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SILICA GEOTHERMOMETRY ESTIMATES OF HEAT FLOW IN THE FUJIAN PROVINCE, (P.R. CHINA)

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ABSTRACT

There is an empirical relationship between temperature calculated via the silica geothermometer and measured heat flow values (Swanberg and Morgan). Using data of the dissolved silica content of 1156 groundwater samples in Fujian province, silica geothermometry and heat flow values have been calculated. The results show that the estimated heat flow based on silica data on the west side of Zhenghe-Dapu fault, Western Fujian, is less than the estimated world average heat flow (41.5 HFU). However, heat flow on the east side of Zhenghe-Dapu fault, eastern Fujian, is higher (about 2 HFU) than the world average heat flow. This area is one which has a slightly positive heat flow.

INTRODUCTION

Heat flow is an important parameter of a regional thermal regime. However, financial restrictions put limits on the number of wells in which heat flow can be measured by the classical method of determining temperature gradient and thermal conductivity for rocks.

Based on data from New York, New Mexico and Egypt, Swanberg and Morgan (1978, 1980, 1983) proposed an empirical linear relation between temperature, calculated using the silica geothermometer and the regional heat flow, i.e.,

$$T\ SiO_2 = \frac{1314}{5.205 - \log(SiO_2)} - 273 \quad (1)$$

$$T\ Si02 = m\ g + b \quad (2)$$

$$g = \frac{T\ SiO_2 - b}{m} \quad (3)$$

where T Si02 is the estimated silica geotemperature (°C) based in the dissolved SiO_2 content of groundwater (assuming equilibrium with quartz); g is the regional heat flow in mWm^{-2} (41.8 mW m^{-2} = 10^{-6} cal/cm^2 sec = 1 HFU); b is the mean annual air temperature, and the coefficient m in equation (2) is related to the minimum average depth to which groundwaters circulate; this was assumed to be about 680°C $m^2\ W^{-1}$.

Using the above method, Swanberg and Morgan (1981) compiled a heat flow map of the United States and compared it with a heat flow map based on conventional methods (Sass et al., 1981). The results were similar. Quaternary volcanic areas, recently active tectonic regions and many geothermal anomaly areas are located within the range of the maximum contour (above 2.5 HFU). Silica heat flow estimates in Egypt were also consistent with this empirical relationship (Swanberg and Morgan, 1983). Zhang Zhifei (1985) researched silica heat flow of Western Sichuan, and found a close coincidence of high values with active sections of regional fault zones.

DATA

Data of the dissolved silica content of 1156 groundwater samples used in this study are based mainly on unpublished data of the Brigade of Hydrogeology and Engineering Geology of Fujian. Although these waters were analysed by different workers and there may be some differences in accuracy, we believe that they are essentially correct.

The Fujian Province was subdivided into blocks of 1" x 40' in size (almost 7000 km^2); each block encompassed an average of between 30 and 70 water samples whose silica contents were determined. The regional average annual air temperatures is 19°C in Fujian Province.

RESULTS AND DISCUSSION

Using equations (1) and (3), we calculated the arithmetic mean of silica geothermometer temperatures, their standard deviations and the estimate of the heat flow from the silica contents of the waters (Table 1).

Swanberg and Morgan (1981) show that for good correlation the standard deviation of silica geothermometer temperature should be less than 25°C. In the total results of Fujian, the standard deviations of 13 blocks are less than 25°C, and 7 blocks have deviations more than 25°C; this means that the reliability of 65% of the block data is high and that of the other blocks is less.

Plotting the silica heat flow values in the center of each block and using an interpolation method, the silica estimated heat flow contour map (Fig. 1) was drawn.

Figure 1 shows that the distribution of the estimated heat flow is rather regular. In the west, towards the Zhenghe-Dapu fault, silica heat flows are less than that of the average heat flow of the world (1.5 HFU), but east to the Zhenghe-Dapu fault, silica heat flows are higher than the world average, Zhangzhou (2.17 HFU), Dehua (2.07 HFU) and Puzhou (1.96 HFU).

Compilation of terrestrial heat flow data for the globe and comparison with the tectonic-thermal events, suggested by Chapman and Pollack (1977) and Sclater et al. (1980), indicates that the age of western Fujian crust (average heat flow is 56.4 mWm^{-2}) should be Paleozoic, and the age of eastern Fujian crust (average heat flow is 70.6 mWm^{-2}), Mesozoic-Cenozoic (Fig. 2).

However, in eastern Fujian which has a rather high silica heat flow, only a weak positive anomaly is indicated. For example, the high enthalpy geothermal fields of United States are located in high heat flow areas (72.5 HFU). The average value of measured heat flow in Yalu Zangbu Jiang, Xizang (Tibet) (Francheteau et al., 1984) is about 3.5 HFU. In Tengchong, western Yunnan, the silica heat flow value is about 3.3 HFU (Wan, 1986).

