LECTURE 1
THE TYPES, DISTRIBUTION AND BASIC CHARACTERISTICS OF GEOTHERMAL AREAS IN CHINA

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ABSTRACT

There are more than 3000 natural geothermal outcrops in China. The two high temperature geothermal areas in China include the Taiwan geothermal zone and the Himalayan geothermal zone. Low temperature geothermal areas are widely distributed in the vast area of Chinese mainland. The distribution of hot springs, geothermal wells and heat flow are controlled by geological structure. Taking the Ordos Basin and the Sichuang Basin as the centre, the geothermal areas in China can be divided into three sections: The eastern geothermal area, the western geothermal area and the middle geothermal area. The division of the Chinese geothermal areas correspond with the distribution pattern of the crustal thickness and the Moho-depth of Chinese mainland. The formation of the Chinese geothermal areas is affected by the geological evolution of the crust during plate motion of modern lithosphere; meanwhile, it is controlled by an isostatic gravity compensation function.

1. THE TYPES OF GEOTHERMAL AREAS IN CHINA

1.1 Hot springs and geothermal water areas

There are more than 3000 natural geothermal outcrops in China, with temperatures above 25°C (Limin Wang, 1992). More than 90% of them belong to low temperature geothermal resources (< 80°C), see Figure 1. The distributions of these hot springs are controlled by geological structures. Early in 1926 the geologist Prof. Zhang Hongzhao pointed out that the distribution of hot springs is closely linked to the geological structures similar to the network of veins. The research of the hot spring distribution is significant for revealing the rule of geological tectonics and facilitating geothermal exploration.

Based on the distribution of various geothermal outcrops around the world, such as volcanoes, hot springs, fumaroles and boiling mud ponds, as well as the distribution of geothermal boreholes and geothermal fields, structural geologists believe that geothermal distribution on the surface of the earth is dominated by the crustal tectonic movements, and that they are linearly distributed.

The geothermal areas in China can be divided into “high temperature areas” and “low temperature areas”, according to the wellhead temperature above and below 90°C, respectively.
FIGURE 1: The distribution map of hot springs in China
(Huang Shangyao, Wang Jun, etc., 1981)

FIGURE 2: Relationship between geothermal belts and global plate tectonics. 1: high temperature geothermal field; 2: the accretion plate boundary, spreading-ridge province, continental rift valley and transform fault; 3: subducting plate boundary: boundary of the deep ocean trench and the volcanic island arc, the boundary in continental edge of the ocean trench and volcanic arc, and boundary of continental collision; 4: geothermal zone around the world.
1.2 High temperature geothermal areas on the plate margin and intraplate low temperature geothermal areas

Almost all of the high temperature areas are distributed in the active volcanic regions, younger than Tertiary age, around the world. There are more than 600 volcanoes in China; only few of them are active volcanoes. Therefore no high temperature geothermal areas are being developed in China, except in the Himalaya (from southern Tibet to western Sichuan and Yunnan) and the Taiwan geothermal areas. High temperature hot springs are densely spaced in these areas. Macao geothermal field in Taiwan is a part of the Western Pacific island arc geothermal zone. The geothermal fields in southern Tibet-western Sichuan-Yunnan are a part of the eastern extension of the Mediterranean-Himalayan suture zone (Figure 2). The high temperature geothermal areas in China are located on the plate margins of the modern lithosphere.

In the interior of the China plate, mainly low temperature geothermal areas are distributed. A part of them belongs to the fold system in the active tectonic zones in late Cenozoic (Figure 3), here the outcrops of hot spring are dense. Another part belongs to the basins between the fold systems, including the active blocks between the active structure zones. Underground geothermal water is abundant here. The borehole data shows that the temperatures normally reach 30–50°C at the depth of 1000 m and 55–80°C at the depth of 2000 m; Few wells reach 90–100°C. It is obvious that the basin geothermal zones are mainly low temperature.

