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Analyses on Mechanism of Geothermal Resources Origin in Panshan Scenic Area of Tianjin

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ABSTRACT

Existing Geothermal knowledge is connected to areas of granite area. Panshan scenic area is made from granite. Geothermal exploration in Panshan scenic area of Tianjin carried out during 2007 to 2012. The paper will analyse the mechanism of geothermal formation, bury patterns and distribution of geothermal resources. It investigated by two geothermal exploration boreholes JDR1 and JDR2. The geothermal exploration result indicated that the granite are made in Triassic period and exposed on the surface. The internal pressure and the radioactive elements formed regional geothermal anomaly. The geologic faults control the rock permeability in the field. Groundwater is cycle through the deep faults that are made by many times tectonic movement. Underground heat flow can transfer by deep cycle to geothermal reservoir near the surface. The fracture zone is formed geothermal reservoir. The wells are thus usually completed with production coming from multiple feed zones.

1. INTRODUCTION

Tianjin Geothermal Exploration and development has been more than 80 years alredy, but the distribution of geothermal resources, mostly in the plain area. Geothermal resources in the warm basins in rifting tectonic background. Jixian County is the back garden of Tianjin, scenic area. Development of geothermal resources will promote tourism service. Is it been find the potential geothermal resources in Jixian County, which is related to the quality of tourism resources in Jixian County. Geothermal exploration have been carried out in Tianjin Jixian County Panshan area by Tianjin Bureau of Geology and Mineral Resources. Two geothermal well have been drilled successful. Where the geothermal resources is come from in Jixian County Panshan area, and where is stored, whether there is a regular pattern.

2. GEOLOGY

Tianjin is in the northern margin of the North China platform which is the first tectonic units of the geological structure. It is divided to north and south plain area by the boundary, Ninghe - Baodi fault (Figure 1), which the geological structure characteristics of two regions has obvious difference. The northern mountains belongs to the Jixian Baodi uplifted fold zone of the second tectonic units, Yanshan platform fold belt. It is made of Paleozoic and Prepaleozoic formation. The main tectonic line is in the East Westt (EW)direction. Fracture direction is by the East-West mainly, and followed by three groups of faults which are North West (NW) , North East (NE) and North North East (NNE).

The formation distribution and its shape are controlled by the faults. Jixian Panshan scenic area is the area which the granite exposed to the surface. It is made of 4 granites which are Langjia Yu, Guan Zhuang, Dong Luozhuang and Panshan. There are dike rocks with quartz feldspar, and faultes around the granite distribution. There are 4 faults Jixian (F1), Ta Yuan - Ju Guan Tun (F2), Da Sun Zhuang (F3) and Guan Zhuang (F4), which formed during Triassic period. (Figure 2)

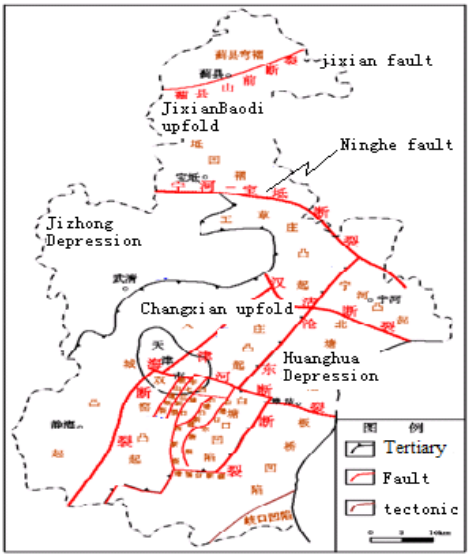

Figure 1: Geological structure

3. GEOTHERMAL

Tianjin is located in the northeastern part of North China Basin. The exploration of geothermal resources in Tianjin started in early 1970'.10 geothermal anomalies were delineated in an area of 8700 km^2 in the south of Tianjin. North of Tianjin is the recharge channel of ground water due to bedrock directly exposed surface or the cover is very thin in northern mountainous area, which is low geothermal gradient zone. Geothermal exploration is carried out during last 5 years, which are by water temperature investigation in more than 40 meters depth wells. We find two geothermal anomalous areas according to the regional background temperature values greater than 15 ℃ in plan view. It can be seen groundwater temperature anomaly zone are both located at the intersect of Jixian fault(F1) which is east west direction and Ta Yuan - Ju Guan Tun fault(F2), Da Sun Zhuang fault (F3) which are north- west direction from the map of geothermal geology. Geothermal reservoir boundary is Jixian fault (F1), in which, north part of fracture zone is geothermal anomalous, and south part of fracture is non- anomalous area (Figure 2) . Deep active faults (F1) and its secondary faults intersect (F2, F3) control geothermal fluid action .

