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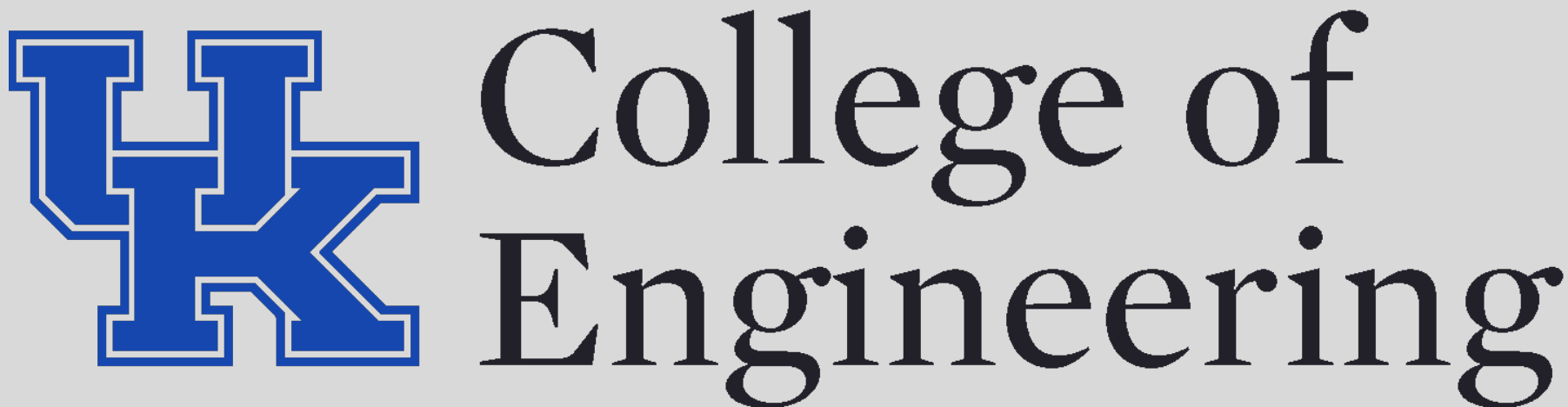
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Characterization of Domestic Allanite Rare Earth Ore