(Zhang Guomin, Ma Hongsheng, Wang Hui, etc.2005)
1.3 Brief characteristics of three types of geothermal zones

To sum up the above, China can be divided into three types geothermal zones: high temperature geothermal zones on plate margins, related to the active volcanoes; hot spring zones in fold systems related to active structure zones within the plate or in the block margin; and geothermal water zones in the basins related to the active blocks within the plate.

1.3.1 Plate marginal high temperature zones

High temperature zones on plate margins are located along the junction between the Western Pacific island arc and the Mediterranean-Himalayan suture zone in the global geothermal belt. Because the heat sources of volcanoes exist in the shallow part of the earth’s crust, the local geothermal high heat flow anomalies can be observed here. Hot springs are common on the surface, and most with temperatures higher than 90°C. Also some high temperature geothermal activity can be found, such as hydrothermal explosion, geysers and boiling springs. Usually the temperature in these geothermal fields is higher than the local boiling point, most of them above 200-300°C. Under the influence of volcano-magmatic activity and the control of local geochemical conditions, the geothermal water is mainly acidic water of the Cl-Na type with low mineralization. It contains silicic acid, metasilicate, arsenic acid, carbon dioxide, sulphur dioxide, sulphurated hydrogen, hydrochloride gas and fluoride prussic acid gas, etc. The geothermal resources are abundant. Its isotopic components are close to the precipitation in recharge areas and belong to the modern meteoric water cycle.

1.3.2 Hot spring zones in fold systems

The artesian hot springs are exposed in low altitude structural fracture zones of the uplifted mountain areas and small scale inter-mountainous basins. The flow rate of a single spring generally is 20-200 m³/day; few of them can reach more than 1000 m³/day. The meteoric water is the primary recharge, and it circulates to the deep crust along tectonic fractures. The heat source comes from the natural geothermal gradient, only one or two high temperature areas are related to modern volcanics or magmatic residual heat. The geothermal water is mainly fracture-vein water of varying water quality and flow rate, with temperatures less than 80°C, except in few areas. The temperature increment is not evident with depth. The hot springs are of HCO₃-Na type and have weak alkalinity with low mineralization, usually less than 2 g/l. Cl-Na type water exists along the coastal area, and its TDS values can reach 10 g/l, with large contents of CO₂, nearly a hundred milligrams per litre. Hot springs often contain Sr, Ra, Al, F, B and SiO₂ etc., and H₂SiO₃, H₄SiO₄, F⁻ and Rn are typical elements.

1.3.3 Geothermal water zones in the basin

Geothermal water is abundant in the inner zone of large scale artesian basins, where the runoff circulation is low or stagnant. The reservoir lithology comprises clastic rock, carbonate rock and crystalline rock. There is a lack of natural springs but boreholes often have very high pressures. The heat source is the natural geothermal gradient, and the temperature and flow rate are relatively stable. The temperature lies on the geothermal gradient, gradually increasing with depth. They can reach 30-50°C at a depth of 1000 m, and 50-90°C at a depth of 2000 m. The flowrate of a single well is 100-500 m³/day to 1000-2000 m³/day. According to the formation conditions, the geothermal water in the basin can be classified into 2 types: Open circulation systems and closed or sealed systems. The former type is mainly derived from the precipitation since late Pleistocene. It has low TDS values, generally 1-2 g/l, only few with more than 30 g/l. The origin of the latter is a more complicated mixture of ancient meteoric water and sea water. Also it may be influenced by water-rock interaction, diagenesis or endogenesis and other geological process. The hydro-chemical types of the geothermal waters are mainly Cl-Na and Cl-Na-Ca type. Compared with modern meteoric water, the isotopic composition of ²H is low but the chemical concentration Ca⁺⁺ is higher than that of modern sea water. Some of the waters accompanied by salt mineral deposit have the higher TDS values of 50-320 g/l in
addition to H$_2$S gas, B, Li, K, Rb, Sr, etc. Others accompanied by hydrocarbon mineral deposit have TDS value of 50-150 g/l and are rich in methane, Br and I, etc.

