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Geothermal Gradient in the Ordos Basin

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ABSTRACT

The Ordos Basin is a large-scale sedimentary basin, locating in the northwestern China. Three hydrogeological units are present in the basin, i.e. karst groundwater area in the margin of the basin, the Cretaceous Artesian Basin in the middle and the loess covering area in the west. The paper, firstly, presents the geologic and hydrogeological conditions, which provides the basic understanding of the basin. Then the paper shifts to the major part, the distribution of the geothermal gradient of the basin. In the karst groundwater area, features on geothermal gradient are discussed, mainly for the east and south margin, where geothermal resources are abundant. In the Cretaceous artesian basin, features on geothermal gradient are presented for different zones.

1. INTRODUCTION

The Ordos Basin, located in the eastern part of the north-western China in a large meander of the Yellow River, overlaps Gansu, Shaanxi, Shanxi, Ningxia and Inner Mongolia provinces or autonomous regions. It covers an area of about 270 000 km^2 (Figure 1). The Ordos basin is a low-temperature geothermal field and the major geothermal reservoirs are sandstone and limestone. The basin contains three major hydrogeological units, Karst groundwater area, the Cretaceous Artesian Basin, and loess covering area(Wang et al., 2002).

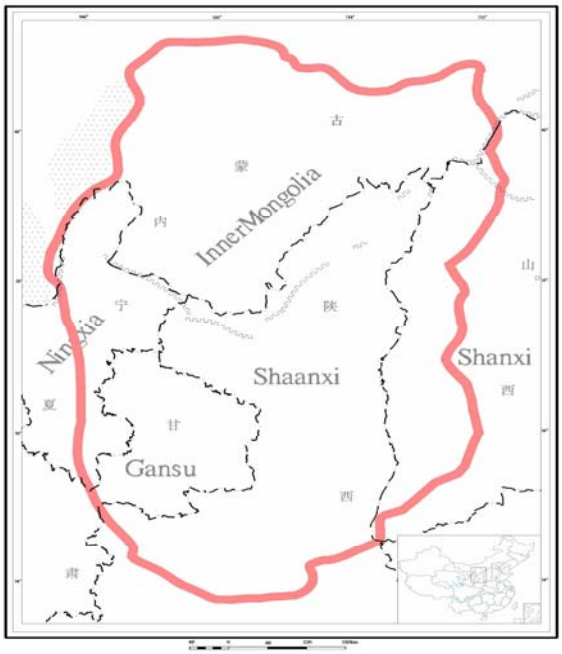

Figure 1 Location Map of the Ordos Basin

Numerous studies on geothermal have been carried out in the Ordos Basin. Chen,M.X., Wang, J.Y., Deang, X. (1994) described the thermal gradients for different depth in the Ordos Basin. Miao, Z.H., (1990) presents hot springs and thermal resources in the Ordos Basin. Liu, S.B., and Si, S.R., (2001), described geothermal resources in the provinces located in the Ordos Basin. In recent years, Ministry of Land and resources, China launched a deep groundwater investigation project, form which new information were obtained form boreholes. The paper integrates the new data into the understating of the thermal resources in the Ordos Basin.

2. GEOLOGICAL AND HYDROGEOGICAL CONDITIONS

The Ordos Basin is a synclinal sedimentary large-scale basin with its axis directing south-north approximately. The distance is 620Km from south to north, 400 Km from west to east. The geometry of the basin is extremely asymmetric. Its east limb extends gently, with average dip angle of 1-2^o, and its west limb consisting of a series of north-south fault zones.

Karst groundwater basin in carbonate rocks of Cambrian and Ordovician bases on crystal metamorphic rocks of pre-Cambrian which is of asymmetric feature. Water-bearing formation is dominated by limestone with some interbeding dolomite and little clastotile. The total thickness is up to 2000m. Depth of limestone of Ordovician, occurring in peripheral area of the basin, is about 4000m in the center of the basin. Based on hydrogeological conditions, the karst groundwater system is divided into 9 sub-systems.

The artesian groundwater basin is located in the middle-west part of the Ordos Basin, 600km long from south to north and 300km from east to west. The geometry of the basin is asymmetric, east limb gentle and west limb steep. The Baiyu Mountain divides the artesian groundwater basin inot two parts, i.e. desert plateau in the north and loess plateau in the south.

Desert plateau is in the north of the basin with gentle relief. The basin is covered by sand, which is favorable to infiltration of rainwater. Groundwater is discharged in means of evaporation and artificial discharge mainly, beside discharge to rivers in the peripheral area of the basin. Groundwater water in different aquifers has close links, due to absence of regional aquitard.

In the south part of the basin is loess plateau that has fragment surface. Groundwater recharge is relatively small besides loess Yuan area and outcrops area. Groundwater discharges to regional erosional basis. Aquifers in cretaceous system have different water level, quantity and water quality. Luohe aquifer has relatively large amount and good quality across the whole basin.

3. THERMAL GRADIENT IN THE BASIN

3.1 Thermal Gradient in the Cretaceous Artesian Basin

Figure 2 shows the distribution of the thermal gradient in the Cretaceous Artesian Basin. Thermal gradients are calculated form the temperature logging data obtained form logging in the petroleum and hydrogeolgical boreholes. Thermal gradient calculation is form the temperature constant zone which varies in different zones to the bottom of the borehole. the Generally speaking, the thermal gradient ranges between 2.5-3.0□/100m. In the south, the thermal gradient is higher that that in the north. This feature is mainly due to the difference on the hydrogeological conditions, i.e. in the north regional aquitard is absence.

