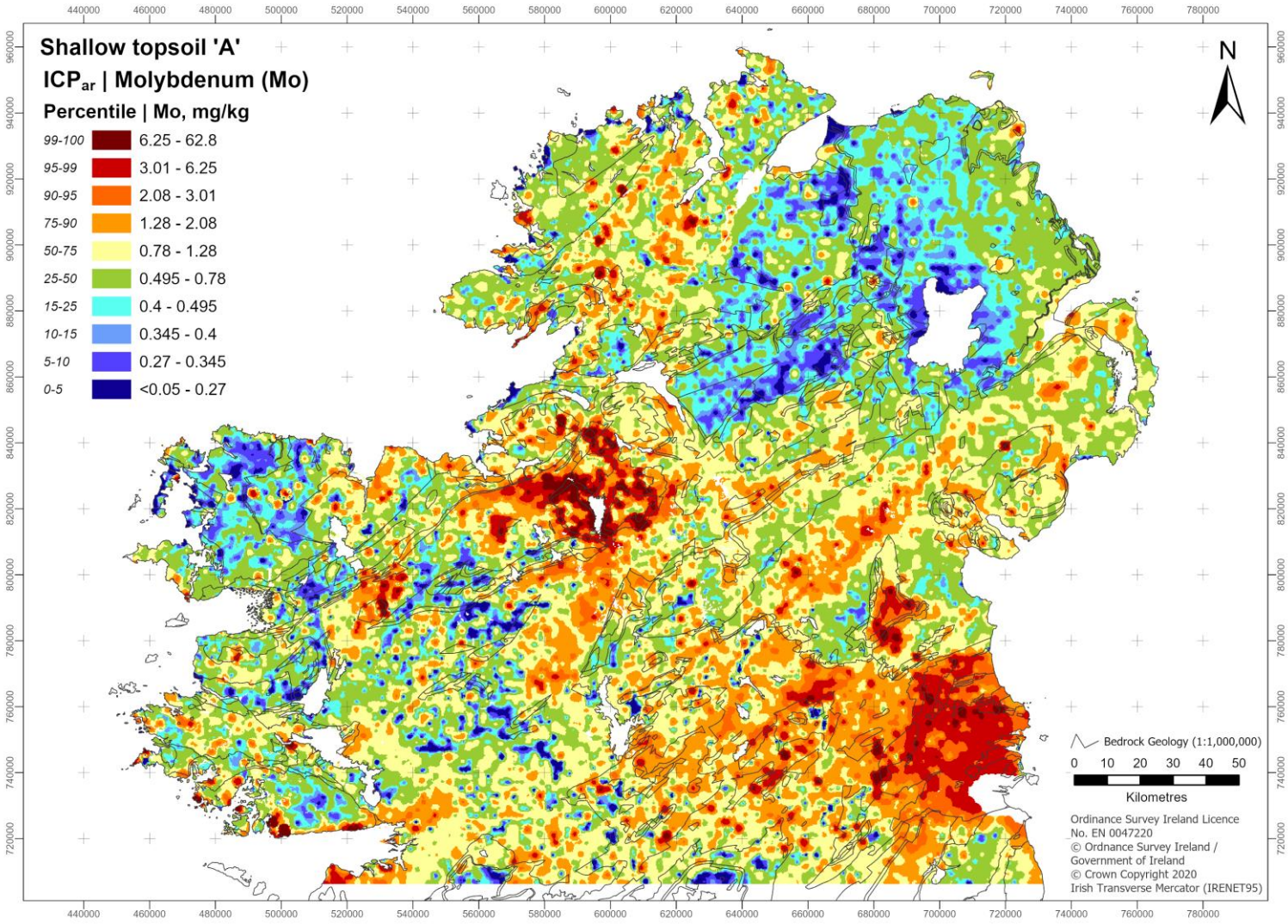
2.24. Magnesium (Mg)



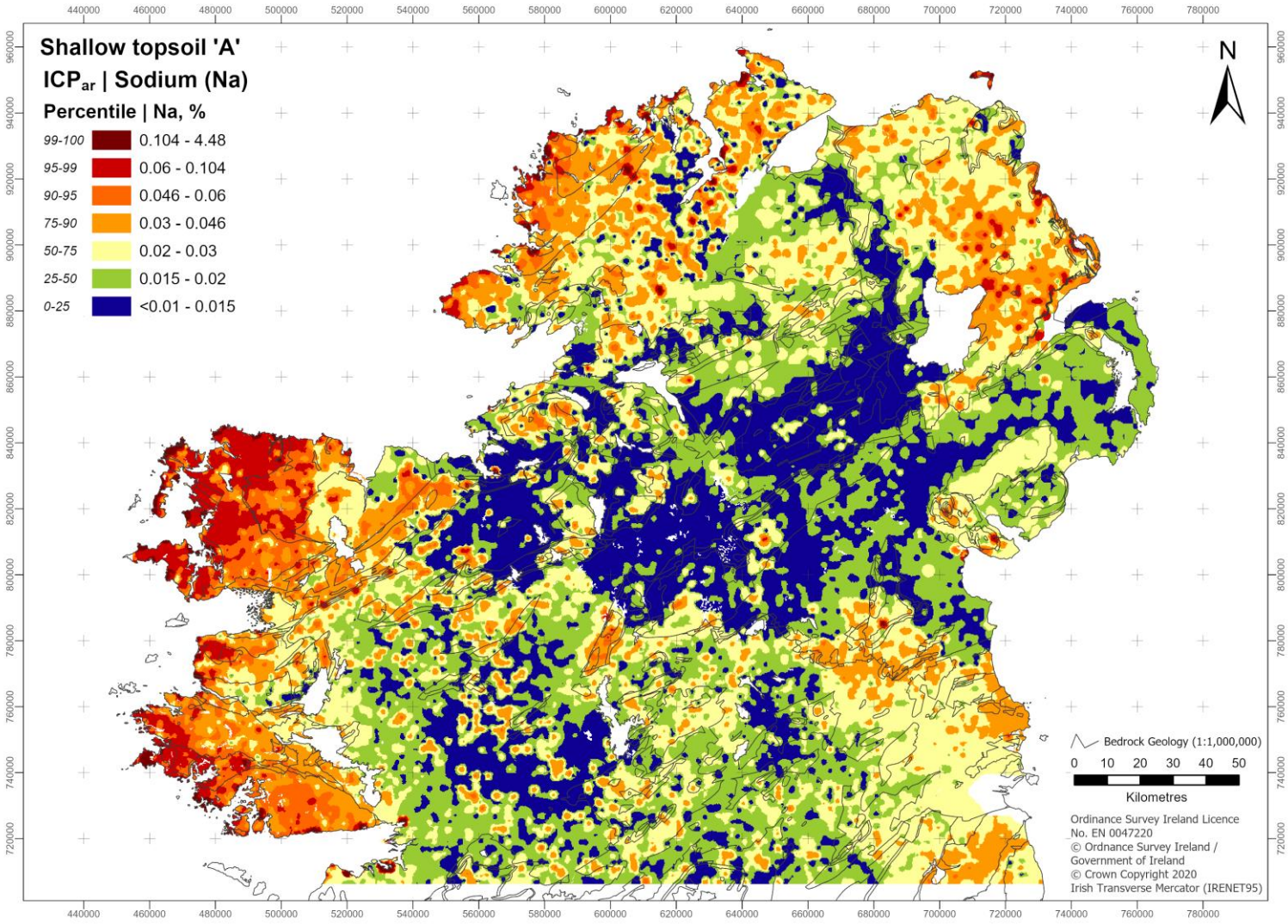
2.25. Manganese (Mn)



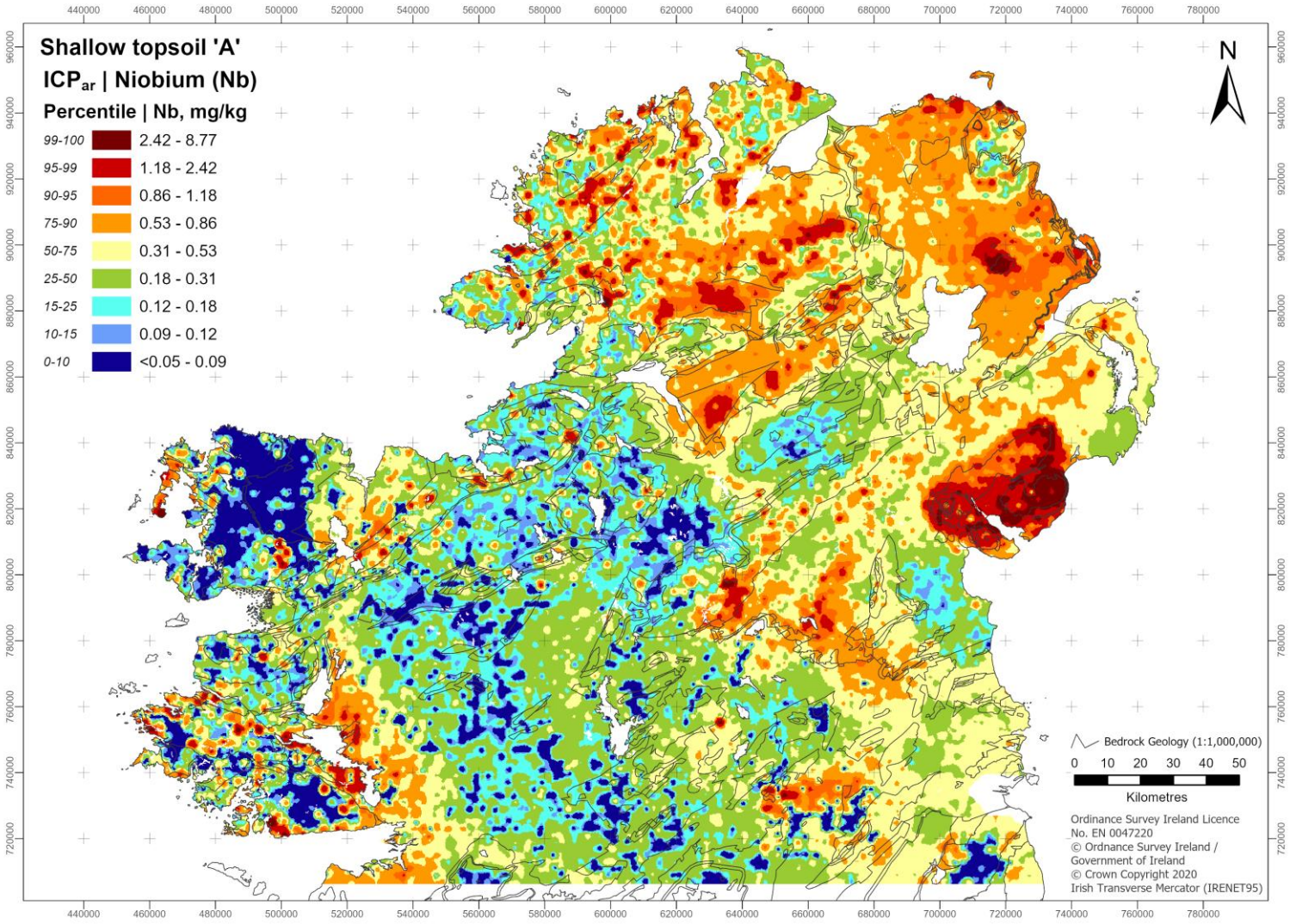
2.26. Molybdenum (Mo)



