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Prediction of Terrestrial Heat Flow in the Ordos Basin Using Machine Learning

Yuanjin Sun[1], Chuanqing Zhu[1]*, Yongwang Zhang[2], Xiaoxue Jiang[1], Fang Xie[1],Kefu Li[1]
1 State Key Laboratory of Deep Geothermal Resources, China University of Petroleum (Beijing), changping Beijing, China
2 College of Geosciences, China University of Petroleum (Beijing), Changping Beijing, China
*corresponding author, Email: zhucq@cup.edu.cn

INTRODUCTION

Terrestrial heat flow is a comprehensive geothermal parameter reflecting the regional thermal background. The terrestrial heat flow data are of great significance to understanding the thermal state and activity of the crust, the thermal structure of the lithosphere, and the evaluation of geothermal, oil and gas resources. Due to the limitations of the distribution of boreholes and rock coring, the spatial distribution of measured terrestrial heat flow data in China is uneven, and there is a large blank area of heat flow data outside sedimentary basins. The surface heat flow is closely related to the thickness of the lithosphere, the buried depth of Curie surface, and the geomorphology and the age of geological events. This study takes Ordos Basin as the research area, uses XGBoost method. Through the analysis and summary of various geological and geophysical parameters such as digital geomorphology, thermal tectonic events, and Moho surface burial depth, an intrinsic logical connection between multiple types of parameters and heat flow is constructed. Regional-scale geodetic heat flow prediction has been achieved.

SENSITIVITY ANALYSIS

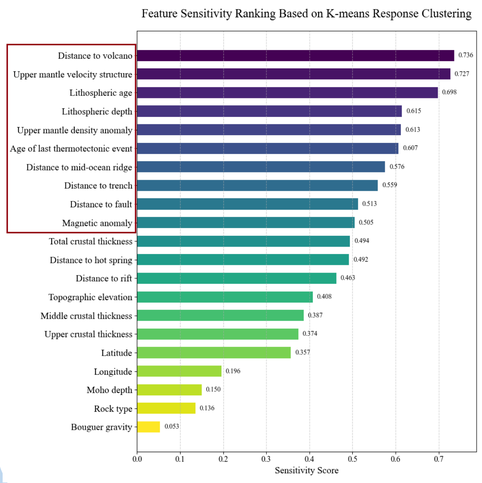
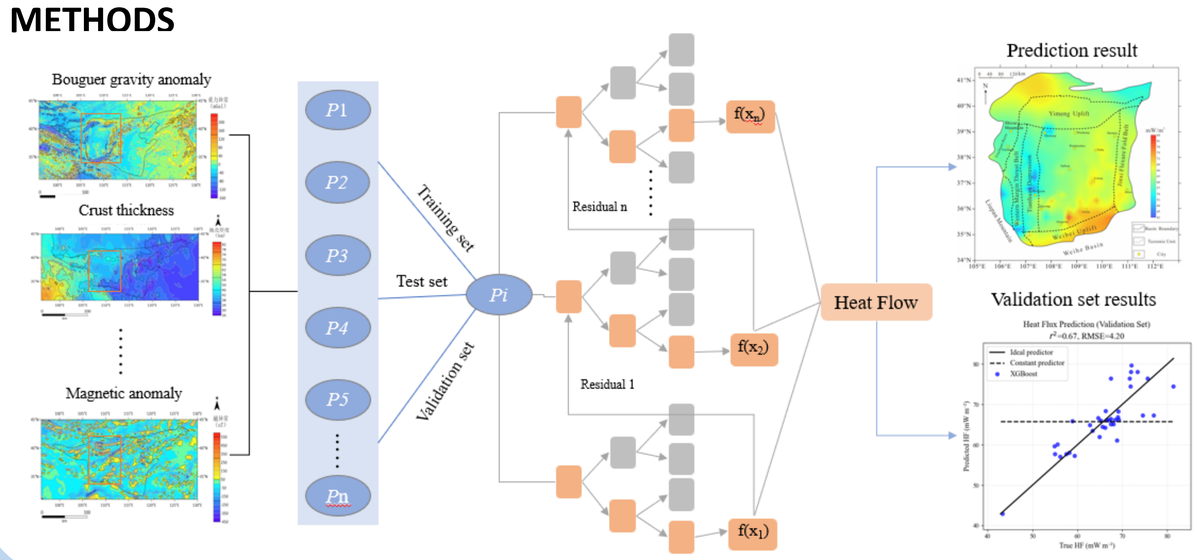