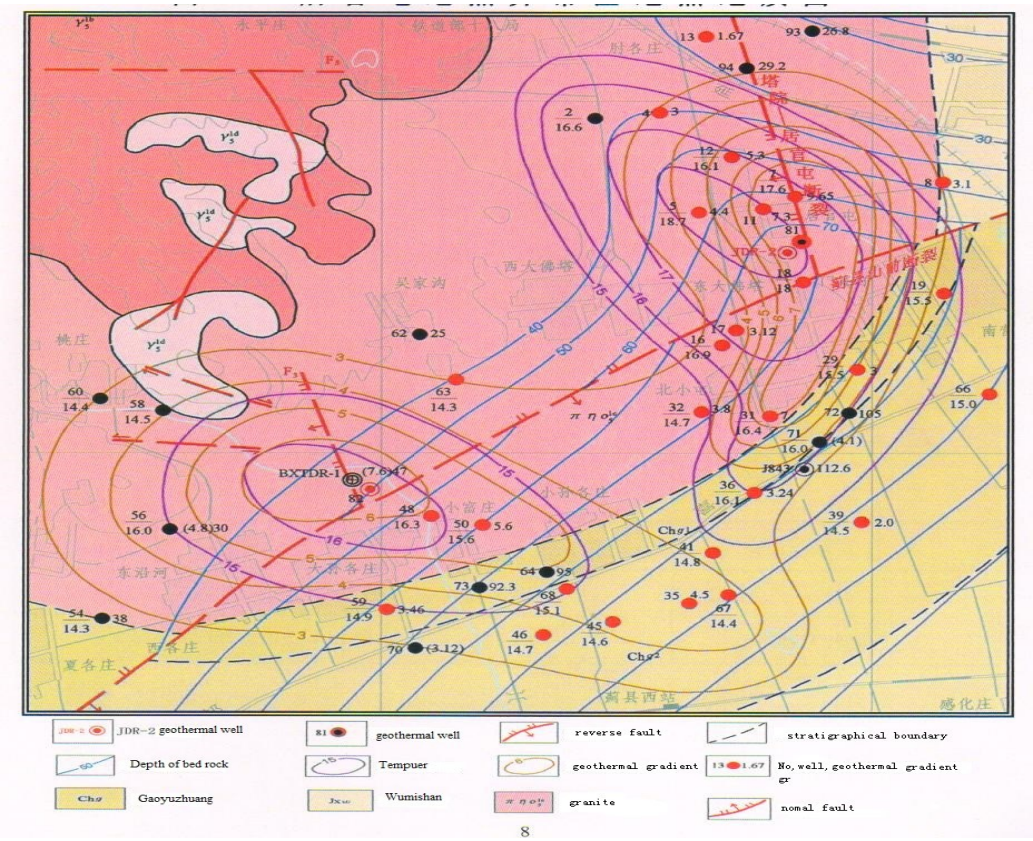

Figure 2 geothermal geology

From the cross section, the depth of thermostat layer in geothermal anomaly zone between 15-25 meters, the temperature is 14.1-16.2 ℃. The geothermal gradient of Quaternary cap rock reached to 3.0-9.65 ℃/ 100 m (Table 1). The distribution direction of the geothermal gradient is similar to the faults. The value of the geothermal gradient is highest near the intersection. It is 32.5 ℃ at depth 206 meters in well 81. It is 43.5 ℃ at depth 790 m in exploration well JDR1, and it is 48 ℃ at depth 1203 m in well JDR2.

Table 1 Geothermal gradient of Quaternary cap rock in the geothermal anomaly area

well	Depth of thermostat layer(m)	Temp of thermostat layer(℃)	geothermal gradient (℃/ 100 m)
3	16-21	15.3	4.5
7	15-17	15.5	9.65
11	12-15	14.1	7.3
12	17-20	15.2	5.3
32	25	14.3	3.8
56	12	14.6	4.8

In the non-geothermal anomaly area , the depth of thermostat layer is 30 m , the temperature is 13.0-13.9 ℃. The geothermal gradient of Quaternary cap rock is only 1.6-3.0 ℃ / 100 m. It is indicated that the depth of thermostat layer is deeper in non-geothermal anomalies, and the temperature is lower.

