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GEOTHERMAL POTENTIAL IN ZHANGZHOU BASIN, FUJIAN PROVINCE, CHINA

Wan. Tianfeng Chu Mingji

Deijing Graduate School, Wuhan College of Geology, Beijing, P.R. China

ABSTRACT

A network of intersecting with NW and NE trending faults was developed in Zhangzhou Basin. The NW faults with extension or extensive-shear, especially, the intersection of NW and NE trending faults, are favourable for forming low enthalpy hot-water system, It is suggested that active faults act as good passage and meteoric water as a supplement source in a deep circulation system. Sugar refinery--Gutang area, is the most favourable area for forming low enthalpy hot-water field and has been a low electrical resistivity anomalous area, which may be unfavourable for generating electricity, but benificial to the prehensive utilization in urban industries, agriculture and the medical treatment.

ACTIVE FAULT SYSTEM

Active faults have controlled over the formation of heat source bodies, the migration and thermal reservoir (Wan, 1981, 1984). It is important that active faults affect the exploration and exploitation of geothermal fields. Zhangzhou basin is located at the intersection of NE trending Changle--Zhaoan fault and NW trending Jiulongjiang fault, in which there are many microearthquakes and thermal spring. The temperature of springs is highest in Fujian province. The area is the most favourable for forming hot water field in Fujian (Wan, Chu, 1984, a,b).

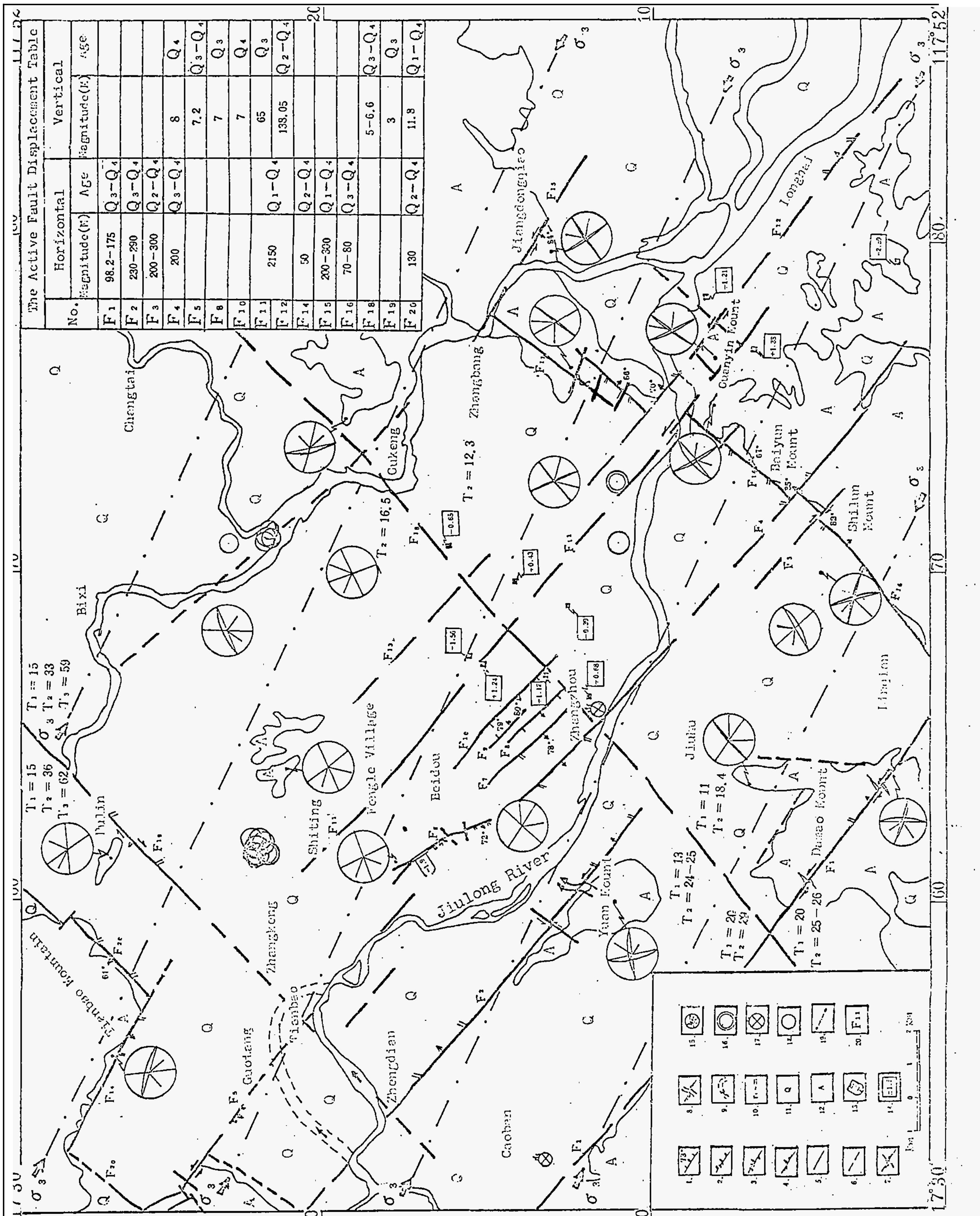
Based on the systematic collection and analysis of geological and geomorphologic evidence, seismic events, bore hole data, geophysical data, satellite images and air-photographes, sixteen NW trending ective faults and four NE trending active faults were studie i from geometric, kinematic and dynamic(Fig. 1). High angle faults near the earth surface were developed with a network of intersection of NE and NW trending faults due to the reactivation of pre-existing faults. NW faults and NE faults are prevailing normal sinistral strike-slip and dextral strike-slip reverse faults respectively. The maximum horizontal fault displacement is 2150 meters since early Pleistocene and common displacements are hundreds or tens meters; the maximum vertical fault displacement is 138.05 meters since middle Pleistocene and common displacements ere tens or several meters. NW trending fault displacements are larger than NE trending ones. That NW faults with extension or extensive-shear are more active than NE fault with compressiveshear. It proved through establishing a model of NW 290-300' with low angle maximum principal compressive stress directions of the present tectonic stress field.

