Questions from Rep. Stauber for Dr. Graham Lederer, Jataware

1. **During your testimony, you discussed the growing role of artificial intelligence in accelerating mineral discovery and resource characterization. Prior to your current role, your work at the U.S. Geological Survey focused on geophysical inversion and the integration of gravity, magnetic, and electromagnetic datasets to better understand subsurface geology. From your experience developing and interpreting these datasets, to what extent does the effectiveness of AI depend upon the quality, density, and resolution of the underlying geophysical information? How could higher-resolution datasets, including Full Tensor Gravity Gradiometry (FTG), improve AI's ability to identify prospective critical mineral systems?**

Interpretation of geophysical datasets, whether through the use artificial intelligence tools or traditional manual workflows, relies fundamentally on the quality, resolution, coverage, and types of data available. AI-driven methods are effective at scale, and can speed up the interpretation, but depend on having consistent resolution data throughout a study area. The ideal case would be to have full coverage at high resolution for all data modalities (magnetics, radiometric, gravity, electromagnetics, spectral), but the limited budget, time and capacity of any data acquisition campaign imposes practical decisions about optimizing coverage and resolution at a scale that derisks exploration. For this reason, exploration projects typically follow a phased approach, starting with broad coverage with cost-effective techniques (e.g. airborne magnetics) at moderate resolution, and revisiting prospective areas with higher resolution, more expensive data acquisition campaigns suitable for detecting the ore deposit of interest (e.g. airborne electromagnetic or airborne gravity). At each decision point, the value of acquiring more information is weighed against the cost of acquisition. For regional work, two-dimensional analysis is generally sufficient because the vertical dimension (e.g. the uppermost few km of Earth's crust accessible by modern mining methods) is small relative to the surface area (>100s of square km). As targets are delineated, the prospective area decreases in size, and geophysical inversion can be used to constrain three-dimensional geometries. For this work, having multiple geophysical methods (e.g. magnetic and gravity) in the same footprint, and at similar resolution, can help make the inversion more robust.

Within the scope of Earth MRI, there is a trade-off between acquiring higher resolution data for specific areas vs. increasing the coverage area. Similarly, there is a balance between covering the same area with multiple techniques (gravity + magnetics + hyperspectral) vs. covering different areas with different techniques, with each modality best suited to detecting the deposit types of interest in an area (e.g. airborne electromagnetic surveys for graphite; radiometric surveys for rare earths). A substantial amount of effort goes into survey design and matching the best, most cost-effective methods suitable for an area of interest that could host mineral commodities and deposit types of interest. Because the emphasis of Earth MRI has been broader, regional coverage at a useful resolution rather than tightly focused surveys of specific targets, the data are best used to interpret permissive and prospective areas as a precursor step to focus exploration efforts rather than the delineation of specific ore bodies. Incorporating other techniques, such as FTG, which provides high resolution data with a smaller footprint, could enable three-dimensional geophysical inversions, but only for smaller targeted areas.

2. **Given your background in advanced geophysical modeling and your previous experience at USGS, what role do you believe Full Tensor Gravity Gradiometry (FTG) and other advanced gravity techniques can play in complementing Earth MRI's existing gravity, magnetic, radiometric, and geological datasets? Could these higher- resolution gravity measurements improve our understanding of deeper subsurface structures that may not be fully resolved through regional mapping alone, particularly in complex critical mineral environments?**

I am not a potential field geophysicist, but I have worked closely with geophysicists to incorporate gravity, magnetic, and other data types into prospectivity models. My understanding of FTG and other gravity techniques is that they can be useful for delineating specific structures and ore bodies that have a strong density contrast with surrounding rocks. At the scale of most airborne geophysical surveys, gravity data is most useful for delineating crustal-scale faults, terrane boundaries, margins of intrusive bodies, and other large scale geologic features. FTG is typically acquired at smaller footprints, higher resolutions, and can resolve density contrasts of ore bodies and dense materials at a finer scale and at depths where drilling and mining is likely to take place. There are also cost-effective alternatives to FTG, such as airborne gravity gradiometry (AGG) and airborne scalar gravimetry, that could complement existing geophysical surveys.

3. **As Congress considers the future evolution of Earth MRI, how important is it that the program continue incorporating emerging geophysical technologies, including Full Tensor Gravity Gradiometry (FTG), to improve subsurface imaging, reduce exploration risk, and strengthen the scientific foundation for AI-enabled mineral assessments? Based on your experience at USGS, do you see value in expanding the use of complementary high resolution geophysical datasets in areas identified through initial regional mapping to accelerate responsible domestic critical mineral development?**

When considering the entirety of the Earth MRI data acquisition portfolio, it is pragmatic to incorporate a variety of geophysical, geochemical, and geologic mapping techniques and balance their deployment with budget and coverage constraints. Some techniques have a very high technical readiness level (TRL) and can be deployed at scale, cost-effectively, and in a reasonable timeframe (e.g. aeromagnetic and radiometric surveys). Other techniques may be newer, lower on the TRL scale, and have niche platforms and capacity constraints that could limit their broad application to nationwide coverage. The more specialized techniques should perhaps constitute a limited portion of the overall portfolio. That said, there are specific study areas where higher resolution, more novel techniques are justified. Ultimately, the taxpayer may receive more value from broader coverage using the most mature technologies. Characterizing specific deposits provides useful data, but the benefit of that information is concentrated among the stakeholders within that study area. As the exploration process progresses, there is typically a transition in scale from public data providing a robust baseline toward industry acquiring additional targeted data on a specific project for which they have access or mineral rights. The public data derisks many projects simultaneously, rather than a single target. In the broader context of national security and supply risk, there may be other mechanisms better suited to derisking specific projects through sharing of exploration costs. For example, a federal program active during the Cold War, the Defense Minerals Exploration Administration provided up to 75% cost sharing for exploration work conducted for certain strategic minerals. This represents a different sort of program, with different stated objectives compared to Earth MRI. The language of the Earth MRI authorization legislation, for an “initial comprehensive national modern surface and subsurface mapping and data integration effort” seems to favor broad coverage as the primary objective, while leaving open the opportunity for detailed characterization and 3D modeling.