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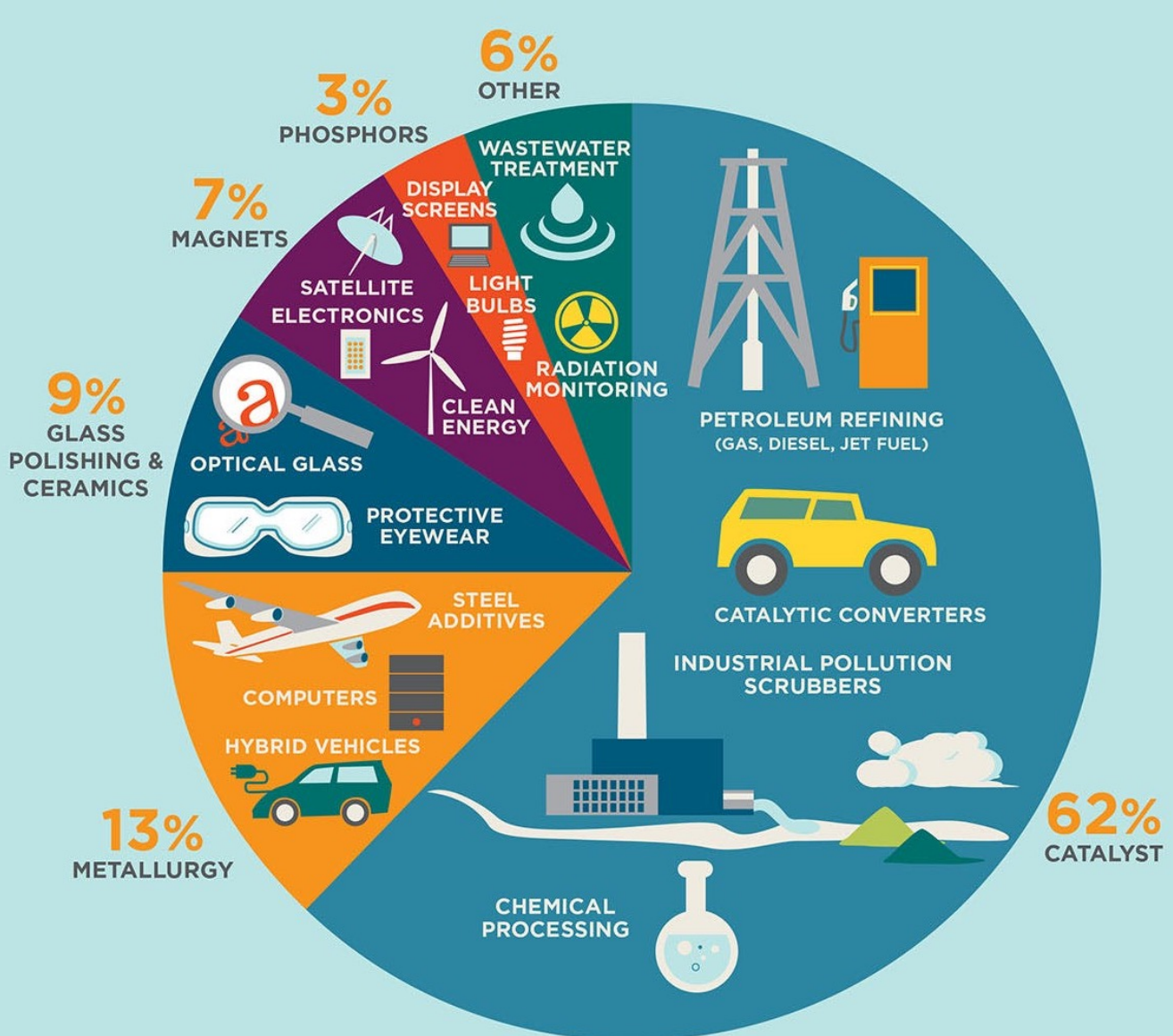
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Introduction

