ABSTRACT

For the

Medeshova Nazgul Adilkhanqyzy`s thesis " Hydrogeochemical criteria for prospecting ore deposits on the example of the northwestern regions of the Torgai trough ", submitted for the degree of Doctor of Philosophy (PhD) in the major: 6D075500 – Hydrogeology and Engineering Geology».

Relevance of the Research

The relevance of the research is determined by the decreasing reserves of strategically important mineral resources and the depletion of shallow and near-surface deposits. New scientific approaches are required for predicting and discovering deposits, ensuring the sustainable development of Kazakhstan's mineral resource base.

The relevance of this dissertation is associated with the need to develop scientific and applied directions of hydrogeochemical methods for prospecting strategic metals in the Republic of Kazakhstan, and to substantiate hydrogeochemical criteria for ore-bearing potential in the northwestern regions of the Torgai trough.

The research objects are hydrogeological wells, water wells, and rock samples.

The main goal of the thesis work is the development of hydrogeochemical criteria for prospecting ore deposits on the example of the northwestern regions of the Torgai trough.

Key Provisions Submitted for Defense

1) Groundwater of the studied region is highly diverse in terms of total mineralization and chemical composition. It was established that major cations enter the solution during weathering of silicate rocks. On Gibbs diagrams, representative points are evenly distributed between the fields of rock weathering and evaporative concentration, which indicates that both the host rocks and evaporative processes contribute significantly to the chemical composition of fresh HCO_3–Ca waters and saline underground waters of Cl–Na and Cl–SO_4–Na types.
2) Primarily, the occurrence of saline waters (>10 g/dm³) is related to continental salinization processes, considering the arid climate of the study area. In general, the dominant water types are HCO_3–Cl Ca–Mg–Na, SO_4–HCO_3–Cl Na–Ca–Mg, SO_4–HCO_3–Cl Mg–Ca–Na, and SO_4–Cl–HCO_3 Ca–Mg–Na. The highest concentrations were identified for Bi, As, Mo, Cu, and Zn. The background (zonal) microcomponent composition of groundwater is represented in the following order (mg/dm³): Zn 3.65 > Cu 1.43 > V 1.15 > Cr 0.99 > Co 0.39 > Pb 0.20 > Bi 0.18 > Mo 0.17 > Sn 0.14 > As 0.12 > Be 0.09 > Ag 0.05.
3) The most contrasting hydrogeochemical anomalies are recorded for Cu, Zn, Sn, and Bi. The first type of anomaly is characterized by a copper–pyrite association with increased contents of Cu, Zn, Co, and the presence of As and Sn. The second type is characterized by a polymetallic association with increased Cu, Zn, along with Bi, Pb, Ga, As, Ag, Cr, and V. The third type

shows increased Cu, with Mo, Be, and Bi, which are elements typical of rare-metal mineralization.

Research Methods

The methodology of prospecting by secondary dispersion halos is based on the laws of chemical element migration in different landscapes—a combination of geological, hydrological, and biological factors. An important stage in choosing prospecting methods is landscape zoning, since areas with specific landscape settings represent unified conditions for prospecting. Each type of landscape has its own erosion exposure conditions of ore-bearing formations, thickness and genesis of loose sediments, types of secondary halos, geochemical barriers, and physico-chemical conditions. The research territory mainly corresponds to steppe and forest-steppe landscapes, with well-developed processes of oxidation and removal of mobile metals from upper soil horizons.

Each ore body has a primary halo, formed synchronously with ore formation processes, and its characteristics are typomorphic for each type of ore occurrence, thus having significant prospecting value. Secondary halos form due to the impact of external factors on ore bodies, leading to increased concentrations of certain components in surrounding rocks. Further migration paths of these components are called dispersion flows. The use of halos and dispersion flows is justified by their relative closeness to the surface and much larger area compared to the ore body. Secondary halos are especially well developed in eluvial–deluvial deposits. In allochthonous sediments (glacial, aeolian, alluvial), imposed halos can form due to diffusion and capillary rise. Typical element concentrations in lithochemical halos: 100–1000 g/t (Cu, Pb, Zn, Ni, Cr, Sn); 10–100 g/t (Co, As, Sb, U, Li, Be, Cs, REE, W, Mo); 1–10 g/t (Ta, Nb); less than 1 g/t (Ag, Mo, Au).