Radiocarbon data of eleven samples representing different fault-blocks suggest that the average rates of tectonic uplift or submerge rang from +3.53mm/yr to -0.65mm/yr since 5990 - 1870 years.

Depending on the data of natural earthquakes, microearthquakes and P-wave low velocity layer, it is considered that there is a large-scale listric active fault (detachment) system with a east dipping,low angle (4-10°) , belonging to a part of the listric fault of Fujian and Taiwan in the upper lithosphere, which is unfavourable for the development of high enthalpy system (Wan, Chu, 1984). However, the NW trending faults with extention or extensive-shear, especially, the intersections of NE and NW faults, are favourable for low enthalpy hot-water system.

DEEP CIRCULATION SYSTEM OF GROUND-WATER

Granitic rocks with a low permeability under Zhangzhou Basin became a high permeability zones due to the developing of the active fault in the upper lithosphere and the exis-



The Active Fault Displacement Table

No.	Horizontal Magnitude(M)	Horizontal Age	Vertical Magnitude(M)	Vertical Age
F_1	98.2–175	Q_3-Q_4		
F_2	230–290	Q_3-Q_4		
F_3	200–300	Q_2-Q_4		
F_4	200	Q_3-Q_4	8	Q_4
F_5			7.2	Q_3-Q_4
F_8			7	Q_3
F_{10}			7	Q_4
F_{11}	2150	Q_1-Q_4	65	Q_3
F_{12}			138.05	Q_2-Q_4
F_{14}	50	Q_2-Q_4		
F_{15}	200–330	Q_1-Q_4		
F_{16}	70–80	Q_3-Q_4		
F_{18}			5–6.6	Q_3-Q_4
F_{19}			3	Q_3
F_{20}	130	Q_2-Q_4	11.3	Q_1-Q_4

Fig. 1. A sketch of active faults, in Zhangzhou Basin, Fujian province.