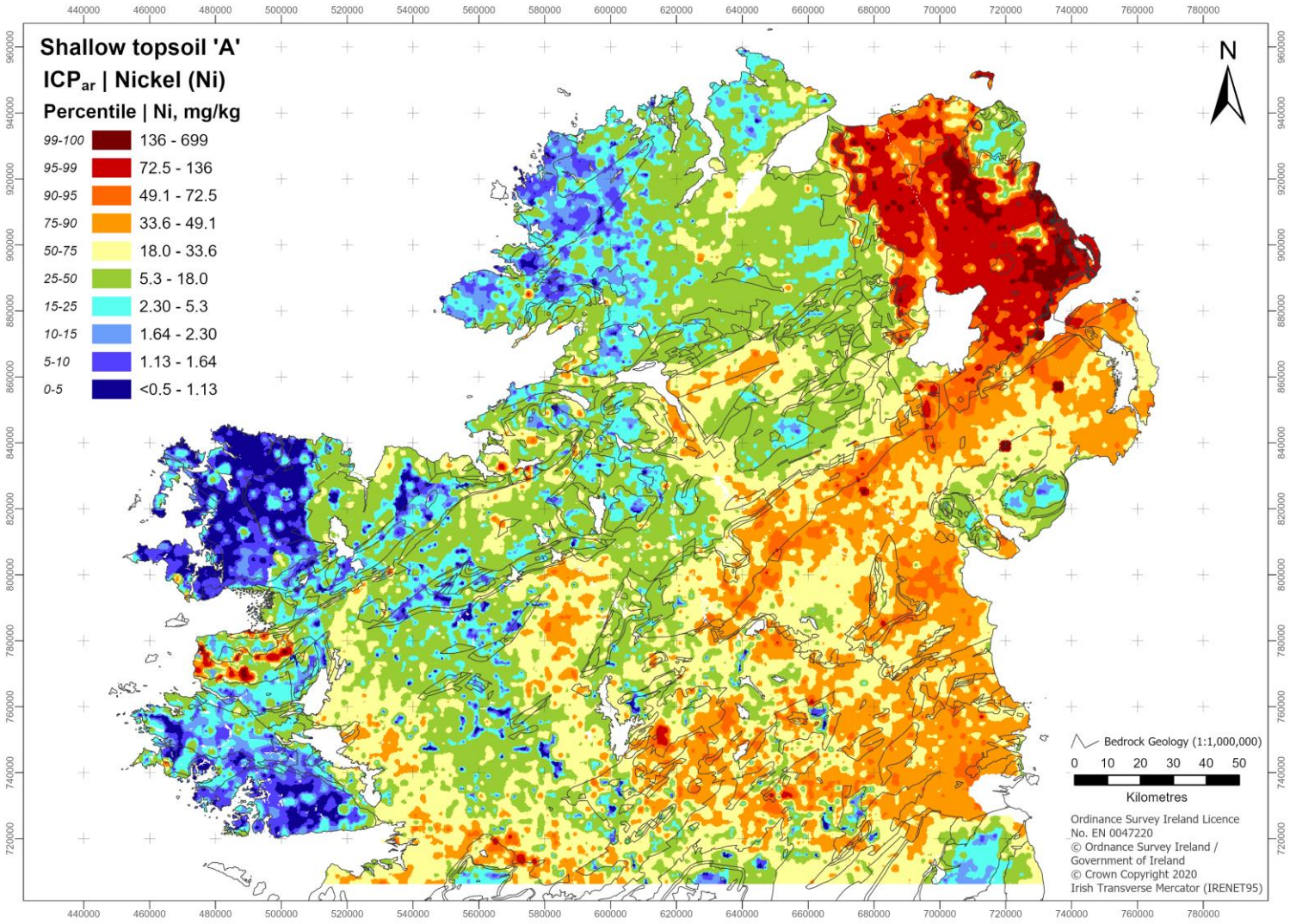
2.27. Sodium (Na)



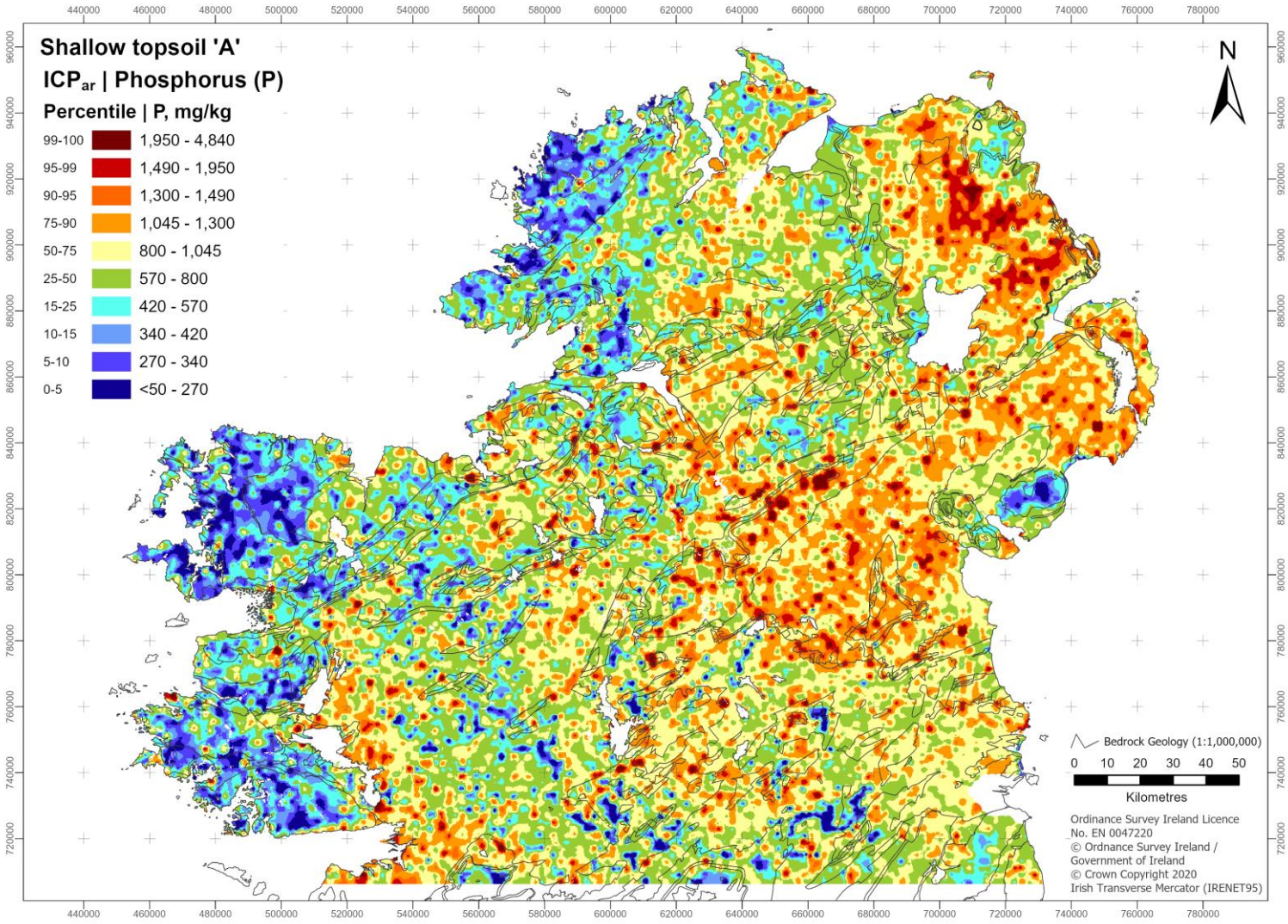
2.28. Niobium (Nb)



