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Hydrogeochemical characteristics and genesis of Hongshuilantang Hot Spring and its water temperature anomalies during the Rushan earthquake swarm in Eastern China

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Water temperatures of hot springs close to tectonic fault zones often show some variations before earthquakes, and analyses of earthquake precursors in hot springs have significant referential meaning for earthquake monitoring and forecasting. This study measured the concentration of major ions in water from the Hongshuilantang Hot Spring in 2017 and 2020. The ion composition was classified by hydrochemistry into the $HCO_3 \cdot SO_4$-Na chemical type. The composition of hydrogen and oxygen isotopes in the Hongshuilantang Hot Spring were located near the global meteoric water line (GMWL), indicating that the recharge source of the hot spring was meteoric water. The δD and δ18O values were not plotted on the Glogal Meteroric Water Line (GMWL), and there were some deviations, which suggested that hot spring water underwent water–rock interactions. Deep circulation water played an important role during the evolution process of thermal water. Water temperature showed a decreasing trend from October 2013 to June 2015 during the Rushan earthquake swarm in eastern China. Because of the occurrence of the earthquake swarm, we inferred that regional stress in this area began to be released, allowing continuous rebalancing. Free surface water appeared in some aquifers, and the seepage of low-temperature underground water into the upper aquifer led to a drop in water temperature in the hot spring. The Hongshuilantang Hot Spring and the epicenter of the Rushan earthquake swarm were located on the Muping–Jimo seismological fault zone, with the same seismotectonic system and some genesis relationships.

KEYWORDS

Hongshuilantang Hot spring, anomaly analysis, Rushan earthquake swarm, genesis, hydrogeochemistry

Introduction

Geothermal resources have significant economic and social value and are clean and recyclable (Tiwari et al., 2020; Lai et al., 2021; Verma et al., 2021). The study of hot springs is important and indispensable for the development and utilization of geothermal resources (Luan and Li, 1993; Wang et al., 2011). In recent years, hot springs have been widely used for seismic monitoring and forecasting, including the observation and analysis of ion concentrations and isotope compositions in hot springs that are close to fault zones (Gao et al., 2015; Che et al., 2016; Zhang et al., 2021). Seismic precursors, co-seismic responses, and the tidal effects of water temperatures have been recorded in a number of hot springs and geothermal wells (Mogi et al., 1989; Che et al., 2014; Liu et al., 2015; Ma et al., 2015; Miyakoshi et al., 2020). Anomalies in the water temperature of thermal water can be critical and especially useful earthquake precursors (Ma, 2016). For seismic fluid geochemistry, the determination of hydrogeochemical characteristics and measurement of stable hydrogen and oxygen isotopes is a promising and important method for earthquake monitoring and forecasting (Favara et al., 2001; Claesson et al., 2004; Pope et al., 2014; Skelton et al., 2014; Li et al., 2019; Miyakoshi et al., 2020). A large amount of useful information on the origins and migrations of thermal water can be obtained from hydrochemical compositions and environmental isotopes, which provides the basis for determining geochemical characteristics, such as hydrochemical type, genesis, and stage of water–rock reactions (Tiwari et al., 2020; Lai et al., 2021; Sasaki et al., 2021; Song et al., 2021; Su et al., 2021; Verma et al., 2021; Zhang et al., 2021; Duan et al., 2022).

The Jiaodong Peninsula, Shandong Province, eastern China, is located in the eastern part of the Penglai–Weihai fault zone with extensive distributions of metamorphic rocks and granites that have relatively high terrestrial heat flow values. Hot springs are widely distributed in the Jiaodong Peninsula (Jin et al., 2000). The Hongshuilantang Hot Spring is located in the eastern part of the Jiaodong Peninsula, which is a continental margin region of the Middle-Cenozoic crustal tectonic activity zone (Luan and Li, 1993; Jin et al., 2000; Zhou et al., 2002). A great number of moderate-to-strong earthquake swarms have occurred in the vicinity of these areas (Chen et al., 2006; Gu et al., 2020); therefore, Hongshuilantang Hot Spring has been explored as a potential seismic monitoring well by the local earthquake administration in order to capture valuable information related to earthquake precursors. A total of 7420 earthquakes with magnitude >1.0 occurred during the Rushan earthquake swarm from 1 October 2013 to 30 June 2015; the strongest earthquake was M_L 5.0 on 22 May 2015. Earthquakes caused cracks in some houses in local rural areas and had a great impact on the residents of Rushan city. During the Rushan earthquake swarm, the water temperature of Hongshuilantang Hot Spring appeared to decrease, so it is very important to study the relationship between earthquake swarm and water temperature. Due to the relatively abundant hot springs and frequent seismic activities in this region, it is an ideal site for research on the relationship between deep geofluids and earthquakes. Much research on the geochemistry of hot springs for the purposes of geothermal development has been carried out in the study area and its surroundings (Luan and Li, 1993; Shangguang et al., 1998; Jin et al., 2000; Wang et al., 2011). However, few studies on hot spring geochemistry have been carried out on seismic monitoring and forecasting. In this paper, the anomalies in water temperatures in the hot spring during the period of the Rushan earthquake swarm were analyzed, and possible relationships between temperature changes in the Hongshuilantang Hot Spring and the Rushan earthquake swarm were discussed together with background information on the geological structure. Combined with hydrochemical compositions, environmental isotopes, and geological and geomorphological investigations, a model map of the genesis of the hot spring was built. The results of this paper provide an important reference for exploring the genesis and earthquake precursor anomalies of geothermal wells and hot springs in other areas.

