

A new way to evaluate association rule mining methods and its applicability to mineral association analysis

A new way to evaluate association rule mining methods and its applicability to mineral association analysis
 Anirudh Prabhu*, Shaunna Morrison*, Donato Giovannelli^

*Earth and Planets Laboratory, Carnegie Institution for Science, Washington, DC, USA. | ^University of Naples Federico II, Naples, Italy.

Introduction

An approach to evaluate rules

Most training data subsetting:

Subsetting data vertically:

Results

Method	AP	PR	F1	Recall
Apriori	0.04	0.04	0.04	0.04
Apriori-Pruned	0.04	0.04	0.04	0.04
Apriori-Pruned-Opt	0.04	0.04	0.04	0.04
Apriori-Pruned-Opt-Pruned	0.04	0.04	0.04	0.04
Apriori-Pruned-Opt-Pruned-Opt	0.04	0.04	0.04	0.04

Mineral Association Analysis

Observations and Future Work

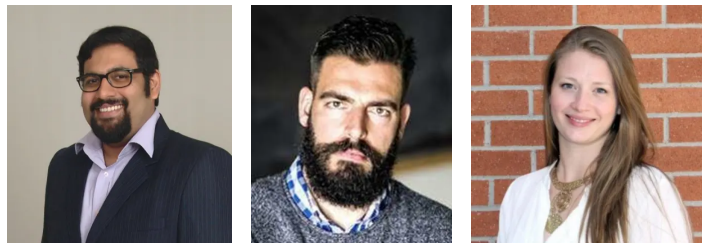
- Currently restricted to RHS of size 1.
- The difference in the number of rules between the full set and subsetting.
- Need for aggregates of rules, and potential consequences from the aggregation.
- Classic difference in the number of rules generated for the subset reduction, even though on 70% of the mineral occurrences were randomly removed.

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Accept

Anirudh Prabhu*, Shaunna Morrison*, Donato Giovannelli^

*Earth and Planets Laboratory, Carnegie Institution for Science, Washington, DC, USA. | ^University of Naples Federico II, Naples, Italy.

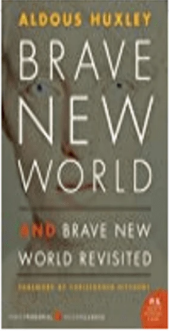


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INTRODUCTION



Brave New World / Brave New World Revisited by Aldous Huxley
★★★★☆ 4.16 avg rating — 128,989 ratings — published 1932
The astonishing novel Brave New World, originally published in 1932, presents Aldous Huxley's vision of the future--of a world utterly transformed. Through the most efficient scientific and psychological engineering, people are genetically designed ...[more](#)
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The Wind Dancer (Wind Dancer, #1) by Iris Johansen
★★★★☆ 3.99 avg rating — 3,864 ratings — published 2007
A hidden killer...a conspiracy of treachery...and two of the most desperate game of all...In Renaissance Italy, the intricate as carved cathedral doors, but none is so complex as the surrounding the prized Wind Dancer, ...[more](#)