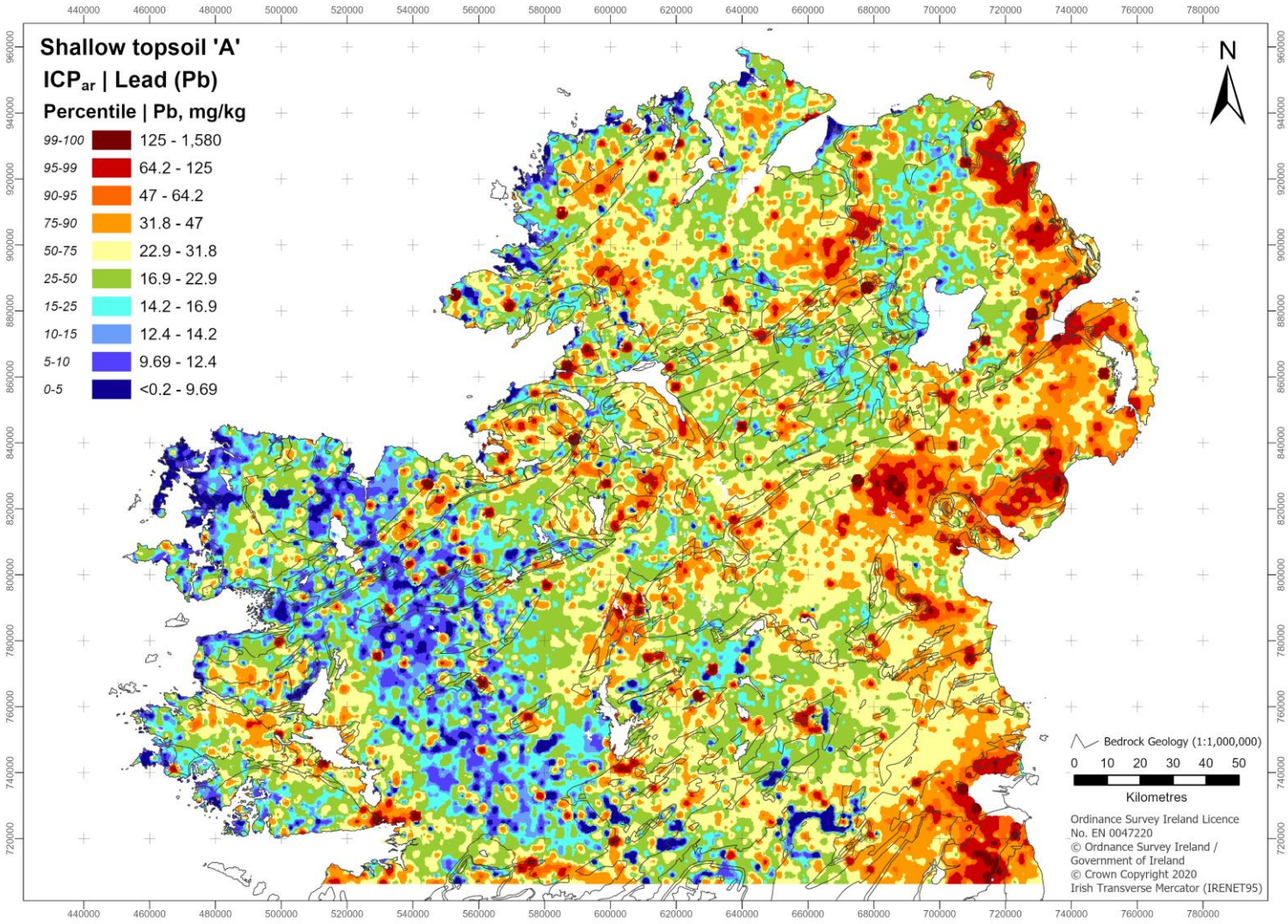
2.29. Nickel (Ni)



2.30. Phosphorus (P)



2.31. Lead (Pb)


Shallow topsoil 'A'
ICP$_{ar}$ | Lead (Pb)
Percentile | Pb, mg/kg
99-100 125 - 1,580
95-99 64.2 - 125
90-95 47 - 64.2
75-90 31.8 - 47
50-75 22.9 - 31.8
25-50 16.9 - 22.9
15-25 14.2 - 16.9
10-15 12.4 - 14.2
5-10 9.69 - 12.4
0-5 <0.2 - 9.69
N
Bedrock Geology (1:1,000,000)
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Irish Transverse Mercator (IRENET95)
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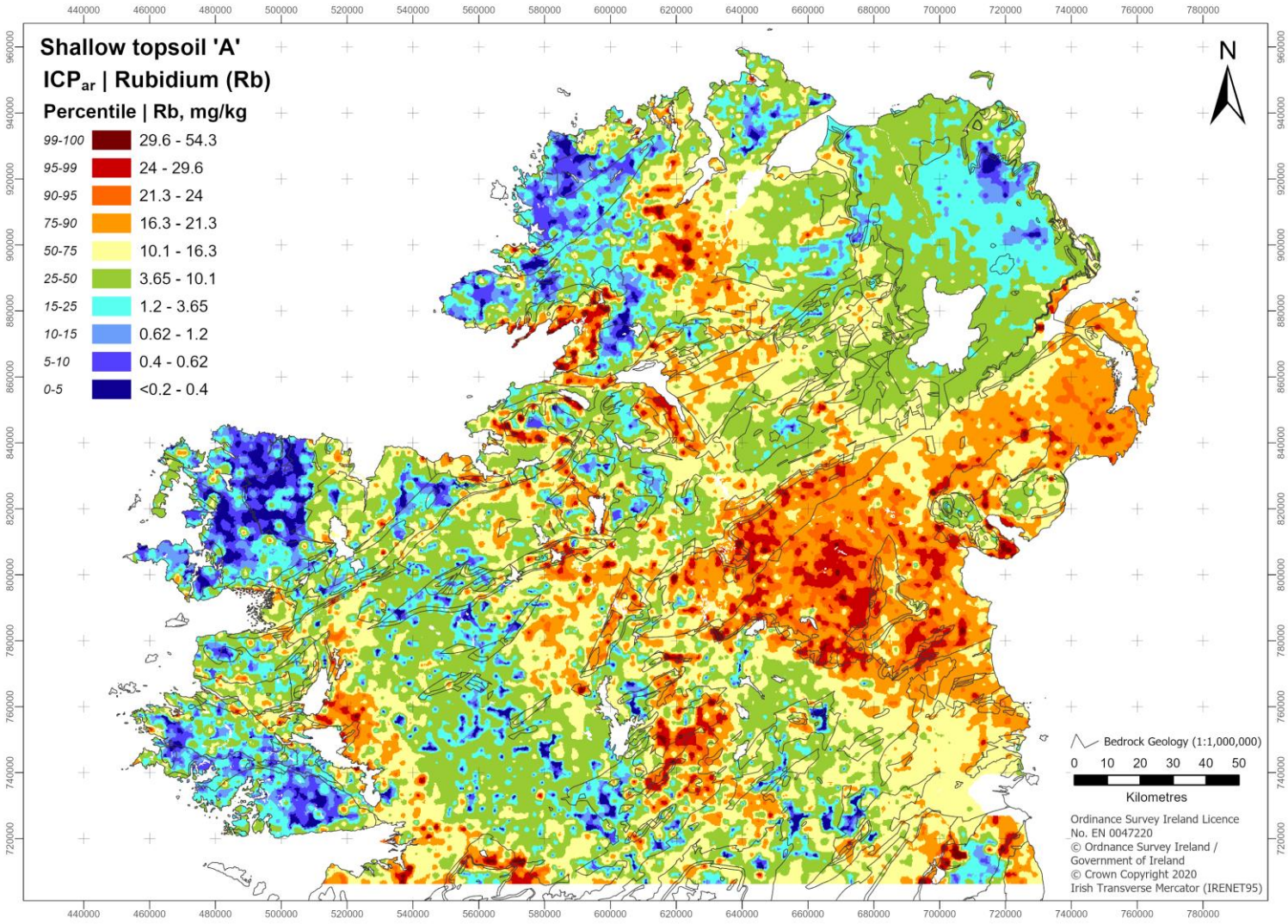
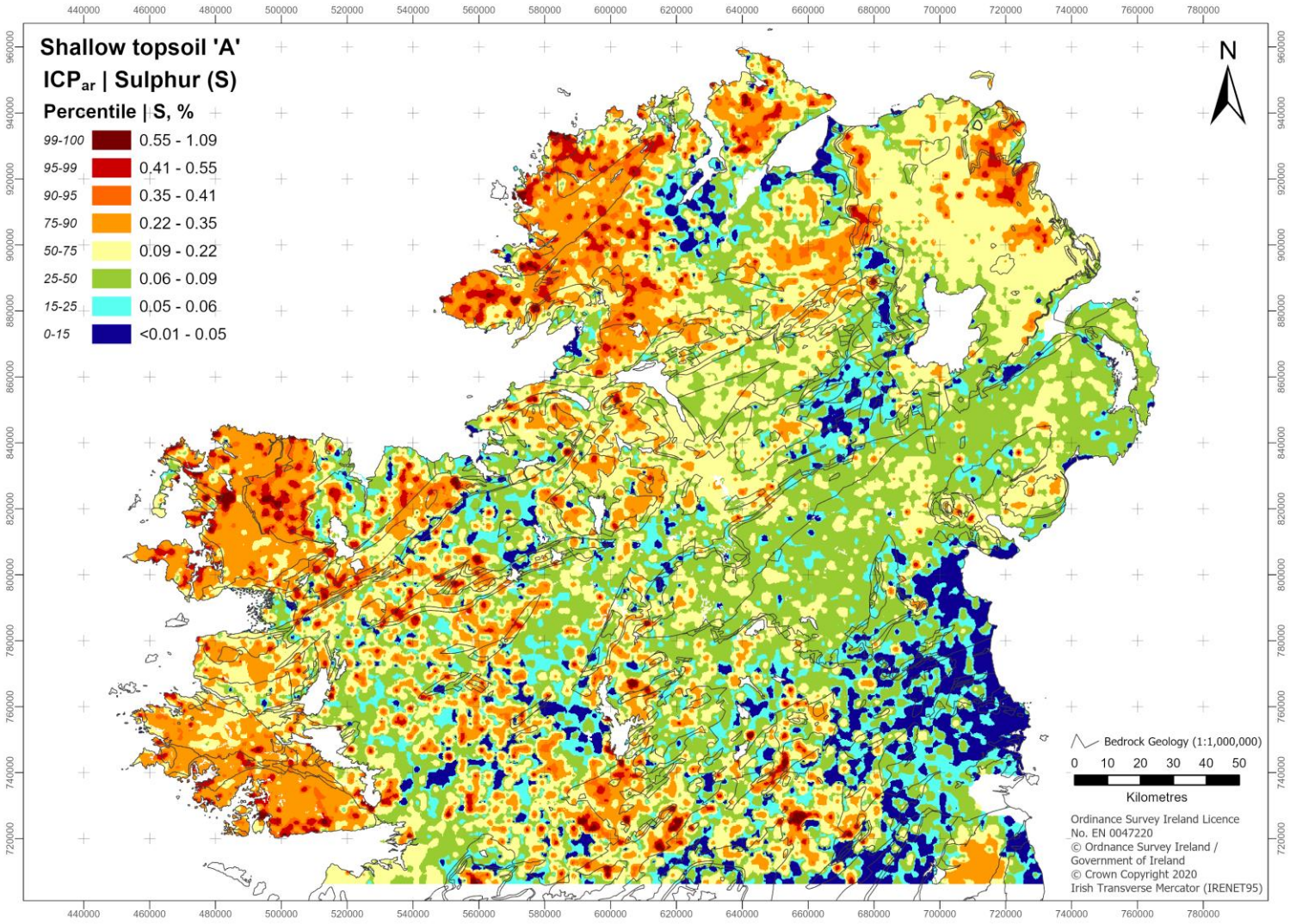
960000 940000 920000 900000 880000 860000 840000 820000 800000 780000 760000 740000 720000

