Rare Earth Element Detection

Using AI to Detect Strategic Materials

maximus

U.S. DEPARTMENT of ENERGY

NATIONAL ENERGY TECHNOLOGY LABORATORY

UX Research and Design
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The Challenge

The Problem

The global competition for **rare earth materials** is intensifying as they remain essential to clean energy, advanced electronics, and defense applications. Securing stable supply chains has become a national priority, pushing industries to accelerate discovery and processing of domestic sources. The ability to locate these elements faster and with greater accuracy is now directly tied to economic resilience and technological leadership.

AI-powered geological analysis offers a path forward by rapidly interpreting seismic data, core samples, and remote sensing imagery to pinpoint high-value deposits. When paired with **strong UX design**, researchers gain intuitive tools for visual exploration, pattern recognition, and team collaboration. A well-designed interface can streamline decision-making, reduce exploration time, and make complex datasets easier to analyze — ultimately speeding the discovery of rare earth materials.

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What we did...

The Process

Understand the Science

Develop a deep understanding of the process of Natural Rear Earth Element Concentration and how detection works

Develop Workflows

Review proof of concept application and develop workflows and features that will accomplish the needed goals.

Determine Best Practices

Conduct a comparative and competitive analysis of other mining applications discover best practices for such applications

Prototype the Solution

Develop high fidelity prototype in concert with development capability using the Microsoft Fabric Design System