In the north part, the thermal gradient is lower than 2.5□ /100m, except two zones. One is located in the south-west corner, another is located in the west margin. In the south part, the thermal gradient is between 2.5-3.0□/100m in most area, only in the south-west corner the thermal gradient is lower then 2.5□/100m (Chen,M.X.et al., 1994).

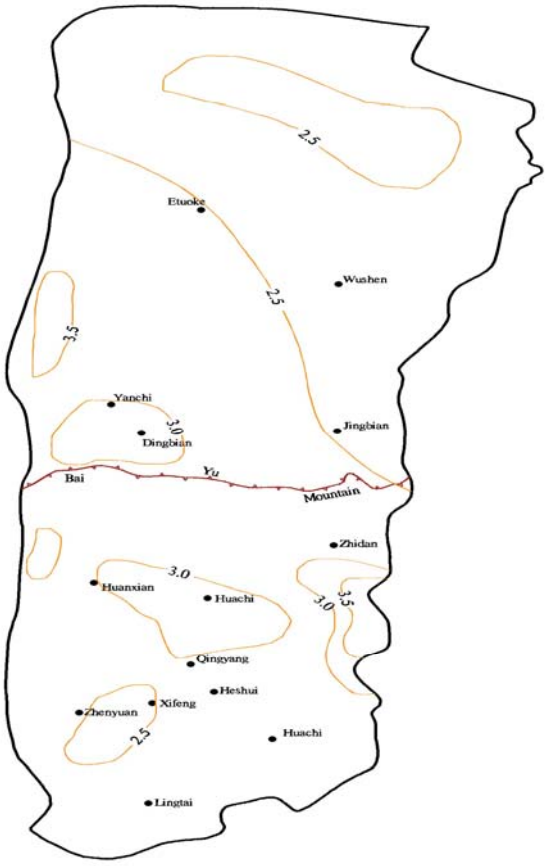

Figure 2 Thermal Gradient in the Cretaceous Artesian Basin

3.2 Thermal Gradient in the Karst Area

The thermal flux in the karst area is 70mw/m^2 in most area with the maximum of 276mw/m^2. The average thermal gradient in the karst area is 4.29□/100m, which is higher than that in the Cretaceous Artesian Basin. Difference of the thermal gradient among different zones is as large as 17.1□ /100m(Li et. al., 1997). Generally speaking, the east margin and south margin are the places where thermal gradient is higher.

The thermal gradient distribution is discussed for two subsystems, Liuling subsystem in the west margin and East Weibei subsystem in the south margin. The Liuling subsystem is located in the Middle West margin, covering an area of 10 000km^2. The major reservoir in the subsystem is limestone of Ordovician. Thermal gradient was measured in 15 boreholes and the values are listed in the figure 3. The thermal gradient is less than 3□/100m in the north, divided by the SanChuan creek, while greater than 3□/100m in the north (Yuan et. al., 2002).

The East Weibei subsystem is located in the south margin, covering an area of 6 200km^2. the major reservoir is limestone, dolomite and sandstone of Ordovician and Cambrian. The thermal gradient in the subsystem varies between 3.0-3.5□/100m, increasing form north to south. In the south boundary, groundwater temperature is the highest due to the presence of active faults and the thermal gradient is as high as 7.1/ □/100m local places (Dang et. al., 2002).

The thermal gradient patterns are different in the Cretaceous Artesian Basin and the karst area. In the Cretaceous Artesian Basin, the thermal gradient is controlled by the confining bed. In the north where regional aquitards are absent has lower thermal gradient than that in the south. In the karst area, the thermal gradient is controlled by the fractures which provide conduits to the deep hot water. Energy release in the dissolution of gypsum present in the carbonate rocks provides hot sources in some area ,.

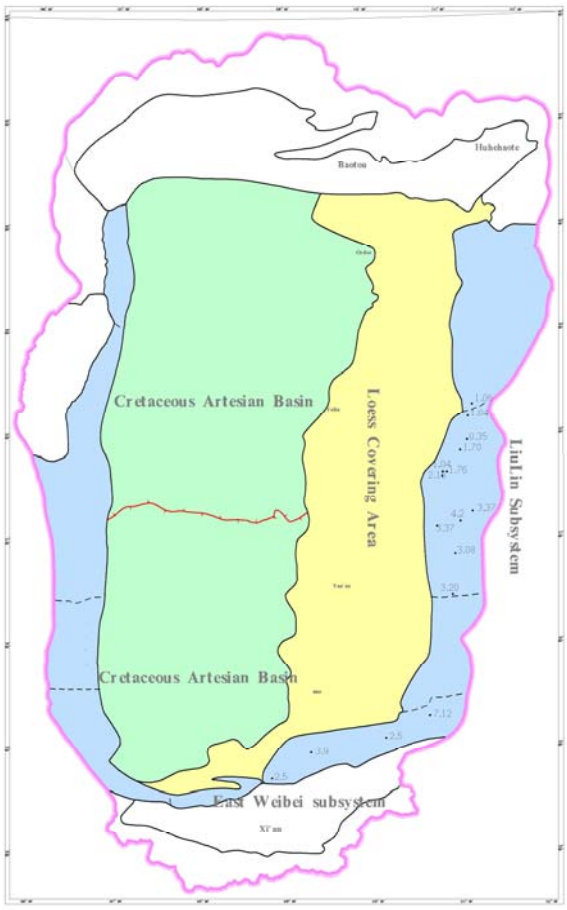

Figure 3 thermal gradient values in the karst subsystems and major hydrogeological units

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