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TITLE

Machine Learning Approach for Tectonic Discrimination Using Geochemical and Isotopic Data

INTRODUCTION

Magmatic rocks form in a wide variety of tectonic settings, which primarily include mid-ocean ridges, ocean island, continental arcs, oceanic plateaus, back arc basins and island arc etc. These rocks characterized by a whole geochemical signature of major elements (SiO_2, TiO_2, Al_2O_3, Fe_2O_3T, CaO, MgO, Na_2O, K_2O), some of trace elements (Sr, Ba, Rb, Zr, Nb, La, Ce, Nd, Hf, Sm, Gd, Y, Yb, Lu, Ta, Th) and isotopes ($^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$, $^{208}Pb/^{204}Pb$, $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$).

The geochemical discrimination of the tectonic setting of magmatic events is one of the most important and useful applications of whole-rock geochemistry .This approach allows the discrimination of the tectonic setting of a given suite of magmatic rocks using whole-rock geochemical data, including major and trace element and isotopic ratios. These data helps to recognize the rock-forming environment and geological processes across various tectonic settings.

LITERATURE SURVEY

Trace element discrimination diagrams were introduced as a technique to determine the tectonic origin of basalts and other volcanic rocks (Pearce and Cann, 1973). These classification diagrams utilized only a few elements plotted as binary or triangular diagrams.

These diagrams are mainly hindered by their limited dimensionality due to visualization requirements (Snow et al., 2006). An alternative probabilistic methods are proposed and reported single analysis classification for volcanic rocks from island arcs, ocean islands and mid-oceanic ridges environments.

Further research revealed the limitations and inaccuracy of binary and triangular diagrams in effectively categorizing tectonic environments based on geochemical analyses of igneous rocks.(Li et al., 2015).

It is notable that the application of ML techniques and their use is still virtually unexplored with regards to the solution of petrological problems.

RESEARCH GAP

Traditional methods of tectonic discrimination based on geochemical and isotopic data analysis often require manual interpretation and might lack the efficiency and accuracy needed for comprehensive analysis.

Also, these 2-D and triangular diagrams are useful for only a few elements means that these diagrams cannot identify several tectonic

settings, and this creates doubt on the veracity of the results generated by these diagrams.

