Wyoming State Geological Survey Proposal for Goal #2

Proposal: Statewide Airborne Geophysical Survey

Program Overview

Hard rock mineral exploration is an expensive and risky business. Wyoming has favorable geology for significant deposits of economic minerals, yet much of those potential deposits lie under thin layers of sediment. Airborne geophysics surveys, including magnetics, electromagnetics, radioactivity, and gravity gradiometry, are the most cost-effective way for geoscientists to "see" through the upper part of the Earth's crust and delineate economic mineral deposits. Statewide coverage of public, or pre-competitive, airborne geophysical data reduces exploration risk, attracting statewide investment.

Mineral exploration is just one use for these types of data. Similar programs internationally have been used to determine radon hazards, near-surface faults, delineate karst hazards, and improve groundwater management.

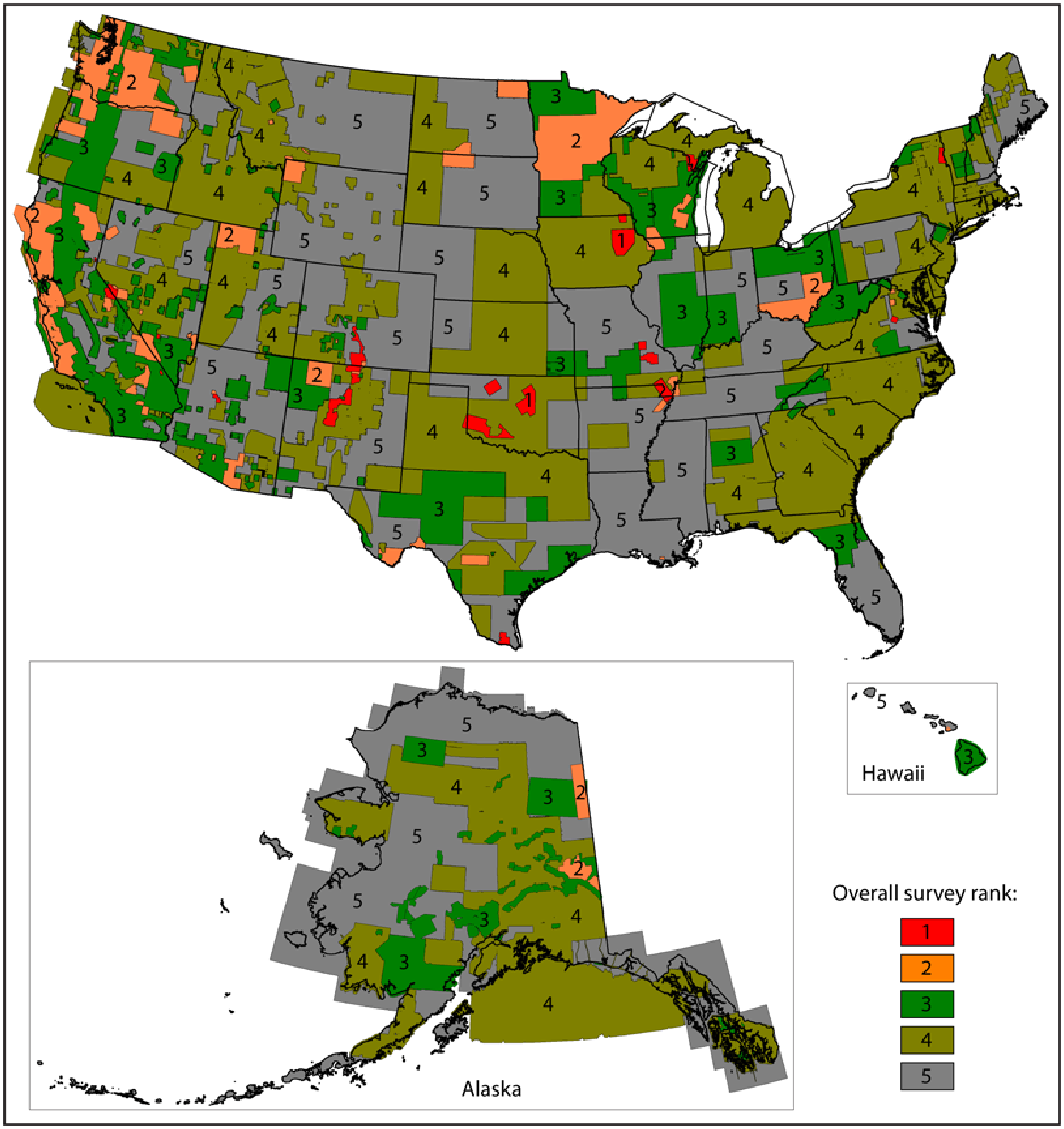
The United States has inferior public airborne geophysical data coverage relative to other developed countries, and Wyoming has some of the worst coverage in the United States. Government-sponsored large-scale geophysical surveys are common in other countries, including Australia (with an economy heavily dependent on the mining sector), Ireland (whose program reaches far beyond mining), Canada (beginning with the province of Ontario), and much of Africa. Wyoming has a unique opportunity to lead the way nationally and even internationally, with the expectation of a significant return on investment.