1. Normal fault, number shows dip angle.
2. Normal fault with strike-slip.
3. Reverse fault with strike-slip.
4. Strike-slip fault, arrow shows the direction of fault slip.
5. Fault, type unknown.
6. Inferred fault.
7. Gully, cut by active fault, arrow shows the direction of fault slip.
8. Curved gully, caused by sinistral strike-slip fault.
9. Acient river bed.
10. River terrace and its sea level height.
11. Quaternary.
12. Bedrock.
13. Short distance leveling over fault, relative motion rates (mm/yr) of fault blocks.
14. Uplift (+) or submerge (-) rates(mm/yr), calcullated by C data.
15. Diagram of principal stress axes from recent conjugate shear joints.
16. Epicentre, Ms 5.5.
17. Spring, bars in the circular show the active faults which control the spring.
18. Epicentre, Ms 2.0.
19. Maximum compressive principal stress traces.
20. Number of active fault.

ting a network with high angle faults near the earth surface. Then there are favourable pathes for deep penetration of meteoric waters. In addtion, in Zhangzhou Basin the natural topograph in the west is higher than that in the east; the fault plane of the listric fault in the west is shallower than in the east; there are many drainage systems and rich water source. In a word, there are good condition forming a deep circulation system of groundwater. Fault or fracture zones (kept open by seismic activity) provide pathes of circulation for the geothermal system; warm water supply came from the rainwater of Tianbao Mountain and Wufeng Mountain in the west and in the basin; water head is the force of groundwater movement (Fig. 2).

DISCUSSION OF GEOTHERMAL POTENTIAL IN SUGAR REFINERY--GUTANG AREA

Zhangzhou Sugar Refinery--Gutang geothermal

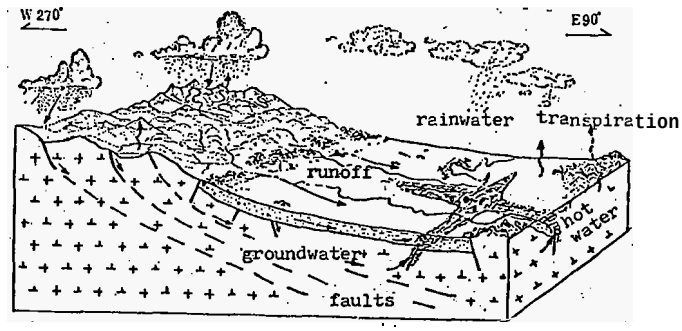


Fig. 2. A block diagram showing a deep circulation model for the geothermal system in Zhangzhou Basin, Fujian.

prospect area is located at the intersection of the most active Fengle village--Guanyin mount fault (F 11) and Changtai--Linxia fault (F 18). The area was divided into four fault-blocks by F 11 and F 18. The average uplift or submerge rates of the fault blocks are calculated by means of four radiocarbon data: an average rate of A-fault-block is +1.56mm/yr since 42652130 years, B-fault-block +1.24mm/yr since 5050±80 years, C-fault-block -0.39mm/yr since5655±115 years and D-fault-block +0.43mm/yr since5390±105 years respectively (Fig. 3). The geothermal potential area occupys up 4km^2 and appears a dark blue spot which shows a full of water on the satellite image of false colour composite, and the highest differential stress area in the calculation of Zhangzhou Basin for recent tectonic stress field made by means of the finite element method. Then rocks were strongly breaked up and permeability increased.

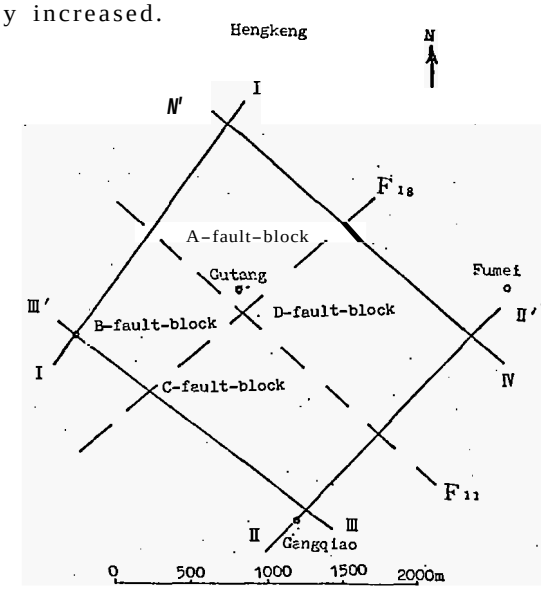


Fig. 3. A schemetic map of Wenner survey profiles in Sugar Refinery--Gutang geothermal potential area.
F 11 Fengle village--Guanyin mount fault;
F 18 Changtai--Linxia fault.