Settings

Geological settings

The Jiaodong Peninsula, with its many northeast-trending tectonic faults, is located in the northeastern part of the North China Block. It is not only an area with frequent moderate-to-strong earthquakes in the North China Earthquake Zone but also a continental margin zone exhibiting Middle-Cenozoic crustal tectonic activities (Figure 1). The Tanlu fault zone, a NE-trending deep fault zone running through the western part of the Jiaodong Peninsula in eastern China, crosses the Bohai Sea in the north, connects to the lower Liaohe fault zone, and ends at the Yangtze River in the south. The main tectonic evolution pattern of the Tanlu fault zone in recent years has largely comprised compressional activity with right-sided strike–slip characteristics (Pan et al., 2015; Qu et al., 2021). The largest earthquake along the Tanlu fault zone was the 1668 Tancheng 8.5 earthquake. The Penglai–Weihai fault zone, an NW-trending deep fault, is located in the northern part of the Jiaodong Peninsula and controls the distribution of seismic activities (Chen et al., 2006; Zhu G.et al., 2018; Gu et al., 2020). The western segment of the Penglai–Weihai fault zone was active in the late Pleistocene, and the eastern part of it was active in the mid-Pleistocene with no late-Pleistocene offset found. It is considered that the intersection of the Penglai–Weihai fault zone and the NE-striking branch faults of the Tanlu fault zone is the epicenter for medium-to-strong earthquakes, such as the Weihai M6 and the Bohai M7 (Figure 2B, Wang et al., 2006).

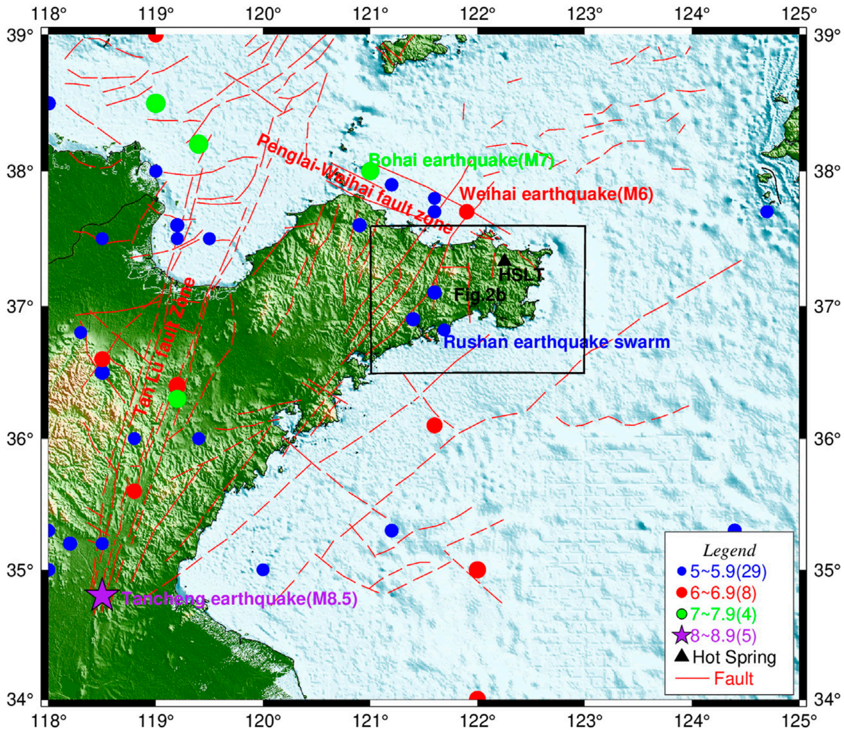

FIGURE 1
Seismotectonic settings of the Hongshuilantang Hot Spring in Jiaodong Peninsula, China. (Data of faults and earthquakes are from Chao et al., 1997).