2. DISTRIBUTION OF THE GEOTHERMAL AREAS IN CHINA

2.1 Trisection pattern of the geothermal areas in China

The Chinese geothermal exploration shows that the hot spring zones in fold systems and the geothermal water zones in the basins are controlled by geological tectonic, as for example, the foreland pediment, basin boundaries or inner deep tensional fractures, fracture zones at the anticline axis and boundaries of the graben structure, etc., commonly called “heat-controlling structures”. The geothermal features are usually well developed at the intersection of heat-controlling structures. Taking the Ordos Basin and the Sichuang Basin as the centre, the geothermal areas in China can be divided into three sections according to the strike of the geothermal zones (Figure 4 and 5): The eastern geothermal area, the middle geothermal area and the western geothermal area. The structural strike in the eastern geothermal area is mainly NE and NNE, and NW and EW. In the western area it is mainly NW and EW, and NE and NNE. In the middle area the strike is mainly SN, and EW. The division is called the “trisection pattern” of geothermal areas in China.

FIGURE 4: The geological map of the Chinese Mainland. The two white lines indicate the boundary of the trisection pattern of geothermal areas in China. The eastern line: Big Xinganling Mountain-Taihang Mountain-Wuling Mountain. The western line: Helan Mountain-Longmen Mountain-Tectonic Zone from north to south. (Geng Shufang, Fan Benxian, 1976)
2.1.1 Eastern geothermal area

In the eastern geothermal area, the fold system hot spring zone includes: a high temperature zone in Taiwan, and a low temperature zone at the south-eastern coastline and Jiaodong-Liaoning etc. The basin geothermal zones are the Songliao Basin, the Circum-Bohai Basin, the Jianghan Basin and the Nanyang Basin, etc. The main strike of the hot spring zones and geothermal zones are longitudinal, and secondly transverse. The most active heat-controlling structure is the Taiwan rift Fault, which is part of the Western Pacific island arc fracture belt. The Tancheng-Lujiang Fracture is the largest inland heat-controlling structure; The Taihang Mountain Fracture is the second largest.

2.1.2 Middle geothermal area

Generally, the middle geothermal area stretches north to south on the China Mainland. The main fold system hot spring zones include the Taihang Mountain, the Qinling Mountain, the Helan Mountain, the Longmen Mountain, the Big Snow Mountain etc. The main basin geothermal zones are located in the Ordos Basin and the Sichuan Basin. The strike of the hot spring zones and geothermal zones are in longitudinal and transverse directions. The active heat-controlling structures are the Qinling northern slope fracture, the BeiShan southern slope fracture, the Longmen Mountain Fracture and the Sanjiang Tectonic zone.

2.1.3 Western geothermal area

In the western geothermal area, the fold system hot spring zones include the Tianshan Mountain, the Qilian Mountain, the Kunlun Mountain Hot etc. The main basin geothermal zones are located in the Tarim Basin, the Junggar Basin and the Qaidam Basin etc. The largest and most active heat-controlling structure is Brahmaputra Fracture.

2.2 Heat flow distribution of the boundary and the inland in China

2.2.1 Heat flow distribution at the boundary in China

The average terrestrial heat flow of China is 63±16m W/m² (Chen Moxiang, Huang Shaopeng and Wang Jiyang, 1994), which is similar with the global continental statistic result. The southeast boundary of the Chinese mainland coincides with the plate boundary of the Philippine Sea and the Pacific. Meanwhile the India plate has severe influence upon the southwest of China. So in China, the southern boundary has a higher heat flow, while the heat flow at the northern boundary is lower.

