

# Examples of Applications of Artificial Intelligence in Geology





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# Artificial Intelligence (AI) - types

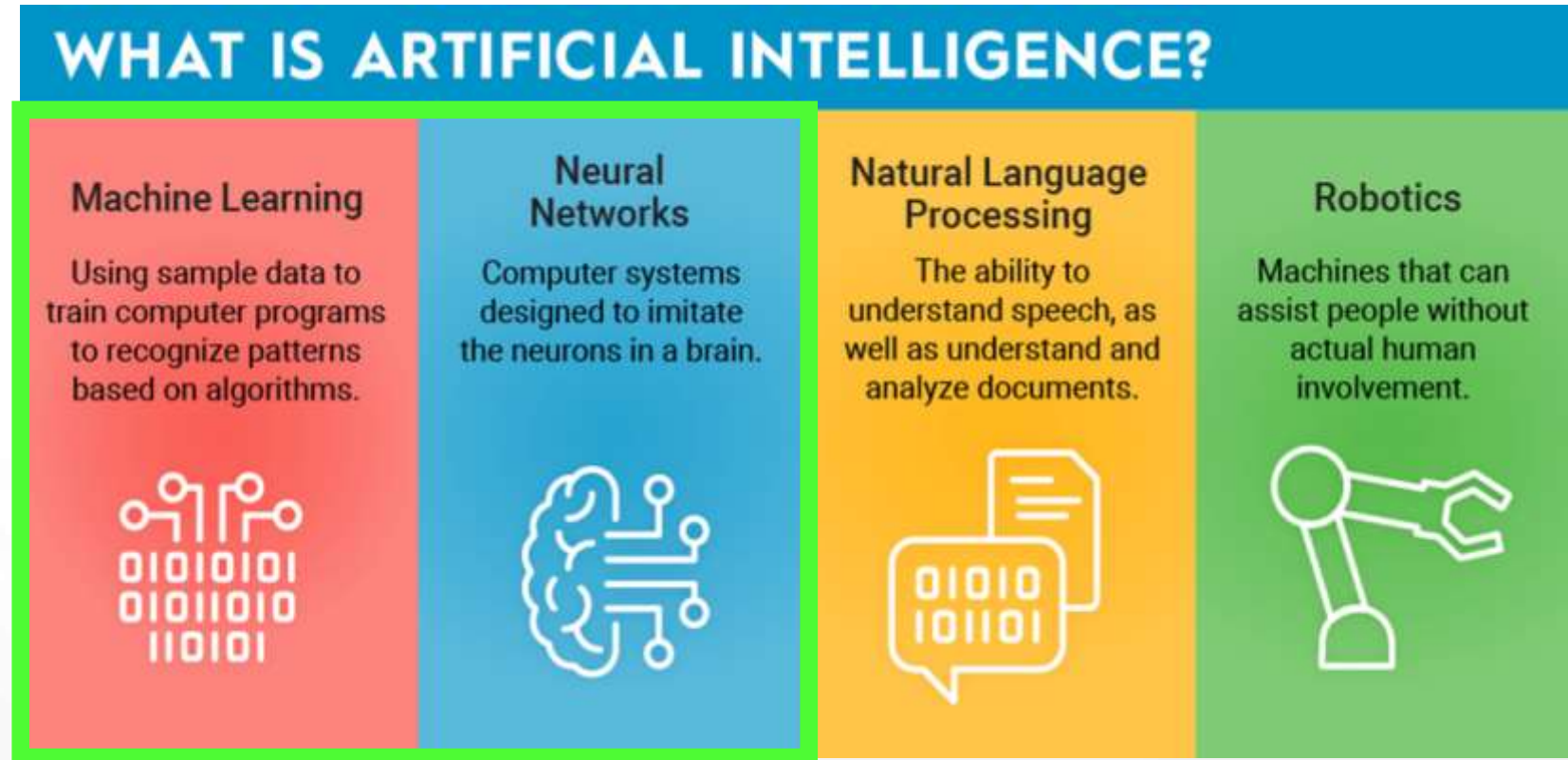
Artificial intelligence uses machines to mimic human intelligence

## WHAT IS ARTIFICIAL INTELLIGENCE?

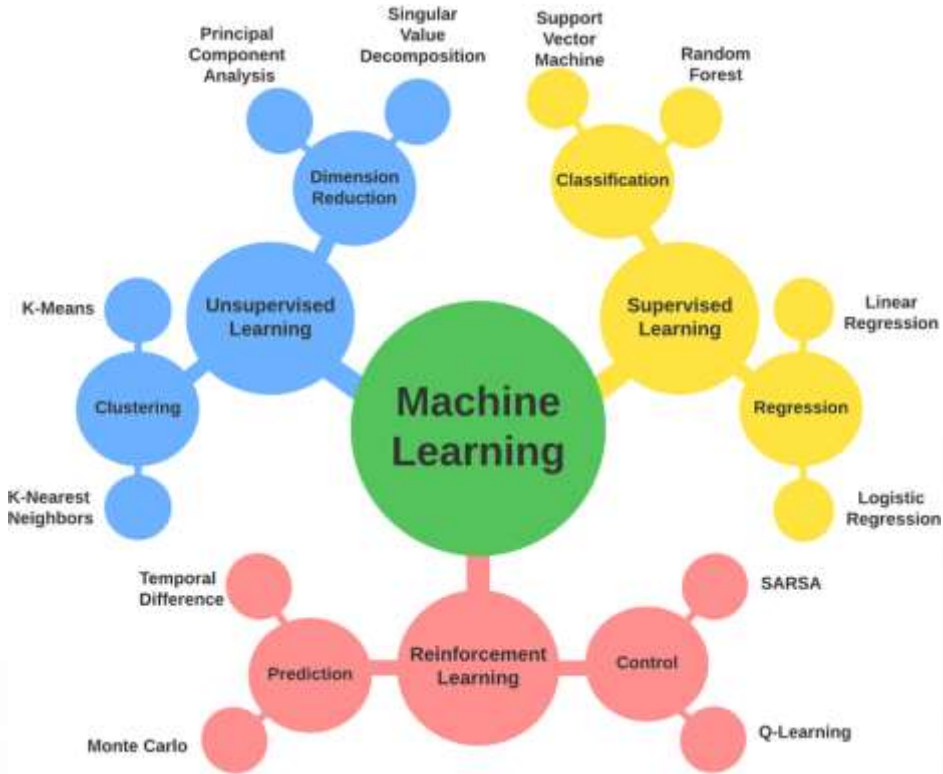
<h3>Machine Learning</h3> <p>Using sample data to train computer programs to recognize patterns based on algorithms.</p> 	<h3>Neural Networks</h3> <p>Computer systems designed to imitate the neurons in a brain.</p> 	<h3>Natural Language Processing</h3> <p>The ability to understand speech, as well as understand and analyze documents.</p> 	<h3>Robotics</h3> <p>Machines that can assist people without actual human involvement.</p> 
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# Artificial Intelligence (AI) - types