The NE-trending fault zone in the study area includes the Wulian–Yantai fault zone, a northern boundary of the Sulu orogenic belt, and the Muping–Jimo fault zone, an important NE-oriented fracture (Zhou et al., 2002).

Hongshuilantang Hot Spring, on the east side of the Qilitang–Hengshan fault and close to the Muping–Jimo fault zone, is located in the eastern part of the Jiaodong Peninsula (Luan and Li, 1993; Jin et al., 2000; Zhou et al., 2002). (Figure 2A). The NW-trending Qilitang–Hengshan fault (F1) and the three inferred faults (F2, F3, and F4) may control the development of the Hongshuilantang Hot Spring.

Climatic settings

The hot spring explored in this study is located in the northeast of Shandong Province in northern China (Figure 1). It has a marine monsoon climate, with an average annual precipitation of 740 mm and an average annual temperature of about 12.0°C. Because of the influence of its land and sea location, topography, and other factors, there is more precipitation in summer. As it is surrounded by the sea on three sides and traversed by mountains from east to west, there is a large amount of strong convective weather and heavy snowfall in winter. The amount of precipitation in spring (from March to May), summer (from June to August), autumn (from September to November), and winter (from December to February) accounts for 15%, 53%, 25%, and 7% of total annual precipitation, respectively (Liu, 2021).

Methods and data

Hydrochemical characteristics and δD and $\delta^{18}O$ stable isotopes

To determine the genesis of water temperature anomalies, water samples were collected from the Hongshuilantang Hot Spring in March 2017 and June 2020. Chemical ion concentrations and δD and $\delta^{18}O$ stable isotope compositions of water samples were measured simultaneously. High-density polyethylene bottles with a 50 ml capacity were used as sample containers. Before sampling, the bottles were rinsed three times with the water samples, and at least three bottles of each water sample were collected for analysis. The bottles were filled with water samples, making sure there were no air bubbles, and the bottle mouths were sealed with a sealing film as quickly as possible. The chemical ion concentrations and δD and $\delta^{18}O$