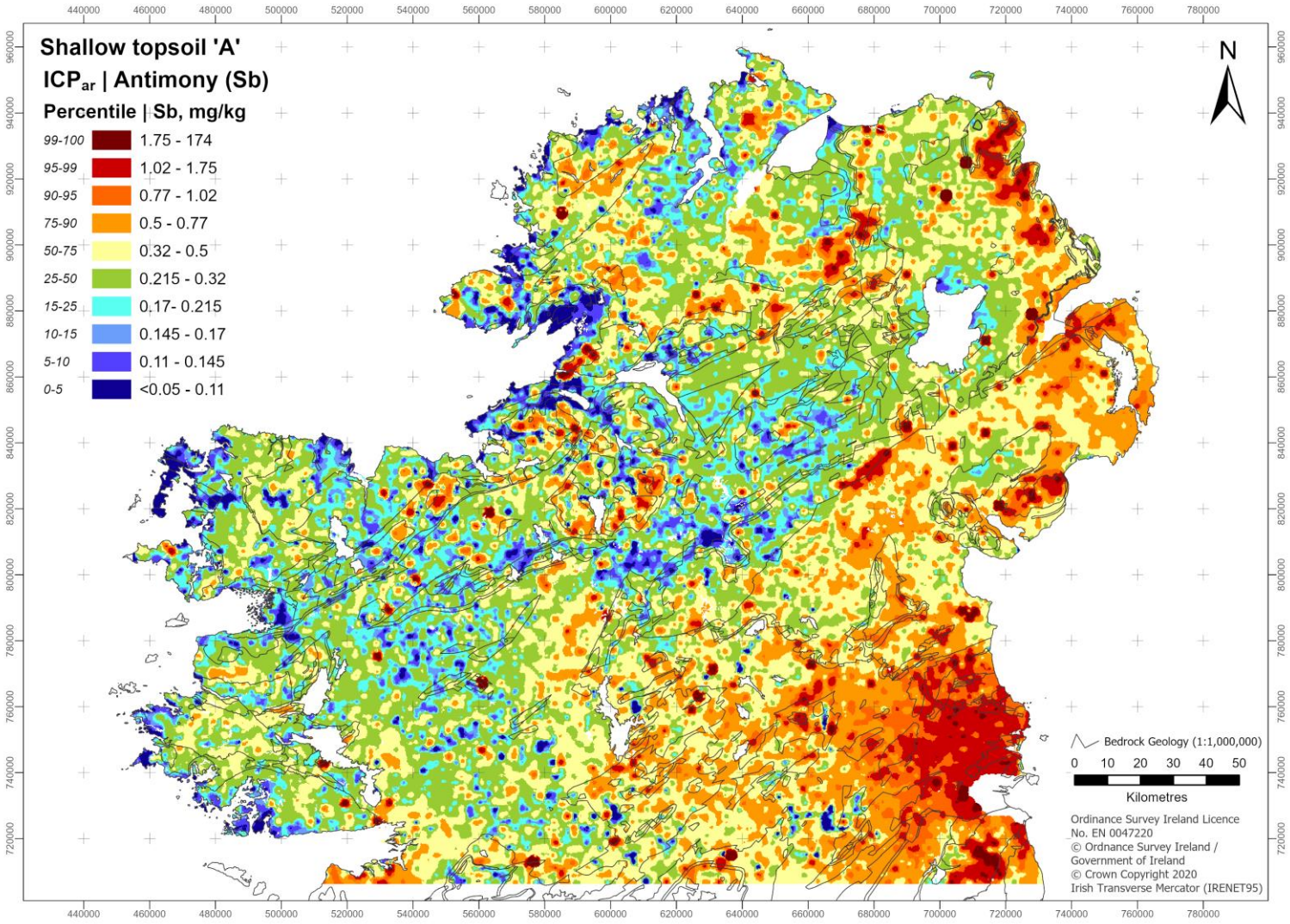
2.32. Rubidium (Rb)



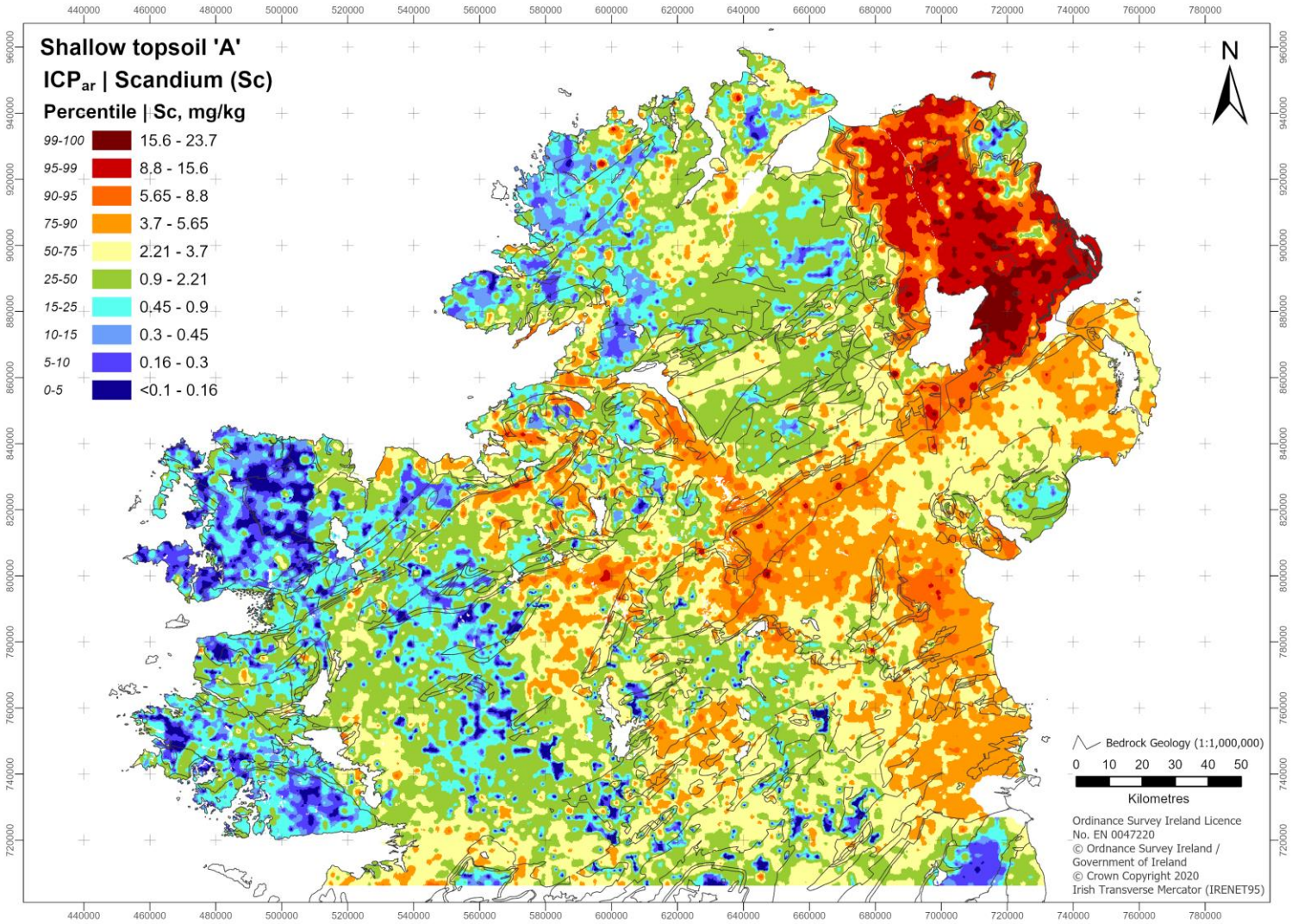
2.33. Sulphur (S)



