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Research Paper

Preparation of a Pb-Zn Potential Map in the Ardestan Area Using the AHP-TOPSIS Hybrid Method

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Abstract: Ardestan area is located in parts of Central Iran and Urumieh-Dokhtar zones, and due to its special geological features, is one of the most promising areas for Pb-Zn mineralization in Iran. The purpose of this research is to model the mineral potential using the hybrid AHP-TOPSIS method, to increase the accuracy of the results and thus to reduce the cost and the risk of exploration operations. For this, in the first step, the evidential layers, which include the geochemical anomaly map, the phyllic, argillic, and iron oxide alterations, the fault density map, and finally carbonate rock units, were transformed in the range of 0 to 1 using the Logistic function. In the next step, all the evidential maps and their corresponding classes weighted using the Analytical Hierarchy (AHP) method and incorporated with the technique of prioritization similar to the ideal solution (TOPSIS). The results show the positive spatial correlation of Pb-Zn elements with lithologies prone to mineralization. Finally, the Prediction-Area (P-A) curve was used to validate the applied method. According to this curve, the intersection point of the prediction rate curves and the corresponding occupied area showed the value of 68. The results of this curve proved the acceptable ability of this method in identifying promising areas.

Keywords: Ardestan, AHP-TOPSIS, Concentration- Area, Mineral Prospectivity Mapping, P-A plot.

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INTRODUCTION

Exploration mineral activities are costly and time-consuming, emphasizing the need for mineral prospectivity mapping (MPM) to pinpoint zones with high mineral potential. MPM serves as a crucial process that combines diverse geoscience datasets collected at various scales [1]. To do so, numerous approaches have emerged in the last thirty years, broadly classified as either data-driven or knowledge-driven methods. This research aims to use a high hybrid multi criteria decision making (MCDM) approach, namely AHP-TOPSIS, for identifying areas highly prospective for Pb-Zn in the Ardestan area.

METHODS

Ardestan area is located in parts of Central Iran and Urumieh-Dokhtar zones, and due to its special geological features, is one of the most promising areas for Pb-Zn mineralization in Iran [2-4]. This research seeks to map the promising area of Pb-Zn in the Ardestan area using the AHP-TOPSIS methodology. This approach combines AHP to establish the weights for criteria and sub-criteria, followed by the application of the TOPSIS method to prioritize decision alternatives [2,5]. Although each of the two methods has individual capabilities and competence, practical experience has demonstrated that combining these two MCDM methods and utilizing their potentials simultaneously yields superior results and enhances the overall performance of the MPM [1,6]. The primary and essential step in MPM is to identify and gather geospatial data relevant to the targeted deposit type [6]. In this study, the mentioned data is considered, taking into account its availability, along with theoretical and empirical analysis of the spatial relationship between Pb-Zn mineral deposits and various datasets [7,8]. In this context, eight evidential layers were employed as predictor maps to delineate potential Pb-Zn zones. These layers encompass multi-element geochemical signatures relevant to Pb-Zn mineralization (two factors derived from PCA method), proximity to Cretaceous and Triassic carbonate rocks, proximity to faults, and proximity to argillic, phyllic, and iron oxide alterations.

FINDINGS AND ARGUMENT

The spatial evidence values in the acquired maps do not share identical maximum and minimum values [4,9,10]. Consequently, the evidential values from these maps were converted into a new space [9]. Subsequently, the concentration-area (C-A) fractal model was utilized to categorize the spatial values of evidential maps [6,9,10,11]. Next, the AHP-TOPSIS MCDM method was employed to produce the Pb-Zn prospectivity map [1,7,12,13]. In this context, the AHP method was employed to assign weights to criteria and sub-criteria (Table 1), while the TOPSIS method was utilized to prioritize alternatives [3,14]. To facilitate this, a decision matrix measuring 361,638×8 was established, encompassing 8 criteria (represented by evidential maps) and 361,638 alternatives, each corresponding to a specific cell with defined coordinates in the evidence layers. Ultimately, the Pb-Zn prospectivity map was created (Figure 1). To assess the