Program Goals, Objectives, and Deliverables

The overall ***goal*** of this program is twofold: 1) attract investment in Wyoming by derisking initial geological exploration, and 2) provide data to keep Wyoming citizens and infrastructure safe and healthy by quantifying known hazards and resources. The ***objective*** is to collect airborne geophysical data over all, or much, of the state. Currently Wyoming is covered by Rank 5 geophysical data (aeromagnetic and gravity data) collected from the 1950s to 1997. These data are only useful at the national to continental scale. Collection of Rank 1 geophysical data would be ideal, as it is the most cost-effective, meeting modern standards for best practices and quantitative interpretation for detailed mapping (see Table 2 of Drenth and Grauch, 2019). ***Deliverables*** are state-of-the-art geophysical datasets that would be freely available to the public for future use on a wide range of topics.

Availability of Other Funding

The U.S. Geological Survey's (USGS) EarthMRI program is currently targeting the highest-priority areas nationally for Rank 1 airborne geophysical surveys. One of their high-priority areas is in the Medicine Bow Mountains of southeast Wyoming, which is scheduled for a $500,000 survey during the summer of 2022 (the State of Wyoming contributed $50,000 to this survey). The EarthMRI program is expected to expand over the coming years and may be an excellent source of matching funds in some areas. The availability of these potential matching funds may depend on the infrastructure bill that is currently in congress. Regardless, the State would partner with the USGS to help support the design and technical aspects of the proposed survey to assure it meets the USGS standards for Rank 1 surveys being conducted nationwide. Other agencies to partner with for this survey are the Bureau of Land Management and the U.S. Forest Service.



Assessment of the quality of existing aeromagnetic surveys for the United States, with rank 1 indicating the best quality and rank 5 indicating the worst. The map results from the ranking scheme applied to each public aeromagnetic survey by Eric Anderson, Ben Drenth, V. J. S. Grauch, Anne McCafferty, Anji Shah, and Dan Scheirer of the USGS. From Drenth and Grauch (2019).

Revenue or Return on Investment

Once complete, the survey would require no additional work on the part of the State other than storing and distributing the digital data. The return on investment would be immediate and expected to be significant. Multiple studies have attempted to quantify this return, including Hutchins and others (2007), Drenth and Grauch (2019), and especially Rainsford (2019). Australia and Ireland have continued their data acquisitions programs because their investment return has been so significant.

The return on investment from the environmental and hazards perspective would be enormous. As water can be worth more than minerals, understanding our groundwater systems may prove to be more important to Wyoming than any other investment, with implications for human health and crop development. Radon, always a potential hazard in the state, could be mapped for safer communities. Data such as these have also been used to delineate faults with recent earthquake-producing activity, karst terrain, soils, and a whole host of other applications.

Proposed Budget

The expected price of surveys of this sort depend on:

1. the type of geophysical data being collected: specific data could be collected in specific areas;
2. the size of the survey: survey can be targeted at high-priority areas;
3. the topography of the ground surface: flying in basins (using fixed-wing aircraft) is cheaper than in mountainous areas (which require a helicopter);
4. and the flight-line spacing: tighter line spacing equates to better data.