The formation patterns of secondary halos reveal proportionality between the amount of metal in the halo and the productivity of the ore body. Dispersion flows are proportional to the productivity of halos within the same denudation basin and indicate the scale of expected ore occurrences. Objects of hydrogeochemical prospecting include: 1)Natural groundwater springs. 2)Surface watercourses and reservoirs (rivers, streams, swamps, lakes, ponds). 3)Waters exposed in shallow mine workings (trenches, pits). 4)Waters exposed in wells, boreholes, adits, and other mine workings.

Scientific Novelty

- For the first time, characteristics of zonal and local hydrogeochemical backgrounds have been determined for 10 prospecting sites in the northwestern Torgai trough.
- It was revealed that the highest concentrations in groundwater are of Bi, As, Mo, Cu, and Zn, with the most contrasting anomalies for Cu, Zn, Sn, and Bi.
- For the first time, hydrogeochemical background and anomalies were identified, and parameters of the concentration coefficient (CC) and the standardized contrast coefficient (SCC) were calculated for Be, Pb, Sn, Bi, Mo, V, Cu, Zn, Ag, Co, Cr in groundwater.

- Three types of hydrogeochemical anomalies have been substantiated: Copper–pyrite association, 3olymetallic association. Rare-metal association. Practical Significance and Application

Field of application: Hydrogeology, Hydrogeochemistry.

The practical significance of the research lies in substantiating hydrogeochemical criteria for ore potential in the northwestern regions of the Torgai trough.

For the purpose of detailing prospecting works in the northwestern regions of the Torgai trough, the characteristics of the hydrogeochemical background and anomalies have been identified for the first time, and the parameters of the *concentration coefficient (CC)* for Be, Pb, Sn, Bi, Mo, V, Cu, Zn, Ag, Co, Cr (a), as well as the *standardized contrast coefficient (SCC)* for Be, Pb, Sn, Bi, Mo, V, Cu, Zn, Ag, Co, Cr (b), have been calculated in groundwater of the prospecting sites. Further research should be directed toward expanding prospecting indicators, including the application of methods involving stable and radioactive isotopes.

Personal Contribution of the Author

The author's personal contribution includes: formulation of the research goals and objectives; collection and synthesis of materials; preparation of thematic maps; genetic interpretation of results; formulation of conclusions and key provisions submitted for defense; preparation of scientific articles and conference reports on the thesis topic.

Publications

The main results of the thesis were discussed and approved at international and national scientific conferences. They are published in 6 articles, including: 2 articles in international journals indexed in Scopus (News of the National Academy of Sciences of the Republic of Kazakhstan. Series of Geology and Technical Sciences; Bulletin of the Tomsk Polytechnic University. Geo Assets Engineering), 1 article in a national specialized journal recommended by the Ministry of Education and Science of Kazakhstan (Geography and Water Resources), 3 abstracts in the proceedings of international and regional conferences.

Structure of the Dissertation

The dissertation consists of an introduction, five main chapters, a conclusion, and a list of references. At the end of each chapter, well-argued conclusions and results are presented.

The dissertation is a completed independent research work containing new specific solutions aimed at developing hydrogeochemical methods for prospecting ore deposits.

The introduction substantiates the relevance of the research, formulates the objectives and tasks, describes the novelty and approbation of results, and briefly outlines the content.

Chapter 1 describes the current state of the research problem.

Chapter 2 presents the geological structure and mineral deposits of the study area.

Chapter 3 describes materials and methods.

Chapter 4 discusses hydrogeological features of the region and its hydrogeochemistry.

Chapter 5 examines water halos of ore deposits at the main prospecting sites and prospects for identifying ore bodies based on microcomponents.

The dissertation comprises 112 pages, including 12 tables, 24 figures, 76 references, and 2 appendices.

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