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Hydrological Processes of Hot Springs in Mountain Fault Zones Constrained by Geothermal Field: A Case Study in the Chuxiong Basin, SW China

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GEOLOGICAL SETTING

The Chuxiong Basin, located adjacent to the South Tibet–West Yunnan, the largest high-temperature geothermal belt in China. The basin is characterized by high regional heat flow (averaging 72.1 mW/m²) , with numerous hot **springs** distributed along the fault zones.

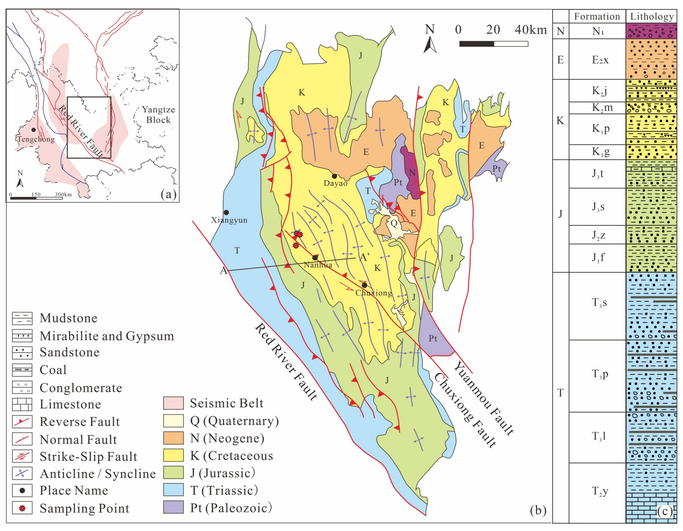


Figure 1. Location and geological map of Chuxiong Basin

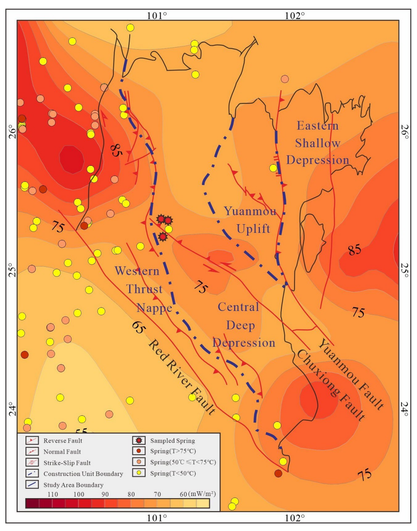


Figure 2. HF and hot spring locations

METHODS <HYDROCHEMICAL ANALYSIS>

The hydrochemical type of the hot springs is classified as **HCO_3-Na**. Groundwater in the Chuxiong area is predominantly of the HCO_3-Ca type.

The hydrochemical characteristics of the hot springs are mainly influenced by **silicate mineral** weathering.