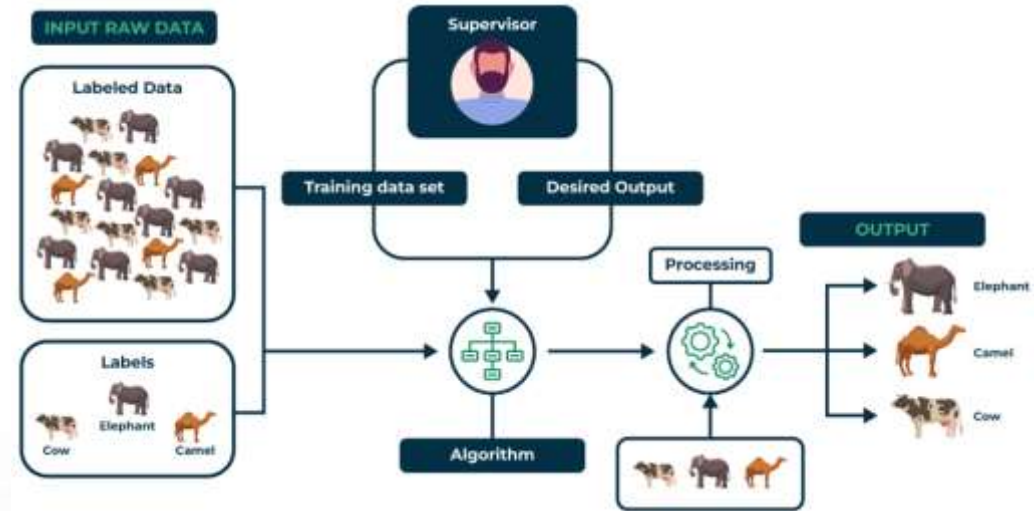
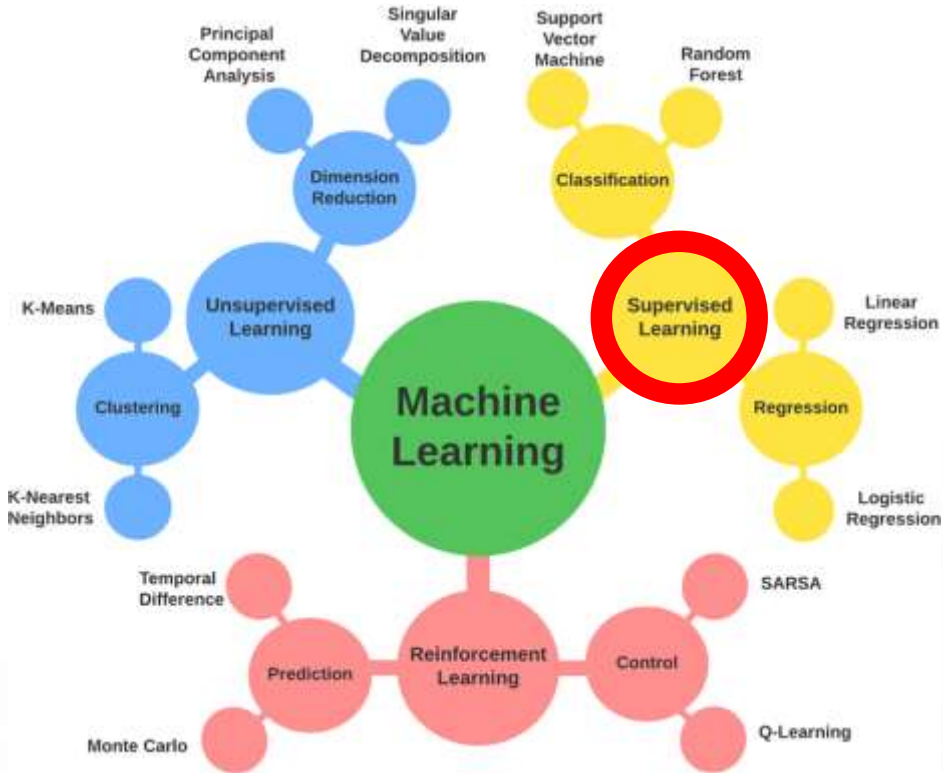
Artificial intelligence uses machines to mimic human intelligence