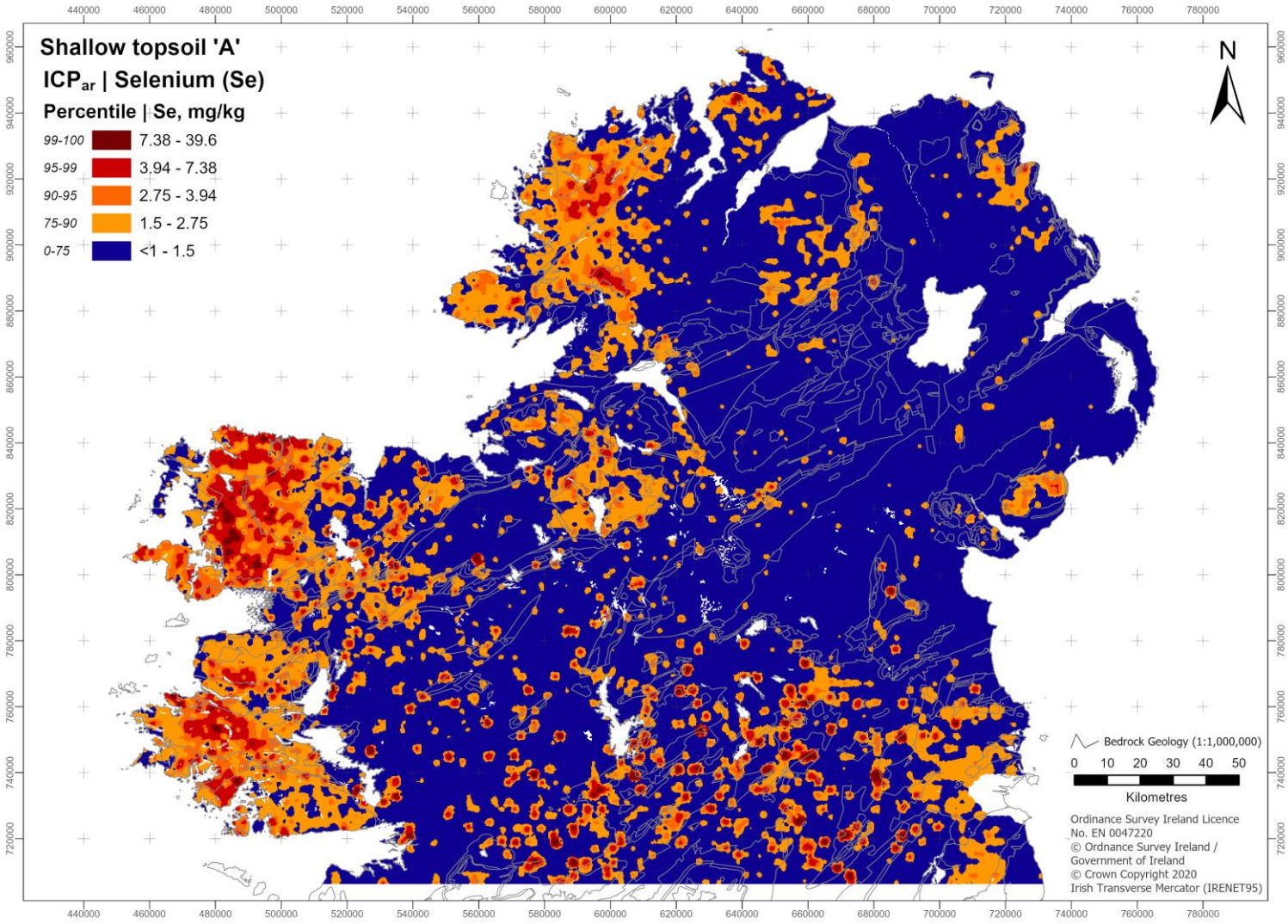
2.34. Antimony (Sb)



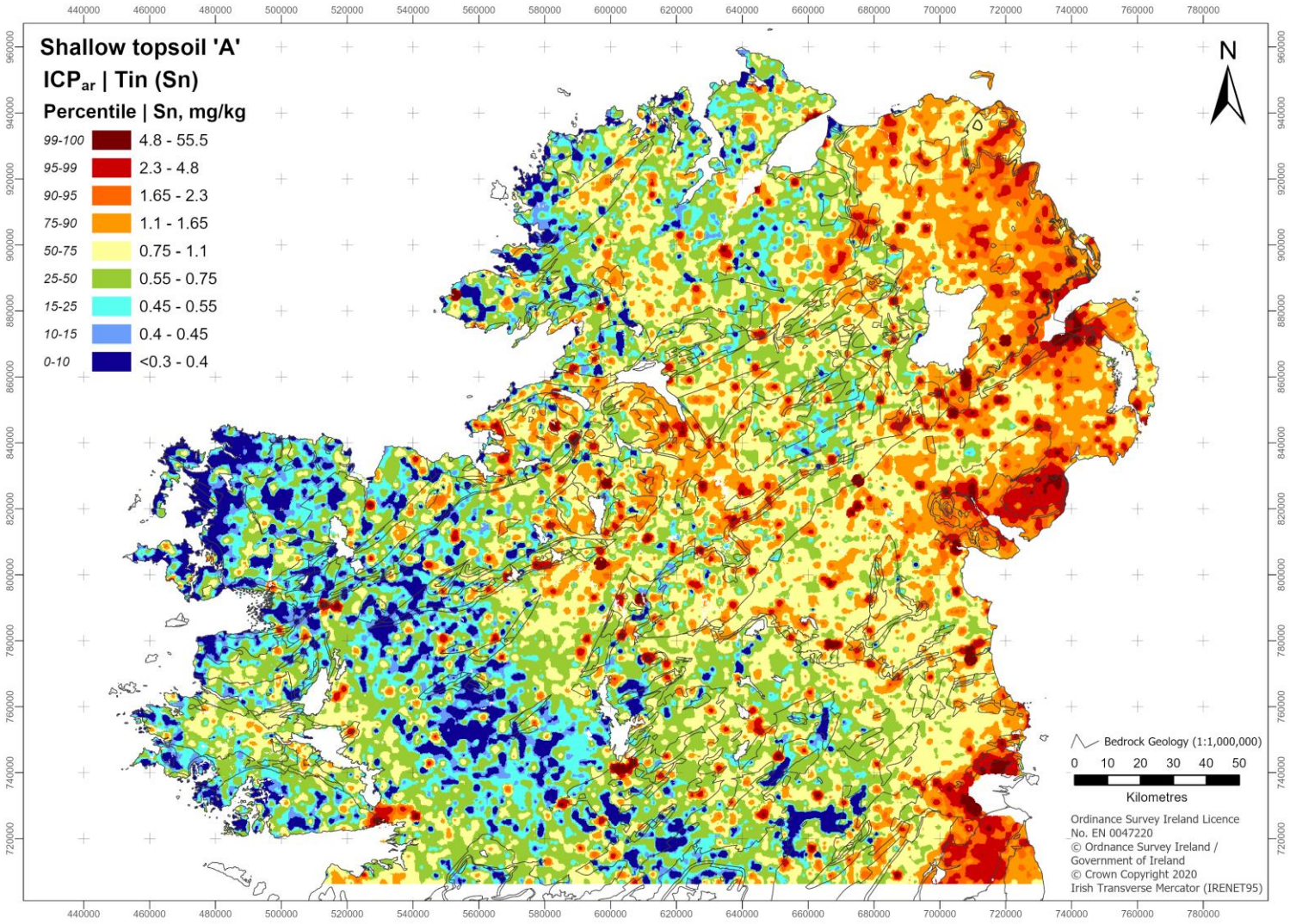
2.35. Scandium (Sc)