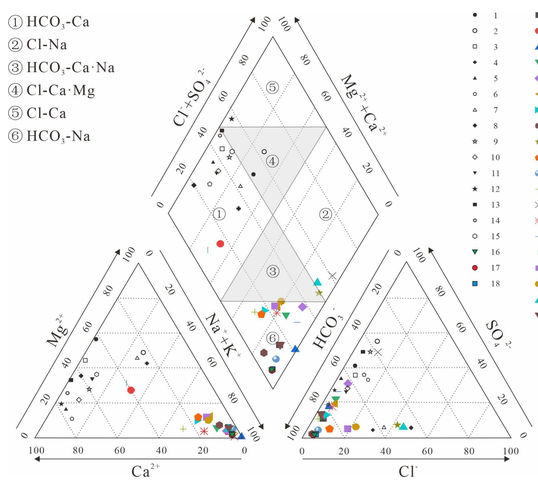


Figure 3. Piper diagram: Red River -Chuxiong Fault Zones

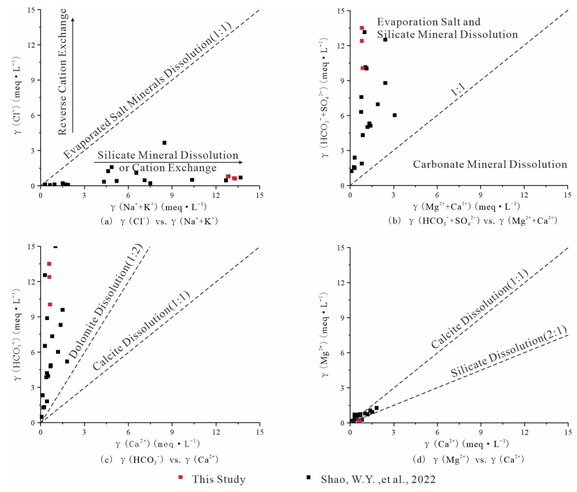


Figure 4. Major ion ratios in water samples

MERHODS <GEOTHERMAL FIELD>

Temperature is a key factor affecting the mineral dissolution rate. We calculated the temperature at the bottom of the major sedimentary layers in the basin using a one-dimensional steady-state equation (Figure 5).

Under the constraints of the conductive geothermal field, a coupled water-heat transport model was established to simulate **the precipitation recharge–fracture zone seepage system**.（It should be noted that the conductive geothermal field only provides a reference for the overall formation temperature, and although convection exists locally, its impact on the overall geothermal field is limited.)