The Lord of the Rings by J.R.R. Tolkien

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Hybrid



MINERAL ASSOCIATION ANALYSIS



	lhs	rhs	support	confidence	lift	count
[1]	{Calcite,Pumpellyite-(Mg)}	=> {Quartz}	0.001013685	0.9545455	2.512686	84
[2]	{Pumpellyite-(Mg),Quartz}	=> {Calcite}	0.001013685	0.9767442	5.491850	84
[3]	{Corvusite,Tyuyamunite}	=> {Carnotite}	0.001049888	0.9666667	56.331786	87
[4]	{Carnotite,Corvusite}	=> {Tyuyamunite}	0.001049888	0.8529412	92.031020	87
[5]	{Pascoite,Tyuyamunite}	=> {Carnotite}	0.001001617	0.9431818	54.963224	83
[6]	{Carnotite,Pascoite}	=> {Tyuyamunite}	0.001001617	0.8556701	92.325467	83
[1]	{Calcite,Pyrite,Quartz,Sphalerite}	=> {Chalcopyrite}	0.03715637	0.7634515	4.258493	3079
[2]	{Calcite,Chalcopyrite,Pyrite,Quartz}	=> {Sphalerite}	0.03715637	0.7102653	4.901061	3079
[3]	{Calcite,Chalcopyrite,Galena,Pyrite}	=> {Quartz}	0.03768735	0.9075850	2.389070	3123
[4]	{Calcite,Chalcopyrite,Galena,Quartz}	=> {Pyrite}	0.03768735	0.9305721	3.484536	3123
[5]	{Calcite,Galena,Pyrite,Quartz}	=> {Chalcopyrite}	0.03768735	0.7840823	4.373571	3123
[6]	{Calcite,Chalcopyrite,Pyrite,Quartz}	=> {Galena}	0.03768735	0.7204152	4.202896	3123