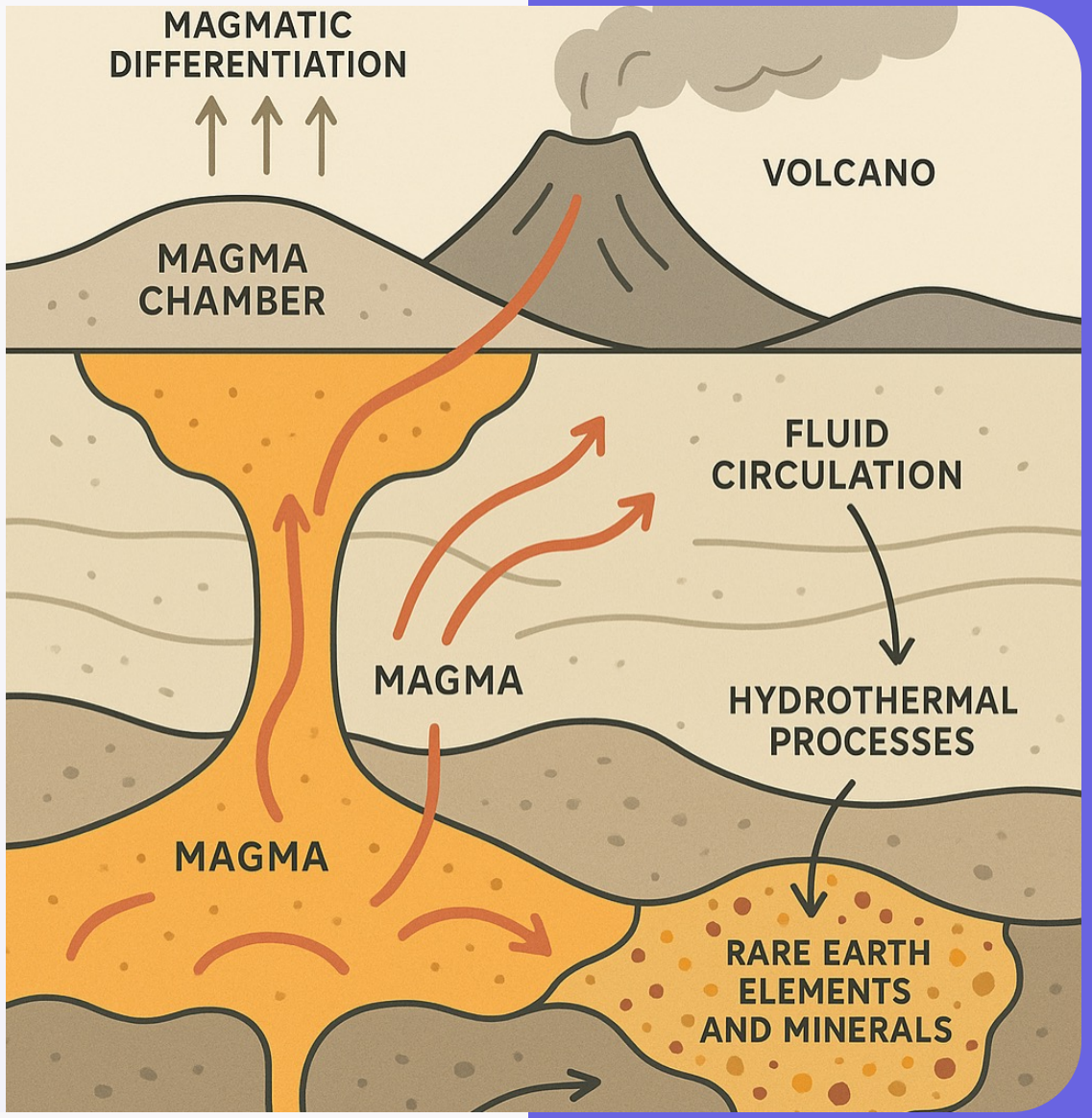
Understanding

The Science

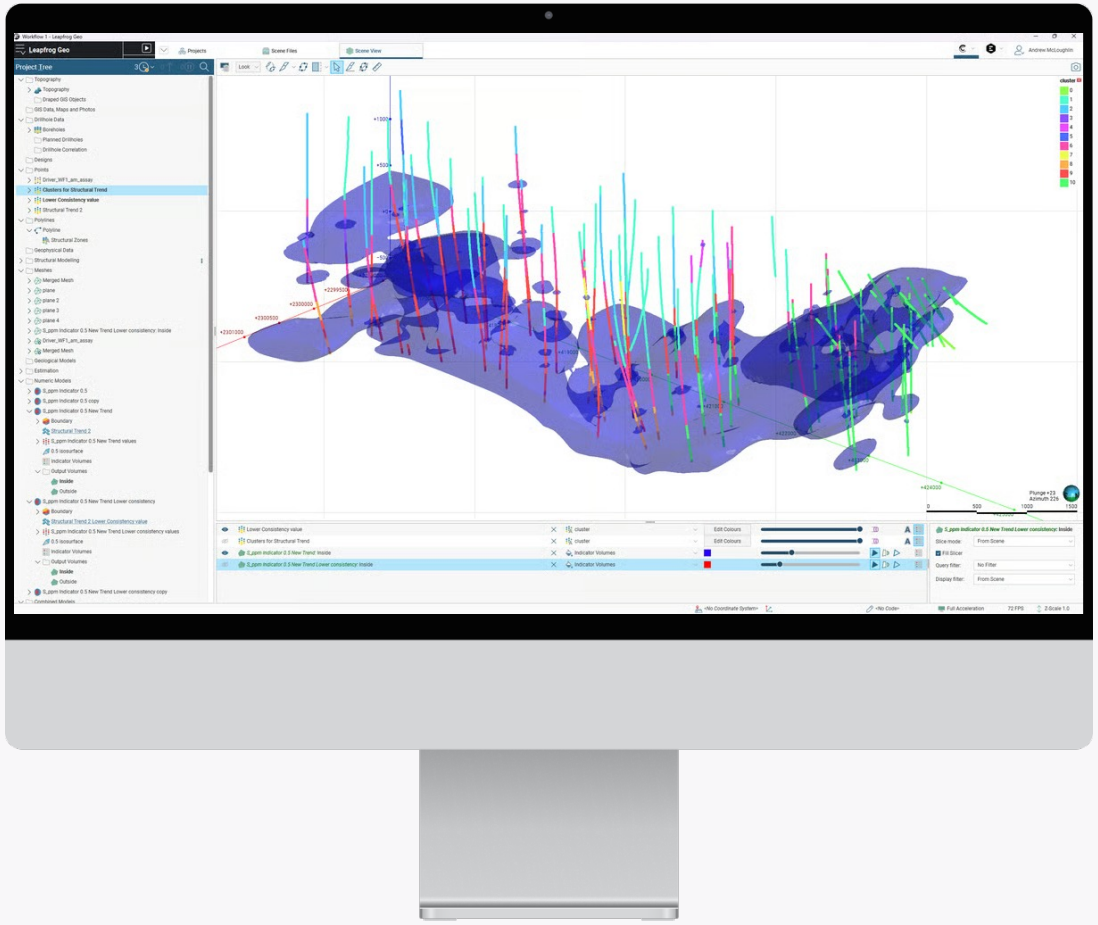
Rare Earth Materials Concentration and Mining

Natural **rare earth element (REE) concentrations** form through slow geological processes such as magmatic activity and hydrothermal circulation, where minerals cool, separate, and deposit into enriched pockets underground. Over time, these processes create zones with higher REE density which are key targets for exploration.

X-ray fluorescence (XRF) allows rapid, non-destructive testing of rock and soil samples to detect rare earth signatures, making it ideal for field screening. When paired with **AI**, geological and XRF data can be analyzed alongside satellite imagery and historical maps to identify patterns and predict the most promising areas for exploration. This combination speeds discovery, reduces cost, and improves decision-making for mining teams.



Best Practices



Multi-layer geological visualization

Enable users to overlay and toggle data layers such as XRF readings, satellite imagery, fault lines, soil chemistry, and topographic maps to reveal correlations that point toward REE concentration zones.