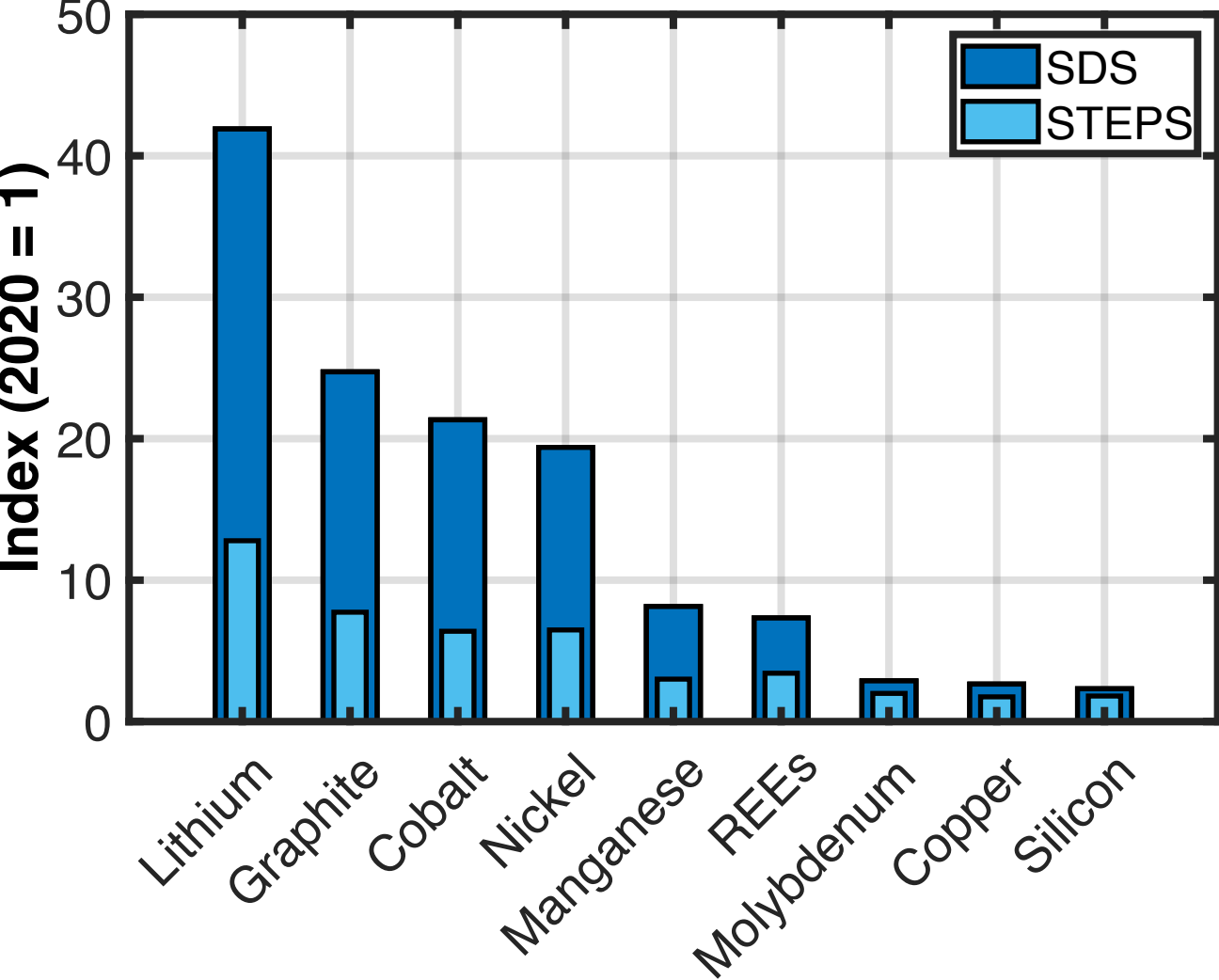
- Rare earth elements (REEs) (i.e., scandium, yttrium, lanthanoids) have significant value for energy infrastructure, decarbonization, and defense technologies (**Figure 1**).
- Revolutionary demand is projected during rapid global clean-energy transition (**Figure 2**).
- Geopolitical weaponization of 98% of REE supply [1] creates market instabilities threatening emergence of global clean-energy economy.
- Recent legislation (e.g., U.S. Energy Act of 2020, H.R. 4447) has designated extraction/recovery of REEs and other critical materials from low-grade sources as a matter of national security.
- Characterizing abundant but underutilized domestic REE source materials is crucial to alleviating REE supply vulnerability.

Figure 1. U.S. rare earth element applications.



Note. Adapted [reprinted] from "Rare Earths Infographic Rev." by Thorium Energy Alliance, n.d. (<https://bit.ly/3EYyEn>).

Figure 2. Projected demand growth in 2040 relative to 2020 under the Sated Policies Scenario (STEPS) and Sustainable Development Scenario (SDS).