Calcite



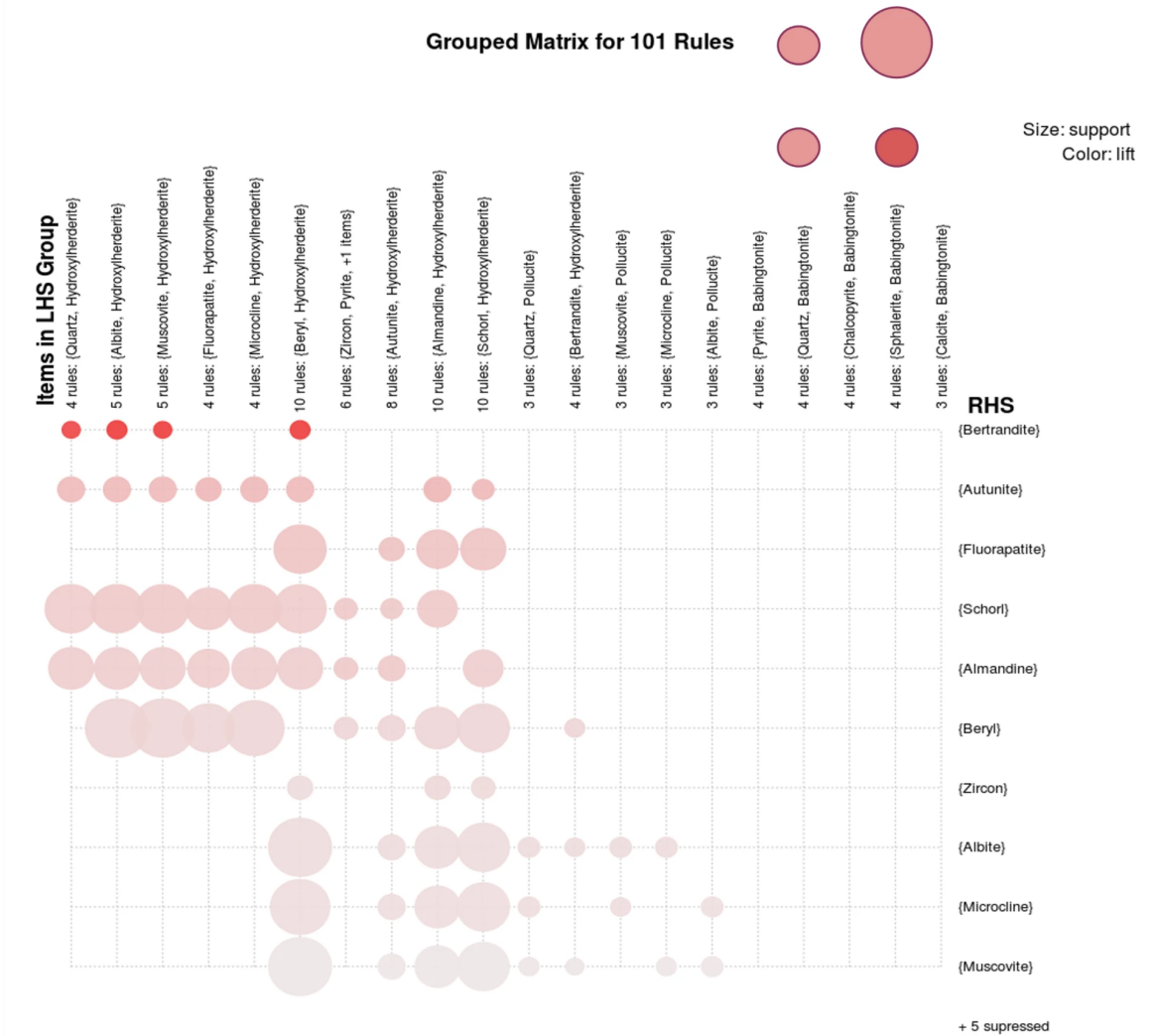
Pumpellyite-Mg

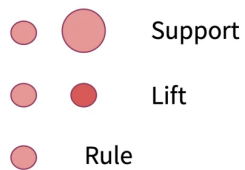
=>



Quartz

Morrison et al. (2022) in Prep
Prabhu et al. (2022) in Prep

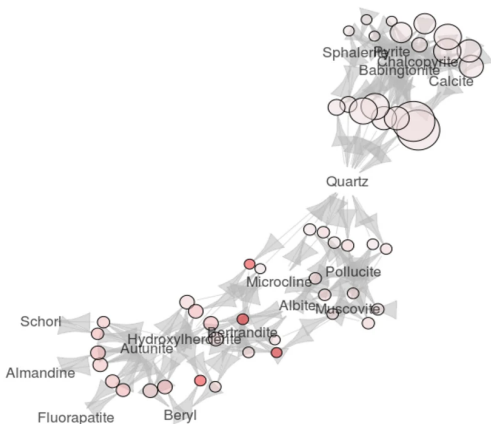




Mineral

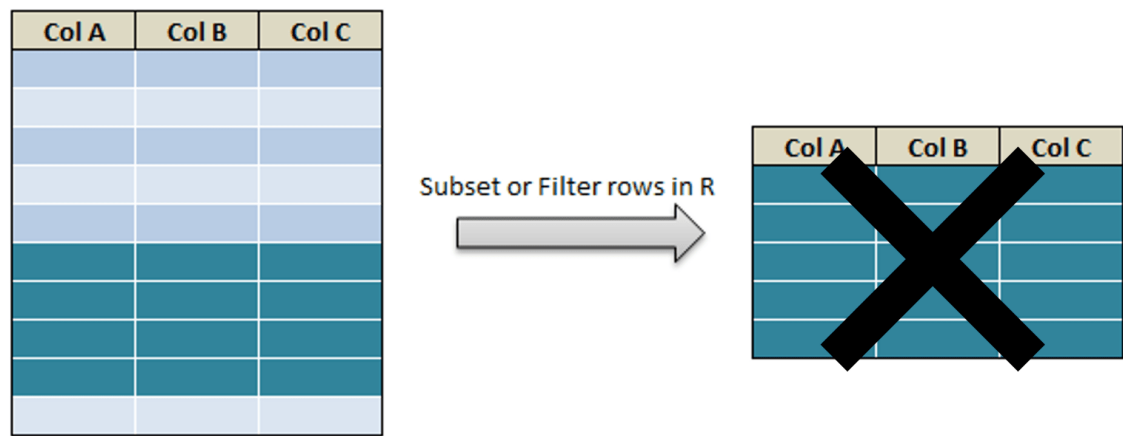
Graph for 51 rules

size: support (0.001 - 0.001)
color: lift (2.492 - 166.972)



AN APPROACH TO EVALUATE RULES

Most training data subsetting:



Subsetting data vertically:

Mindat ID	Locality Name	Minerals
235733	Broken Hill District, Yancowinna Co., New South Wales, Australia	Uraninite,Torbernite
72	New South Wales, Australia	Uraninite,Torbernite
Block 14	Opencut, Broken Hill, Broken Hill District, Yancowinna Co., New South Wales, Australia	Torbernite
15622	Northern Territory, Australia	Wyartite,Uranopilite,Uraninite,Torbernite,Sklodowskite,Saleeite,Rabejacite,Parsonsite,Metatorbernite,Johannite,Dumontite,Dewindtite,Curite,Coffinite,Brannerite,Autunite
263589	West Arnhem Region, Northern Territory, Australia	Wyartite,Uranopilite,Uraninite,Torbernite,Sklodowskite,Saleeite,Rabejacite,Parsonsite,Metatorbernite,Johannite,Dumontite,Dewindtite,Curite,Coffinite,Brannerite,Autunite
277956	Kakadu, West Arnhem Region, Northern Territory, Australia	Wyartite,Uranopilite,Uraninite,Torbernite,Sklodowskite,Saleeite,Rabejacite,Parsonsite,Metatorbernite,Johannite,Dumontite,Dewindtite,Curite,Coffinite,Brannerite,Autunite
41611	Jabiluka Uranium Deposit, Kakadu, West Arnhem Region, Northern Territory, Australia	Sklodowskite,Saleeite,Coffinite,Autunite,Uraninite
4622	Ranger Mine (Ranger Uranium Mine), Kakadu, West Arnhem Region, Northern Territory, Australia	Wyartite,Uranopilite,Uraninite,Torbernite,Sklodowskite,Saleeite,Rabejacite,Parsonsite,Metatorbernite,Johannite,Dumontite,Dewindtite,Curite,Coffinite,Brannerite
41442	Ranger No. 1 Deposit (Ranger No. 1 Pit), Ranger Mine (Ranger Uranium Mine), Kakadu, West Arnhem Region, Northern Territory, Australia	Wyartite,Uranopilite,Uraninite,Sklodowskite,Saleeite,Rabejacite,Metatorbernite,Dewindtite,Brannerite
41443	Ranger No. 3 Deposit (Ranger No. 3 Pit), Ranger Mine (Ranger Uranium Mine), Kakadu, West Arnhem Region, Northern Territory, Australia	Torbernite,Saleeite,Metatorbernite,Dewindtite
127	Queensland, Australia	Ytrotantalite-(Y),Uranocircite-II,Uraninite,Torbernite,Richtite,Phurcalite,Davidite-(La),Coffinite,Carnotite,Brannerite
6471	Cloncurry Shire, Queensland, Australia	Ytrotantalite-(Y),Uranocircite-II,Uraninite,Torbernite,Richtite,Phurcalite,Davidite-(La),Coffinite,Carnotite,Brannerite
133	Cloncurry, Cloncurry Shire, Queensland, Australia	Uraninite,Torbernite,Richtite,Phurcalite,Coffinite,Brannerite

Association Rules Example:

Full Set	Subset
$M_1M_2M_4 \rightarrow M_6$	$M_1M_4 \rightarrow M_6$
$M_2M_4 \rightarrow M_5$	$M_2M_4 \rightarrow M_5$
$M_8M_7 \rightarrow M_3$	$M_6 \rightarrow M_3$
$M_5M_2M_9 \rightarrow M_7$	$M_1 \rightarrow M_8$
$M_1 \rightarrow M_8$	
$M_3 \rightarrow M_5$	

Resilience of a Rule:

For $\exists RHS_i$,

- If no matches on LHS skip rule.
- Else, create a full set of items from the LHS of both rules.