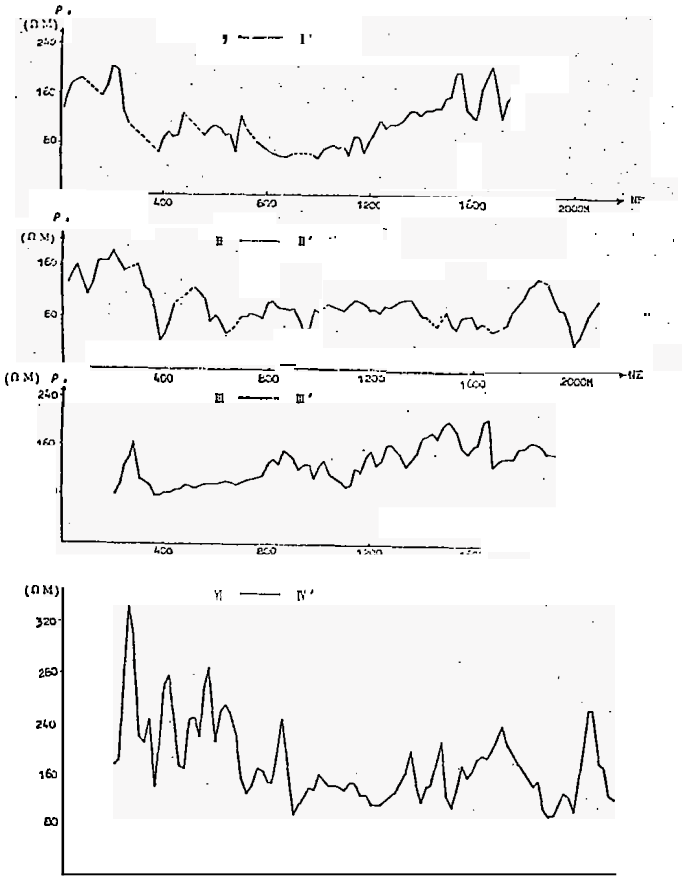


Fig. 4 . Wenner survey profiles in Sugar Refinery--Gutang geothermal potential area (AB= 400m , MN= 20m), after Hydrogeological and Engineering Geological Term, Fujian Geological Bureau, 1985.

Authors consider that there are conditions favourable for the migration and reservior of ground hot water. Four Wenner survey profiles (Fig. 4) show low resistivity anomolous zones on the active faults, especially , I–I* and 11–11' resistivities are lower wider coinciding with that F 11 is a main warm water path, which shows NW trending dark blue line on satellite image of false colour composite and open by seismic activity.

In Zhangzhou Basin a known ground warm water field is located at the intersection of F 4 and F 18 , and the output is 2000 tons/day. Sugar Refinery--Gutang geothermal potential area is situated at the intersection of F 11 and F 18. As the activity of F 11 is much more than that of F 4, the output of geothermal potential area may be more than 2000 tons/day. Depending on the contents of Na and K in hot water determining by flame-emission spectrometry and atomic absorption spectroscopy, subsurface temperatures calculated by the Na/K method are 168°C and 184 °C respectively (Group of Hydrogeological Regional Plan, Fujian Geological Bureau, 1984). However, water--make is very little in depth, for example, single well output is 0.1 litle/sec,it was isolated from cold waters in Zhangzhou Longshi. As granitic rocks have a 4.0°C/100m of geothermal gradient (Wang, 1985), ground warm waters with 200°C need to circulate about 5 km in depth.

and that more than 150°C thermal waters with large flow rate may be difficult to obtain from Sugar Refinery--Gutang area. Its water quality may be Cl/Na,Ca containing H_2S too. This hot water field is unfavourable for generating electricity, but beneficial to the prehensive utilization in urban industries, agriculture and the medical treatment.

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