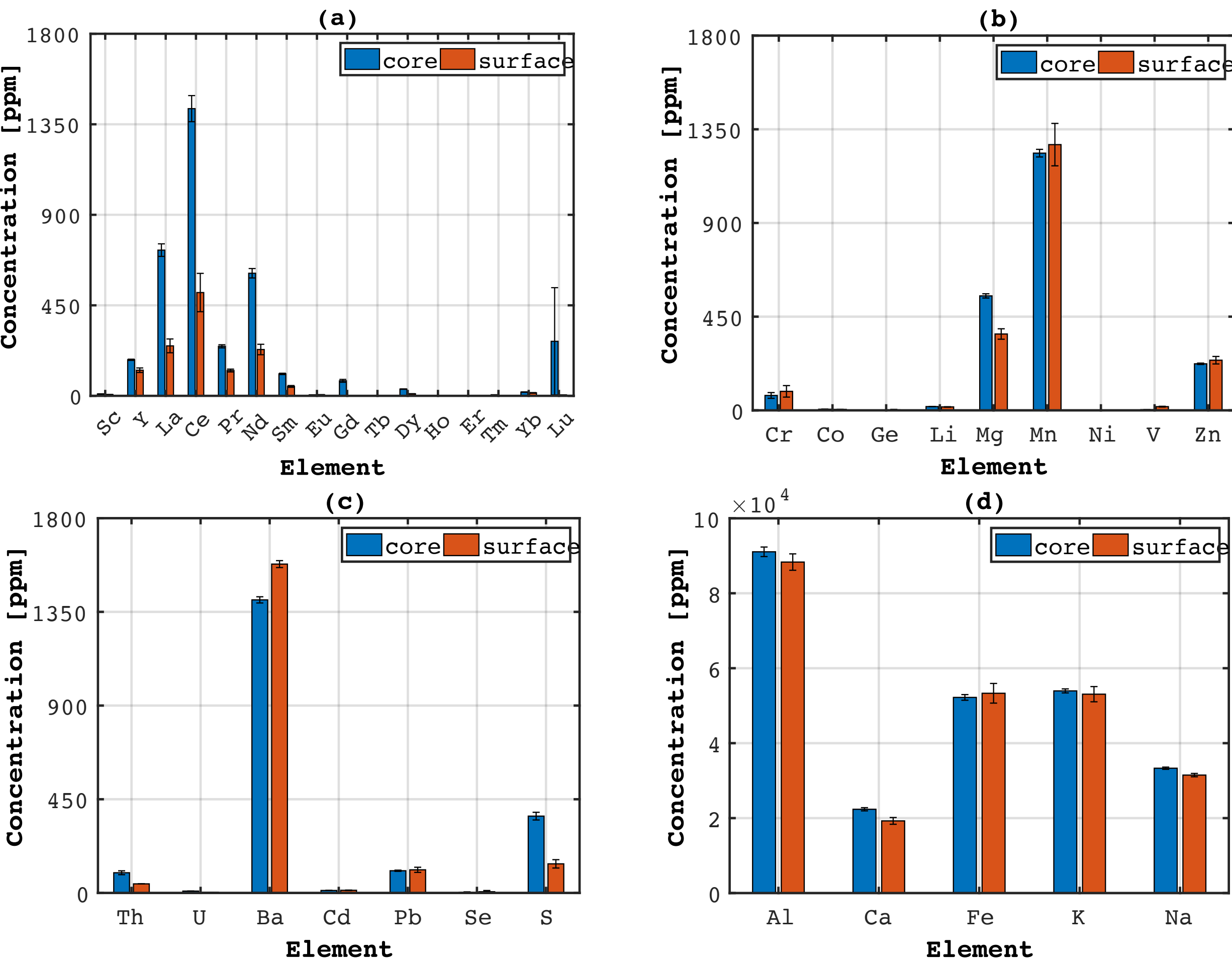
Note. IEA. (2021). Growth in demand for selected battery-related minerals from clean energy technologies in 2040 relative to 2020 levels by scenario. [Data Set]. IEA. Retrieved November 25, 2022, from <https://bit.ly/3FtZvS>

Materials & Methods

- Subsurface (core, 160 kg) and near-surface (surface, 15 kg) allanite-based ores from Halleck Creek, Wyoming were crushed to top size of 2-4 mm via laboratory jaw and roll crushers.
- Bulk samples riffled into 1 kg representative sample lots for testing.
- Fine material (i.e., < 150 μ m) separated via wet sieving before dry sieving samples via testing sieve shaker for 20 min for particle size-by-size weight and elemental distribution analysis.
- Grinding tests performed in laboratory rod mill ($\varnothing$ 206 mm x 263 mm) with steel rods (7 $\varnothing$ 13 mm x 232 mm, 8 $\varnothing$ 16 mm x 232 mm, 9 $\varnothing$ 19 mm x 232 mm) operated at 50 rpm with 65 %w/w slurry.
- Materials pulverized via ring-and-puck mill prior to analysis.