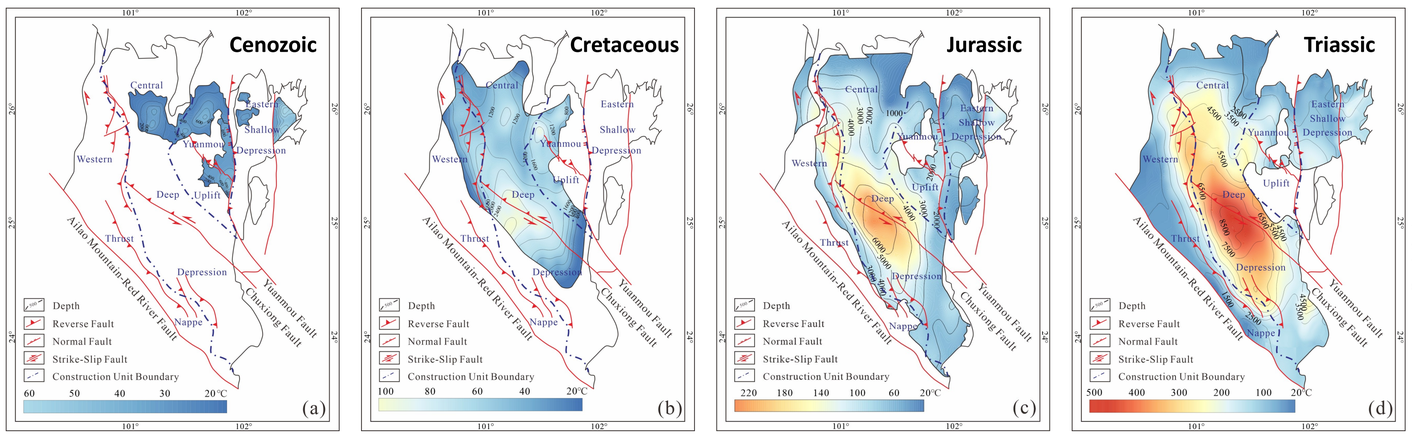


Figure 5. Estimation of the temperature at depth

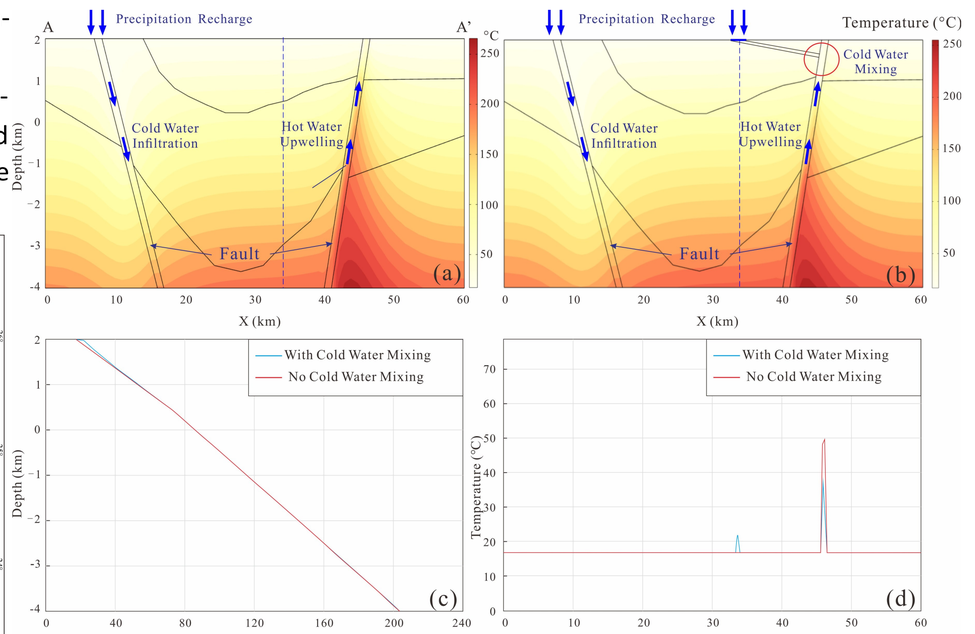


Figure 6. Simulation of the geothermal field along profile A-A' in the Chuxiong Basin

Cold water percolating along faults lowers the surrounding temperature, while hot water upwelling raises it to form local thermal anomalies; the Chuxiong Fault has permeable strata at the surface, and the upwelling hot water cools down after mixing with shallow cold water, eventually emerging as low-temperature hot springs (38℃) at the surface.

