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Terrestrial Heat Flow Distribution Pattern and Its Implication for Geological Processes in Sichuan Basin

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ABSTRACT

Terrestrial heat flow (THF) has been considered as a significant parameter reflecting internal information of earth, which can imply further meanings about subsurface tectonic and geophysical processes in the planet. Sichuan Basin is a craton with thick sedimentary strata varying from continental to marine facies with a crystalline basement. This paper collects 147 THF values from hydrocarbon well steady temperature logging and previous publications for Sichuan Basin, which almost cover all tectonic units in the basin. Subsurface characteristics for structure and material &energy movement can be macroscopically demonstrated by the THF distribution pattern. In addition, statistical distribution diagrams of these THF data are calculated to further compare with other basins in China. Tectonic and deposition behaviors of basin are further discussed in the point of geothermal view.

1. INTRODUCTION

Heat transferring has three different mechanism, heat conduction, heat flux and heat radiation. Research activity about Sichuan Basin heat regime has been tens of years. As this basin has a long history for salt production, people are able to look deep into the underground temperature field in those drilling wells. After 1970s, a large number of deep wells finished in this basin because of natural gas exploration & exploitation has increasingly developed here, which begins to open a window to observe subsurface heat kinetics. Furthermore, there are more than 100 heat flow (HF) values from previous work and publications are used within Sichuan Basin in order to get something interesting for tectonic and crust-mantle comparison.

2. GEOLOGICAL BACKGROUND

The stratigraphic framework and tectonic movement history of the basin has been well studied and (Wang et al.,1989; Guo et al.,1996; Cai et al., 2003 and so on), and tectonic evolution phase experienced of the Basin has been widely investigated, recognized and broadly discussed. Guangxi movements (Caledonian), the Yunnan and Dongwu movements (Hercynian), the Indonesian movement, the Yanshanian movement and the Himalayan movement, were all recorded in the sedimentary sequence (Zhu et al., 2016). In addition, Sichuan Basin is a combination of marine facies and lacustrine facies. The sedimentary environment changes dramatically during Permian (He et al., 2014), while the famous Emeishan basalt magma eruption exist in the same geological age.

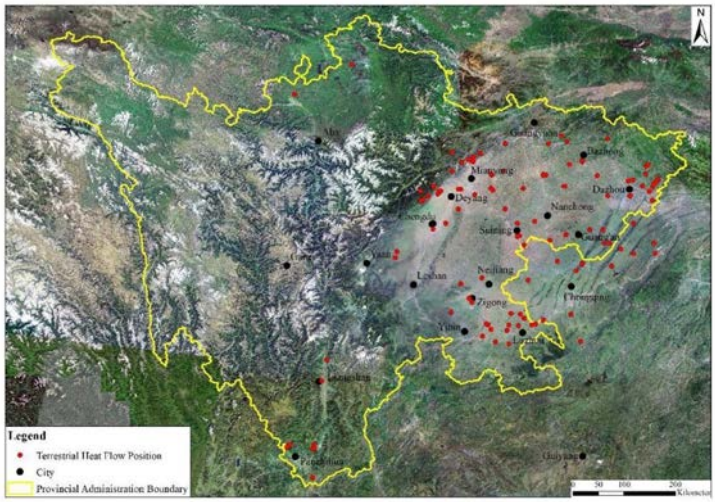

Figure 1: Distribution of Terrestrial Heat Flow in Sichuan

3. HEAT FLOW FOR SICHUAN BASIN

Based on Fourier's law, one-dimension steady heat conducting equation:

$$q = -k \cdot \frac{dT}{dH}$$

q: heat flow, W/m^2

k: heat conductivity, W/m.K

dT/dH: temperature gradient, K/m.

We have collected 136 subsurface steady heat flow (HF) values measured from drilling holes or hydrocarbon wells in this Basin and surrounding Panxi Rift Valley (PRV) from our own material and relevant publications (Hu et al., 2001; Jiang et al., 2019) and make assumption that heat flow in the basin is uniform, without heterogeneity. According to data quality classification method (Wang et al., 2015), 69 values in A level, 33 values in B level and C-D level values are 32. The HF values dominantly cover the basin as well as majority of them are located along Longmen mountain fault zone (west boundary), central and southeastern basin and Huaying mountain folded belt (east boundary), as shown in Fig 1.