# Three Machine Learning paradigms



# Supervised Learning

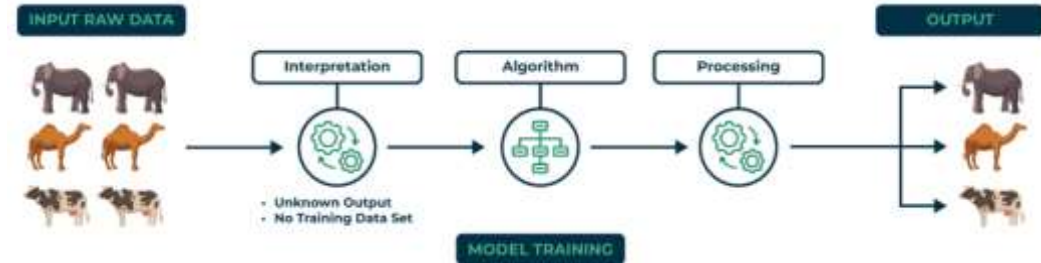
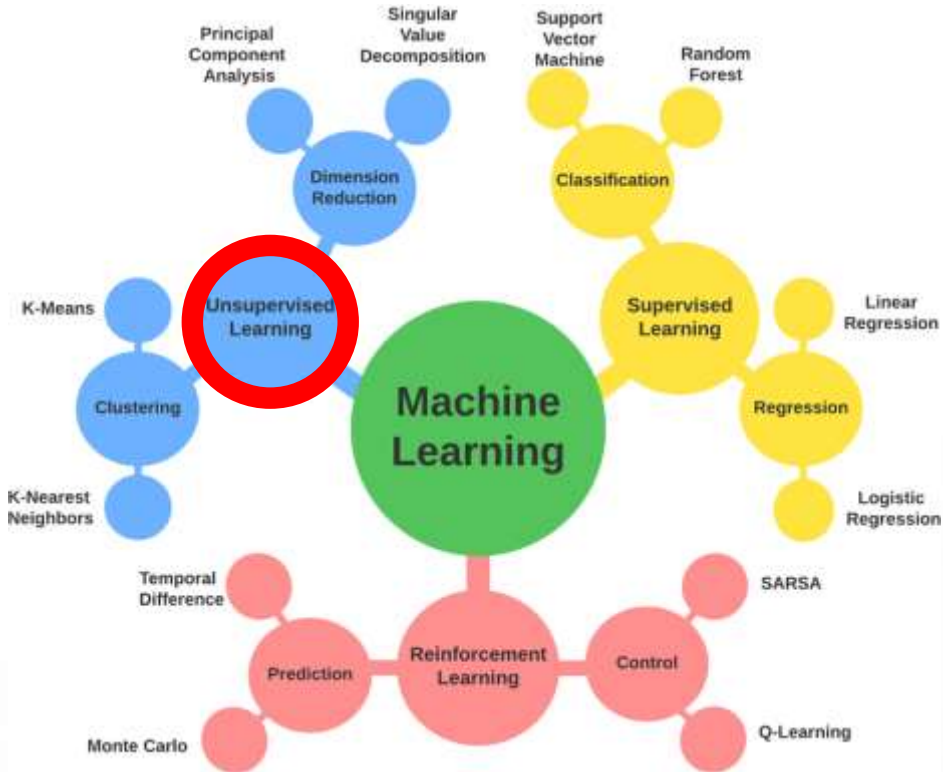


**Labeled data:** The algorithm is trained on a dataset where each data point has a corresponding label.

**Goal:** To learn a mapping function that can predict the output for new, unseen data.



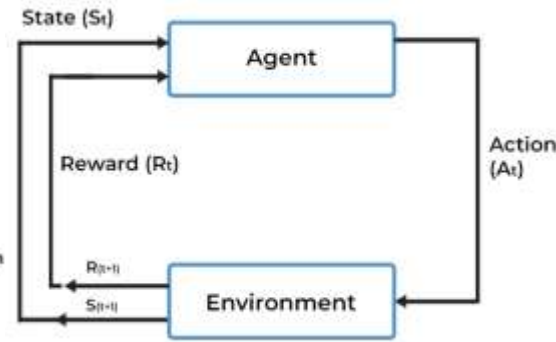
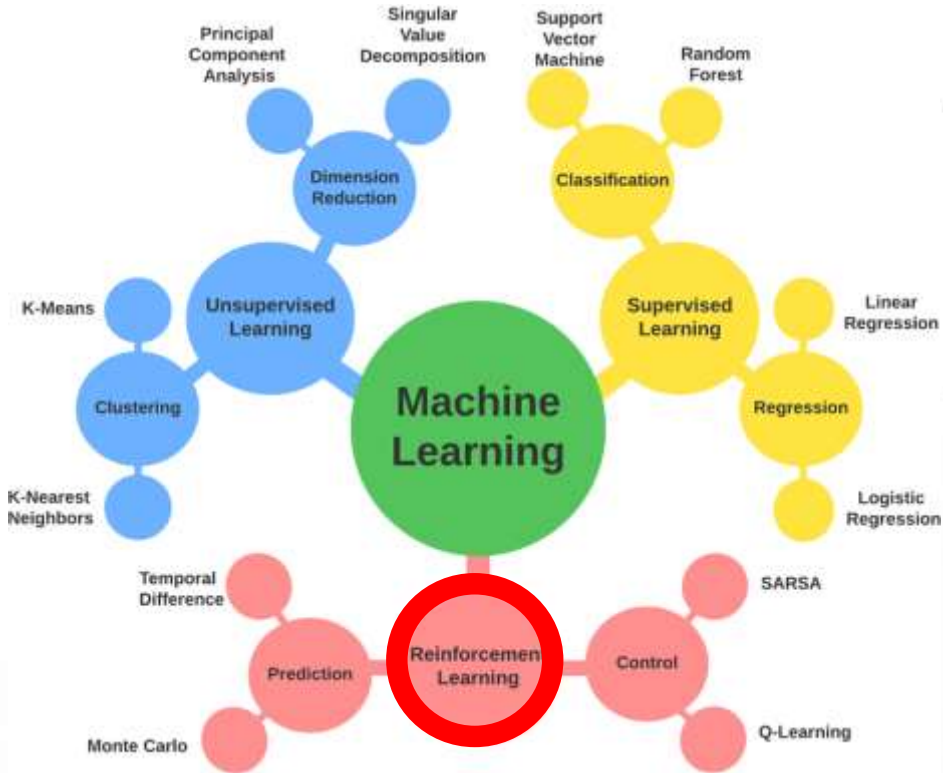
# Unsupervised Learning



**Unlabeled data:** The algorithm is trained on a dataset where the data points do not have corresponding labels or output values.