2.36. Selenium (Se)



2.37. Tin (Sn)


Shallow topsoil 'A'
ICP$_{ar}$ | Tin (Sn)
Percentile | Sn, mg/kg
99-100 4.8 - 55.5
95-99 2.3 - 4.8
90-95 1.65 - 2.3
75-90 1.1 - 1.65
50-75 0.75 - 1.1
25-50 0.55 - 0.75
15-25 0.45 - 0.55
10-15 0.4 - 0.45
0-10 <0.3 - 0.4
N
Bedrock Geology (1:1,000,000)
0 10 20 30 40 50
Kilometres
Ordinance Survey Ireland Licence No. EN 0047220
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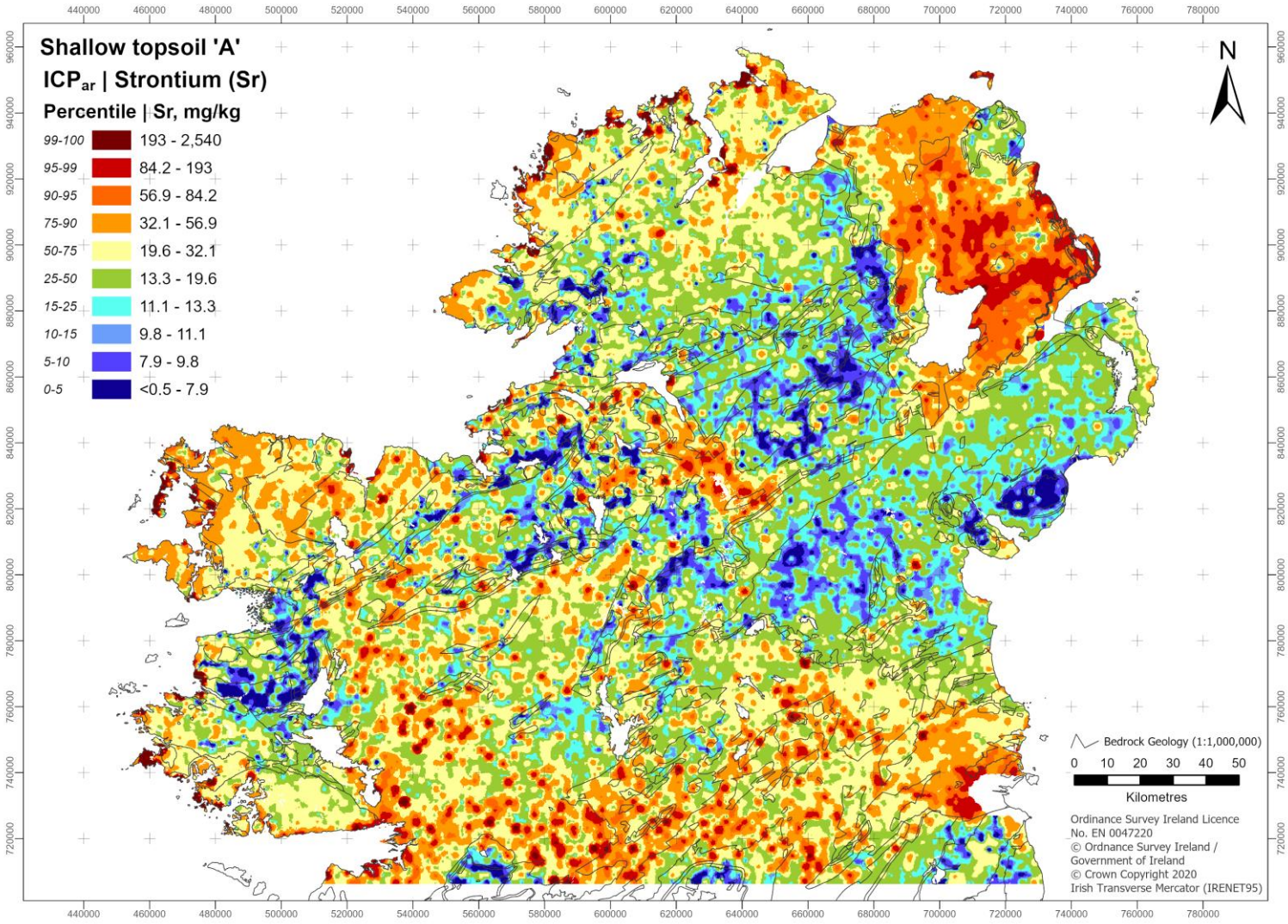
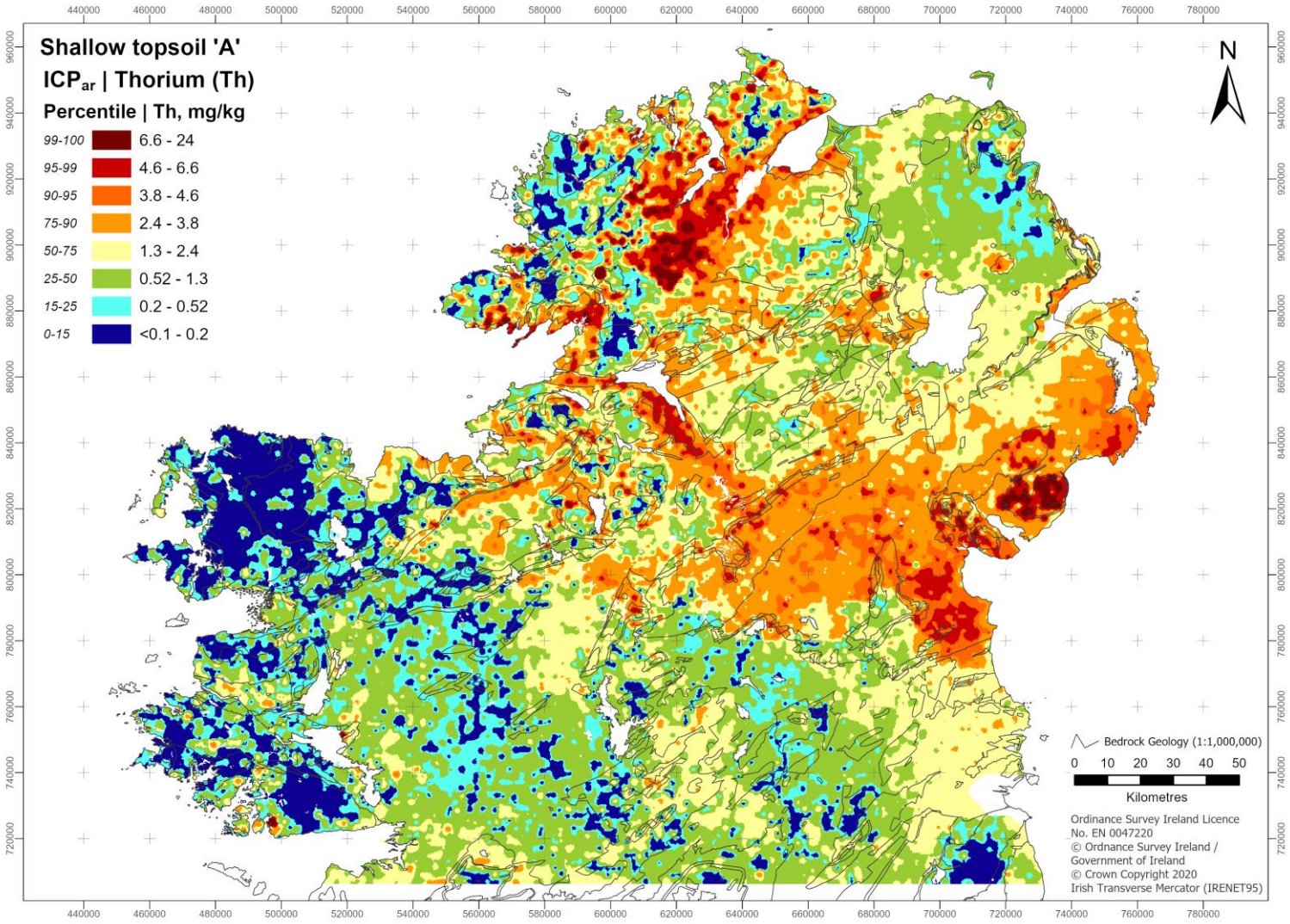
© Crown Copyright 2020
Irish Transverse Mercator (IRENET95)
440000 460000 480000 500000 520000 540000 560000 580000 600000 620000 640000 660000 680000 700000 720000 740000 760000 780000
960000 940000 920000 900000 880000 860000 840000 820000 800000 780000 760000 740000 720000

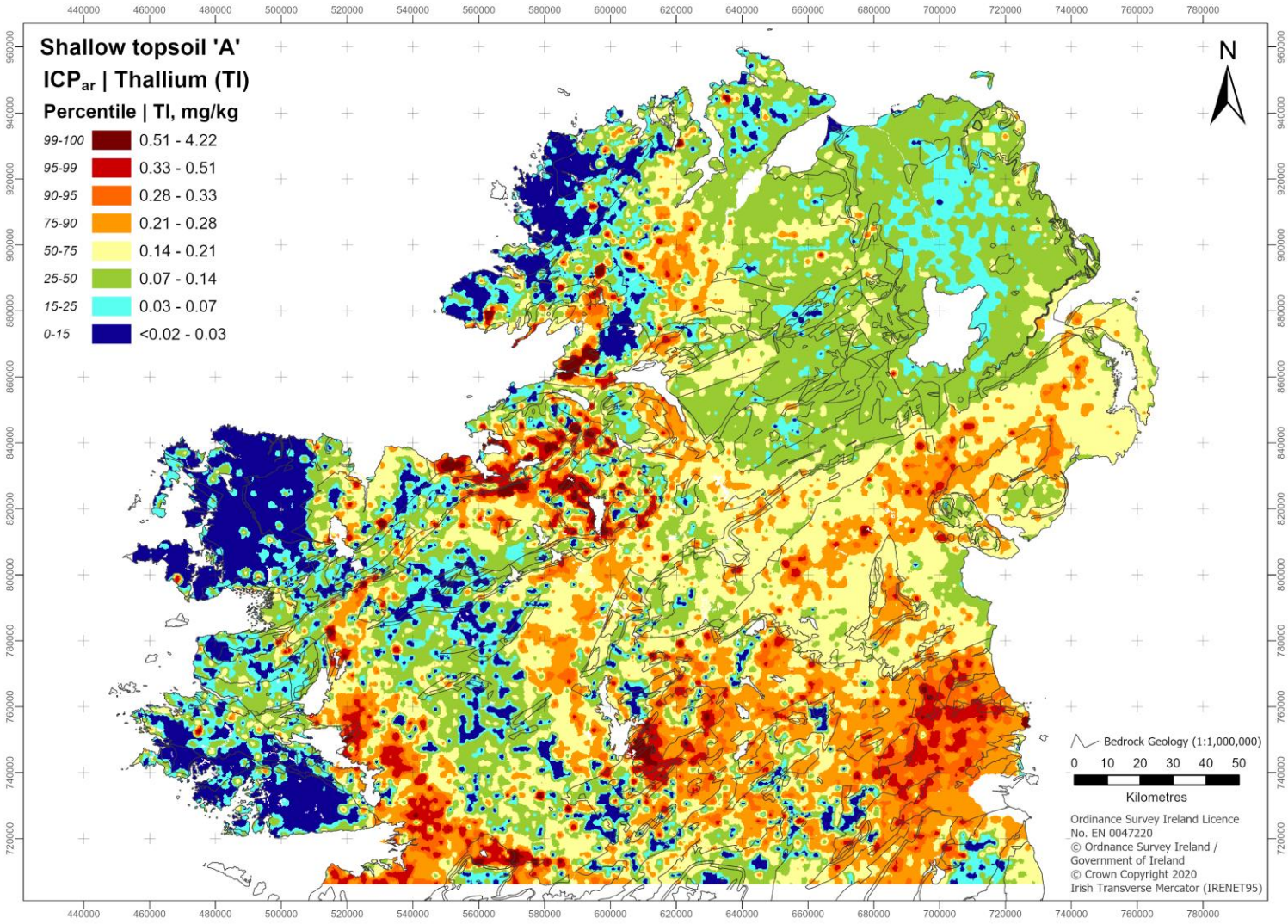
2.38. Strontium (Sr)