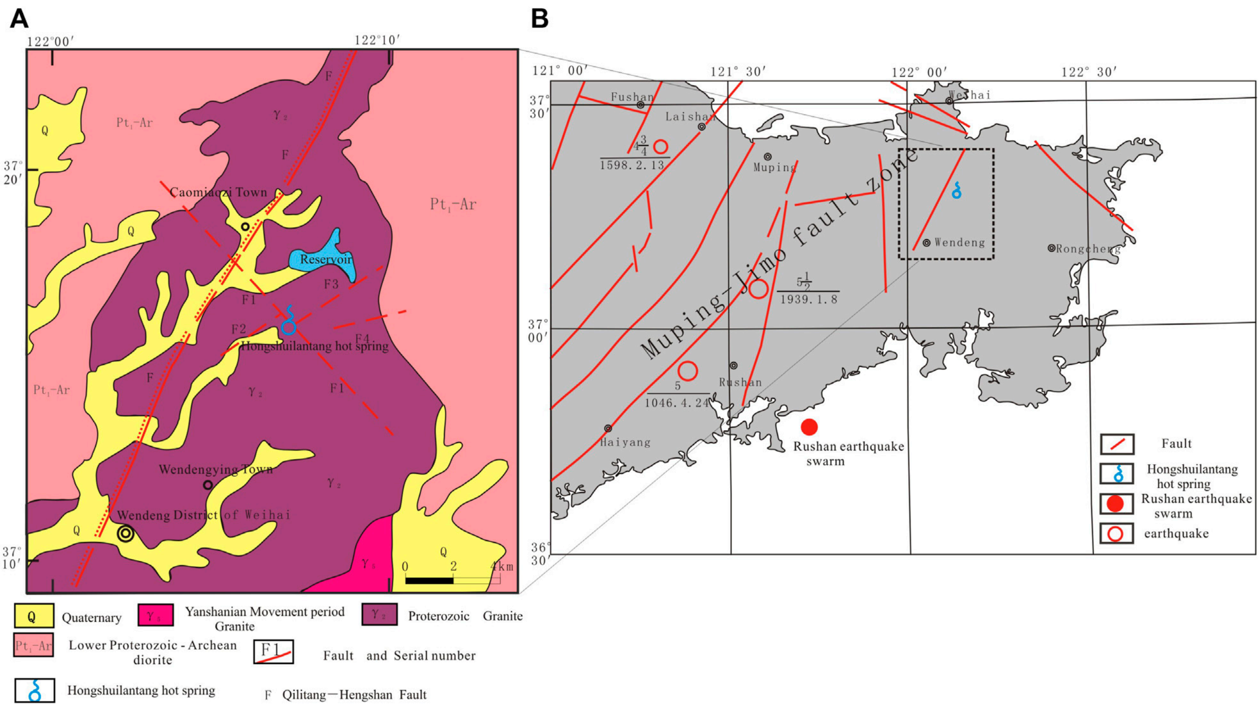

FIGURE 2
Geological settings and regional location of Hongshuilantang Hot Spring. **(A)** Geological settings; **(B)** regional location.

stable isotope compositions were measured in the Underground Fluid Dynamics Laboratory Unit, Key Laboratory of Crustal Dynamics of the China Earthquake Administration. Volumetric methods and CIC-200 ion chromatography were used for hydrochemistry analysis. δD and $\delta^{18}O$ stable isotopes were measured with an LGR 912-0008 hydrogen–oxygen stable isotope analyzer calibrated with water standards GBW04458, GBW04459, and GBW04460.

Long-term observation of water temperature

Before seismological observations were begun, the Hongshuilantang Hot Spring was an artesian well. The hot spring cannot flow on its own because of the decrease in the water table. However, when pumped, the hot spring can flow on its own. At present, water from the hot spring is mainly used for freshwater aquaculture by local residents. The Hongshuilantang Hot Spring is a seismic observation well belonging to the Weihai Earthquake Monitoring Center. The station observer uses a thermometer to measure and record the water temperature of the hot spring once a day. Temperature observations began in 2001, meaning we have data covering 21 years.

Thermometry

In this study, Na/K, K/Mg, and SiO_2 thermometries were selected to calculate the temperature of thermal reservoirs (Jiang et al., 2022).

Na/K thermometry used the following formula (Tian, 2012; Shi et al., 2019; Jiang et al., 2022):

$$t = \frac{933}{\left(\lg \frac{C1}{C2} + 0.933\right)} - 273.15. \tag{1}$$

K/Mg thermometry used the following formula (Tian, 2012; Jiang et al., 2022):

$$t = \frac{4418}{\left(13.95 - \lg \frac{C2}{C3}\right)} - 273.15. \tag{2}$$

Silica thermometry used the following formula (Tian, 2012; Jiang et al., 2022; Shi et al., 2022):

$$t = \frac{1522}{(5.75 - \lg C)} - 273.15 \tag{3}$$

where *C* is the concentration of SiO_2 in thermal waters, *C1* is the concentration of Na^+, *C2* is the concentration of K^+, and *C3* is the concentration of Mg^{2+}.

TABLE 1 Hydrochemistry characteristics of the Hongshuilantang Hot Spring in Jiaodong Peninsula.

No.	T °C	K^+ mg·L^{-1}	Na^+ mg·L^{-1}	Ca^{2+} mg·L^{-1}	Mg^{2+} mg·L^{-1}	Cl^- mg·L^{-1}	SO_4^{2-} mg·L^{-1}	HCO_3^- mg·L^{-1}	Date	Data source
1	63	287.96		25.05	2.33	177.76	176.58	323.77	1994	Jin et al. (2000)
2	76	19	222	24	2.4	56	230	329	2007	Tian (2012); Wang et al. (2011)
3	73	5.77	151.27	10.92	n.d.	52.98	102.10	258.41	2017	This study
4	74	12.7	161.74	23.55	1.4	11.93	114.06	284.745	2020	

"n.d." denotes that no data were collected.

TABLE 2 δD and $\delta^{18}O$ stable isotope characteristics of different waters in Weihai city.