**Goal:** To discover hidden patterns and structures within the data.

# Reinforcement Learning

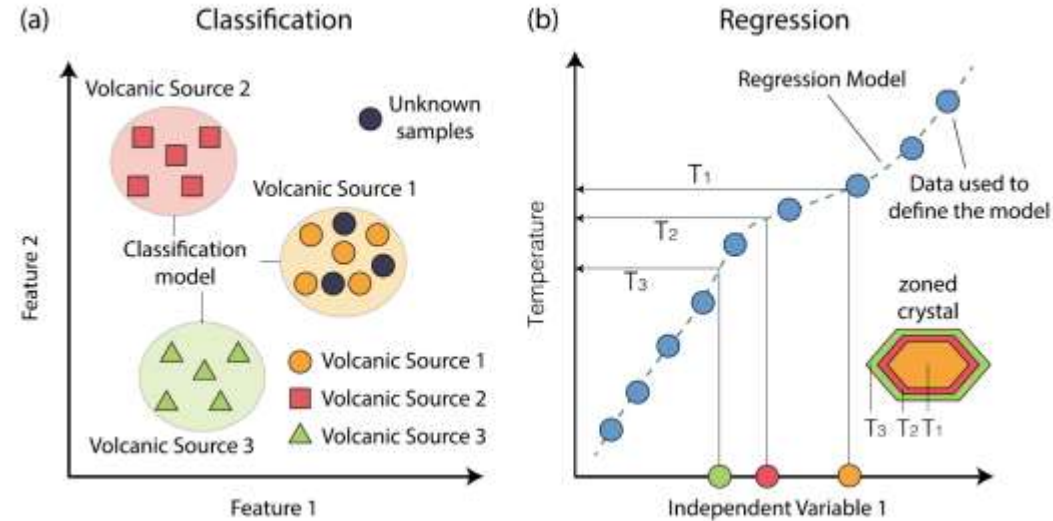
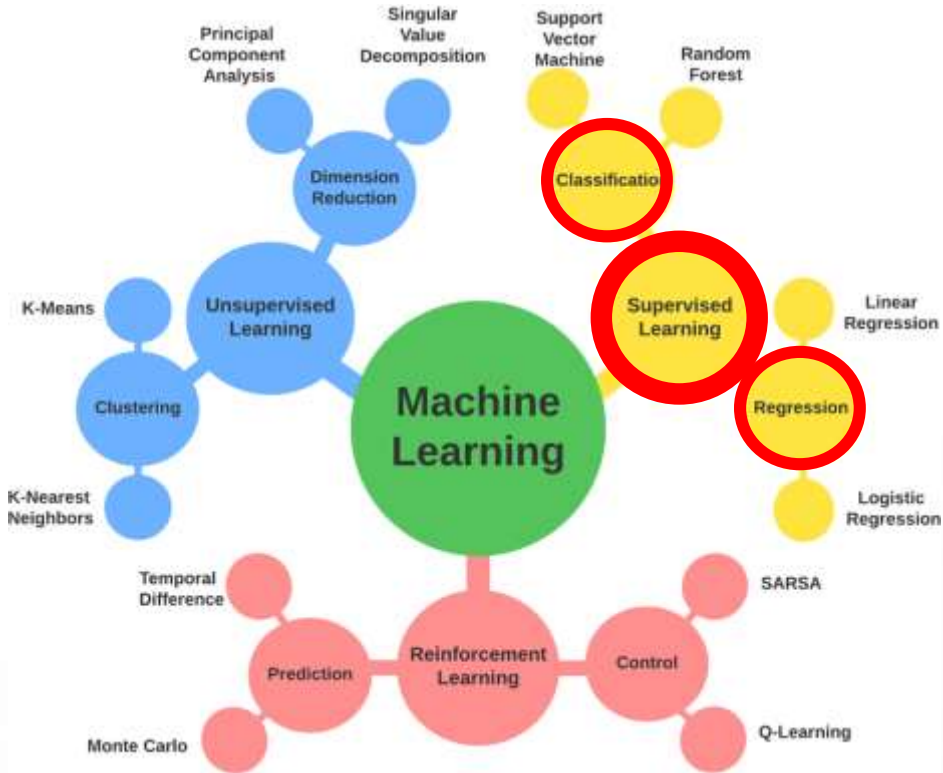


**Agent-environment interaction:** An agent learns to make decisions by interacting with an environment.

**Reward system:** The agent receives rewards or penalties based on its actions.

**Goal:** To maximize cumulative reward over time.

# Supervised Learning - methodologies



**Classification:** algorithms categorize new observations into distinct classes, each characterized by identical labels

**Regression:** algorithms focus on estimating the values of one or more dependent variables

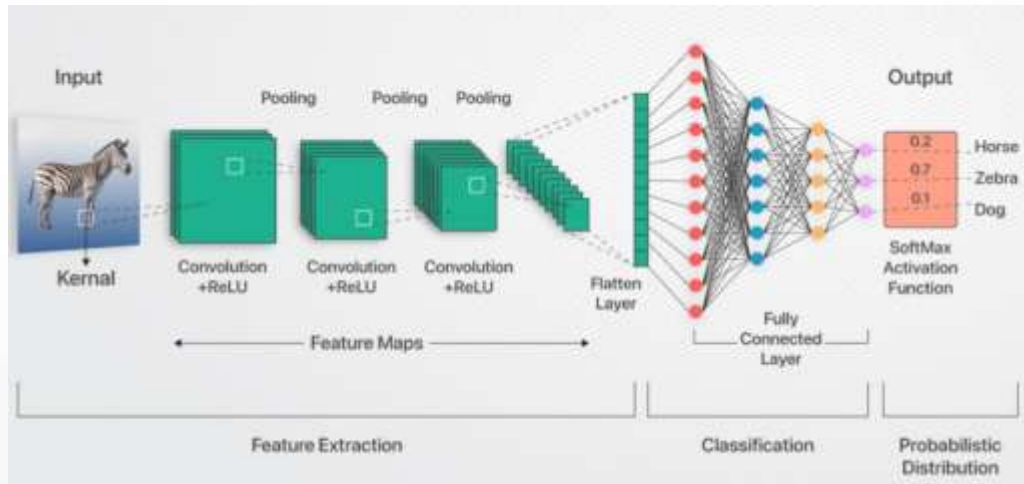


# Sediment core analysis (supervised - classification)

**Data:** High-resolution digital images of Holocene sediment cores.

**Methodology:** Deep learning with Convolutional Neural Networks (CNNs).

**Results:** Six sedimentary facies associations



	Original Image	Model Prediction	Ground Truth
A			
B			
C			
D			
E			

Legend for sediment facies:

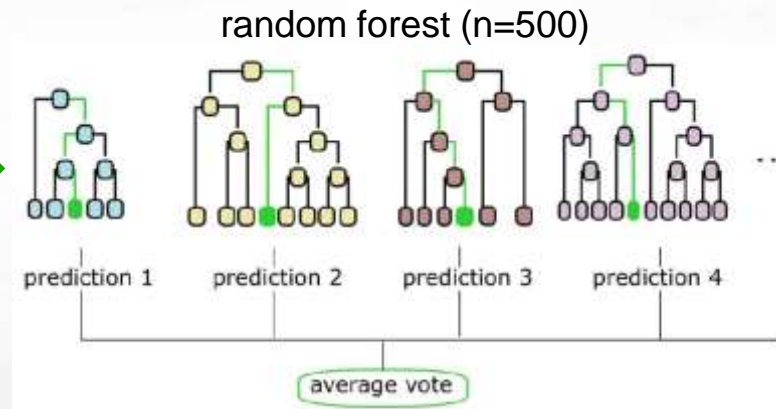
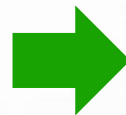
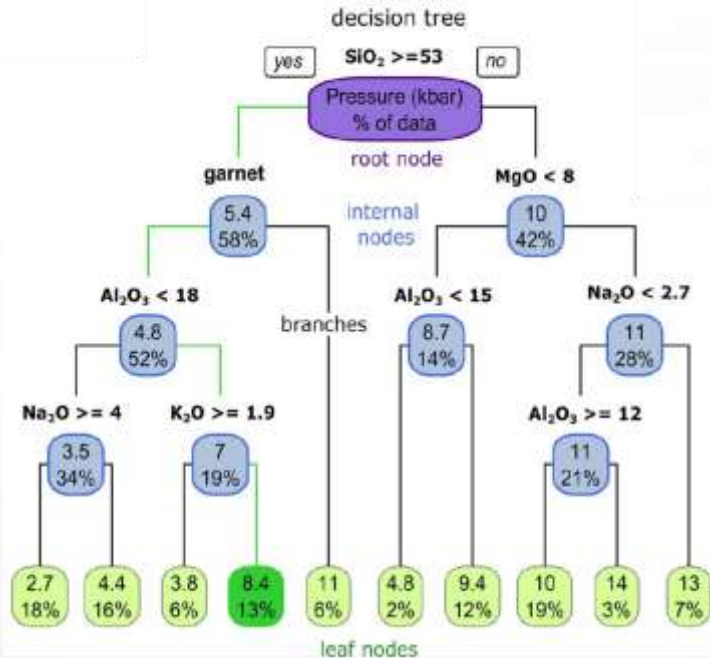
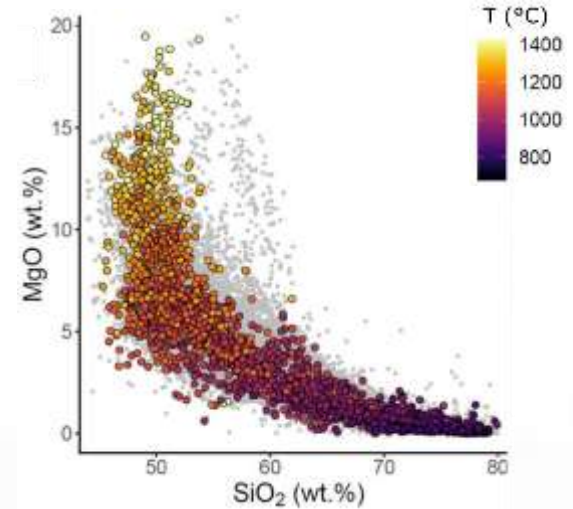
- Well-drained floodplain (WDF) - Yellow
- Poorly-drained floodplain (PDF) - Light Green
- Swamp (Sw) - Dark Green
- Peat layer (PL) - Blue
- Prodelta (P) - Purple
- Fluvial sand (FS) - Orange
- Background - Black

# Thermobarometer (supervised - regression)

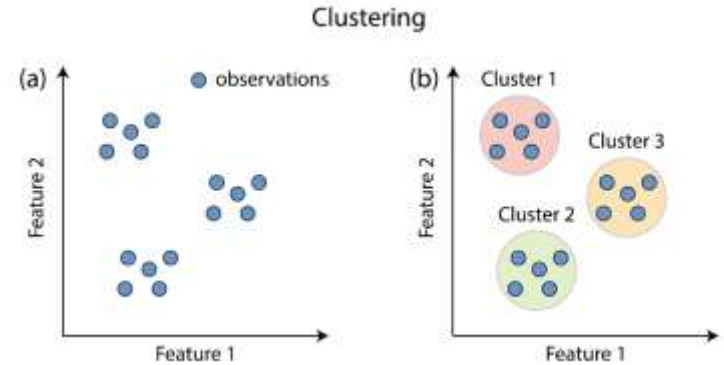
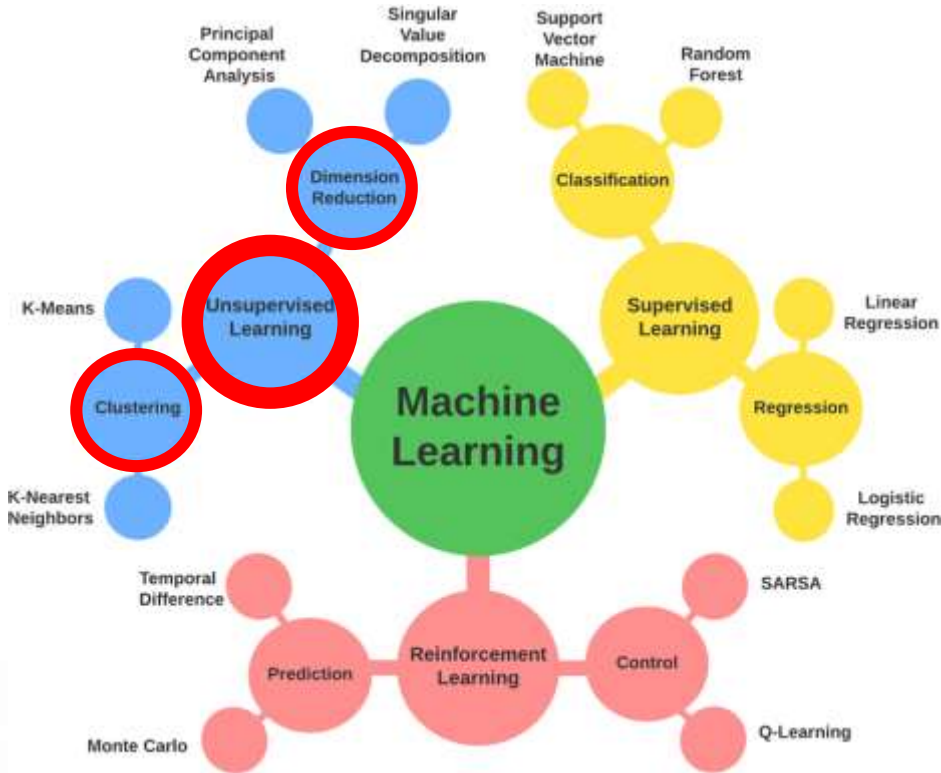
**Data:** Compilation of 2545 experiments from 127 published studies – Si – Al – Ti – Fe – Mg – Ca – Na – K – H<sub>2</sub>O + minerals

