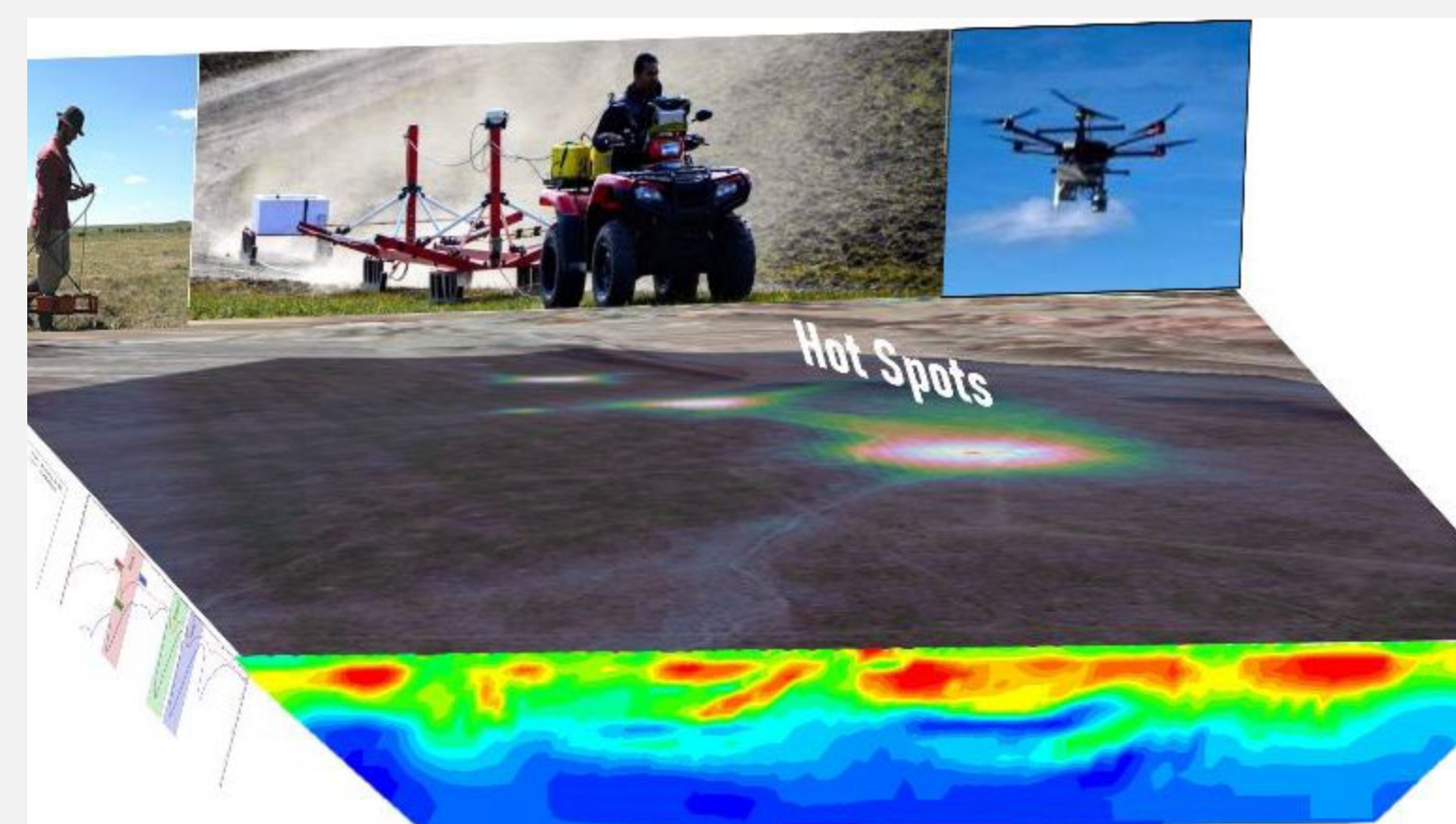


## INTRODUCTION

**Prospecting** for Rare Earth Elements (REE-CM) in unconventional and secondary sources is a complex task that needs to overcome the challenges of detecting low and variable concentrations and the uniqueness of every source material deposit in terms of composition, host material, and disposal environment. Like in traditional mineral prospecting, delineation of the REE-CM “hot zones” is critical for assessing the economic viability of these sources. Here, hot zone is defined as a spatially delineated volume of high REE-CM concentrations within the tailing deposits

## TECHNICAL OBJECTIVE



The machine learning (ML) - aided multi-physics prospecting technology under development at LBNL is designed for pinpointing REE-CM hot zones in mine tailings, concentrating on coal tailings, and byproducts like fly ash. This method merges cutting-edge geophysical, radiological, and optical technologies on various platforms for effective REE-CM exploration. Supported by AI, this integrated system enhances hot zone identification and mineralogical characterization, leveraging LBNL's expertise in diverse sensing technologies and ML for robust data analysis and recovery optimization, aiming to boost the economic viability of REE-CM extraction from secondary sources.

## MULTISCALE MULTIPHYSICS PROSPECTING TECHNOLOGY

**Airborne Magnetic & HSI**

**Vehicle Towed Transient EM**

**Lab Focused Technologies**

**Airborne Radiation**

**Ground & Handheld Geophysics**

**XRF/LIBS RoboScanner**

**Associated Particle Imaging**

**ICP-MS/XRD**

## AI DRIVEN DATA INTEGRATION AND HOT-SPOT IDENTIFICATION

**Core functionality: Multiphysics data integration**

**Algorithm Test Case**

- CNN transformer, Gradient Boosting (GB); GB is shown to perform better
- T/T/L is a short-hand for take-off, transit, and landing
- Data Augmentation to increase the instances of minority classes
  - SMOTE Synthetic Minority Oversampling Technique
  - Account for proximal similarity of classes
  - WW weighted majority voting

**Multiphysics signal correlations**

Correlation Matrix of Updated Columns:

REE_Total	Density_Th232	Density_U40	REE_Sm	REE
1.00	0.96	0.89	0.61	0.62
0.96	1.00	0.86	-0.77	-0.79
0.89	0.86	1.00	-0.55	-0.54
-0.61	-0.77	-0.55	1.00	1.00
-0.62	-0.79	-0.54	1.00	1.00

Scatter Plot of REE total vs Nd

Scatter plot of Density\_Th232 vs REE\_total

**Scale**

Whole tailing scale  
Surface/ transect scale  
Borehole/sample scale  
Lab scale

Fidelity ↓ ML/AI ↑ Scale

**Ground Truth (USGS)**

**Prediction: XGBoost + SMOTE + WW**

## NEXT STEP ACTIVITIES

- Local testing to validate and improve the different technologies, e.g., long duration, multi-play load, terrain following drone technologies
- Continuing to improve AI algorithms for data assimilation, analysis and prediction for “hot zone” identification
- Field campaign to demonstrate technology feasibility in Penn (ash, refuse, AMD)
- Technology validation and improvements
- **Welcome collaborative opportunities**

## UPCOMING FIELD CAMPAIGNS

