Postprint: Hydrogeochemical Processes of Groundwater Formation in the Kashgar River Basin, Xinjiang

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Abstract

The formation of groundwater in the Kashi River Basin of Xinjiang is primarily influenced by dissolution, evaporative concentration, cation exchange, and mixing processes. The dissolution of gypsum, halite, and fluorite minerals provides important sources for SO42-, Na+, Cl-, and F- in groundwater; the dissolution of gypsum, feldspar, calcite, and dolomite minerals provides primary sources for Ca2+ and Mg2+ in groundwater. Gibbs diagram analysis indicates that in the northern Kizilsu River groundwater system, phreatic water is primarily influenced by the combined effects of rock weathering and evaporative concentration, while confined water is mainly affected by rock weathering; in the southern Gez River groundwater system, phreatic water is primarily influenced by evaporative concentration, with individual shallow confined water sampling points affected by rock weathering. The cation exchange process in the northern Kizilsu River groundwater system is stronger than that in the southern Gez River groundwater system; simultaneously, the cation exchange process intensifies with the gradual increase in aquifer depth. Mixing occurs between surface water and groundwater, and also exists between different aquifers.

Full Text

1.2 Sampling Sites

The groundwater and surface water sampling network was established based on hydrogeological conditions in the study area. Groundwater was classified into two types according to burial depth: shallow groundwater (depth $\leq$ 100 m) and deep groundwater (depth $>$ 100 m). Sampling sites were distributed across the Kezilesu River groundwater system in the northern part and the Gaizi River

groundwater system in the southern part. Well depths ranged from 5.0 to 140.0 m, covering unconfined, shallow confined, and deep confined aquifers.

1.3 Groundwater Classification

Groundwater classification was based on aquifer depth and type. The shallow groundwater primarily occurs in unconfined aquifers, while deep groundwater is associated with confined aquifers. This classification facilitates analysis of hydrochemical evolution in different groundwater systems.

1.4 Analytical Methods

1.4.1 Ion Balance Analysis

Hydrochemical data quality was verified using ion balance error calculations. The cation-anion balance error was calculated as:

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where the error (%) = (ΣNc - ΣNa)/(ΣNc + ΣNa) × 100, with Nc representing total cation concentration (meq·L^{-1}) and Na representing total anion concentration (meq·L^{-1}). All samples exhibited ion balance errors within the acceptable range of -2.01% to 3.82%, confirming data reliability.

1.4.2 Analytical Methods for Major Ions

Concentrations of major ions were determined using standard methods. The detection limits and analytical precision met requirements for hydrochemical studies.

3.2 Gibbs Diagram Analysis

Gibbs diagrams were employed to identify dominant mechanisms controlling groundwater chemistry, including rock weathering, evaporation-concentration,

and atmospheric precipitation. The relationship between $\gamma(Na^+/(Na^+ + Ca^{2+}))$ and Total Dissolved Solids (TDS) indicates the primary controlling factors.

The Sodium Adsorption Ratio (SAR) was calculated to assess sodium hazard:

$$SAR = [Na^+]/\sqrt{([Ca^{2+}] + [Mg^{2+}])/2}$$

where concentrations are expressed in $meq \cdot L^{-1}$. presents SAR values for different groundwater types in the study area.

[Figure 6: see original paper] shows the relationship between SAR values and well depths, demonstrating that SAR generally increases with depth in the Kezilesu River system, reflecting enhanced cation exchange processes at greater depths.

3.4 Hydrochemical Processes

Hydrochemical processes in the Kashgar River Basin include mineral dissolution, cation exchange, and mixing. The dissolution of gypsum, halite, and fluorite contributes significant amounts of SO_4^{2-}, Na^+, Cl^-, and F^- to groundwater. Calcium and magnesium originate primarily from dissolution of gypsum, feldspar, calcite, and dolomite.

Cation exchange is more pronounced in the northern Kezilesu River groundwater system compared to the southern Gaizi River system. The process intensifies with increasing aquifer depth. Mixing occurs between surface water and groundwater, as well as among different aquifer layers, as evidenced by hydrochemical relationships shown in [Figure 7: see original paper].

References

[The references section lists relevant literature on groundwater hydrochemistry in the Kashgar region and Xinjiang.]

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Abstract: Groundwater formation in the Kashgar River Basin is mainly affected by leaching, evaporation, cation exchange, and mixing processes. The dissolution of gypsum, halite, and fluorite minerals provides important sources of SO_4^{2-}, Na^+, Cl^-, and F^- to groundwater. Ca^{2+} and Mg^{2+} are mainly derived

from the dissolution of minerals such as gypsum, feldspar, calcite, and dolomite. Gibbs diagrams show that unconfined groundwater was mainly affected by rock weathering and evaporation-concentration, whereas confined groundwater in the northern Kezilesu River groundwater system was predominantly affected by rock weathering. Unconfined groundwater was mainly affected by evaporation-concentration, while shallow confined water was affected by rock weathering in the Gaizi River groundwater system in the southern part. Cation exchange was stronger in the Kezilesu River groundwater system in the northern part than in the Gaizi River groundwater system in the southern part. In general, cation exchange gradually increased with aquifer depth downward. Mixed action occurred both between the surface and groundwater, and also among different aquifers.

Keywords: groundwater; hydrochemical characteristics; hydrogeochemical; the Kashgar River Basin; Xinjiang

Note: Figure translations are in progress. See original paper for figures.