Table 1.The model evaluates the results of the validation data

	6	8	10	12
RMSE	4.87	4.8	4.20	4.87
MAE	3.69	3.75	3.22	3.76
R^2	0.55	0.56	0.67	0.55

	14	16	18	20
RMSE	4.87	4.33	4.56	4.52
MAE	3.98	3.44	3.46	3.64
R^2	0.55	0.64	0.61	0.62

METHODS



RESULTS

The prediction results of heat flow in the Ordos Basin:

1.The heat flow shows a distribution of low in the west and high in the east, and the high-value areas are concentrated in the Hetao Basin and the Weibei Uplift.

2.The predicted heat flow values range from 45 to 84 mW/m². The average heat flow is 62.84 mW/m²

3.Due to limited data, the prediction uncertainty of the basin boundary is relatively high, and the overall volume prediction error is ≤8 mW/m²

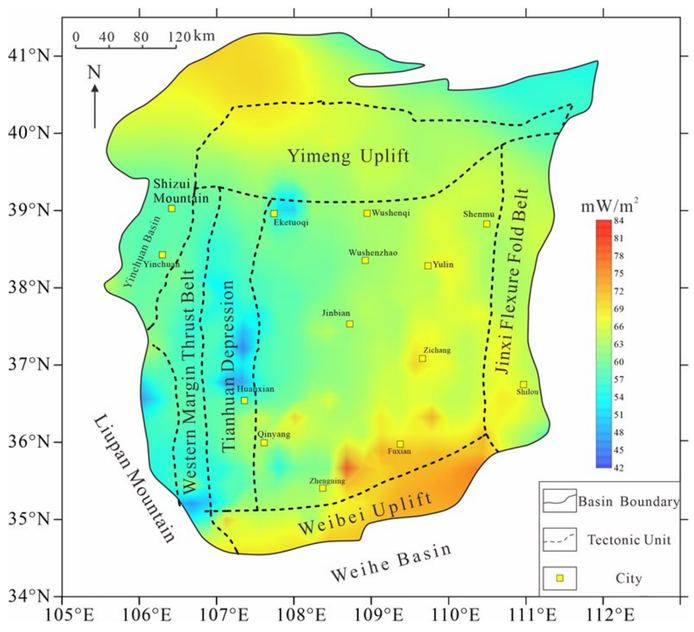


Figure 1. Heat flow prediction results of the Ordos Basin

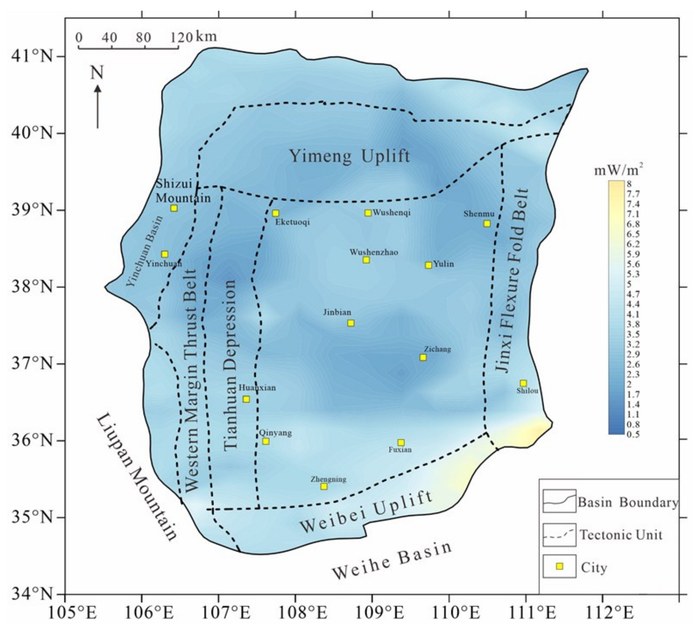


Figure 2. Model uncertainty analysis

Table 2.Comparison of heat flow results of different tectonic Units in Ordos

Tectonic unit	HF(mW/m²)	Avg_HF (mW/m²)	Pre_HF(mW/m²)	Avg_Pre_HF (mW/m²)
Yishan slope	61.7-68.8	65.6	49.8-83.9	63.7
Tianhuan depression	55.8-61.3	57.87	52.1-63	57.12
Jinxi fault-fold belt	69.2-69.8	69.57	57.4-68.4	64.45
Weibei uplift	60.2-67.2	64.94	59.1-73.6	69.36
Yimeng uplift	54-58.1	56.1	53.7-68.7	63.7
Western Margin thrust belt	53.7-70	56.8	45-65.8	57.6
Yinchuan Basin	—	54.43	58.3-62.4	59.2
Hetao Basin	—	—	54.9-70.2	63.65

DISCUSSION

1.The predicted heat flow distribution shows a good correspondence with the undulating pattern of the Moho surface

2. The high heat flow anomaly area and the low resistance body are highly consistent in space, confirming the accuracy of the model and revealing a unified cause: deep thermal activity triggers the melting of the lower crust and the upwelling of fluids, which, while forming the low resistance body, efficiently transport heat to the shallow part.