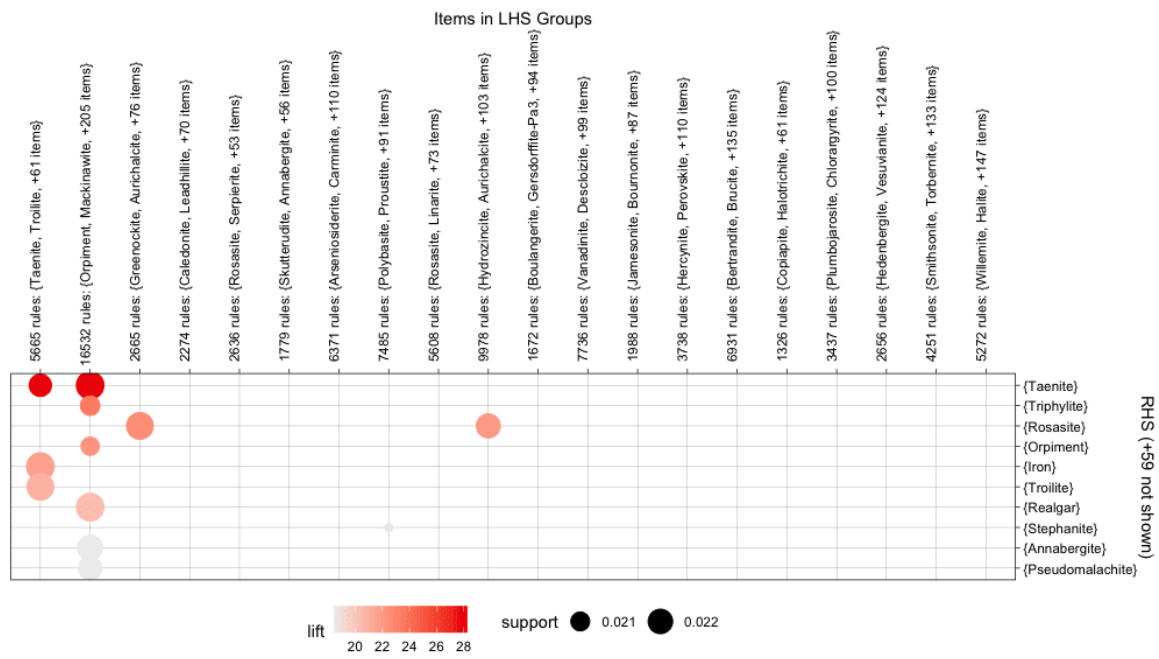
$$\frac{N_{LHS_F}}{N_{LHS_T}} \times |L_F - L_T| \times \frac{1}{N_{LHS_{F \cap T}}}$$

The ideal resilience of a rule is 0. The higher the score, the lower the resilience of the rule.