Standardized sampling + metadata capture

Ensure each sample is tagged with location, depth, lithology, collection method, and instrument readings so AI models have structured, high-quality input for training and prediction.

Automated data cleaning + anomaly detection

Implement pipelines that detect outliers, normalize readings, and flag inconsistent or low-confidence data to maintain reliability in predictive models.

Decision-support workflows

Provide ranking, heatmaps, and probability scoring to help geologists prioritize drill targets, with the ability to export or share findings across field, lab, and leadership teams.

The Steps

Develop Workflows

Developing a workflow for this application involves mapping how geological samples move from field collection to XRF analysis, then into an AI-driven evaluation pipeline for predictive modeling. The process should include steps for data ingestion, cleaning, visualization, and decision outputs that guide exploration teams toward the highest-potential sites.

01

Create A Project

Create a project to store project data

02

Build a Team

Choose your team members.

03

Upload Data

Upload geological and XRF data for analysis

04

Render Visualization

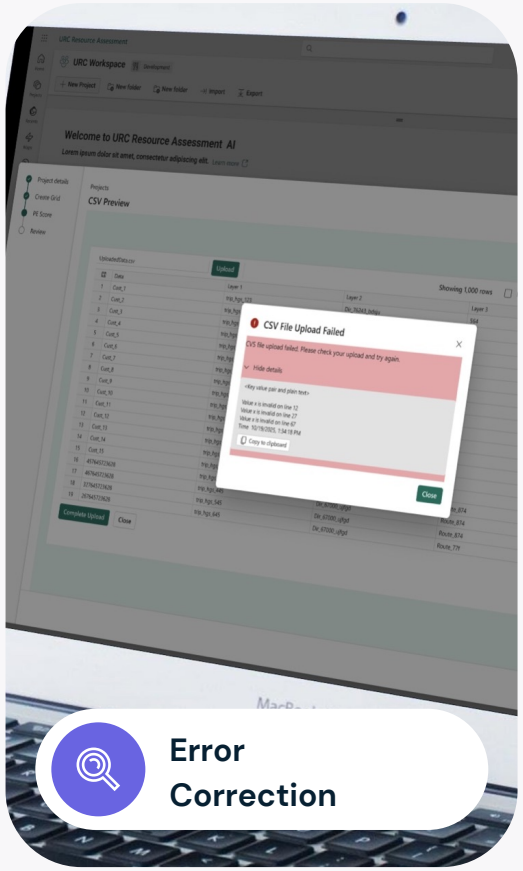
Apply the Application's AI capabilities to create a visualization that highlights areas of rare earth material potential.

05

Manipulate Data

Use the application's layer and AI features to refine resource visualizations.

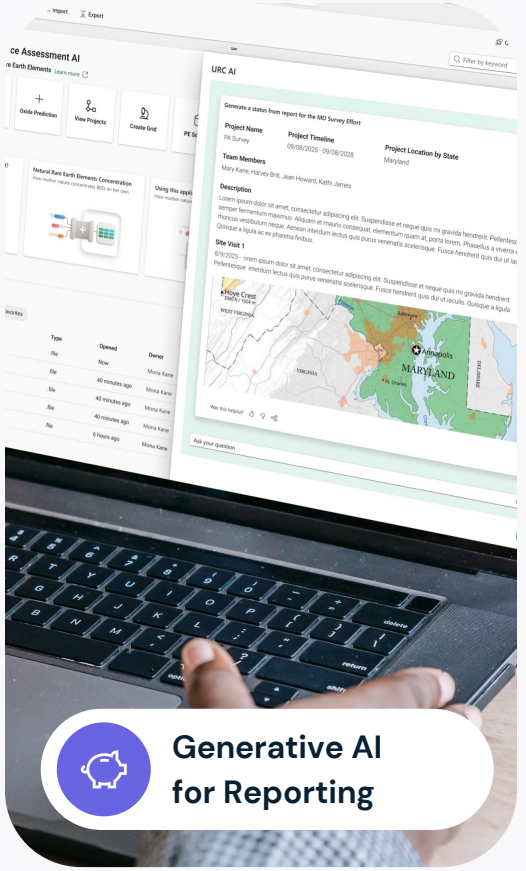
Solution Designed



Error Correction

Rare Earth Visualization

Visualized Correlations



Generative AI for Reporting

The Outcome

Development Ready Design

A Microsoft Fabric Compliant Design was delivered to the Department of Energy.

Key Features Addressed

All major functionalities were designed and delivered in the form a high fidelity Figma prototype.

AI Integration

Potential AI features were integrated into this prototype allowing for Report Creation, Forecasting etc.

Continued Relations

The successfully delivery of this project to the strengthened the relationship with Department of Energy