No.	Type of water	δD	δ^2O	Data	Data source
a	Rainfall	−105	−14	1992	Tian (2012)
b	Seawater	−13.8	−2.34	2006	
c	Stream water	−52.63	−7.98	2006	
d		−56.70	−8.01	2007	
e	Hongshuilantang Hot Spring	−59.00	−8.20	2012	Tian (2015)
f		−55.80	−7.47	2017	This study
g		−59.72	−8.52	2020	

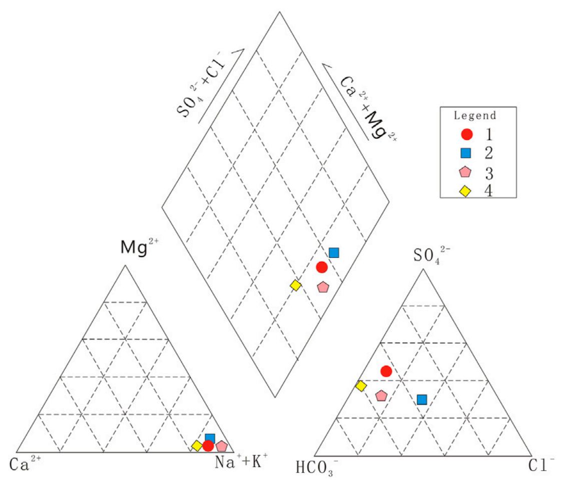

FIGURE 3
Piper diagram of waters from Hongshuilantang Hot Spring. The numbers in the figure correspond to those in Table 1.

Estimation of circulation depth

The circulation depth of the Hongshuilantang Hot Spring is given by the following formula (Jin et al., 2000; Tian, 2012):

$$H = \frac{t - t_0}{r} + h \quad (4)$$

where H is the circulation depth of hot spring water (m), r is the geothermal gradient, t is the temperature of the reservoir, t_0 is the average annual temperature of the recharge area, and h is the depth of the local normal temperature zone over a period of many years.

Results

The hydrochemical characteristics and the δD and $\delta^{18}O$ stable isotope compositions are shown in Table 1 and Table 2. To determine the genesis of the Hongshuilantang Hot Spring, we used data from other published studies (Jin et al., 2000; Wang et al., 2011; Tian, 2012; Tian, 2015).

Chemical type of hot spring water

Based on data measured in this paper and collected from published studies (Jin et al., 2000; Tian, 2012), a Piper diagram was plotted (Figure 3). The spring water was classified as an HCO_3·SO_4-Na type. The content of HCO_3^- in hot springs is relatively high; therefore, we hypothesized that the recharge source may be from surface water. The concentrations of Cl^- and SO_4^{2-} also have implied meanings for the depth of groundwater circulation, retention time, and recharge path.

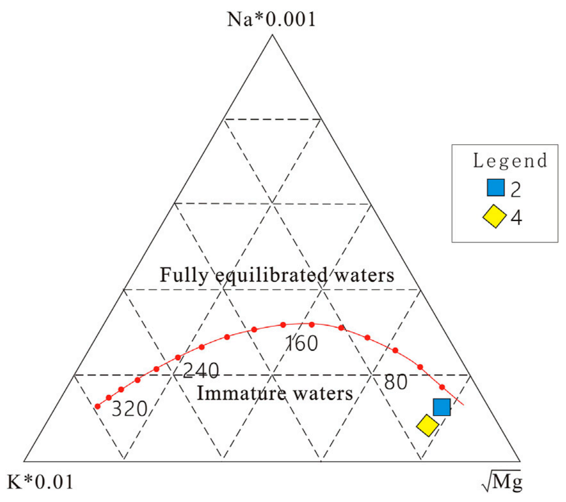

FIGURE 4
Na–K–Mg diagram of the Hongshuilantang Hot Spring. The numbers in the figure correspond to those in Table 1.

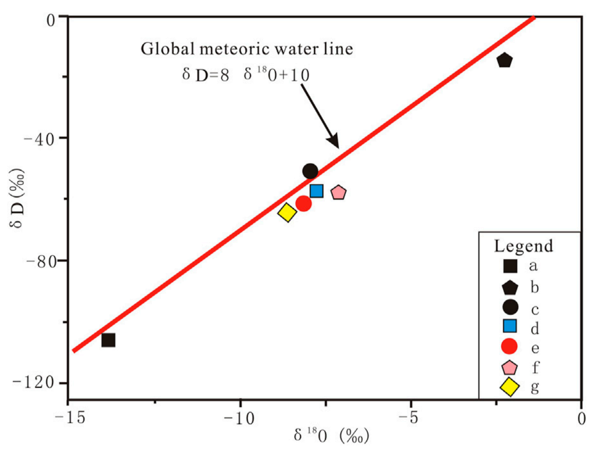

FIGURE 5
Relationships between δD and $\delta^{18}O$ values of the hot spring and the global meteoric water line (GMWL). The numbers in the diagram correspond to those in Table 2 and the GMWL is from Craig (1961).