RESULTS

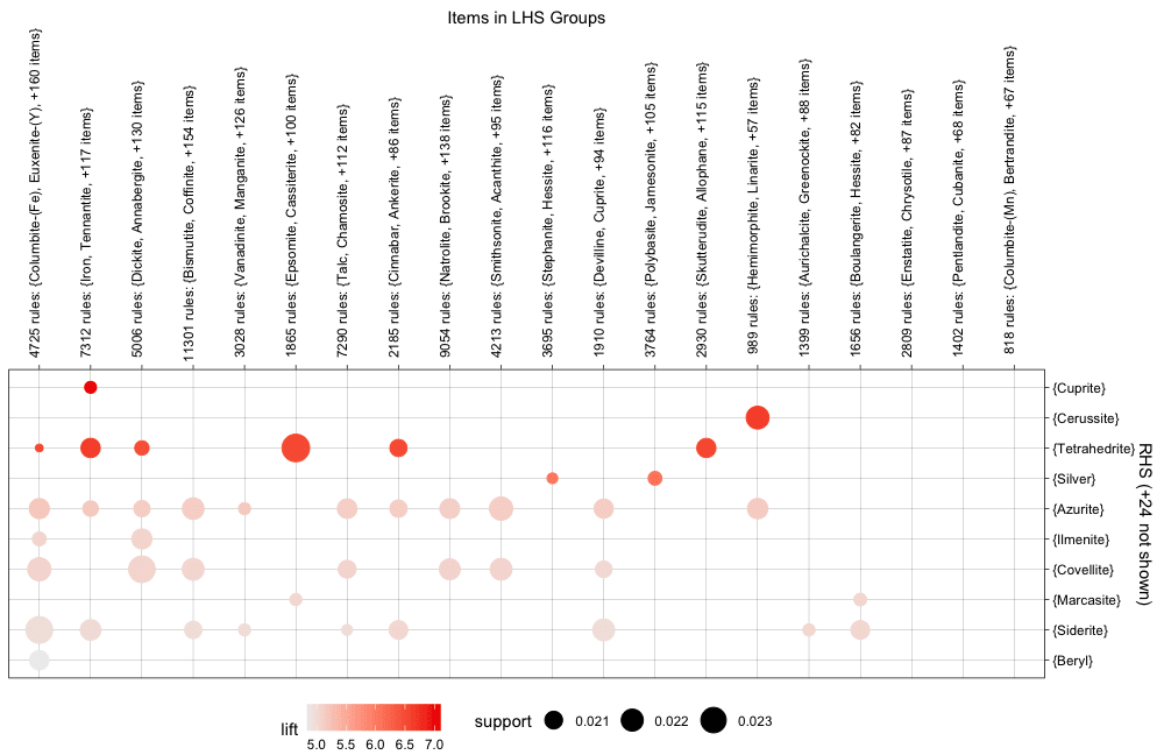
LHS_F	LHS_T	RHS	Resilience
Copper, Pyromorphite, Tenorite	Azurite, Copper, Pyromorphite	Cuprite	0.045
Copper, Lollingite, Pyromorphite	Azurite, Copper, Pyromorphite	Cuprite	0.227
Aragonite, Aurichalcite, Pyromorphite	Aragonite , Calcite, Pyromorphite	Cerussite	0.054
Anglesite, Hemimorphite, Xenotime-(Y)	Anglesite, Covellite, Hemimorphite	Cerussite	0.110

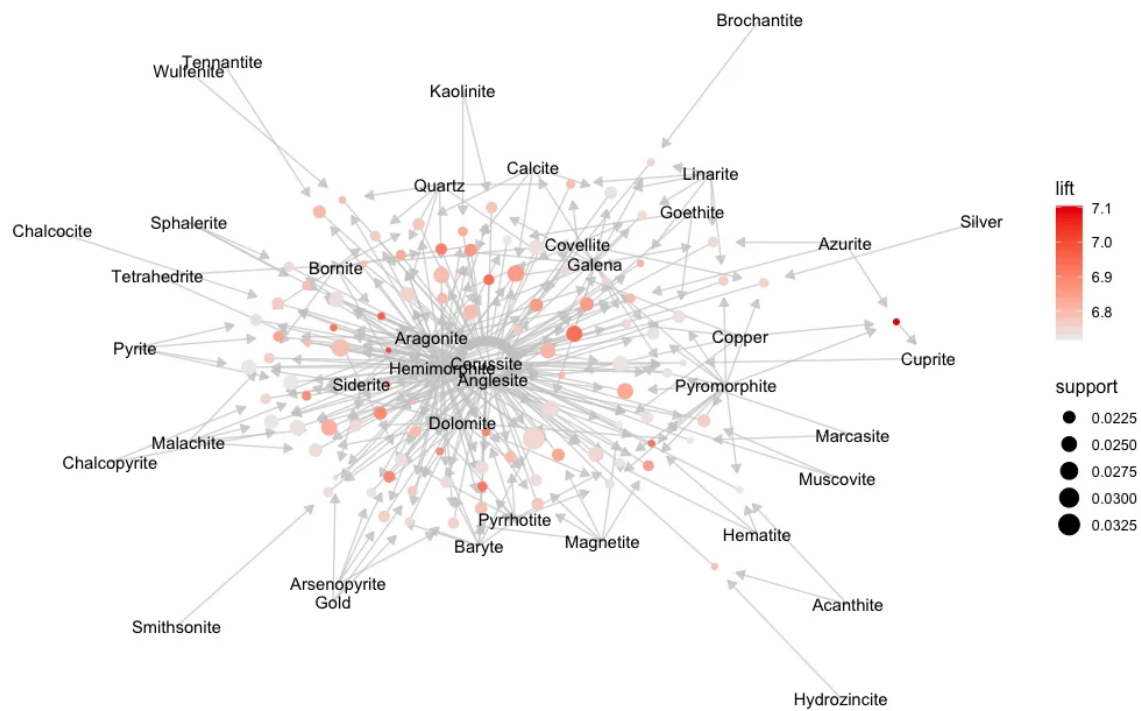
Full Rulebase:





