House Committee on Appropriations
Subcommittee on Interior, Environment, and Related Agencies
Public Witness Hearing (non-tribal programs)
February 6, 2020, 10:00 AM USGS Panel
2007 Rayburn House Office Building (Formerly B-308)

Thematic Testimony of David Jonas Bardin on USGS Geomagnetism Program

Chair McCollum and Ranking Member Joyce,

Thank you for letting me testify orally, as an individual. Following your lead, [1] a Minibus [2] preserved the Geomagnetism Program under the Natural Hazards mission, enlarging it to complete a geophysical, earth-conductivity reconnaissance survey ("MT Survey") of the contiguous United States (CONUS) - in accord with Executive Order 13865 (of March 2019). — The Appropriators explained: "The recommendation includes ... $4,000,000 for Geomagnetism including $1,726,000 for the magnetotelluric survey as well as funding to maintain operation of all observatories." [3]

- USGS has been working to carry out that recent law.
- My testimony today focuses, thematically, on USGS's post-Minibus responsibilities:
  - How will USGS describe all aspects of its Geomagnetism Program?
  - How soon will USGS carry out new responsibilities for MT Survey of CONUS?
  - Should USGS expand geomagnetic observatories and variometer stations and operations?
- Supplemental written testimony may address specifics of the forthcoming FY 2021 Request.

Enhancing descriptions of Geomagnetism Program activities and observatories.

USGS should enrich its useful Geomagnetism web site to update activities and outputs (see https://www.usgs.gov/natural-hazards/geomagnetism). USGS could well add to that web site:

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[1] See House Report 116/100 (June 3, 2019), pp. 45, 47, 191: https://www.congress.gov/congressional-report/116th-congress/house-report/100/1 [PDF pp. 45, 47, 191 of 247].

[2] Public Law No. 116-94, approved December 20, 2019; H.R. 1865 - Further Consolidated Appropriations Act, 2020 (116th Cong.).

[3] Division D of the Joint Explanatory Statement [posted at https://docs.house.gov/billsthisweek/20191216/BILLS-116HR1865SA-JES-DIVISION-D.pdf], which also includes following table:

DEPARTMENT OF THE INTERIOR, ENVIRONMENT, AND RELATED AGENCIES APPROPRIATIONS ACT, 2020

(Amounts in thousands)

	FY 2019 Enacted	FY 2020 Request	Final Bill	Final Bill vs Enacted	Final Bill vs Request
Natural Hazards:					
Earthquake hazards	83,403	64,303	84,903	+1,500	+20,600
Volcano hazards	30,266	28,121	30,266	---	+2,145
Landslide hazards	3,538	3,554	4,038	+500	+484
Global seismographic network	6,653	6,661	7,153	+500	+492
Geomagnetism	1,888	1,888	4,000	+2,112	+2,112
Coastal/Marine hazards and resources	40,510	40,498	40,510	---	+12
Total, Natural Hazards	166,258	145,025	170,870	+4,612	+25,845

A. USGS ground-based, geomagnetic data are:
— used by the National Geospatial Agency to calculate the World Magnetic Model (WMM), on which all forms of navigation rely;
— used by NOAA Space Weather Prediction Center for real-time monitoring of geomagnetic disturbances (GMDs);
— used by Air Force to calculate atmospheric expansion, for tracking low-orbiting satellites;
— used by the oil and gas industry for directional drilling; and
— used to calibrate (validate) non-USGS facilities.

B. USGS collects *geomagnetic* field data at all 14 observatories (see map) — six in CONUS (in Virginia, Mississippi, Colorado, Arizona, California, and Washington), as well as at variometer stations — three in CONUS (in Minnesota, Montana, and New Mexico), but does not yet report locations of variometer stations. [4] —
USGS now collects *geoelectric* field data at only one of its observatories (in Colorado). (Hopefully, USGS will come to collect such data at more venues.)

Dr. Jeffrey J. Love's USGS staff profile includes information not yet in the Geomagnetic Program's own website. See https://www.usgs.gov/staff-profiles/jeffrey-j-love.

New responsibilities for MT Survey of CONUS

USGS has not yet obligated any of the FY 2020 $1.726 million toward completion of an MT Survey. MT survey field work requires equipment, trained field crews, planning, organization.

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[4] USGS describes its 14 geomagnetic observatories at https://www.usgs.gov/natural-hazards/geomagnetism/science/observatories?qt-science_center_objects=0#qt-science_center_objects. It does not yet describe its variometer stations or report their total number.
— Ground-based monitoring of geomagnetic field variation (for frequencies less than 1 Hz) is typically accomplished with a fluxgate magnetometer or "variometer." For many applications, raw variometer data are sufficient, but for other applications, "observatory"-standard data are required, whereby the drifting variometer response is minimized through temperature stabilization and, otherwise, corrected in data processing with application of auxiliary calibration measurements. Magnetic observatories are more expensive and labor-intensive to operate than variometer stations, and their geographic distribution is relatively sparse; variometer stations are less expensive to operate and their deployments are sometimes geographically dense.
— USGS magnetic observatories are operated with a 99%+ temporal continuity, for decades of time, and data from each observatory are promptly made openly available to the user community in near-real-time.
— Variometer stations in the United States are typically operated on a campaign basis by universities for specific research projects, often funded by the National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA). These variometer operations are not usually intended to provide long-term, continuous, real-time data service; for this reason, variometer data are not commonly used in operational space-weather projects, such as those supported by the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Air Force (USAF).