Airborne geophysical surveys are priced by the flight-line distance, in kilometers, which is determined by flight-line spacing. Typical fixed-wing radiometric and magnetics surveys in an area the size of Wyoming are usually flown at about 200-m spacing. Flying in Wyoming would require both fixed-wing aircraft and helicopters. Price for a radiometric and magnetic survey is approximately $20 million. However, survey costs decrease per flight-line kilometer as fewer costs are devoted to mobilization and demobilization for large surveys. Adding electromagnetics and airborne gravity gradiometry would increase the cost by an order of magnitude to approximately $200 million.

As a point of reverence previously mentioned, the U.S. Geological Survey has contracted with a private company to collect airborne geophysical data over the Medicine Bow Mountains (excluding wilderness areas) and the southeastern part of the Sierra Madre Mountains in southeastern Wyoming. This survey does not include gravity gradiometry (the gravity survey will be conducted on foot, on the ground), and is priced at $500,000.

Expected Outcomes

- Local, national, and international investment in Wyoming
- Increased mineral severance tax
- Increased federal mineral royalties
- Additional jobs
- Better understanding of minerals, groundwater, surface water, soils, and multiple hazards

Explanation of Performance Metrics

Hard metrics would be determined by the measurable investment, increased exploration, number of jobs, total wages paid, and a measurable economic impact in the State. Soft metrics would include a strong positive image about the State of Wyoming, from both the mining and environmental sectors; increased awareness of the positive attributes and progressive leadership of the State; and a closer tie with multiple agencies within the federal government, including the USGS, BLM, and USFS.

Timeline

2022: Contract with geophysical consultant to plan survey and develop an RFP
2023: Solicit bids from airborne geophysical firms
2023–2025: Conduct airborne surveys during the summers and process data during the winters; develop website and data storage plan
2026: Make data available to the public on State website

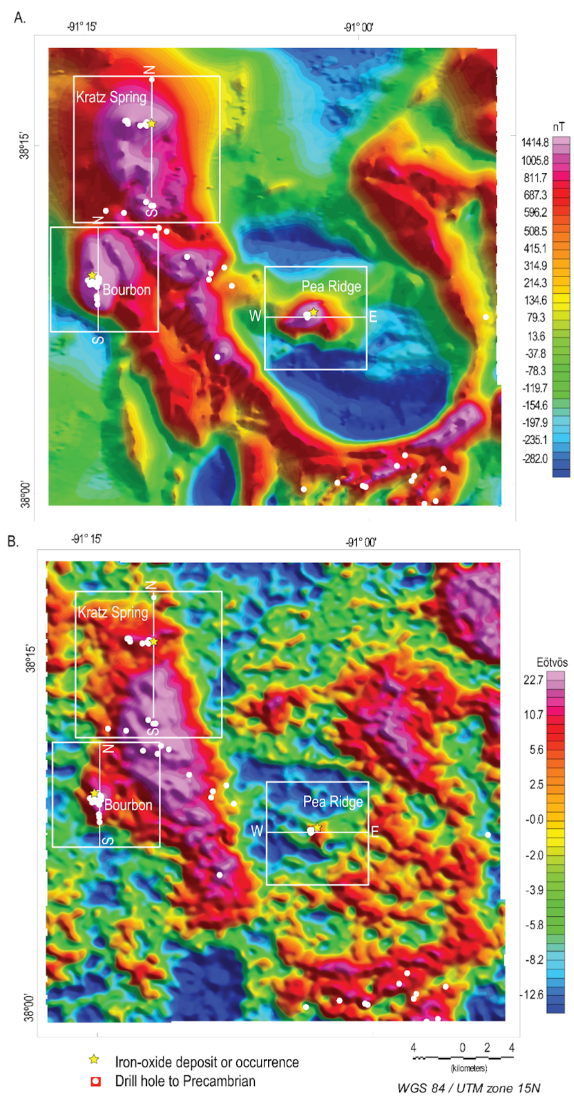
Program Completion

The program will be complete once the data from the study area have been acquired, processed, and made available to the public.