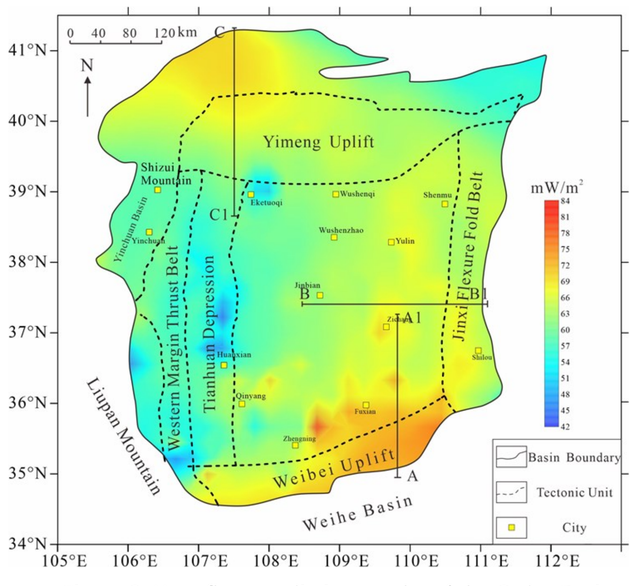


Figure 3. Heat flow prediction results of the Ordos Basin

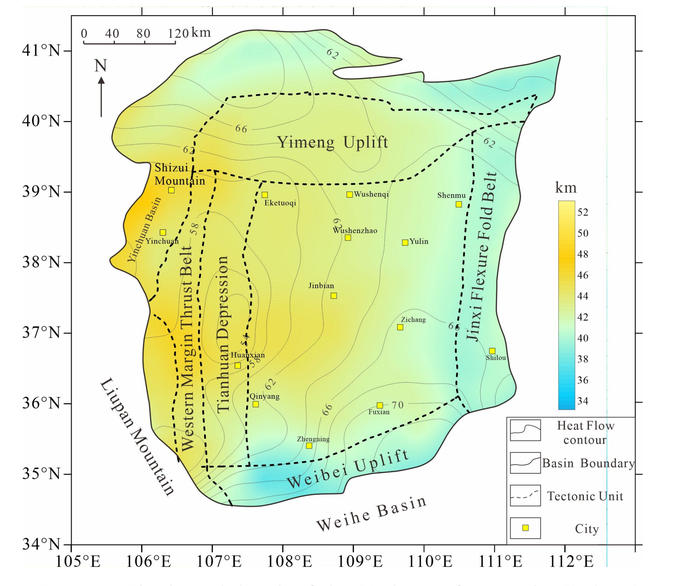