Water–rock reaction characteristics

The Na–K–Mg diagram shows that water samples from the studied hot spring are near the Mg-end (Figure 4) and the equilibrium line, which indicates that the hot spring waters can be classified as immature. The water–rock interactions have not yet reached the state of ion equilibrium, indicating that the water is from a shallow, cold pool.

δD and $\delta^{18}O$ stable isotope characteristics

Environmental isotope analysis has been widely used in hydrogeological research. Measuring hydrogen and oxygen isotope levels is an effective method for ascertaining the origin and migration of water and other fluids circulating within the Earth (Tiwari et al., 2020; Li et al., 2021; Sasaki et al., 2021; Duan et al., 2022). Evaporation and precipitation can result in significant discrepancies in the isotopic composition of the mass of water molecules (Li et al., 2021; Duan et al., 2022). The δD and $\delta^{18}O$ values of freshwater and seawater in Weihai vary significantly from place to place, while the isotope levels in the river and thermal water were similar (Table 2).

Based on data obtained in this study and from other published work by Tian (2012) and Tian (2015), the values of the stable isotopes, δD and $\delta^{18}O$, in the hot spring water fell into the GMWL, and a rightward drift occurred to some extent (Figure 5). The GMWL could reflect the hydrogen and oxygen isotopic composition of precipitation in many marine monsoon climate areas. The nearer the origin is to the coastal areas, the closer its δD and $\delta^{18}O$ stable isotope values are to the GMWL; therefore, the GMWL was used as a reference for the δD and $\delta^{18}O$ stable isotope characteristics in the study (Craig, 1961; Li et al., 2011). There may be two reasons for the rightward drift of δD and $\delta^{18}O$ stable isotope compositions seen in the δD and $\delta^{18}O$ value graph. One is that Rayleigh fractionation occurs in arid and semi-arid areas of low precipitation and strong evaporation, which leads to an increase in $\delta^{18}O$ values. The other is that water–rock reactions between groundwater and siliceous or carbonate rocks cause oxygen drift and equilibrium exchange between hydrogen and oxygen isotopes. Combined climatic and geological conditions around the studied hot spring revealed that water–rock interactions in deep circulation systems may be the main reason for the appearance of $\delta^{18}O$ drift. To sum up, the main recharge resources of the Hongshuilantang Hot Springs are meteoric water, surface water, and groundwater.

Circulation depth of hot spring water

Na/K thermometries of thermal waters from the hot spring were 193°C and 185°C. K/Mg thermometries were 66°C and 68°C. Silica thermometry was 135°C (Shi et al., 2019; Shi et al., 2022). Since Na^+ and K^+ ions do not reach equilibrium easily and water–rock interactions were still in process, the temperatures calculated by the Na/K temperature scale were higher than the true values; therefore, silica thermometry was used to estimate the thermal reservoir temperatures, which should be closer to the actual value (Shi et al., 2019; Shi et al., 2022). In this study, formula (4) was used to estimate the circulation depth in the Hongshuilantang Hot Spring (Jin et al., 2000; Tian, 2012). In the equation, r is the geothermal gradient (4.4°C/100 m close to Huangxian basin in Jiaodong Peninsula), t is the selected silica

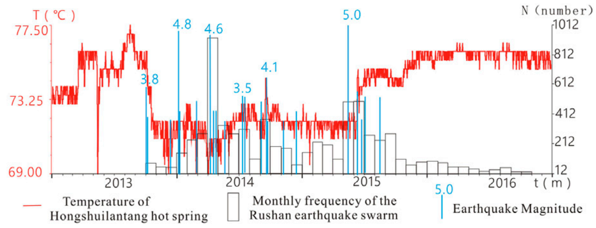

FIGURE 6
Comparison chart of daily temperature variations of the Hongshuilantang Hot Spring and monthly frequency of the Rushan earthquake swarm from 1 Jan 2013 to 31 Dec 2016.

thermometry of 135°C, and t_0 is the annual average temperature in the recharge areas; adopting 12.1°C, h is the depth of the local normal temperature zone for multiple years, which is equal to 25 m. Based on the aforementioned assumptions, the circulation depth was calculated to be about 2793 m.

