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Probability Mapping of Geochemical Dispersions: A Simpler Geostatistical Approach for Processing and Interpretations of Large Data Sets of Stream Sediments

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Abstract

The present study provides an effective geostatistical methodology for extracting high-confidence information from geochemical stream sediment data collected on a grid-based sampling pattern over large areas. Unlike traditional deterministic interpolation methods, our approach employs exploratory data analysis of metal oxides to determine critical thresholds by examining the variability and anisotropy factors through variogram analysis of spatial data. To minimize the '*nugget effect*,' which often causes predicted values to fall below critical thresholds, kriging with probability output surfaces was applied to generate geochemical probability maps indicating the likelihood of each oxide exceeding its statistically derived threshold. The methodology was tested using stream-sediment geochemical dispersion data from the Sittampundi Layered Anorthosite Complex (SAC) and the Ramagiri–Penakacherla Schist Belt (RPS). In the SAC, probable zones exceeding critical thresholds were delineated for Fe_2O_3, CaO, MgO, Ni, Co, and Cr based on 200 samples. Similarly, in the RPS, the method effectively identified such zones for Fe_2O_3, TiO_2, CaO, MgO, and MnO using 770 samples. These case studies demonstrate the utility of geostatistically derived probability maps in delineating geochemical dispersion patterns from systematically collected stream-sediment data over extensive areas.

Keywords: Geostatistics, Kriging, Probability Mapping, Geochemical Dispersion

Introduction

Geochemical surveys and mapping are widely utilized methodologies in mineral exploration at various stages due to their cost-effectiveness and applicability across multiple mapping scales (Tolosana-Delgado and Boogaart, 2014). In mineral and mining exploration, geochemical studies are generally divided into two distinct stages. The first involves the collection and examination of various geological materials, including rocks, soils, and stream sediments. The second stage entails plotting geochemical values on maps, analyzing the numerical data, and interpreting the results (Paz-Ferreiro *et al.,* 2010). Proper analysis of the acquired geochemical data enables the extraction of information about the underlying geology, alteration zones, weathering patterns, and other geological processes, thereby supporting the preparation of regional geological maps (Selia *et al.,* 2019). Historically, such techniques have been among the most productive tools in mineral prospecting, particularly through the application of stream-sediment geochemical surveys (McClenaghan *et al.,* 2011). In this context, stream-sediment analysis serves as a valuable method for identifying potential areas for future exploration.

To delineate prospective zones for mineral exploration, the Geological Survey of India (GSI) has accumulated an extensive geochemical database over the past two decades (2001 onwards) For each composite sample, chemical analyses were done in the NABL-accredited laboratories of GSI. Details of analytical procedures and standards used for NGCM samples are provided in Table 1. With the accumulation of such large-scale geochemical datasets, it becomes essential to employ robust statistical methods for effective visualization and identification of significant spatial patterns and continuities.

In general, statistical analysis of geochemical data requires an understanding of both the geological setting and principles of Statistics. Typically, exploratory data analysis is employed to determine the critical threshold of elements from stream-sediment data (Reimanna *et al.,* 2005). The final step in data processing involves creating an interpolated surface from the sampled data and mapping regions where element concentrations exceed the

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