Examples from Other Surveys

Iron oxide-apatite and iron oxide-copper-gold deposits, southeast Missouri

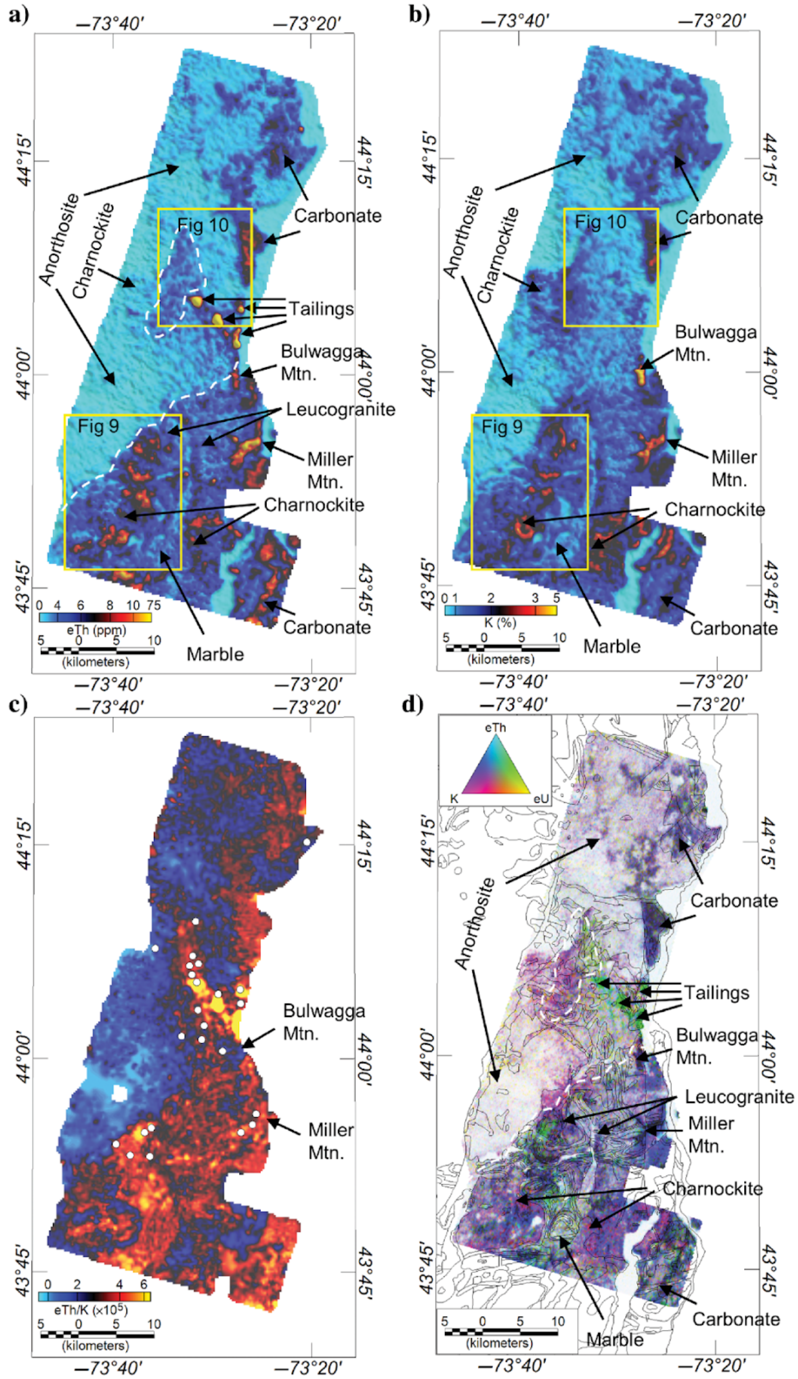
From McCafferty and others, 2016, doi:10.2113/econgeo.111.8.1859



(A). Airborne magnetic anomaly map reduced-to-the-pole. (B). Vertical gravity gradient (Gdd) over iron oxide deposits of northern survey area. Locations of three-dimensional inversion model areas and cross sections extracted from three-dimensional models are shown for each deposit.