**Methodology:** Random forest (500 decision trees)

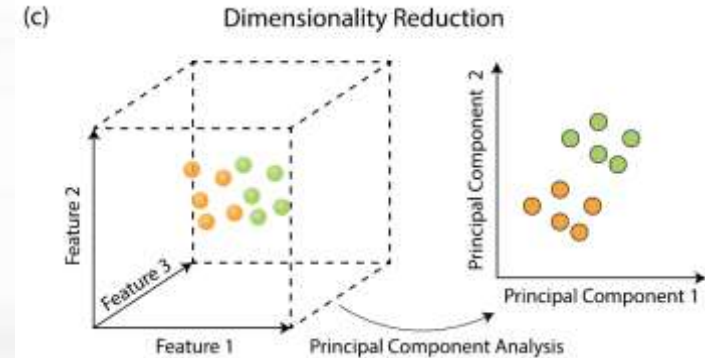
**Results:** Pressure-Temperature is computed by averaging the predictions of all decision trees



# Unsupervised Learning - methodologies



**Clustering** groups similar observations into uniform categories, known as clusters



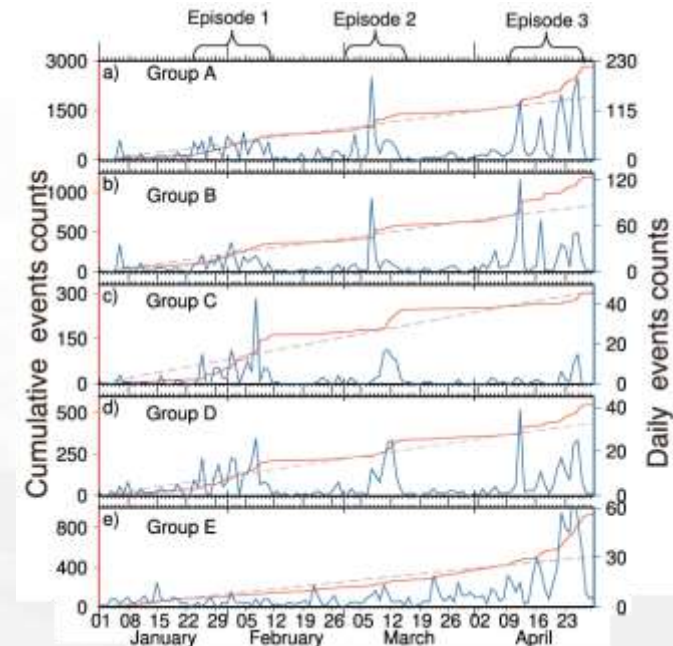
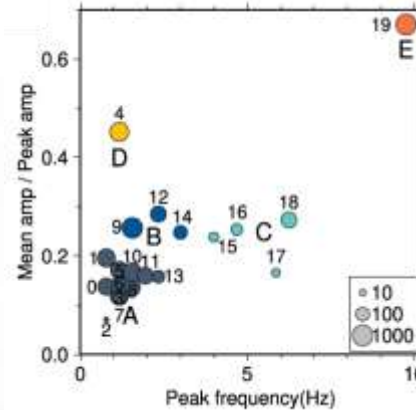
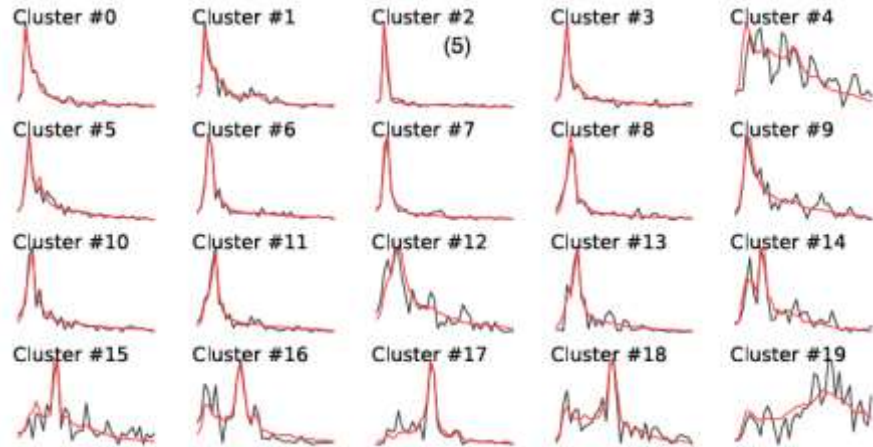
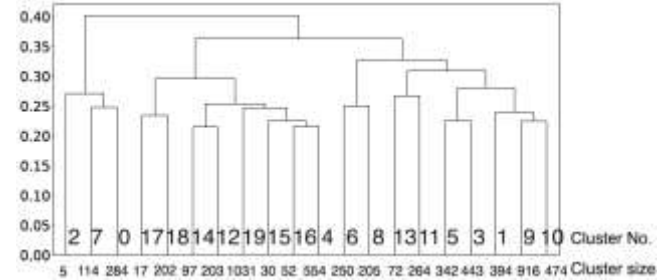
**Dimension reduction** - decrease the number of variables to facilitate the visualization of complex, high-dimensional data

# Seismicity of Kilauea (unsupervised - clustering)

**Data:** Compilation of 5949 P-waves spectral characteristics

**Methodology:** Clustering into 20 groups

**Results:** Groups A-D showed episodic increases during three key intervals before the eruption. Group E steadily increased and peaked shortly before the eruption.