According to the statistics of average and maximum values of heat flow, the high values in the southern boundary are: the Taiwan Island is 80-120 mW/M², the southeastern coastline is 75-80 mW/m², the Tengchong in Yunnan Province is 85-118 mW/m², and the southern Tibet (from Bangong Lake to the Shouthern part of the Nujiang Fracture) is 100-319 mW/m². The low values at the northern boundary are: the Xinganling Mountain < 40 mW/m², the Junggar Basin < 45 mW/m².
2.2.2 Trisection pattern of the heat flow distribution in the interior

Except the two high heat flow areas mentioned above, the heat flow distribution in the interior is similar with the trisection pattern of the geothermal areas. The heat flow reduces stepwise from the eastern to the western area. The east area has a higher heat flow value. The average value is 62±13 mW/m² in the whole Huabei Mesozoic-Cenozoic fault basin, including the Xialiaohoe Basin. The heat flow is 78±14 mW/m² in basement convex area and 51±8 mW/m² in the basement depression area. The distribution and changes of the heat flow can reflect the basement’s tectonic features, as well as the tectonic pattern of alternating uplifts and depressions. The average value is 52±12 mW/m² in the middle area and 43±8 mW/m² in the western area. Figure 6 shows that the temperature of the hot water decreases from east to west in sedimentary basin, which is consistent with the trisection pattern of the heat flow changes.

2.3 Trisection pattern of the character of the geothermal water

2.3.1 Low mineralization and deeply circulating hot water in the eastern geothermal area

The large scale Mesozoic-Cenozoic basins developed in the eastern geothermal area, i.e. the Huabei Basin (upper Tertiary), the Songliao Basin (upper Cretaceous). All of them constitute interbedded sands and clays filled with open deposits of river-lake facieses. Because of the large thickness (hundreds to 2000 m) and the high ratio of sand-clay layer, they are good clastic rock reservoirs.

In the Huabei Basin, the fractures and cavities are widely dispersed and developed in the carbonate rock reservoir beneath the upper Tertiary. In the local extensional stress regime, the tensional fractures and a series of graben structures of alternate uplifts and depressions are developed in the duality structure reservoir. Thus, the heat transfer property of the rock is distinctly different. After the reallocation of the heat flow during the transfer process, the local heat anomaly is formed in the cap rock of the uplift area, where the temperature gradient is higher than 4°C/100 m and the heat flow is more than 65 mW/m². The cap rock is comprises the shallow reservoir and its super stratum Quaternary sediments. The geothermal water is different from the groundwater in the shallow aquifer of the basin foreland. The latter belongs to the modern cycle of meteoric water. Geothermal water is the deep water cycle continuously recharged by ancient meteoric water since the latest glacial period. The low mineralization and deep seating are the main characteristics of the abundant geothermal water in the eastern geothermal area.

2.3.2 The low temperature and sealed fresh brine in the western geothermal area

The multi-layer hydrocarbon mine and the low temperature fresh brine are developed in the western geothermal area. Based on the hydro-geochemical and isotopic research, the origin of the brine is ancient sea water, sediment pore water created through diagenesis and huge amounts of crystallization water emerging from the transformation of gypsum into anhydrite. The fresh brine is sealed hot brine. The chronological studies of rare gas indicate that the residence time of the brine is close to the age of the surrounding rock.
2.3.3 Low temperature and highly concentrated hot brine in the middle geothermal area

In the middle geothermal area, there are several kinds of low temperature and highly concentrated hot brines. For example, the Sichuan Basin is formed in the compressional environment; the brine is widely distributed in the gas fields of the Sichuan Basin from the Sinian period to cretaceous period, but with different concentrations and genesis. The primary brines are the multi-type low temperature brines and highly concentrated hot brines in salt deposits, and the secondary brines are low temperature fresh brines and highly concentrated calcium chloride (CaCl) brines in hydrocarbon deposits. 1