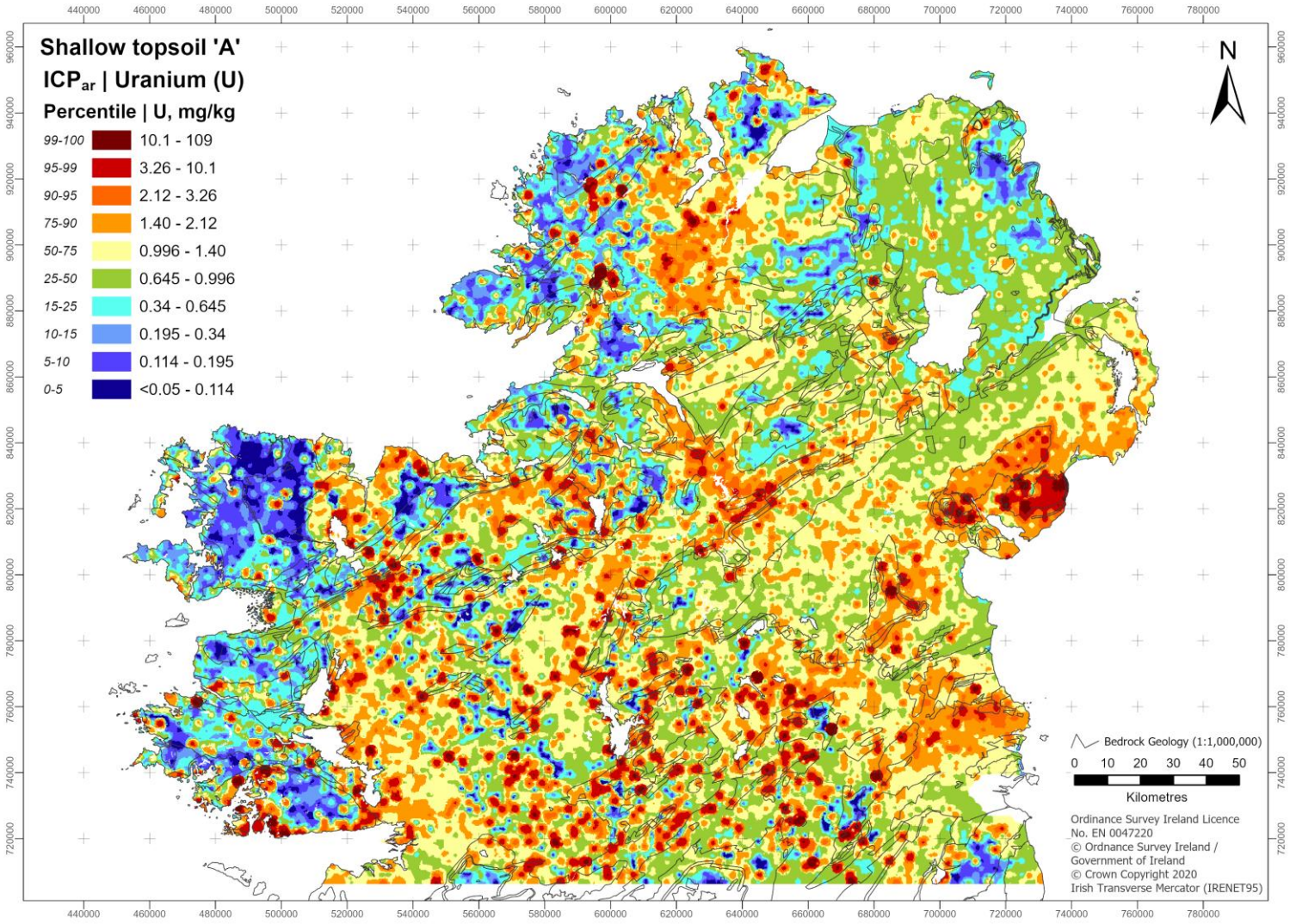
2.39. Thorium (Th)



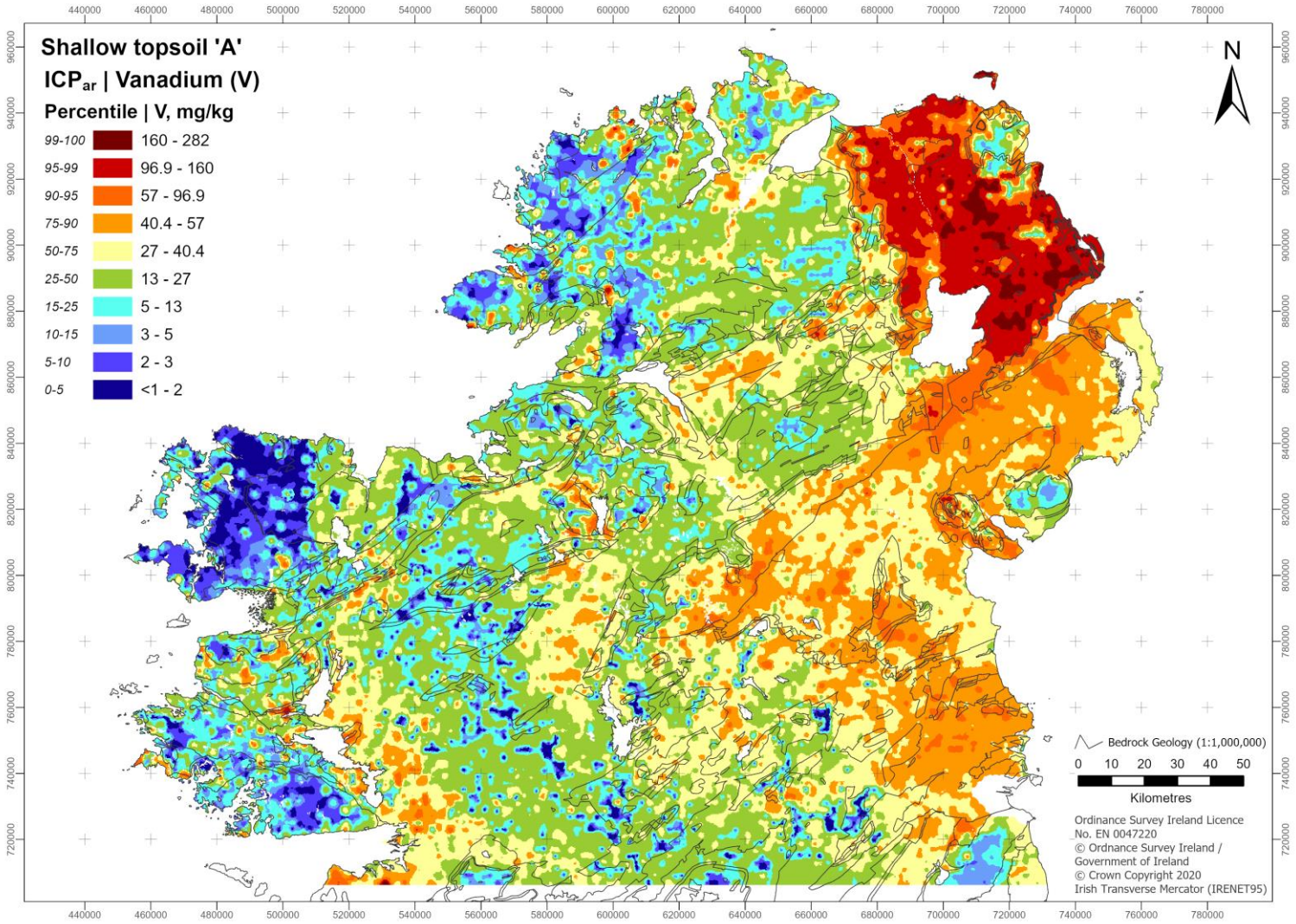
2.40. Thallium (Tl)



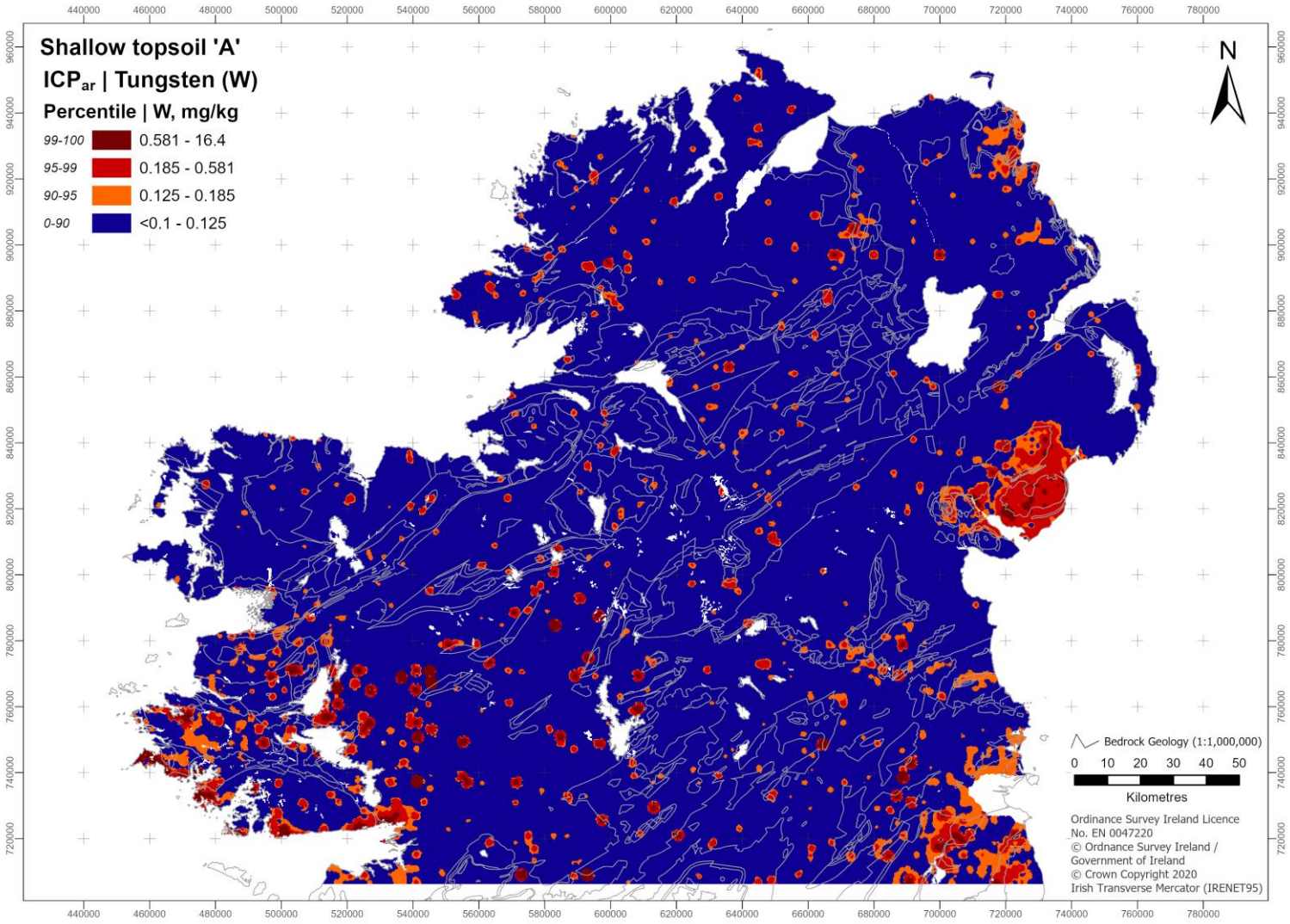
2.41. Uranium (U)