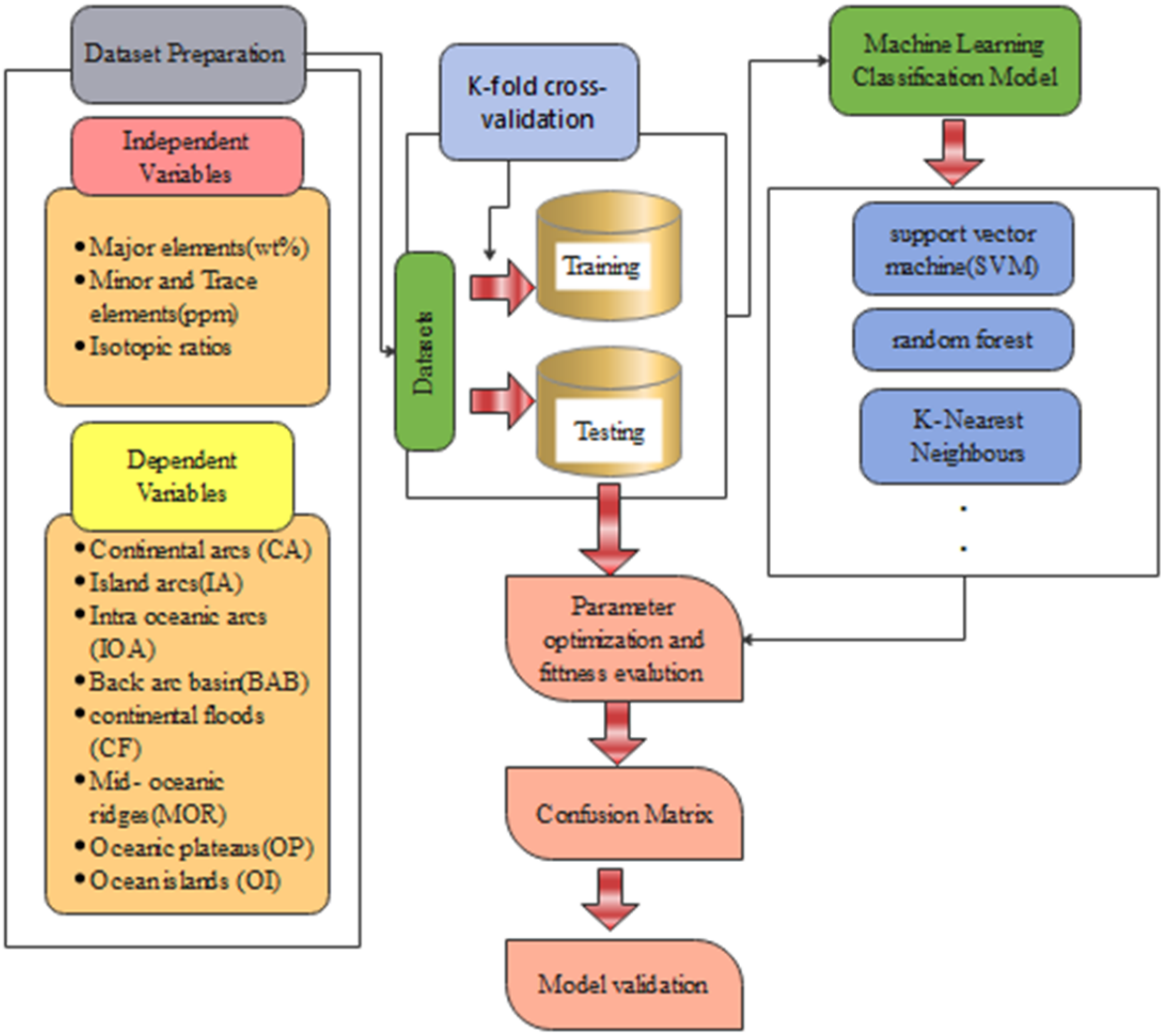
PROBLEM STATEMENT

The challenge is to develop a machine learning model that can effectively utilize geochemical and isotopic data to automatically discriminate Magmatic rocks into their corresponding tectonic settings using geochemical data (major elements, trace elements and isotopic data) as input parameters, overcoming the limitations of conventional methods and providing a robust solution for enhanced accuracy and efficiency in tectonic discrimination.

RESEARCH OBJECTIVE

1. **Developing a Robust Model:** Create a machine learning model capable of accurately classifying rock samples into different tectonic settings based on their geochemical and isotopic data.
2. **Enhancing Classification Accuracy:** Improve the accuracy of tectonic discrimination compared to traditional methods by leveraging the capabilities of machine learning algorithms.
3. **Automating Analysis:** Implement a streamlined and automated process for tectonic discrimination, reducing the time and effort required for manual analysis of geochemical and isotopic data.

METHODOLOGY



EXPECTED OUTCOMES

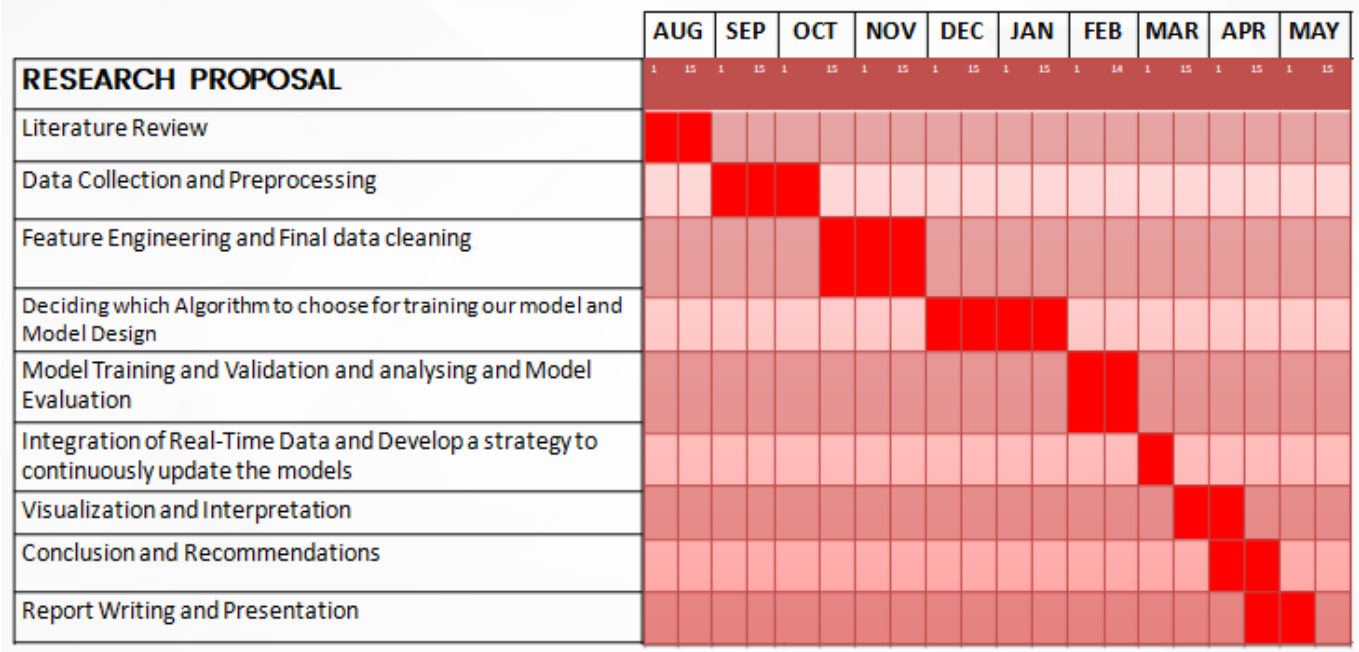
- **Accurate Tectonic Classification:** This Model can accurately classify rock samples into distinct tectonic settings based on their geochemical and isotopic data. This could significantly enhance the precision of tectonic discrimination compared to traditional methods.
- **Automation of Analysis:** Train model could automate the process of tectonic discrimination, saving time and effort that would otherwise be spent on manual analysis. This could expedite geological research and improve the efficiency of data interpretation.
- **Key Geochemical Indicators:** This can Identify the most influential geochemical and isotopic indicators for distinguishing between different tectonic environments.
- **Data-Driven Insights:** The outcomes facilitate data-driven insights, uncovering hidden patterns and relationships within geochemical and isotopic data.
- **Industry Applications:** This model can be applied in resource exploration, mineralogy, and environmental assessments, benefitting industries dependent on geological data**.**

CONCLUSION

Through the application of advanced machine learning algorithms this can demonstrate the potential to revolutionize traditional methods of tectonic discrimination, and potentials of machine learning in petrological and mineralogical field

Collaboration between geology and machine learning could lead to more specialized models that integrate geological domain with data-driven insights.

PROPOSED TIMELINE



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