4. DATA AND METHOD

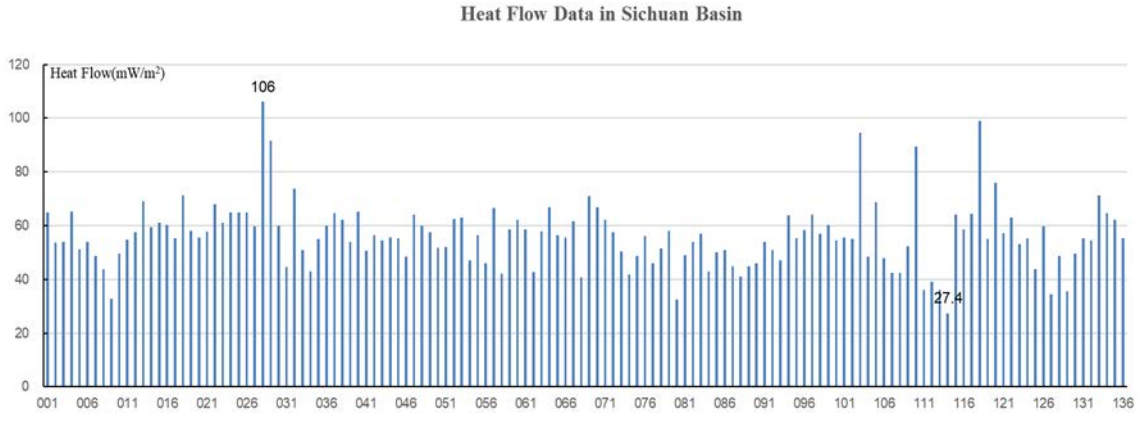

Figure 2: Heat Flow Data Sampled in Sichuan Basin

We plot 136 HF values on axis and the maximum HF is shown as 106 mW/m^2(Weiyuan), locating in central basin, whereas the minimum value is 27.4 mW/m^2 (Panzhihua, demonstrated in fig 3. Furthermore, average value is 56.2 mW/m^2, which is lower than that(61.2mW/m^2) of continental area in China (61.2mW/m^2, referenced as Wang et al., 2015). Most of them are between 40-60 mW/m^2.

Sichuan Basin is divided into five unit according to basement structure type, they are north unit (fold belt), west unit (depression zone), southwest unit (fold belt), central unit (uplift zone) and east unit as thrust-fold belt (Liu et al., 2018), which are displayed in

figure below. There are 20 HF values distributing in west unit, 38 values in north unit, 43 values in east unit, central area includes 17 HF values in our collected data. The range and average of HF of each unit are tabulated below.

The central area has the highest average heat flow as 62.2mW/m^2, and north region generates the lowest one of 51.6 mW/m^2. The average heat flows of southwest and east are relatively high.

Table 1:

Regional Heat Flow Statistic

Region	**No. of HF**	**Range(**mW/m^2**)**	**Average(**mW/m^2**)**
North	38	34.3-66.9	51.6
West	20	42.6-65.2	55.5
Southwest	5	32.6-69.1	57.9
Central	17	42-106	62.2
East	43	40.7-91.6	57.18