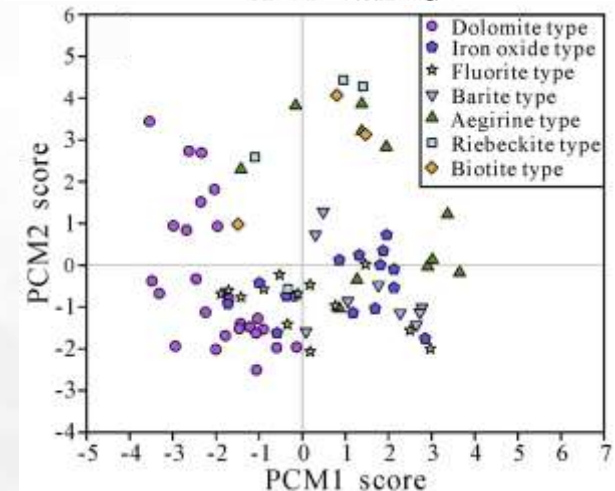
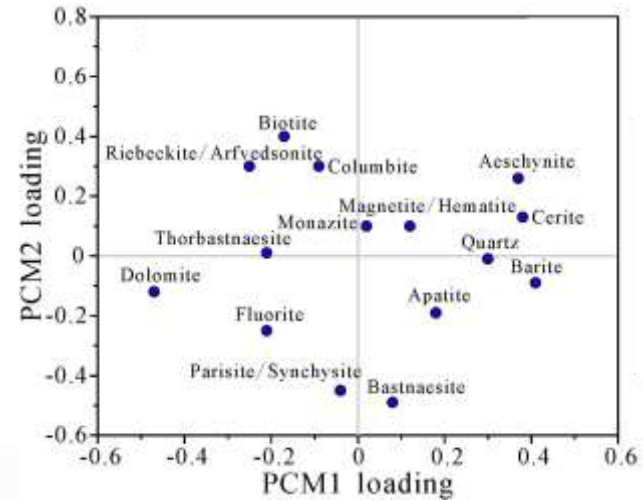
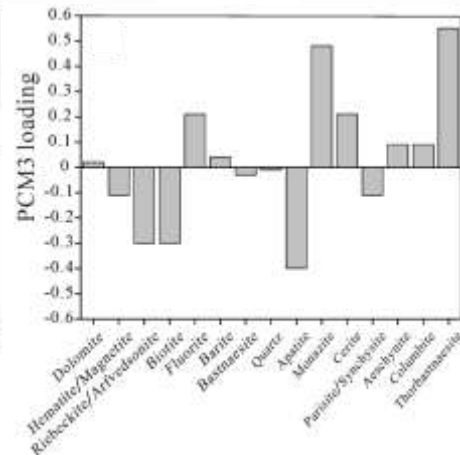
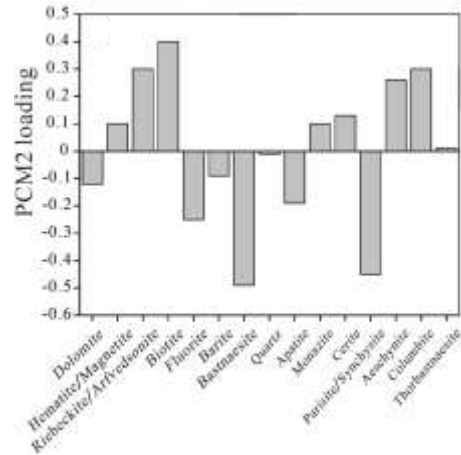
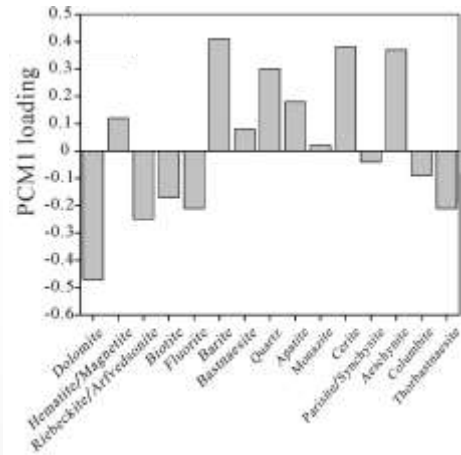