REE-bearing apatite, northern New York

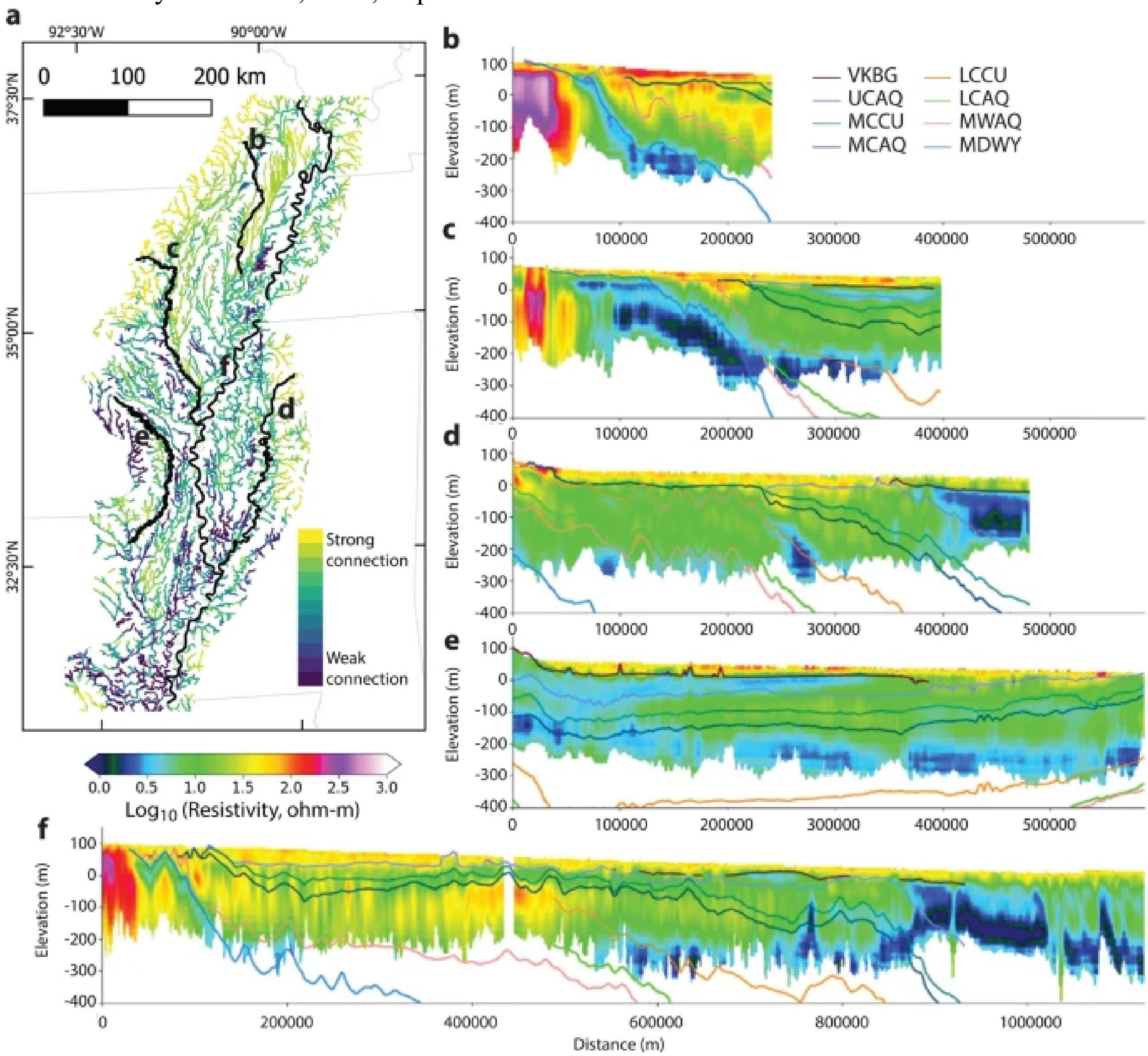
From Shah and others., 2021, http://dx.doi.org/10.1190/geo2019-0783.1



Airborne radiometric data; the yellow boxes show locations of Figures 9 and 10. (a) eTh; the white dashed line delineates broad areas with elevated eTh. (b) K and (c) eTh/K ratio; the white dots show key deposits in Figure 5. (d) Ternary image showing relative amounts of K (magenta), eTh (cyan), and eU (yellow). The gray polygons show the outlines of the geologic units in Figure 2.

