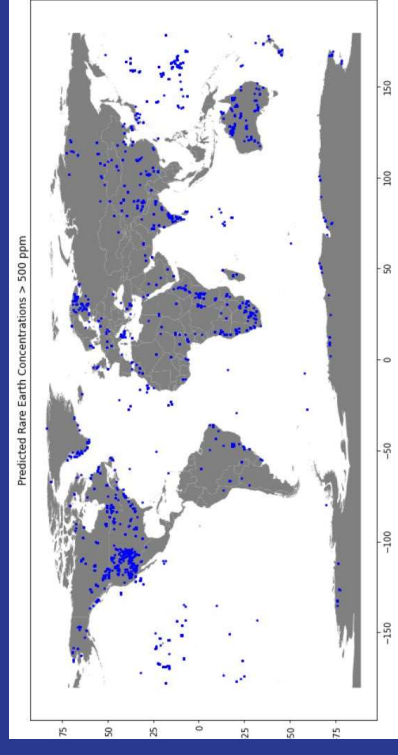


Rare Earth Metals Mining

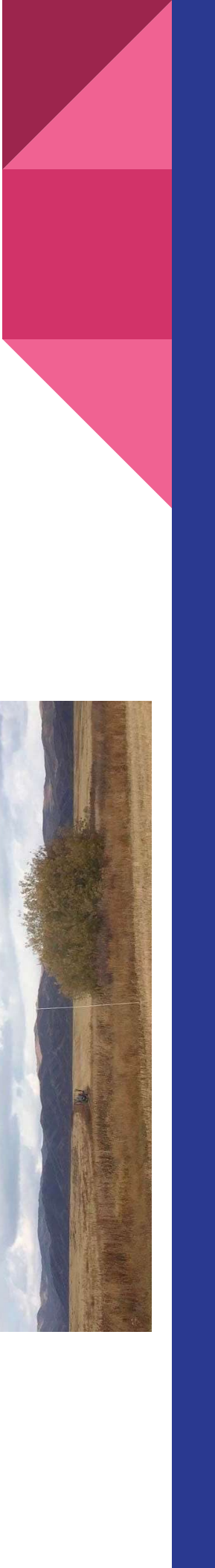
Team Industrial - Final Project

Janice Bolen
Stan Holko
Jamie Norman
Ying Zhu



Project Objective - Value Proposition

To develop a data science methodology that will enable faster, low cost, and reliable detection of potential coinage and rare earth metal deposits from previous assay analysis and aerial magnetic and radiometric scans.



Topic Selection - Rare Earth Metals Mining

Key selection criteria:

- Industrial / Technical in nature
- Must have a geo-spatial element to it
- Environmental Impact



This topic aligns with the professional experience and interests of the group

Quick Background

Key Terms:

Metallurgical Assay - An analysis of the composition of an ore using various methods such as titration, cupellation, spectrometry

Rare Earth Metals - Set of 17 soft heavy metals used primarily in electrical, electronics, lasers, glass, magnetic materials and industrial processes. Less rare than the name implies, many elements are more plentiful than other elements not in this category. Issue is that large deposits are rare, elements tend to be dispersed

Coinage Metals - Refer to silver and gold. Metals used in early currency coins

Rare Earth Elements by Geology.com																	
H																	
Li	Be																
Na	Mg																
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La-Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac-Lu	Rf	Db	Sg	Bh	Hs	Mt									
Lanthanides																	
La Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb Lu																	
Actinides																	
Ac Th Pa U Np Pu Am Cm Bk Cf Es Fm Md No Lr																	

Rare Earth Metals are very useful but hard to find large deposits

Data Sources

Three Data Sources were chosen to be analysed as part of this project:

- Global Whole-Rock Geochemical Database Compilation by Gard, Matthew Geoffrey, Hasterok, Derrick, & Halpern, Jacqueline (2019).
 - 1.0M+ rows of sample data
 - 7 linked tables
 - Consists of temporal, spatial and physical property information
 - Coring sample information logged at locations around the world
- Geophysics of Colorado - National Uranium Resource Evaluation Magnetic and Radiometric Survey by Hill, Patricia L, Kucks, Robert P., & Ravat, Dhananjay (2009)
 - Aerial scan of Colorado for magnetic and radiometric data, common practice for surveying for potential sources
 - 3,000 rows
 - Looking to find trends between the aerial scan and the whole rock database
- USGS - Rare Earth Element Mines, Deposits, and Occurrences by Grauch, Richard I. and Orris, Greta J. (2002)
 - Data on confirmed rare earth mines, deposits and occurrences
 - Used as a reference to confirm correlations to assay data

All databases proved sufficient to support the project objective

Data Questions

- Find most common co-existing elements in samples rich in rare earths
- Determine which features are most useful:
 - Chemistry of other elements
 - Rock type
 - Rock age
 - Formation mechanism
 - Aerial magnetic and radiometric scans

Focus on the identification of key features of the samples rich in rare earth metals