# Ore mineralogy (dimensionality reduction)

**Data:** Content of 58 minerals and 31 elements, that were detected in 80 samples

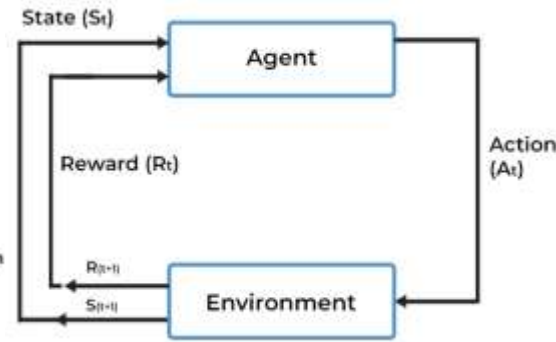
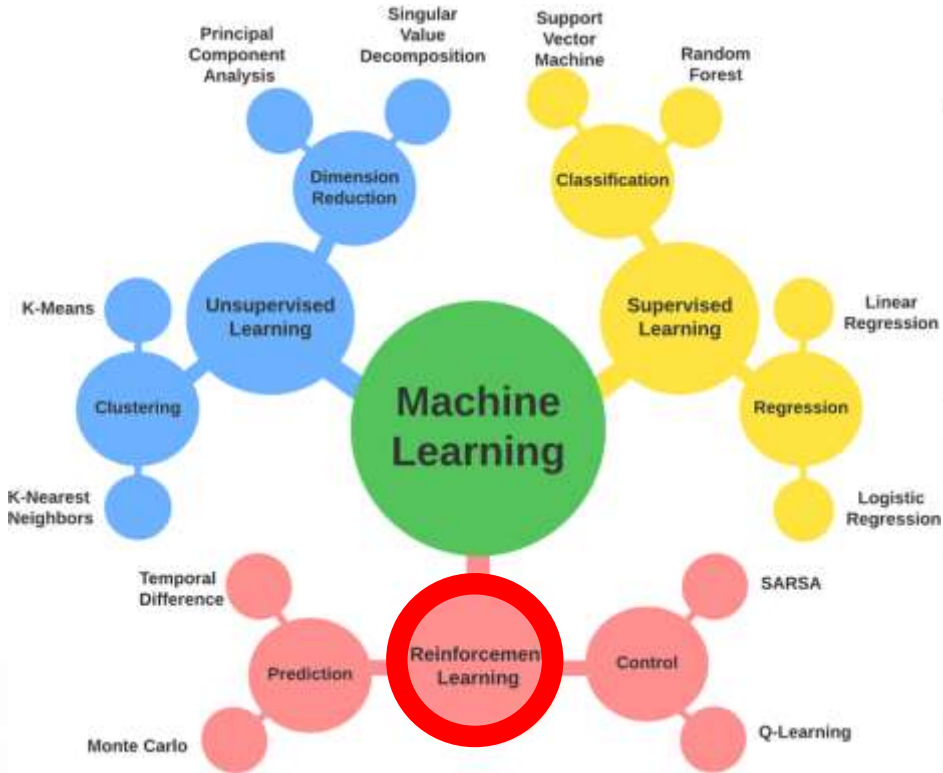
**Methodology:** Principal component analysis (PCA)

**Results:** Mineralization associations information and classification of ores





# Reinforcement Learning



**Agent-environment interaction:** An agent learns to make decisions by interacting with an environment.

**Reward system:** The agent receives rewards or penalties based on its actions.

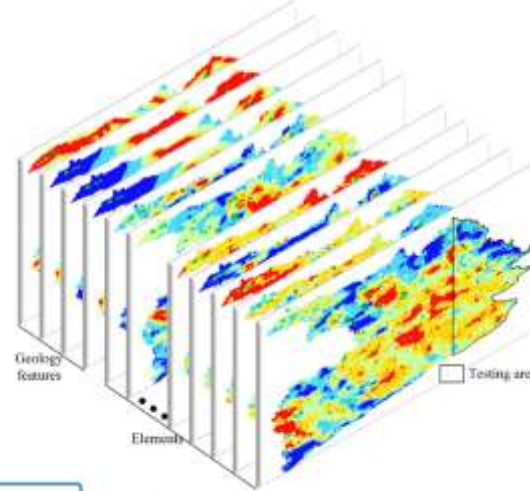
**Goal:** To maximize cumulative reward over time.

# Mineral exploration (Reinforcement Learning)

**Data:** Map of geological features and 39 major and trace elements.

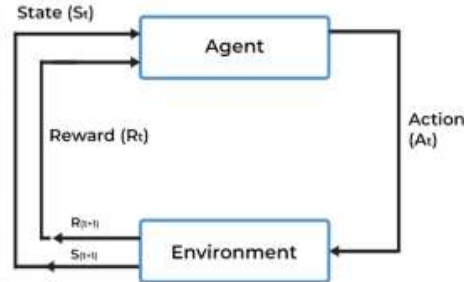
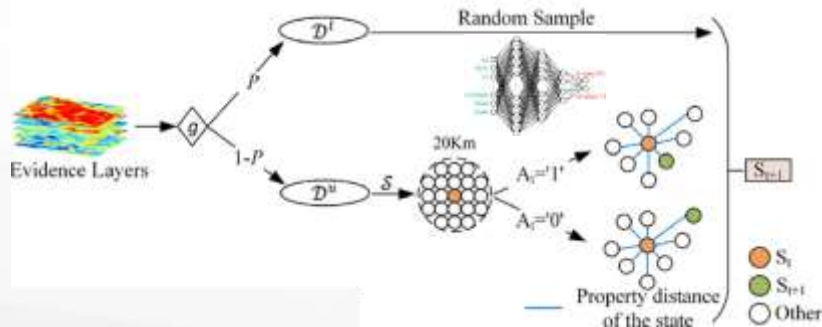
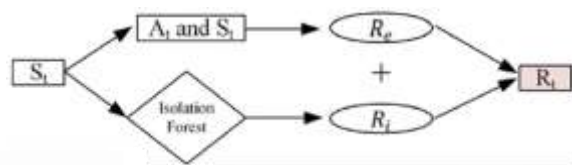
**Methodology:** Deep Reinforcement Learning

**Results:** Evaluation of mineralization potential in unlabeled areas.



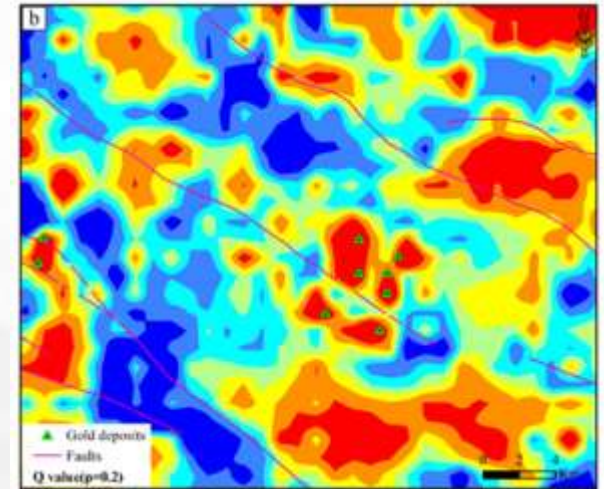
Reward:

- identifying known mineralized areas.
- discovering new potential mineralized zones



Explore:

- nearby if: mineralized,
- farther if: not-mineralized.



# Summary

**Question**

What do we want to predict or understand using AI?



**Data**

Prepare input data, remove noise, missing values...



**Model selection**

Balancing accuracy, interpretability, and computational requirements.



**Learning and testing**



**Acceptation?**

**Thank you**