- EO 13865 gave the Secretary of the Interior four years to complete the CONUS MT Survey. [5]
- FY 2020 budget request and Minibus appropriation were in line with that four year schedule.
- Will USGS ever expend that entire $1.726 million on the MT Survey? How much in FY 2020?
- How much will USGS actually need in FY 2021 and each subsequent year?
- Multi-year planning is in order at least through FY 2023.
- Moreover, as electric power researchers, the North American Electric Reliability Corporation (NERC), Electric Power Research Institute (EPRI), Federal Energy Regulatory Commission (FERC), and possibly others, study and use MT Survey data, there may well be reasons to repeat or intensify some of the reconnaissance surveying.
- Prudence dictates that MT Survey funding be part of Geomagnetism Program's recurring base.

Observatories and variometer stations in CONUS; gap summary; deferred maintenance

National priorities for maintaining and expanding ground-based geomagnetic monitoring are established by the National Space Weather Strategy and Action Plan (NSWSAP, 2019), and the Executive Order for Coordinating National Resilience to Electromagnetic Pulses (EO 13865, March 2019). These specify that the Department of the Interior (DOI), and, by proxy, the USGS, will ensure baseline observation capabilities (NSWSAP, Action 2.1). The USGS Geomagnetism Program magnetic observatory network has been identified as being of "critical" importance in assessments of geophysical monitoring systems. Please note:

- Observatories such as Tucson and Guam have unresolved deferred maintenance issues.
- From an electric grid standpoint, of six observatories in CONUS only 2 are in the Eastern Interconnection area where most Americans live and work; and none is in the Texas Interconnection area.

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[5] Last year I testified that "the magnetotelluric (MT) Survey begun by the [NSF] as part of its EarthScope program (... ended in FY2018) ... included geophysical mapping that uses an Earth imaging technique known as the MT method — overseen by Incorporated Research Institutions for Seismology (IRIS) and executed by Oregon State University (OSU). They were charged with mapping three-dimensional (3-D) geological structure of CONUS; specifically variation in electrical properties of crust and mantle. EarthScope data obtained by OSU were quickly put in the public domain for use without restriction. But there are no data for all or part of 14 southern tier states." Written Testimony dated February 26, 2019.

I explained: "NSF's funding purposes were entirely for geological mapping and related benefits, but others discovered early in this decade that MT data obtained proved of critical importance to evaluating and mitigating space weather risk to electric power transmission grids. Recent studies suggest these data have similar importance for protecting critical infrastructure from EMP.

"There has been broad uptake of these MT data by space weather researchers in USGS Geomagnetism, other government agencies, academic institutions and industrial laboratories.

"NSF's now-ended program (plus USGS mapping of Peninsular Florida and small areas elsewhere) supported completion of MT Survey for nearly 2⁄3 of CONUS. Researchers found large regional variations in ground conductivity with some extremely high geomagnetic hazard concentrations (for example in Minnesota and Maine), to which electric utilities can respond (for example, American Transmission Company and Central Maine Power Company).

"Research into impact of regional variations in ground conductivity seen over the 2⁄3 of CONUS for which there are MT data indicate that critical infrastructure (such as power grids) in areas still without MT data are just as likely to face high risk from space weather and EMP as the rest of CONUS."

- Advisers to the electric power-grid industry (for example) depend upon observatories to supply regional data which are not currently available otherwise and are needed to protect critical infrastructure in both coastal and inland locations.
- USGS has only a sparse network of six observatory magnetometer stations in CONUS. (Through its Global Seismic Network, USGS also operates three variometer stations in CONUS which are being integrated into Geomagnetism Program operations.)
- Comparison of storm-time magnetometer time series demonstrates that the CONUS observatory network is too sparse - the difference between Fredericksburg, Virginia observatory time series and those from the closest "nearby" station — in Ottawa, Canada (over 800 km away) — can be as much as 100%.
- The Nation needs additional operational magnetometer stations, especially across CONUS, so that geomagnetic and geoelectric hazards can be accurately evaluated and monitored.
- USGS magnetometer operations could be expanded with establishment and operation of a combination of magnetic observatories and variometer stations that are operated at high USGS standards and on an essentially *permanent* basis.

The Nation needs more direct *measuring* of geoelectric field amplitudes and orientations, which are often *estimated* instead based on geomagnetic field data and assumed relationships.

- Yet it is geoelectric fields that actually drive geomagnetically induced currents (GICs) which can impact electric power grids and pipelines; and it is geoelectric field *orientations* (i.e., whether parallel to metal facilities, which act as antennas) that determine actual impacts.
- Geoelectric fields are rarely at right angles (orthogonal) to magnetic fields (as some assume).
- Geomagnetic field data alone may inaccurately estimate geoelectric fields and GICs.

Expansion of ground-based magnetometer (and geoelectric field measurement) monitoring operations seems desirable and would benefit projects of importance for the economy and National security, such as assessing space weather conditions and monitoring magnetic storms, mapping of hazardous geoelectric hazards, enabling directional drilling for oil and gas, and performing aeromagnetic surveys for mineral exploration and geophysical investigation.

- Data from such new CONUS magnetometer stations would substantially improve real-time maps of storm-time geoelectric fields across CONUS (NSWSAP Task 2.5), a collaborative project between the NOAA Space Weather Prediction Center (SWPC) and the USGS Geomagnetism Program. (Priority might go to monitoring in areas that statistical analysis shows can experience high storm-time hazard. USGS found such as areas in the Northern Midwest and the Eastern United States — some being of concern for electricity supplies to some very large cities.)
- Data from such new CONUS stations will contribute to hazard vulnerability evaluation projects of NERC that are mandated by FERC.

Respectfully submitted, *David Jonas Bardin* [davidbardin@aol.com] [6]

[6] Retired member of Arent Fox LLP submitting as individual citizen on my own behalf.