Mid-Deep Geothermal Potential and Occurrence Patterns in the Red River Fault Zone, Southwestern China

Xuan Tang[1], Weibo Ma[1], Liangliang Wang[1], Guodong Liang[1]

[1]China University of Geoscience

Abstract

The Red River Fault Zone (RRFZ), a significant strike-slip fault in the Hengduan Mountains, southwestern China, situated between the Xizang (Tibet) Plateau and the Upper Yangtze Plate, represents a prominent high- temperature geothermal zone in the country. The RRFZ stretches from Yunnan province through Vietnam to the South China Sea. There are notable variations in the geochemical and hydrological features of geothermal springs across different sections of the RRFZ, signifying substantial differences in geothermal energy resources related to distinct structural positions within the fault zone. Additionally, due to the absence of geological data in the middle and deep layers, the geological structure of the RRFZ, along with the middle and deep geothermal potential, and the occurrence status of geothermal energy, remains unclear, hindering effective utilization of geothermal energy in this region.

With the aim of better understanding the resource potential and heat transfer mechanisms of mid-deep geothermal energy along the RRFZ, we conducted wide-area electromagnetic surveys and geochemical analysis of hot springs in the northern section of the RRFZ. The wide-area electromagnetic profiles were useful for interpreting deep structures and potential water distribution. The results indicate that the RRFZ plays a significant role in the geothermal source, heat transfer, and the mixing of cold water. The primary hydrochemical types of the thermal spring water are HCO3-Na and HCO3 SO4-Na Ca, characterized by weak alkalinity. The average proportion of cold-water mixing reaches 79.6%, indicating that atmospheric precipitation and subsurface water infiltration are the primary sources of recharge for thermal spring waters. Two water-bearing layers were interpreted in the wide-field electromagnetic profiles, manifested as two low-resistance zones. The lower resistance zone, approximately 4000m deep, is inconsistent with location of the convergence zone of multiple strike-slip faults, which is supposed to be the bottom of water circulation calculated using silica-enthalpy plots, suggesting that the convergence zone may serve as the geothermal source. The shallow zone is crucial for cold water mixing and can control the rate of thermal water flow. The faults play key roles in the delivery pathways of geothermal energy from the deep to the shallow zone.

The depth of the geothermal source in the northern RRFZ is greater than that in the middle and southern parts of the RRFZ. In comparison to the middle and southern segments of the RRFZ, the heightened strike-slip fault activity in the northern segment has led to a more extensively developed fractured zone, resulting in more intense water-rock reactions and cation exchange adsorption between the water and surrounding rocks during the water circulation process. The circulation depth of the geothermal system in the northern segment of the RRFZ is greater than that in the middle and southern segments (with an average circulation depth of 3750 meters). A positive correlation exists between the circulation depth and the surface temperature of springs in the northern segment, which holds practical significance for estimating the circulation depth of hot springs and understanding the potential of geothermal resources.