4. GEOCHEMISTRY OF GEOTHERMAL FLUIDS

We get water samples and analysis in exploration. The samples from Quaternary system water, karst fissure water, granite fissure cold water and granite fissure hot water. Water sample analysis data indicate that the content of Na^+, So_4^{2-}, Cl^-, F^-, Li, $HSiO^{3-}$ are higher in geothermal water than cold groundwater, and the content of Ca^{2+}, Mg^{2+} are lower than cold groundwater (Table 2). It is indicated that the geothermal fluid is come from deep circulating along the faults.

Table 2 chemical composition compare of geothermal fluid and groundwater (mg / l)

	Quaternary water	Karst water	Granite water	Geothermal JDR1	Geothermal JDR2
Na^+	15.12	9.65	37.84	143.10	145.70
Ca^{2+}	56.00	34.50	36.50	7.90	5.30
Mg^{2+}	9.95	12.66	7.54	0.50	0.10
HCO_3^-	178.67	153.59	156.73	164.80	103.70
SO_4^{2-}	25.00	20.00	65.00	85.00	110.00
Cl^-	25.00	17.50	15.00	60.70	67.40
F^-	0.20	1.00	2.00	18.00	15.22
Li		0.02	0.10	0.49	
HBO_2^-		0.17	0.30	3.26	3.15

5. ANALYSIS OF THE MECHANISM OF GEOTHERMAL ANOMALY

Geology and geothermal studies indicate that one part of the Earth's internal heat is come from continuously accumulation which radioactive elements release to radioactivity in rocks due to decay. The radioactive elements have sufficient abundance, longger half-life, which its nucleus have certain energy released in the process of decay. Earth's internal heat generated together form heat energy released. Another part of Earth's internal heat is relate with the increase of pressure in it, and the pressure is relate with gravity. The distance between the molecules of the rock is closer due to pressure increases. When the lattice structure of the molecule is damage due to the pressure, It is disintegration, and crystal lattice energy between molecules is released that the solid rock becomes fluid state magma. This change is occure in the crust and mantle interface. It is immersed in the earth's crust mantle that has caused massive volcanic eruptions, earthquakes, mountain building, and other geological movements. Earth's internal heat is released from the earth in different way.

Panshan granite irruption in the late Triassic. WU Zhenhan and his colleagues have researched the thermal history and uplift process of Panshan granite which is south part of Yanshan used thermal history method. The results indicated that the depth of Panshan granite is about 10km. After granite irruption, it is experiencing a rapid cooling process during 226.48Ma ~ 204.95Ma. The granite cooled to 520 ℃~300 ℃. The average cooling rate is 5.74 ℃ / Ma, e.g. Wu Zhenhan (1999). However, the cooling process is gradually slowed down. The internal temperature of exposed granite are higher than the temperature of the surrounding rock. Earth's internal heat balance is mainly by conduction to exchanged. In the exploration area, such as the main fault with multi-activity features, the disconnecting distance more than 1000 meters vertically, is the larger fault. It is the main channel that heat convection transfer to the surface of the granite. The heat of hot ground water is come from the mantle heat flow and granite .

Jixian fault(F1) intersect with Ta Yuan - Ju Guan Tun fault(F2) and Da Sun Zhuang fault (F3) and piedmont fault the intersection fracture is width of 100 meters. At the intersection rock with more fracture , high permeability and become a good collection reservoir and circulation channel of groundwater. F2, F3 towards north north-west, the faults properties are tensile fracture. It play a role of heat and water conductivity in the control structure. Groundwater heated by deep circulation and going up along the channel. F1 fault toward north-east, the fault properties is compressive. It plays a role of water blocking and underground converged here. This shows that the north- west faults and north east faults get together to form a geothermal anomaly area. The type of reservoir is fractured geothermal reservoir. Quaternary sediments become the cap of the reservoir, because of its low thermal conductivity.

CONCLUSION

Jixian Panshan scenic area is the area which the granite exposed to the surface. Geothermal exploration in Panshan area is carried out during 2007-2012, groundwater temperature anomaly zone are both located at the intersect of faults. Geochemistry analysis indicated that the geothermal fluid is come from deep circulating along the faults. The results indicated that the heat of hot ground water is come from the granite and mantle heat flow. The type of reservoir is fractured geothermal reservoir. The faults become a good collection and circulation channel of groundwater. Quaternary sediments become the cap of the reservoir.

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