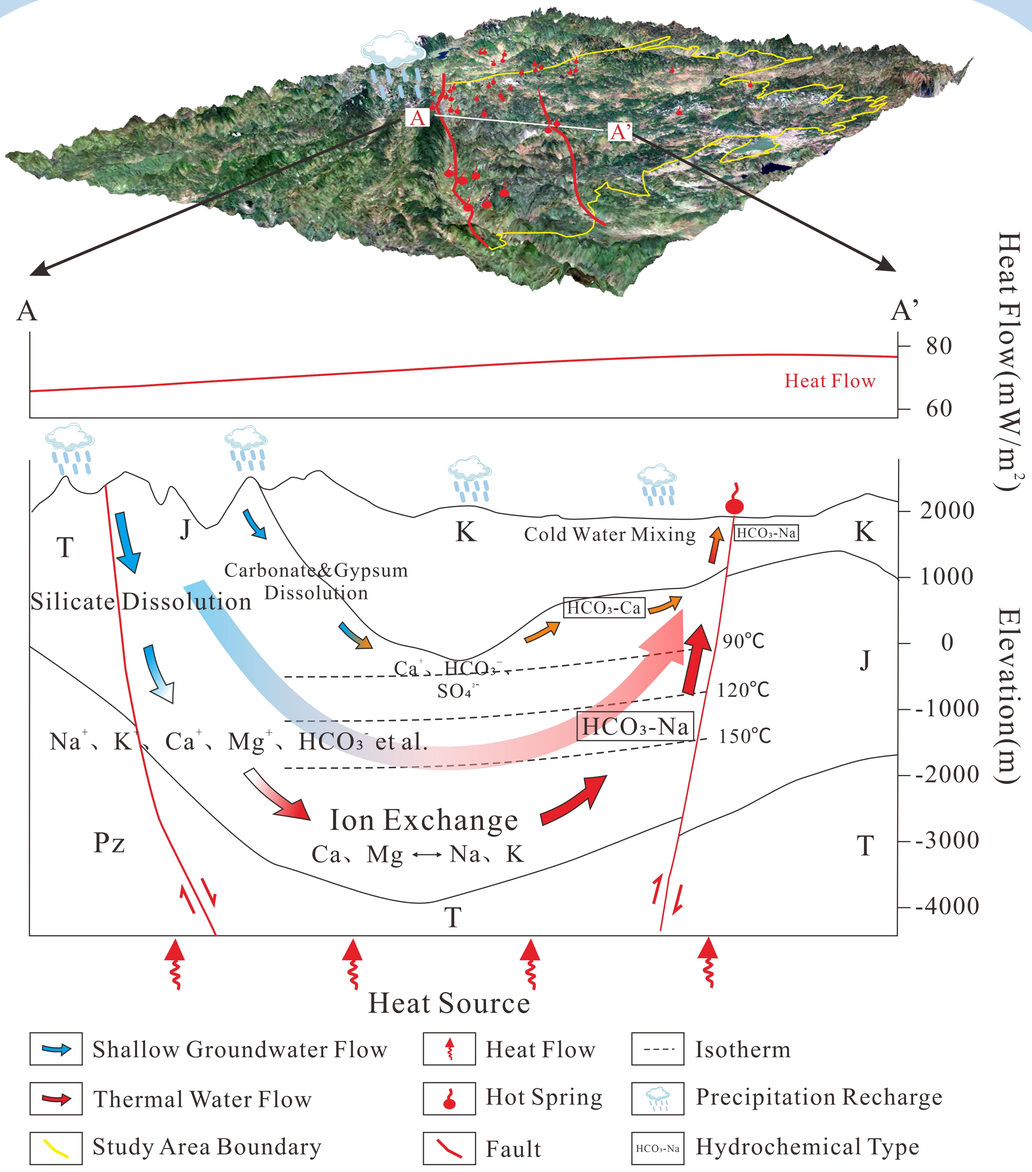


Figure 7. Geothermal formation mechanism

RESULTS <GEOTHERMAL FORMATION MECHANISM>

As illustrated in Fig. 7, the geothermal formation mechanism indicates that precipitation recharge infiltrates along preferential pathways of the Red-RIver Fault, undergoes prolonged runoff and deep circulation via structurally controlled fault zones, and during deep circulation, water–rock interactions (dissolution and ion exchange with silicate minerals in host rocks) gradually convert the hydrochemical facies from HCO_3-Ca to HCO_3-Na type; the ascending deeply circulated HCO_3-Na type geothermal water mixes with shallow HCO_3-Ca groundwater ultimately discharges at the surface.

CONCLUSIONS

The hot spring adjacent to the Chuxiong Fault demonstrates geochemical signatures comparable to those observed along the Red River Fault. Its hydrochemical type is classified as HCO_3-Na, with sodium (Na^+) and potassium (K^+) constituting the dominant cations. The ionic composition is largely controlled by the dissolution of silicate minerals—especially feldspars and aluminosilicates—within the host formations.

The geothermal system is mainly driven by deeply circulated meteoric water. The chemical characteristics of the geothermal fluids are shaped by water–rock interactions occurring at different depths, with significant contributions from leaching processes within both shallow and deep aquifers.

The tectonic architecture of the Chuxiong Basin is largely governed by deep-seated basement faults, which play a critical role in regulating regional heat flow distribution and act as efficient conduits for the transport of geothermal fluids. This structural configuration promotes the ascent of thermally enriched waters, leading to the emergence of surface hot springs.

The evolutionary processes of the hot springs and the subsurface temperature field reveals that the deep geothermal reservoir in the study area possesses both high temperatures and sufficient recharge, indicating promising potential for hydrothermal geothermal resources.

Acknowledgements

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