TABLE 1: SILICA GEOTHERMOMETER TEMPERATURES AND SILICA HEAT FLOW IN FUJIAN

Number	Name of District 'Blocks	Number of samples	Estimated T SiO_2 °C	Standard deviation °C	Estimated heat flow mWm^{-2}	HFU
1	Guangze	61	54	20	51	1.2
2	Pucheng	64	65	16	67	1.6
3	Shunchang	113	58	16	57	1.35
4	Jianou	33	61	12	62	1.5
5	Fuan	60	61	18	62	1.5
6	Sansha	32	69	22	73	1.75
7	Ninghua	32	62	26	63	1.5
8	Sanming	84	59	27	58	1.4
9	Nanping	51	70	24	75	1.8
10	Fuzhou	109	75	24	82	1.95
11	Changting	115	58	32	57	1.4
12	Yongan	106	57	32	56	1.35
13	Dehua	69	78	31	87	2.1
14	Fuqing	83	66	12	68	1.6
15	Shanghang	89	59	30	59	1.4
16	Longyan	33	45	22	38	0.9
17	Quanzhou	33	70	20	75	1.8
18	Zhangzhou	52	81	24	91	2.2
19	Xiamen	29	66	19	68	1.6
20	Dongshan	21	66	27	69	1.65

Practically no heat flow values were available for the Fujian Region described in this paper; the results presented here have closed this gap. The method used cannot replace direct heat flow measurements and does not define more local heatflow anomalies but it allows a description of the regional geothermal regime.

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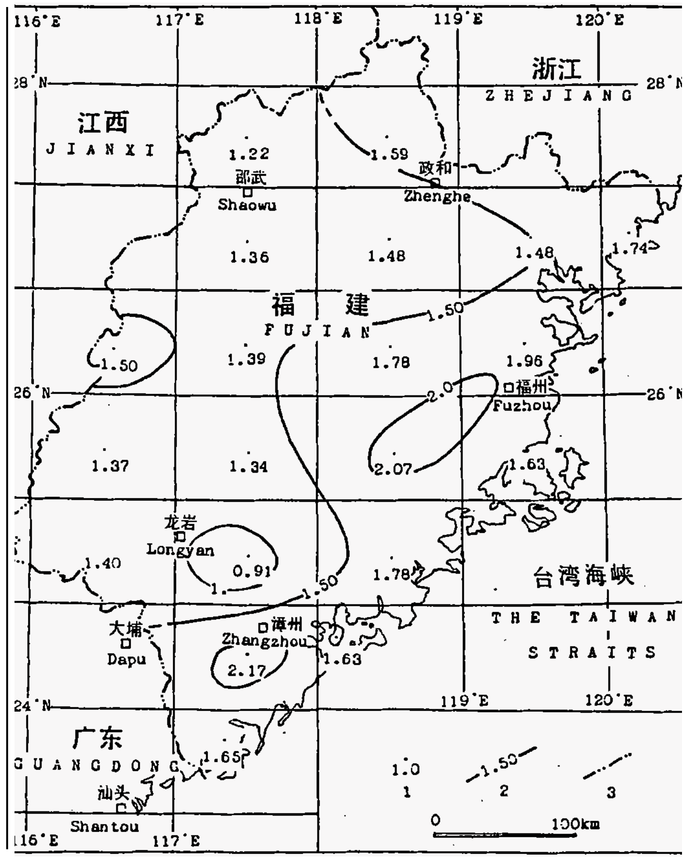

Fig. 1: Silica heat flow map of Fujian.

1. Silica heat flow unit of blocks (HFU).
2. Contour of heat flow units (HFU).
3. Boundary of Province.

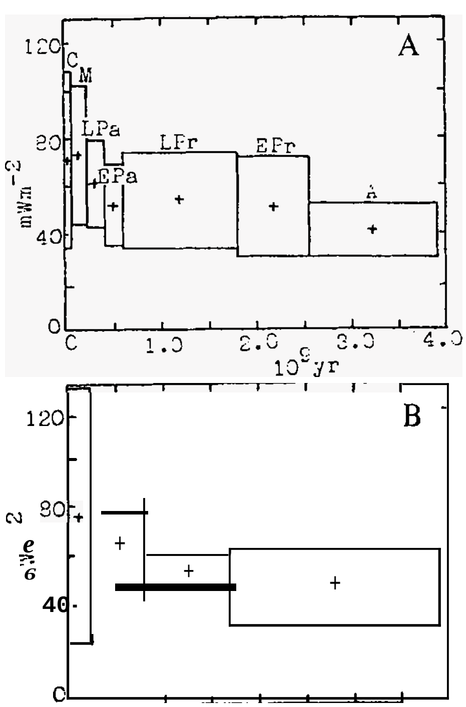

Fig. 2: The relation between terrestrial heat flow of the globe and time.

A. After Chapman & Pollack (1977).

C, Cenozoic; M, Mesozoic; LPa, Late Paleozoic; EPa, Early Paleozoic; LPr, Late Proterozoic; EPr, Early Proterozoic; A, Archean,

B. After Sclater et al. (1980).