3. THE CONTROLLING FACTORS ON THE DISTRIBUTION OF GEOTHERMAL AREAS IN CHINA

3.1 The history of the geotectonic evolution of the Chinese mainland

3.1.1 The geotectonic evolution process and the trisection pattern of geothermal areas in China

The Chinese mainland belongs to Asian Plate and is composed by several blocks. Since the Pliocene (3Ma) epoch, the pattern of crustal movements in China has been fixed (Figure 5). The macro geotectonic evolution can be described as a “teeterboard” process:

Considering the Ordos-Sichuan Basin as a main axis; Western China belonged to the Tethys Ocean in the Paleozoic period, and the landform is lower in the west compared to the east. In the Mesozoic period, the Qiangtang, the Gandise and the India massifs drifted from the southern mainland, then collided to form the suture with the Tarim massif. In the Cenozoic period, the Tethys Ocean evolved into the Qinghai-Tibet Plateau. During volcanic activity, the crust thickened and the topography increased. Later the Pacific Plate turned towards the north-west to dive beneath the plate of Philippine Sea, and to converge with the Eurasian plate. Meanwhile the Australian plate moved northwards, and the area near the Pacific Ocean is pulled apart in north to south direction making the crust thinner, decreasing the topography.

The “teeterboard” evolution of the Chinese mainland is the geological background for the formation of metal ore deposits, hydrocarbon deposits and salt deposits. Furthermore, it is the main controlling factor for the trisection pattern of the geothermal areas in China. The axis of the “teeterboard”, the topographic high in the Ordos-Sichuan Basin affects the advance and retreat of the sea water. The ancient shelf of the shallow seashore occurs on both sides (east and west) of the high. Moreover, the formation of the sealed geothermal water in the Sichuan Basin is related to the closure of the Tethys since the Mesozoic period. The formation of the semi-open geothermal system in the Huabei Basin is related to an extensional stress field in the eastern area originating from the early Tertiary.

3.1.2 The geotectonic evolution and the heat flow distribution

The local heat flow is connected to the geotectonic evolution. According to on the statistic Pollack et al., 1993, the average heat flow value is 41±2.4 mW/m² for Archean units, 58±1.4 mW/m² for Proterozoic units, 58-61 mW/m² for Paleozoic units, 64±3.0 mW/m² for Mesozoic units and 64-97 mW/m² for Cenozoic units. In the eastern geothermal area in China, most of the average heat flow values are within the range of the heat flow in Cenozoic. This indicates that the eastern geothermal area is widely affected by Cenozoic tectonics. The effects on Taiwan and the south-eastern Coast are most intense. In the middle and western geothermal area, the high heat flow is most prominent in southern Tibet and the West Yunnan Province, affected by the collision of the India plate and Asian

1 Classified by TDS (g/L) in water: fresh brine- TDS<30 g/L, concentrated brine-TDS>30-150 g/L, saturated brine-TDS>150 g/L, over-saturated brine-TDS>320 g/L, saturated and over-saturated brine is generally called highly concentrated brine.
mainland. The heat flow is lower in the other places. The average value of the heat flow in the Tarim Basin is only 44 mW/m² and close to the average value of cratons in Archean. Thus the effects of the tectonic events previous to the Cenozoic are rather distinct there.

3.2 Plate movement of the modern lithosphere

3.2.1 Plate movement controls the strike of the folded belts

Based on the theory of plate motion, there are three groups of horizontal driving forces in Chinese modern tectonic movements: The NNE trending compression created by the India plate (Figure 7); the convergence of the Pacific plate and the plate under the Philippine Sea towards the Asia plate (Figure 8); the resistance coming from the Russia plate in the north. Their joint actions bring about the trisection pattern of the folded belts.

3.2.2 The strike of the folded belts dominates the strike of the hot springs and/or hot water zones

The consistency in strike of the hot spring zones and folded belts should attribute to the heat transfer and water conductivity of the deep fractures along the folded belts. But the coherence between the hot water zones in the Basin and the folded belts is, not only, related to the concealed deep faults, but also to the changes in specific thermal conductivity in the rocks. For details, see the following.