Correlation Matrix

- # Correlation Matrix

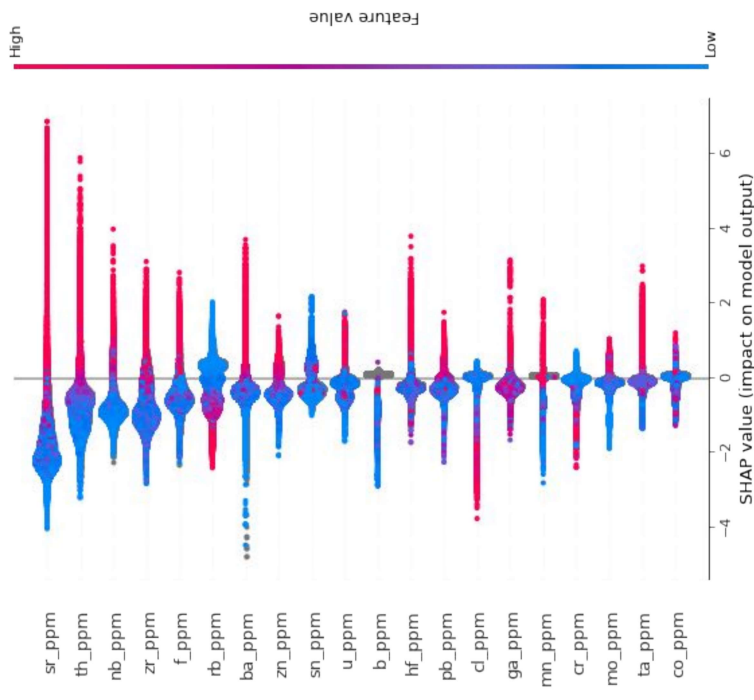
Adequate correlations found between rare earth and other elements in samples

Analysis - Model Selection

Data analysis was performed using an XGBoost (Extreme Gradient Boosting) classification model for the following reasons:

Tree-based models are better able to handle sparse and unbalanced datasets

Easy to understand feature importance



XGBoost was the model chosen to perform the analysis

98%

XGBoost Model Accuracy -
Geochemical Model

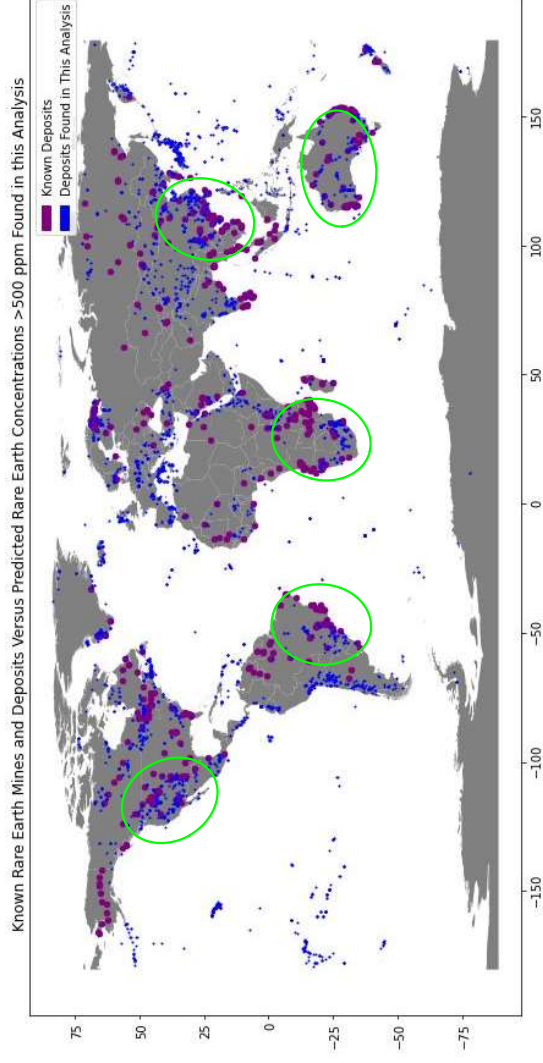
Confusion Matrix

	Predicted 0	Predicted 1
Actual 0	19297	161
Actual 1	73	358

Analysis - Compare with USGS Dataset

Predicted REE points were mapped in comparison of USGS dataset (Rare Earth Element Mines, Deposits, and Occurrences)

- Purple: Known REE Mines and Deposits
- Blue: Predicted REE >1,000 ppm



Lots of potential new sources of Rare Earth Metals!