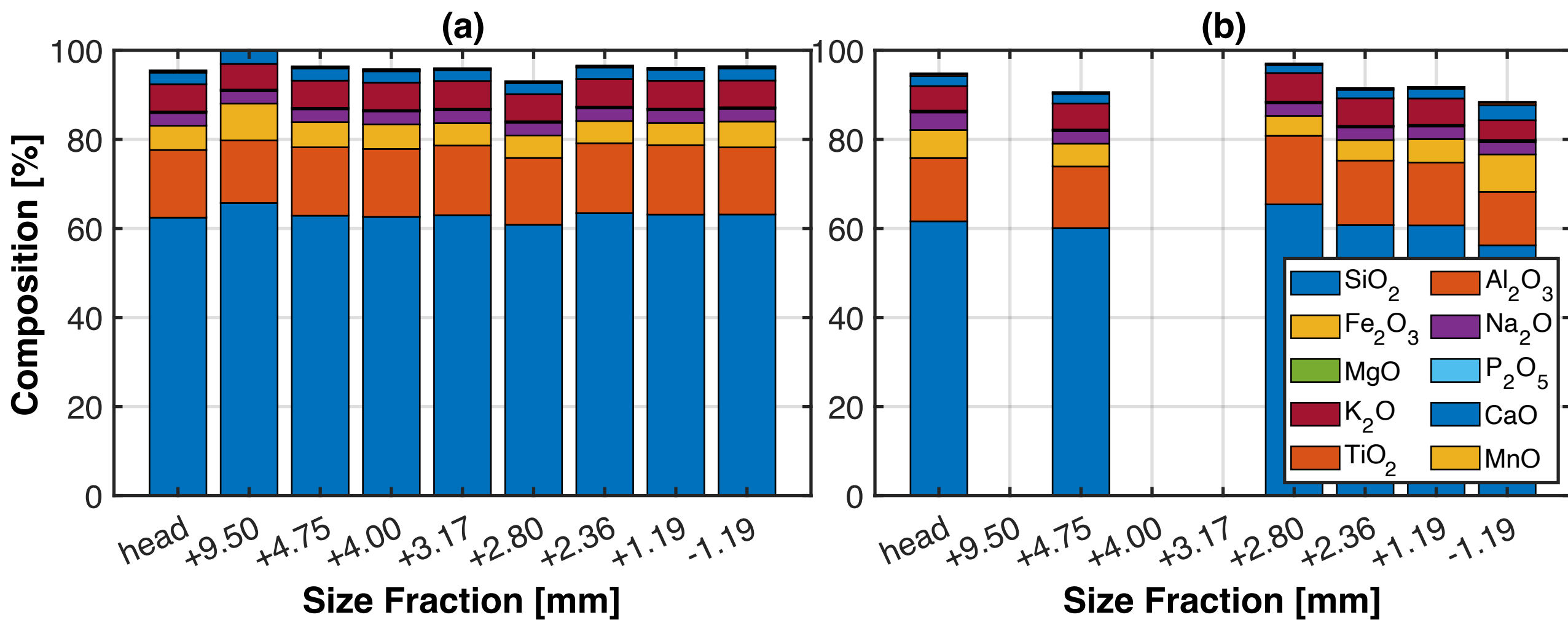
Total Metal Analysis

Figure 3. (a) Rare earth element, (b) critical mineral, (c) environmental hazards, and (d) major contaminant concentrations for crushed core and surface material via ICP-OES and ICP-MS (Th, U).