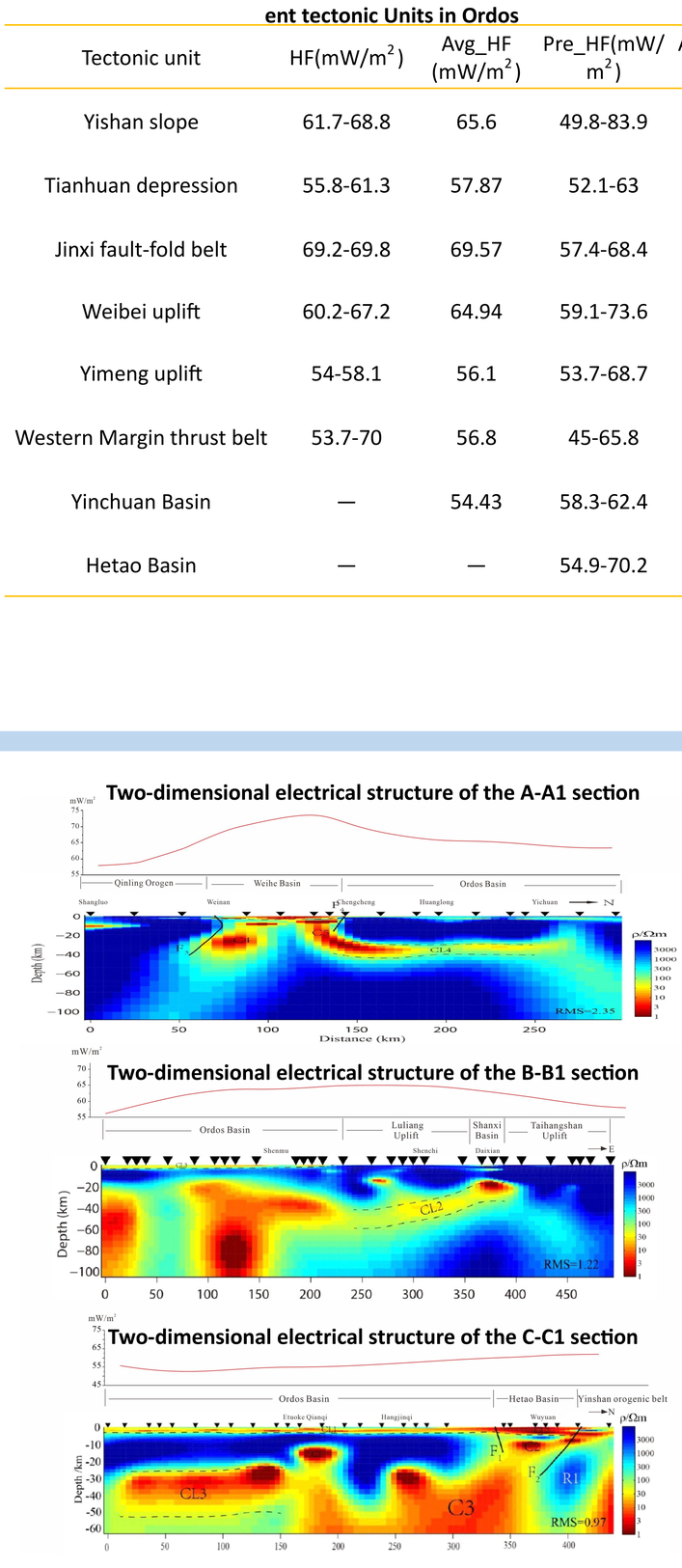


Figure 4. The burial depth of the Moho surface in the Ordos Basin



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