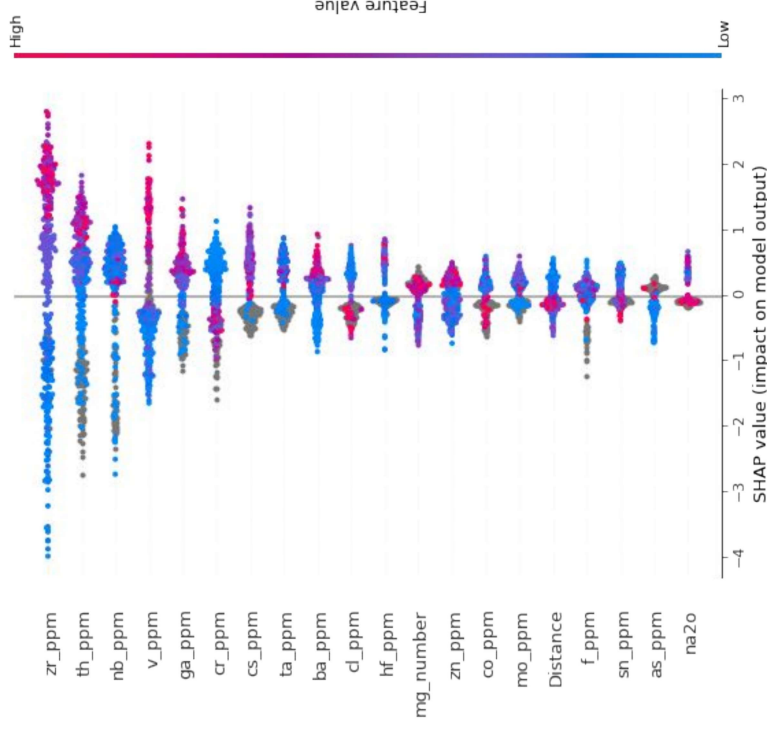
Analysis - Adding Colorado Uranium Resource

Colorado National Uranium Resource Evaluation Aeromagnetic and Aeroradiometric Data were added to our machine learning database using GIS software.

Newly introduced features did not show very strong correlations to REE existence.

Regional dataset may have different major features comparing to whole world dataset.

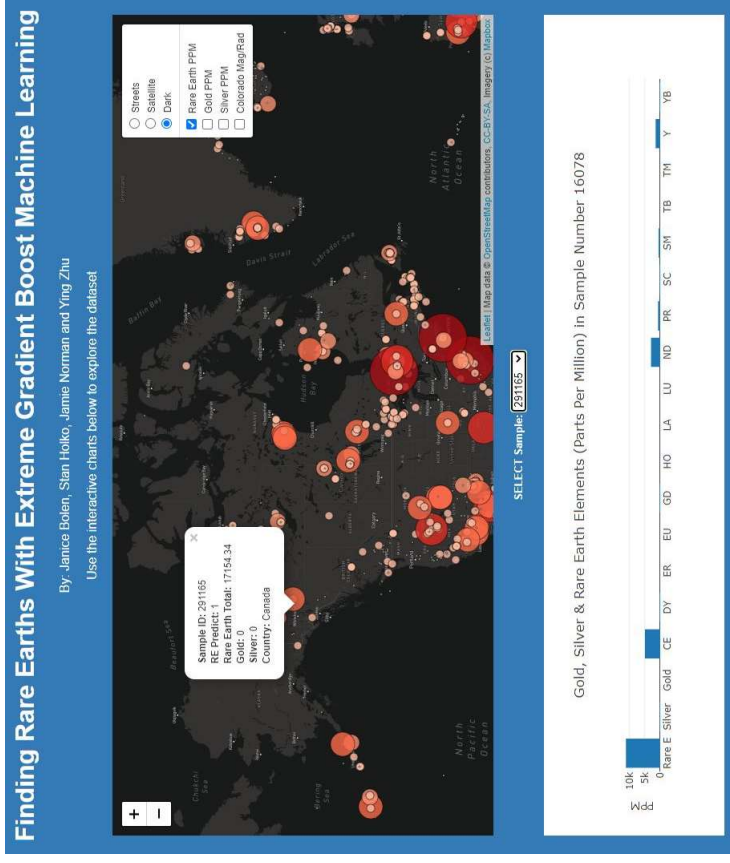
- Colorado Top 10: **zr**, **th**, **nb**, v, ga, cr, cs, ta, **ba**, cl
- Worldwide Top 10: sr, **th**, **nb**, **zr**, f, rb, **ba**, zn, sn, u



No definitive contribution from the aerial data on improvements to the model

Output - Front End Optimization

Used pgAdmin (Elephant SQL) to develop output tables to limit the number of rows and columns



Actual Dashboard - Dynamic HTML Webpage

Future Opportunities

- Create a front end to upload user data to add to existing data and re-run model
- Explore other machine learning algorithms to see if there are better potential solutions
- Run further analysis to look for other elements of value
- Further development of dashboard for greater interactivity - allow for querying for different data features



Excellent potential to add further value

In Conclusion

The data analysis successfully discovered several key correlations in the assay samples in order to provide leads for other potential sources of coinage and rare earth minerals



Thanks!

Janice Bolen

Stan Holko

Jamie Norman

Ying Zhu

github.com/sholkojr/Rare_Earth_Metal_Mining