River-groundwater connectivity, lower Mississippi Valley

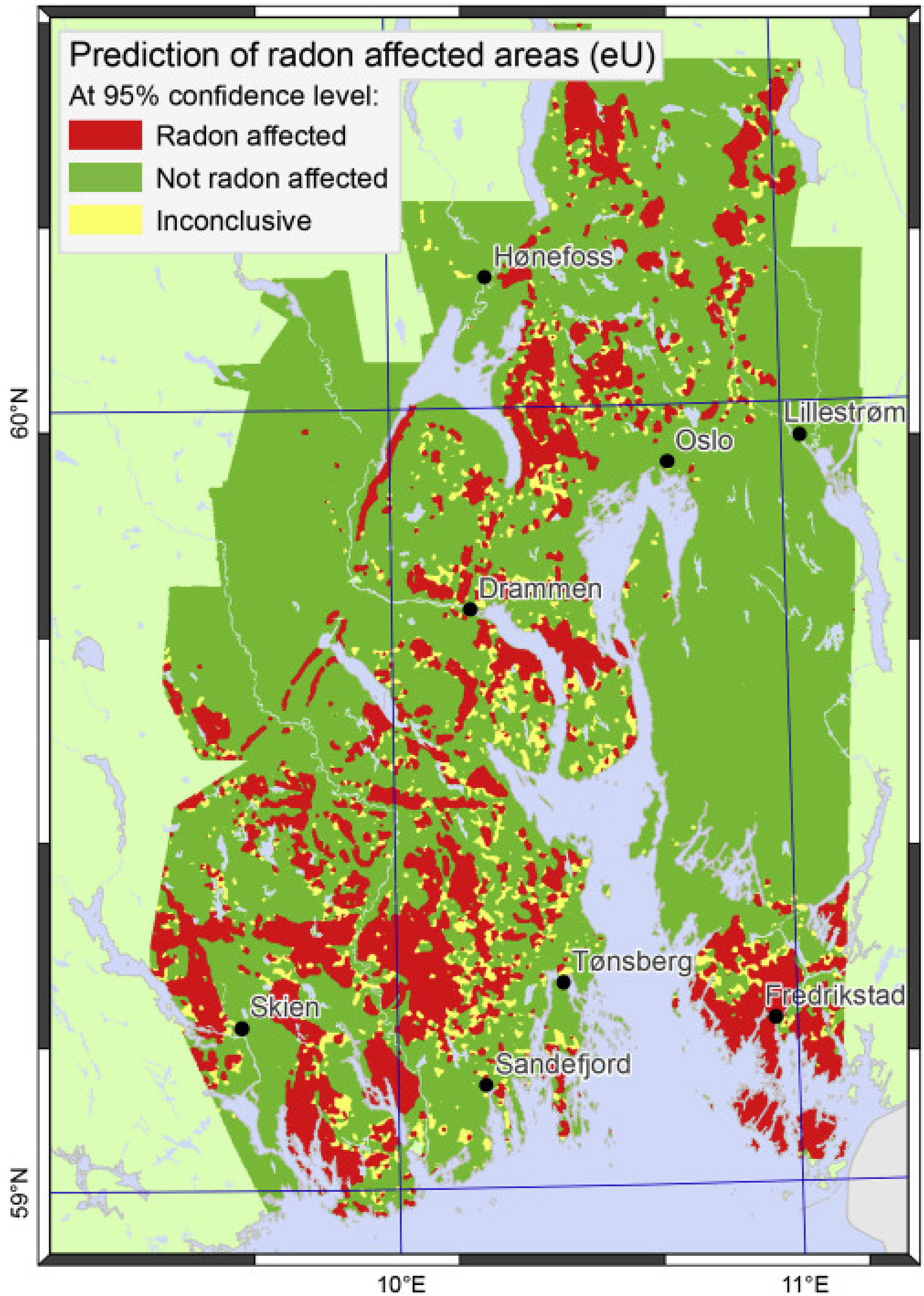
From Minsley and others, 2021, https://www.nature.com/articles/s43247-021-00200-z



(a) River connectivity metric defined along all NHDPlus segments in the study area identifies areas for high or low potential for surface water-groundwater connectivity based on streambed resistivity values. Resistivity cross-sections (from north to south) extracted from gridded data along the St. Francis River (b), White River (c), Yazoo-Tallahatchie River (d), Bayou Bartholomew (e), and Mississippi River (f). The top elevation of Tertiary MERAS model layers43 is indicated as solid lines on top of resistivity cross-sections.

Radon affected areas, Oslo region, Norway

From Smethurst and others, 2017, https://doi.org/10.1016/j.jenvrad.2016.04.006



Map of radon affected areas (RP200 lower 95% confidence limit ≥ 20%) and less affected areas (RP200 upper 95% confidence limit < 20%) according to the eU model in Table 2.