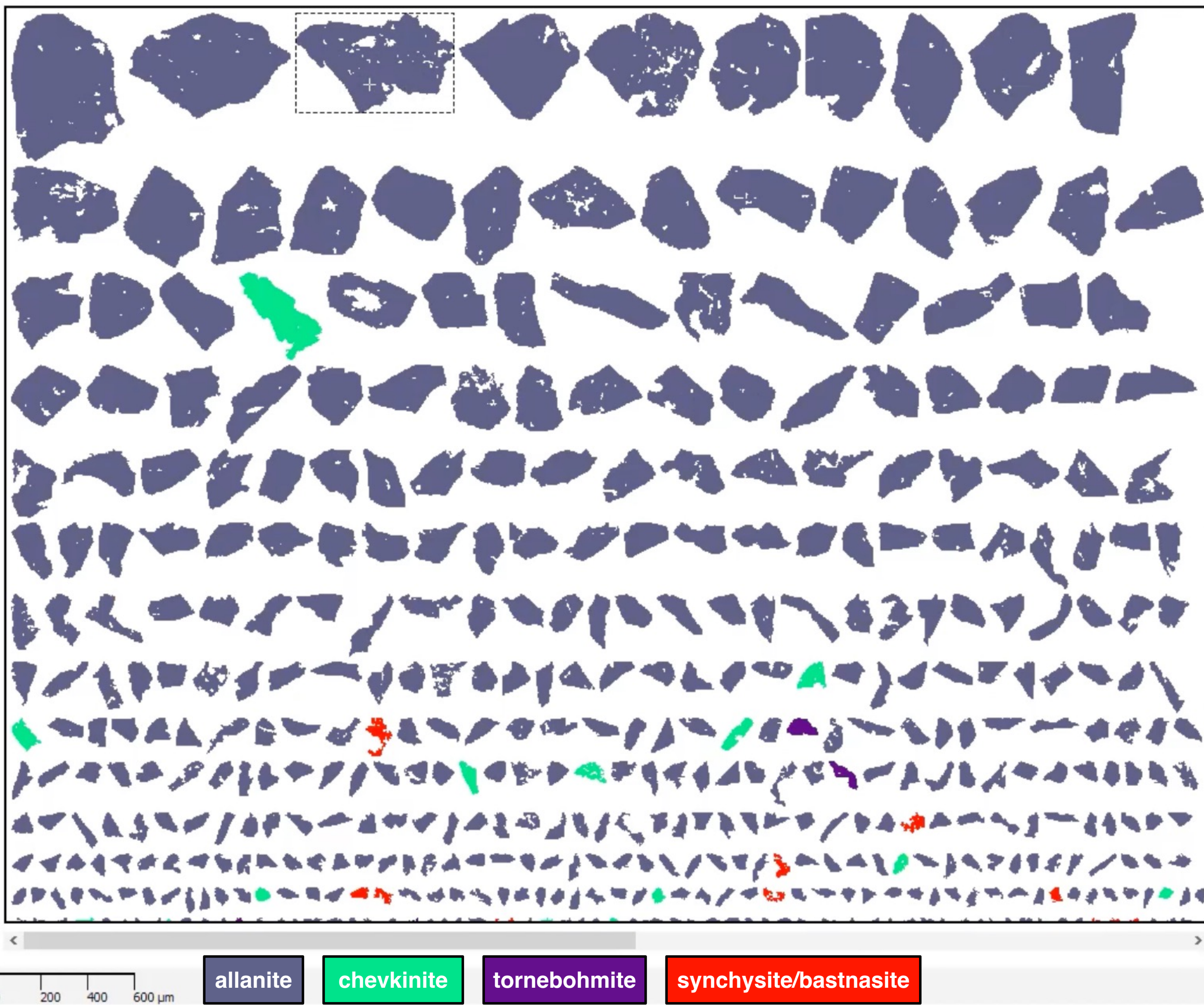
Mineralogical Analysis

Figure 4. Particle size-by-size mineral composition for crushed (a) core and (b) surface material via XRF.



Mineral Liberation Analysis

Figure 5. REE-bearing grains from preliminary mineral liberation analysis (MLA).



- Allanite constituted 90% of total REEs and demonstrated high liberation at a coarse grain size (232 μ m) [2].
- Coarse grain size indicates that a standard Wet High-Intensity Magnetic Separation (WHIMS) process may achieve high REE recovery and upgrading [2].

Conclusions

- Halleck Creek ore contains many important REEs and critical minerals, but also contains penalty elements (e.g., Th).
- Includes 11 REEs, including key heavy REEs (e.g., Dy, Y, Lu).
- Material contains key battery components (e.g., Li, Mn, Zn).
- Harbors environmental hazards like radioactive elements (e.g., Th, U) and heavy metals (e.g., Ba, Pb).
- The simplicity to achieve highly liberated allanite improves the efficiency and lowers cost of beneficiation processes.
- Commercial REE extraction and production may be viable.

References

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