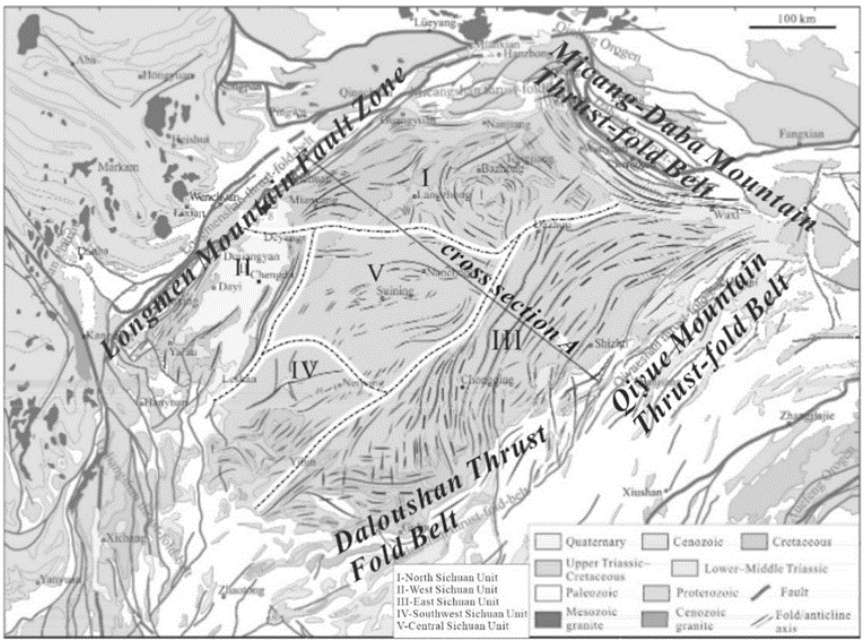

Figure 3: Sichuan Basin Geology (Modified from Liu et al. 2018)

5. DISCUSSION

Tibetan plateau block hits Yangtze block on which Sichuan Basin is formed, mainly controls the structure of Sichuan Basin. The buried geometry of Sichuan Basin is recognized by multi geophysical method, granitic crystalline basement uplift is observed in central Sichuan, and depression structures are found in north, west, southwest and east regions respectively, which are generally formed along fault or fold belt (Song and Luo, 1995). The heat flow in central uplift area is the highest, and large temperature gradient is also found here. Heat tends to move aggregately into uplift part, that's why we get largest flow of heat in central part.

In addition, cross-section A in fig.3 is from northwest to southeast of Sichuan Basin, it goes through north, central and east unit. The geological schematic of the cross-section A demonstrates the tectonic distribution pattern of the basin, and the heat flow curve is also drawn from our data. The heat flow near Jialing River is relatively low, the values close to Yanting and Tongluoxia are relatively large. Furthermore, most of heat flows within central region are not so high as previous discussed. Here we think that this section is going through the north part of central area, far away from the point (Weiyuan) where the heat flow is the largest and the highest point of central uplift is drilled (Gu et al., 2013), which may imply that heat flow distribution can be useful to find out special tectonic point for one structure unit. Heat moving around Longmen Mountain fault zone is not so high whereas crack spaces are always regarded as channel for deep fluid and heat flowing upward. It means that we need to look further into deep crust and even mantle.

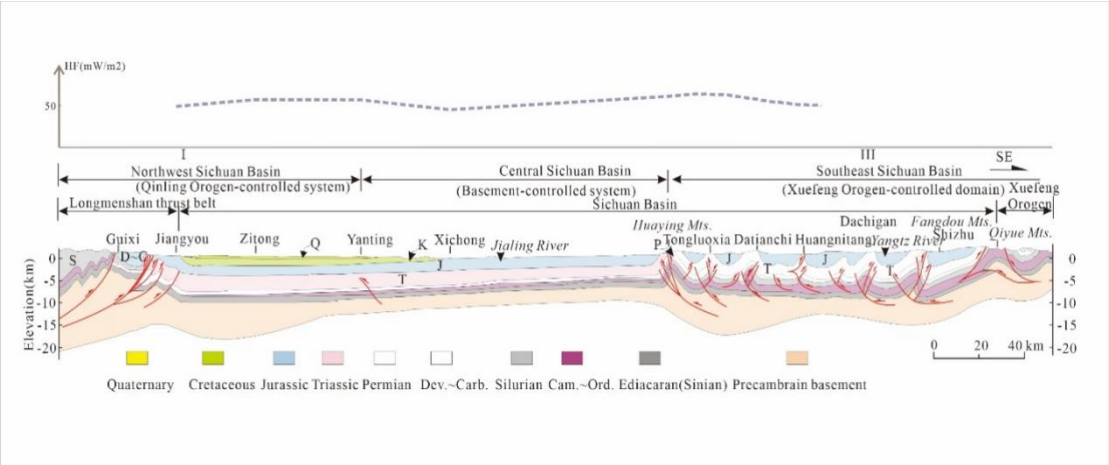

Figure 4: Cross-section A Representing Sequence and Heat Flow From West to East in Sichuan Basin(Modified from Liu et al. 2018)

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