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Geochemical Prospecting in the Open Metallogenic System

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Abstracts: “Geochemical anomaly” is the coresof the discipline of exploration geochemistry. Conventionally, geochemical anomaly is recognized via concentration values. A rule of thumb about concentration is “that high concentration corresponds to positive anomaly, while low concentration meaningless”. However, this ignores the mass and volume changes of the metallogenic system during ore-forming processes. As weknow, the concentration of an element is decided by the ratio of its content to the total system mass. Ignoring the change of volume, the element content and total system mass changing in different relations can result in the same concentrations, for instance, both increasing / decreasing by a same factor and neither changing. If considering the volume, we will get much more complex relations. Element anomaly and activity, hence, cannot be identified simply through the concentration value. The conventional method deciding anomaly is based on the assumption that the metallogenic system does not change in volume and mass, which is not real. Thus, geochemical explorationresearch/projectcannot reveal the element movements during ore-forming processes. Consequently, the efficiency of geochemical exploration is limited bothin depth and breadth. To extract integrated geochemical information and recognize geochemical anomaly from the perspective of dynamic evolution of metallogenic system, we introduce the idea of mass-transfer in the open system into exploration geochemistry.Firstly, all the geological units related with ore-forming processes were considered as a unity of metallogenic system. Two or more immobile elements were, then,identified via Isocon Diagram. After that, three parameters (namely the rate ofsystem mass changeμ, element mass increment ΔC_i^{O-A}, and the rate of element mass changeμi, see equation 1 to 3) induced from Grant’s equation were calculated, and finally, the change of system mass were evaluated and element movements were identified.

$$\mu = (C^o_j/C^A_j - 1)100\% \quad (1)$$

$$\Delta C_i^{O-A} = \left(\frac{\Delta C_i^O}{C_j^A}\right) C_i^A - C_i^O \quad (2)$$

$$\mu_i = \Delta C_i^{O-A}/C_i^O = \left(\frac{c_j^O}{c_j^A}\frac{c_i^A}{c_i^O} - 1\right)100\% \quad (3)$$

This paper took the Zhaojikou Pb-Zn ore deposit in the Anhui Province as a case for study, which wasdiscovered in recent years. All the geological units, including the Qingbaikou system, fracture zones, ore occurrences, and the Jixian system,which present in the ore-bearing areas, were considered as anentire metallogenic system. Results of mass-transfer calculation are list as following: a) The rate of system mass change was 4%. Meanwhile, the mass change rate of the Qingbaikou system was-18%, ore occurrences 23%, fracture zones 14 %, and the Jixian system 16%, respectively; b) The ore occurrences weregenerally present in the system mass enrichment zones (μ> 30%). Sodium dioxide (μNa_2O < –30%) depleted during ore-forming processes, forming negative anomaly. Sulphur (S) and Ag depleted in the Qingbaikou system, Hg depleted in the Jixian system, whereas all the concentrations of them showed positive anomalies.Lead (Pb), Zn, Cu, Au, Mo, As, Bi, Sb, and Se enriched in the ore-forming processes, forming positive anomalies. Metallogenic processes in the open system often caused system mass and volume changes. The conclusions are: a) The rate of system mass change (μ) can work as a new geochemical prospecting index, liking μ> 30% in the Zhaojikou Pb-Zn ore deposit; b) Mass-transfer contained a lot of geologic information. For instance, μ in the metallogenic system of the ZhaojikouPb-Zn ore deposit was ca. 4%, indicating that the ores were formed in an open system andexternal substances were added into the ore-forming system. c) The mass changerate of the Qingbaikou system was -18%, meaning that the Qingbaikou system depleted in mass and could support some ore-forming substances; d) Geochemical anomalyisa conception relativeto thechanges of system mass and volume before mineralization. d) Concentration is the result of the system mass and volume changes during ore-forming processes. High concentration can be formed from both enrichment, such as Pb, Zn, and Cu, and depletion, such as S, Ag, and Hg in the Zhaojikou Pb-Zn ore deposit.

Key words: open metallogenic system, mass-transfer, geochemical prospecting, Zhaojikou

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