Response to earthquakes

The water temperatures in the hot spring dropped from 76 to 70°C between October 2013 and June 2015, representing a maximum decrease of 6°C. After June 2015, the water temperature gradually began to increase, returning to September 2013 values by November 2015, when the whole water temperature oscillation process was over (Figure 6). The Rushan earthquake swarm was accompanied by continuous aftershocks from the M_L 3.2 earthquake on 1 October 2013. As of 30 June 2015, Rushan had experienced 5997 earthquakes with magnitudes of $0.0 \le M_L \le 0.9$, 1216 earthquakes with a magnitude of $1.0 \le M_L \le 1.9$, 182 earthquakes with a magnitude of $2.0 \le M_L \le 2.9$, 21 earthquakes with a magnitude of $3.0 \le M_L \le 3.9$, three earthquakes with a magnitude of $4.0 \le M_L \le 4.9$, and one earthquake with a magnitude of $M_L \ge 5.0$. The M_L 5.0 earthquake hit Rushan on 22 May 2015.

Discussion

Genesis model of the Hongshuilantang Hot Spring

Considering the hydrochemical characteristics, the Na–K–Mg diagram, and the δD and $\delta^{18}O$ stable isotope levels, we concluded that the Hongshuilantang Hot Spring possesses properties of both shallow and deep circulation water. The reason for this complex origin is that the chemical composition of hot spring water is closely related to burial conditions, surrounding rock lithology, recharge conditions of the hot spring, etc., (Shangguang et al., 1998; Jin et al., 2000). Combining the results of the geological and geomorphological investigations, a genesis model map of the Hongshuilantang Hot Spring was created (Figure 7), illustrating that it is not only affected by shallow meteoric water but also by deep circulation water.

Relative motion of the blocks in the vicinity

Based on continuous GPS observation data, Zhu et al. (2018) analyzed the relative motion state of the block continuum on both sides of the Tanlu fault zone after the 2011 Mw 9.0 earthquake in Japan through a sliding block model. The study suggested that the occurrence of the Rushan earthquake swarm may be related to the local regional stress adjustment promoted by the relative motion of the blocks on each side of the Tanlu fault zone. The enhanced relative motion from September 2013 to September 2015, which is vertical to the deep fault zone, promoted the release of the concentrated energy by means of the Rushan earthquake swarm. The vertical motion of the blocks on each side of the Tanlu Fault Zone has decelerated since February 2016, and at the same time, the activity of the Rushan earthquake swarm was also significantly weakened (Zhu C.et al., 2018). The epicenter of the Rushan earthquake swarm and the Hongshuilantang Hot Spring are both located in the Muping–Iimo Fault Zone on the eastern side of the Tanlu Fault Zone and belong to the Muping–Iimo Fault Zone, implying that they should be affected by the same stress conditions. Local stress adjustments also contributed to the variations in pore pressure of ground fluids, which affected the water temperature of the Hongshuilantang Hot Spring (Igarashi and Wakita, 1990; Lai et al., 2021).

Relationships between water temperature anomalies and the Rushan earthquake swarm

As shown in Figure 3, the water temperature of the hot spring declined from 76°C to approximately 70°C, with a maximum drop of 7°C after the Rushan M_L3.8 earthquake on 1 October 2013. After the Rushan M_L 5.0 earthquake on 22 May 2015, the number of earthquakes showed a decreasing trend. The data indicated that the water temperature began to increase from June 2015 and slowly returned to 76°C. As of the end of March 2017, the water temperature had remained stable. There appeared to be a temporal correlation between the Rushan earthquake swarm and the temperature drop in the hot spring. In addition, there was a close relationship between the monthly earthquake frequency during the swarm and the

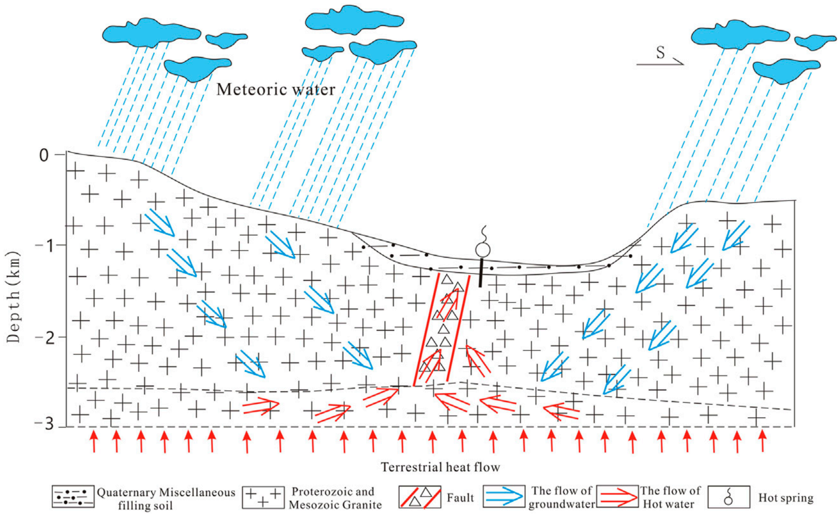

FIGURE 7
Genesis model of the Hongshuilantang Hot Spring.