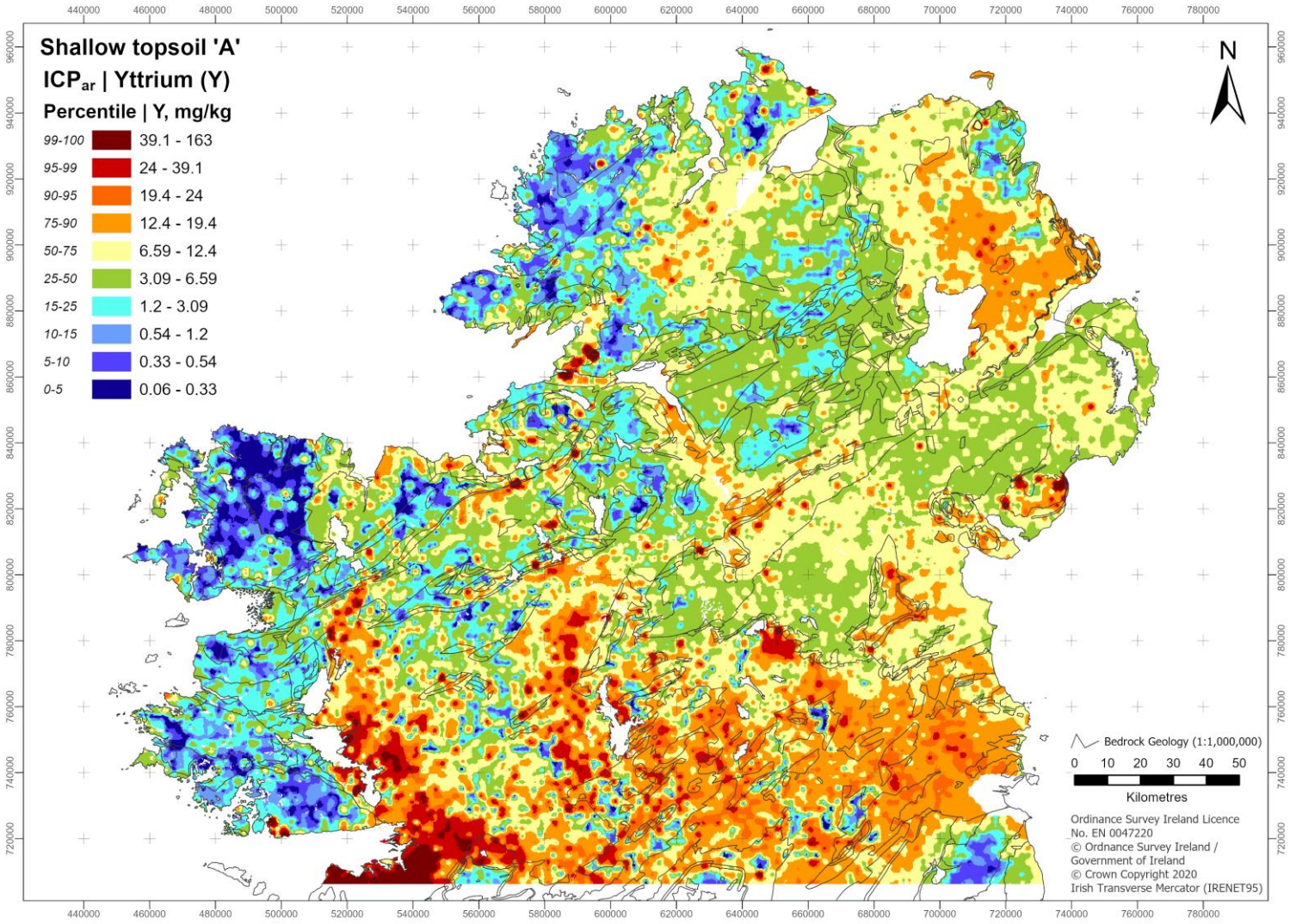
2.42. Vanadium (V)



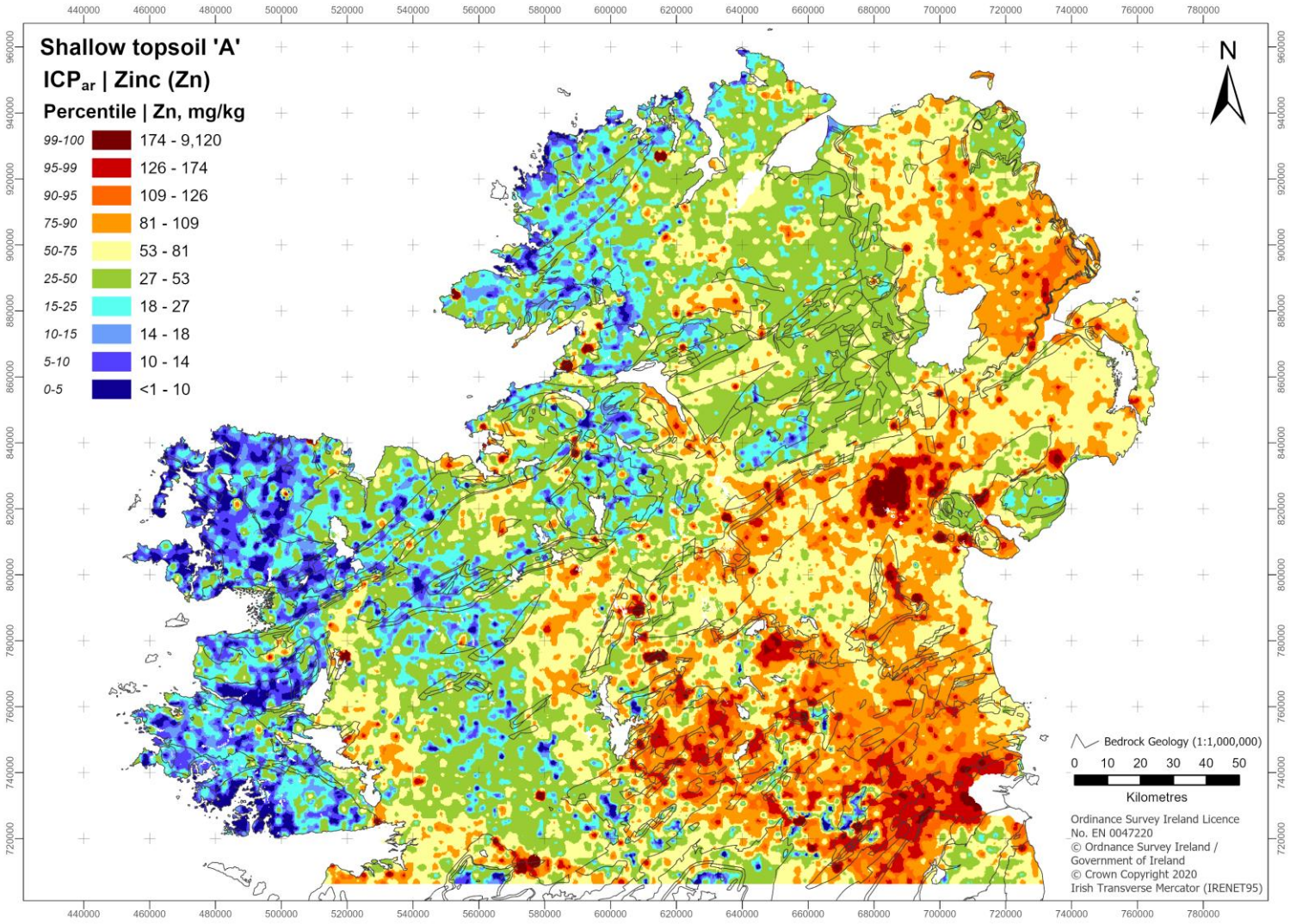
2.43. Tungsten (W)



2.44. Yttrium (Y)



2.45. Zinc (Zn)


Shallow topsoil 'A'
ICP$_{ar}$ | Zinc (Zn)
Percentile | Zn, mg/kg
99-100 174 - 9,120
95-99 126 - 174
90-95 109 - 126
75-90 81 - 109
50-75 53 - 81
25-50 27 - 53
15-25 18 - 27
10-15 14 - 18
5-10 10 - 14
0-5 <1 - 10
N
Bedrock Geology (1:1,000,000)
0 10 20 30 40 50
Kilometres
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Irish Transverse Mercator (IRENET95)
440000 460000 480000 500000 520000 540000 560000 580000 600000 620000 640000 660000 680000 700000 720000 740000 760000 780000
960000 940000 920000 900000 880000 860000 840000 820000 800000 780000 760000 740000 720000

2.46. Zirconium (Zr)