Deposit characterization and exploration pattern recognition applied in fuzzy and neuro-fuzzy modeling: Targeting Cu-Au potential areas in central Iran

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The research aims to reduce the uncertainties in mapping and integrating favorable exploration patterns to identify high Cu-Au potential areas in a less-explored region of some 14,000 km² in the main volcanic arc of central Iran. The genetic and spatial characteristics of the prominent mineralization at the known Dalli porphyry copper-gold deposit and Aftabru iron oxide copper-gold (IOCG) prospect are initially studied in detail to define diagnostic recognition criteria in searching for similar mineralization in the surrounding region. Interpretation of airborne magnetic, Aster satellite imagery, geological, and stream sediment geochemical data are then used to recognize a combination of favorable host lithologies, iron oxides, hydrothermal alterations, structures, magnetic signatures, and multivariate catchment-basin geochemical anomalies that could be associated with Cu-Au mineralization. The identified exploration features are weighted to yield fuzzy predictor maps, and these maps are then combined by using fuzzy gamma operator to produce a final fuzzy Cu-Au favorability map. To move one step further, the identified exploration patterns are also integrated by hybrid neuro-fuzzy analysis, using Takagi-Sugeno adaptive-network-based fuzzy inference system (ANFIS), to determine the numerical probabilities for the occurrence of sufficiently similar mineralization with the 68 known copper-gold occurrences of the area. By using fractal analysis, the fuzzy and neuro-fuzzy favorability maps are reclassified and then correlated with the known Cu-Au occurrences for validation. The well-know mineralized areas, several unknown common and individual potential areas are mapped by both models. In the fuzzy analysis, the high favorable areas cover some 18 percent of the study area and contain 76 percent of the Cu-Au occurrences, while, in the neuro-fuzzy approach the high favorable areas cover some 15 percent of the study area and contain 78 percent of the Cu-Au occurrences. This comparison indicates the power of ANFIS in locating Cu-Au potential targets in this region. The research demonstrates that prior knowledge of controls on the prominent mineralization, leading to diagnostic exploration feature recognition, and the application of combined knowledge-based and data-driven modeling approach are critical factors to reduce the uncertainties in locating areas of interest for follow-up exploration in relatively less-explored regions.