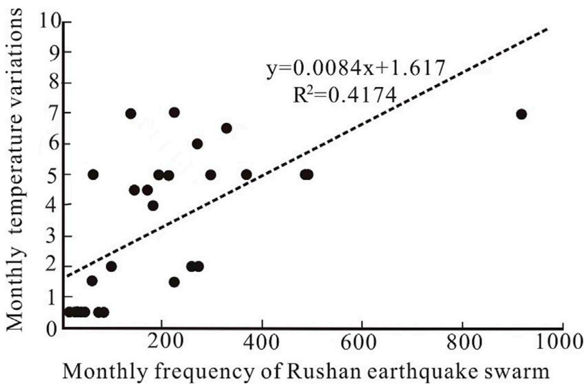

FIGURE 8
Correlation of monthly temperature variations of the Hongshuilantang Hot Spring and monthly frequencies of the Rushan earthquake swarm.

decrease in water temperature. When earthquakes of M_L 4.0 or greater magnitude were occurring in the Rushan earthquake swarm, water temperatures dropped significantly. For example, in January and April 2014, water temperatures of Hongshuilantang Hot Spring dropped by 7°C. The M_L 4.8 earthquake on 7 January 2014 and the M_L 4.6 earthquake on 4 April 2014 occurred during this period, and the highest monthly frequency of 917 earthquakes was recorded during the Rushan earthquake swarm in April 2014. The highest monthly frequency of earthquakes corresponded to the largest drop in water temperature (Figures 6, 8).

The epicenter of the Rushan earthquake swarm and the Hongshuilantang Hot Spring were located in the Jiaodong shield of the Jiaoliao fault block. According to the spatial distribution of local seismic faults, the Hongshuilantang Hot Spring and the epicenter of the Rushan earthquake swarm were both located in the Muping–Jimo fault zone (Figure 2B), suggesting a certain genesis relationship in seismic structure.

The results of the on-site investigation and verification showed no obvious changes in the surrounding observation conditions; therefore, the impact of environmental disturbances on the hot spring water temperature could be ignored. A large number of early Middle Pleistocene and pre-quaternary faults are scattered in the Jiaodong Peninsula. The Weihai *M*6.0 earthquake, which was the strongest earthquake in the history of the area, occurred in the northwest coastal part in 1948. Earthquakes in the Jiaodong Peninsula and its adjacent areas often appeared in the form of earthquake swarms, and the process of energy release was relatively slow (Zhou et al., 2002). The stress changes in the crustal medium and the water circulation in hot springs and aquifers resulted in water temperature variations due to stress increase or unloading. Thus, fluctuations of groundwater temperature could be caused by seepage from hot spring and aquifer systems (Yu and Che, 1997; Sun and Liu 2006). A study of the Xiangcheng Hot Spring also showed that stress changes could lead to connections between two adjacent hot spring aquifers, resulting in variations of water temperature (Ma, 2016).

Conclusion

1) The analysis of water quality, Na–K–Mg thermometry, and δD and $\delta^{18}O$ stable isotope levels shows that Hongshuilantang Hot Spring is not only affected by shallow meteoric water but also by deep circulating water.
2) Both the Hongshuilantang Hot Spring and the epicenter of the Rushan earthquake swarm are located in the Muping–Jimo fault zone, suggesting that they have a certain genesis relationship in seismic structure.
3) The stress increased slowly before the occurrence of the Rushan earthquake swarm, which was a continuously increasing process that changed monotonously. During this process, there were no obvious changes in water temperature caused by the Hongshuilantang Hot Spring; when the Rushan earthquake swarm occurred, the stress began to be released. When a free water surface appeared in the aquifer, the water temperatures of the hot spring decreased owing to the seepage of low-temperature underwater into the upper layer of the aquifer under the action of seismic stress unloading. After stress release, the water temperature gradually returned to normal.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material; further inquiries can be directed to the corresponding author.

Author contributions

GD: methodology, data curation, and writing—original draft preparation. SS: methodology, data curation, supervision, conceptualization, writing—review & editing. XC: writing and reviewing. HR: methodology, data curation, validation, writing— review and editing. ZH: writing— review and editing. XZ: editing.

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Conflict of interest

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