Subsetted Rulebase:





OBSERVATIONS AND FUTURE WORK

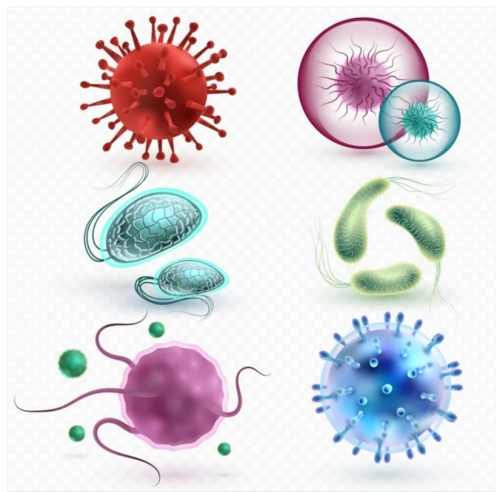
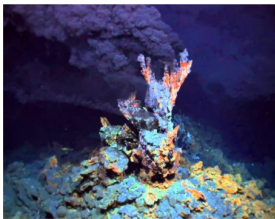
Observations and Roadblocks

- Currently restricted to RHS of size 1.
- The difference in the number of rules between the full set and training set.
- Need for aggregation of rules, and potential consequences from the aggregation.
- Drastic difference in the number of rules generated for the subset rulebase, even though on 20% of the mineral occurrences were randomly removed.

Future Work:

- Increase the size of RHS above 1. (In order to predict more complex mineral assemblages)
- Develop a method to aggregate rules.
- Improve and fine tune evaluation method.

Exploring Microbial Association Analysis:



ABSTRACT

There has been a significant increase in the amount and accuracy of mineral data (from resources like Mindat, MED or the GEMI) and the improvements in technological resources make it possible to explore and answer large, outstanding scientific questions, such as, understanding the mineral assemblages on Earth and how they compare to assemblages and localities on other planets. In the last couple of years, affinity analysis methods have been used to: 1) Predict unreported minerals at an existing locality, 2) Predict localities for a set of known minerals[1]. We've chosen to call this application "Mineral Association Analysis"[2].

Affinity analysis is an unsupervised machine learning method that uses mined association rules to find interesting patterns in the data. Most of the metrics used to evaluate market basket analysis methods focus on either the ability of the model to ingest large amounts of data[3], or using a metric based comparison of various algorithms used for association rule mining[4], or on evaluating the rules mined to more efficiently generate association rules[5]. However, when patterns generated in an unsupervised method are used to predict the occurrences of entities such as minerals, there needs to be a way to evaluate the predictions made by the model. It's in such an area that there has been very little work. In this abstract, we explore the development of a new method to evaluate the results of association rule mining algorithms specifically when used when the association rules generated are utilized in a predictive setting.

[1] Prabhu et. al (2019). In AGU Fall Meeting Abstracts (EP23D-2286).

[2] Morrison et al. Nat. Geo. (2021) In Prep.

[3] Agrawal et al. (1993) SIGMOD'93.

[4] Sharma et al. (2012) IJERT 1(06).

[5] Üstündağ and Bal (2014) Proc. in Comp.

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- [1] Prabhu et. al (2019). In AGU Fall Meeting Abstracts (EP23D-2286).
- [2] Morrison et al. Nat. Geo. (2021) In Prep.
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- [7] <https://www.datasciencemadesimple.com/filter-subsetting-rows-r-using-dplyr/>