3.2.3 The plate movement controls the heat flow distribution

Based on the theory of plate motion, molten mantle material extrudes at the mid-ocean ridges to forms new oceanic crust. The “new” crust gradually cools while spreading. At the ocean trenches, the oceanic crust dives into the asthenosphere of the upper mantle, and gradually disappears. The heat flow normally decreases from the mid-oceanic ridge to the trench, with highest heat flow values of 376.6 mW/m² and an average value of about 79.5 mW/m² at the mid-oceanic ridge. In the trench area, the average heat flow is only about 48.5 mW/m². Whereas, the lowest heat flow values in the basin are about 53.2 mW/m² (Lee, 1970)
3.2.4 The heat flow on the boundary of the Chinese mainland is affected by global geothermal belts

As mentioned above, the heat flow is higher in the south and lower in the north on the Chinese mainland. The heat flow distribution is affected by the global geothermal belts, related to the tectonic magma activities in the collision zone, where the Indian plate and the Pacific plate collided with the Asian plate.

3.2.5 The trisection distribution pattern of the interior heat flow is related to the stress field

On the basis of research on the strain rate fields of the China mainland through GPS data, both inner continuous deformation and block movement deformation exist within the china mainland. Continuous deformations mainly exist in the Qinghai-Tibet Plateau and the Tianshan Mountain, while inner deformations are less obvious and mostly occur in the fracture zones around the block boundary in the Junggar Basin, the Tarim Basin, the Ordos Basin, and in the north-east of China. The deformations of the blocks of the Yinshan-Yanshan Mountain, the Huabei Plain and the eastern Shandong-Huanghai Sea are inverted. This indicates that, the NNE trending compression by Indian plate is the main driving force of the inner deformation of the China mainland. The heat flow on the mainland decreases in an East-middle-west direction. The compression in western China and the extension in eastern China are the important factors creating the trisection.

3.3 The deep-crustal structure and isostatic gravity compensation function

3.3.1 The trisection pattern of crustal thickness and Moho-depth in the Chinese mainland

There are two gravity gradient belts on the Bouguer gravity anomaly map of the China mainland (Figure 9): HeLan Mountain – Longmen Mountain and Daxinganling Mountain-Taihang Mountain-Wuling Mountain. The deep-crustal structure of China mainland is divided into the trisection pattern by these two gravity gradient belts. With the centre of the Ordos–Sichuan Basin, the upper mantle is uplifted in the east and down-faulted in the west.

The map of the Moho-depth or crustal thickness in China (Figure 10) shows that same trisection pattern. The Moho is deeper in the west and shallower in the east. Its depth is about 45 km in the middle area, more than 60-70 km in the western area, and 38 km in the eastern area. The Moho depth gradually decreases towards the east and is only 8 km in Okinawa Trough (Yuan xuecheng, 1996; Huang Jiqing, 1980).

The trisection pattern of the geothermal areas corresponds with the distribution pattern of the crustal thickness and Moho depth of the China mainland.

3.3.2 The isostatic gravity compensation function

In the 1950s, the geologist Dr. Li Siguang pointed out that the modern China mainland topography is apparently correlative with the crustal thickness, and that the correlation is indeed associated with the formation. He subsequently developed the isostatic gravity compensation function, discussed in the formation of the modern China mainland topography.