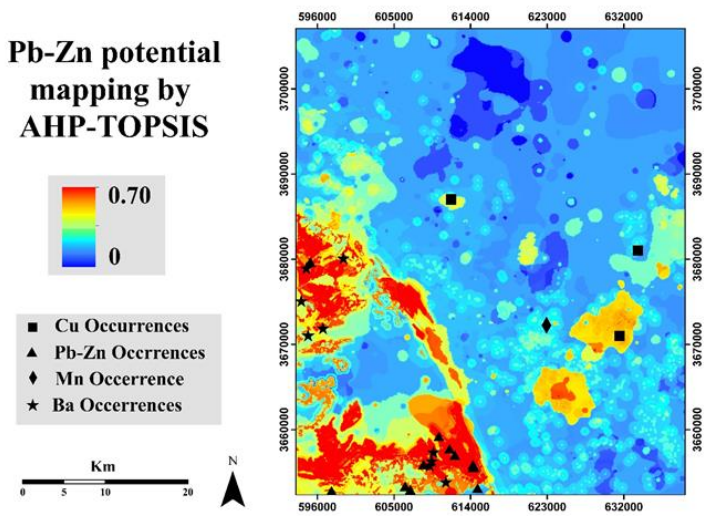

Figure 1. AHP-TOPSIS prospectivity map for Pb-Zn mineralization in the study area

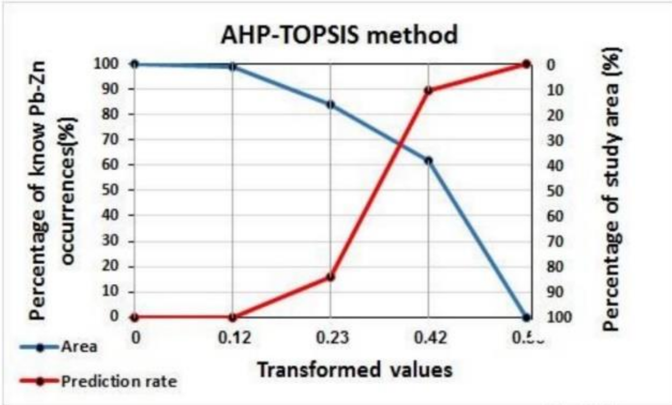

Figure 2. Prediction–area (P–A) plots of AHP-TOPSIS prospectivity models

Table 1. The obtained weights for criteria and sub-criteria using AHP method

Criteria	Sub-criteria	Weight	Criteria	Sub-criteria	Weight
PC2	class 1	0.047	Fault density	class 1	0.045
	class 2	0.118		class 2	0.094
	class 3	0.35		class 3	0.313
	class 4	0.485	Phyllic	class 1	0.042
PC4	class 1	0.031		class 2	0.103
	class 2	0.069		class 3	0.31
	class 3	0.192		class 4	0.546
	class 4	0.267	Argillic	class 1	0.042
	class 5	0.442		class 2	0.103
Carbonate	class 1	0.034		class 3	0.31
	class 2	0.057		class 4	0.546
	class 3	0.111	Iron-oxide	class 1	0.043
	class 4	0.221		class 2	0.073
	class 5	0.577		class 3	0.32
				class 4	0.564

effectiveness of the prospectivity map produced by the AHP-TOPSIS method, Predication-Area (P–A) plot was employed [11-15] (Figure 2).

CONCLUSIONS

This study focuses on the effective implementation of a hybrid MCDM approach, AHP-TOPSIS, to create a predictive model for Pb-Zn mineralization in the Ardestan area. While each method alone has its merits, practical experience has shown that combining two or more MCDM methods leads to superior results. Opting for a combination of the two methods was decided upon, because utilizing them simultaneously results in narrowing down target areas, signifying the high precision of the hybrid method in predicting these areas. Following the creation of the overlay prospectivity map, P–A plot was employed to assess its effectiveness in predicting favourable areas. Based on the findings from this P-A plot, the intersection point in this prospectivity model is 68%. Consequently, this map can serve as the targeted map for further in-depth explorations. The outcomes indicate that the AHP-TOPSIS method can serve as an appropriate tool for quantifying the characteristics of geo-anomalies and delineating target areas in mineral exploration initiatives.

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