Largely, the density of rocks increases with increasing depth in the earth’s crust. The sediment density is 2.4 g/cm³, the sima in the upper crust is 2.72.4 g/cm³, the upper mantle is 3.32.4 g/cm³. When the different morphological units of the continental crust and the oceanic crust reach an isostatic state (Figure 11), the base-level depth of the isostatic compensation should be accordant, with a difference is crustal thickness (the depth of upper mantle). The thickness of oceanic crust is about 11 km and the thicknesses on the craton are 30km on the plain, 36 km on the plateau and 54 km in the mountain area.
The western crust of the Chinese mainland is thickened by the compression and the eastern crust is thinned through extension. Isostasy is evidently changing. The inherent trend of crustal isostasy behaves as: crustal down-faulting as result of loading of sediments or continental glacier, and crustal rise due to mountain erosion, denudation or glacial melt-off. Through local elevation and subsidence and constant adjusting, the earth’s crust reaches an isostatic state. The isostatic gravity compensation function brings up the trisection pattern of the topography, crustal thickness and Moho-depth of the Chinese mainland. Figure 12 shows the isostatic compensation between the continent and ocean. Moreover, factors such as heat flow changes react on the deep crustal structures.
3.3.3 The relation of geological evolution and crustal thickness to heat flow

On the stable continent, the heat flow increases from the paleostructures to the neotectonic regimes, and reflects the processes of the geological evolution. But in the active tectonic zone, the energy is redistributed. The temperature at depth has a higher horizontal gradient, so the relation between the crustal thickness and heat flow is complicated. Through research of heat flow and crustal thickness (Huang Shaopeng, 1992), the terrestrial heat flow is constituted by that of the earth’s crust and the mantle. The crustal heat flow has a positive correlation with crustal thickness, while the mantle heat flow tends to lack correlation with its thickness. Thus the terrestrial heat flow is related to upwelling of the upper mantle and the associated thinning of the earth’s crust in rift valley basins.

3.4 The rock’s thermal conductivity

The thermal conductivity of rocks represents the rock’s capacity for heat transfer, and is controlled by its constituents, structure, humidity, temperature and pressure, etc. Among the rock-forming minerals, the thermal conductivity of quartz is the higher (17.0 cal/cm·s·°C) and of feldspar is the lower (4.5 cal/cm·s·°C). The geological age and the structure are the main controlling factors of thermal conductivity. Ancient crystalline rocks and compact rocks have higher thermal conductivity, while semi-consolidated or loose sediments in Cenozoic have lower thermal conductivities. The rock has higher thermal conductivity along the direction of the parallel texture plane, and the heat flow is...
concentrated areas of low resistivity. So the higher values of heat flow can be observed in the anticline axis and the upper part of other positive structures, where the thermal conductivity is higher, and where the upper loose stratum is thin. Thus, the average heat flow is 62±13 mW/m² in the Huabei Mesozoic-Cenozoic fault basin, 78±14 mW/m² in the basement uplift area and 51±8 mW/m² in the basement depression area. The distribution and changes of the heat flow primarily reflects the alternating normal and reverse faults in the basement structure.

4. CONCLUSIONS

1. There are two high temperature geothermal areas in China: the Taiwan geothermal zone and the Himalaya geothermal zone, which belong to the global geothermal belts.

2. Low temperature geothermal areas are widely distributed in the vast area of the Chinese mainland. The allocation of hot springs, geothermal wells and high heat flow areas are controlled by geological structure.

3. Taking Ordos - Sichuang Basin as the centre, the geothermal areas in China can be divided into three sections:
   a) The Eastern geothermal area. The strike of the geothermal zone is mainly north-east. The local crustal stress field is extensional. The heat flow is high and the geothermal system is a low temperature hot water cycle.
   b) The Western geothermal area. The strike of the geothermal zone is mainly north-west. The local crustal stress field has an extrusive nature. The heat flow is low in most areas, except the Himalayan high temperature geothermal zone. The geothermal system carries a low temperature freshwater brine in hydrocarbon mines with low mineralization water.
   c) The Middle geothermal area. The strike of the geothermal zone is mainly north-south. The local crustal stress field has the extrusive nature. The geothermal system carries a low temperature and highly concentrated hot brine.
   d) The trisection pattern of the Chinese geothermal areas is corresponding to the same distribution pattern as that of the crustal thickness and Moho-depth of the Chinese mainland, this represents an inner relationship among of them. The development of the Chinese geothermal areas is affected by geological evolution of the crustal and by the isostatic gravity compensation function.

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