3-D Basin Modeling of the Changling Depression: A New Method of Exploring Petroleum Generation and Migration in Deep Tight Sandstone Reservoirs*

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Abstract

Tight sandstone reservoir has become a research hotspot among unconventional reservoirs. However, there is little research on the tight sandstone hydrocarbon reservoir forming characteristics and petroleum system. The 3D basin modelling is an effective method to address the masses and characteristics of petroleum generated, accumulated, and lost during the evolution of the basin. The Changling depression is the largest reservoir with abundant resources in the South Songliao Basin, China. The 3D structure model of the Changling depression was constructed from the basement to the ground surface based on the 3D seismic data along with well penetrations. The heat flow history was calibrated by present formation temperatures and observed maturity (vitrinite reflectance). Three main erosion episodes during the burial history (one in Early Cretaceous and two in Later Cretaceous) were also taken into consideration. The maturity levels of the Early Cretaceous source rocks (Shahezi Formation and Yingcheng Formation) were reconstructed and source rock evaluation studies show good gas generating potential. The reservoirs strata include Denglouku Formation and Quantou Formation in the Early Cretaceous. As we all know, tight sandstone reservoir has poor physical property and strong heterogeneity. Furthermore, Changling depression has complex fault system and multiple tectonic movements. In order to reach higher modelling accuracy, the Denglouku Formation is additionally subdivided into several subunits with different porosity, permeability, lithology, and sedimentary micro-facies distribution, based on the core analysis and Petrel simulation. Our research based on the source rock evaluation, reservoir fine modelling, and basin modeling, in order to study the abundance, types and maturity of source rocks, thermal history and hydrocarbon generation history of single wells and cross sections, speculated the process of hydrocarbon accumulation in the Changling depression. We

have the following recognitions: A) We found out that the hydrocarbon generation period is between the end of Early Cretaceous and the middle of Late Cretaceous. B) According to the inclusions homogenization temperature analysis, the Early Cretaceous reservoir should be formed at the end of Late Cretaceous. C) The petroleum system model of the Changling depression shows new favorable gas exploration targets and deepen the understanding of deep tight sandstone reservoirs.

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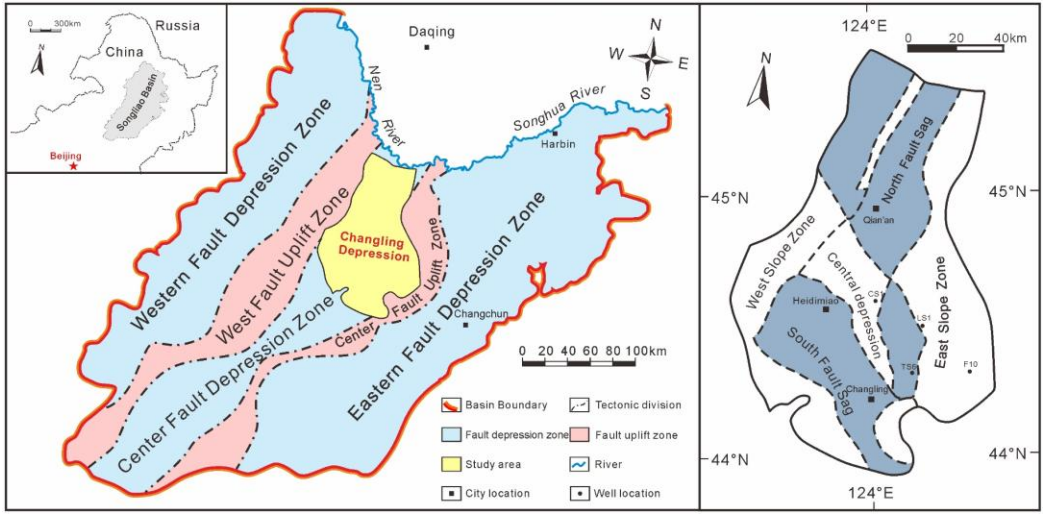
Introduction



The Changling fault depression is the largest petroliferous block in south Songliao Basin, north-east China.

The hydrocarbon accumulation is mainly in Cretaceous strata with the burial depth of 2000~4000m.

The Early Cretaceous reservoir didn't received enough attention due to the deep burial depth until the unconventional reservoir became the research hotspot.

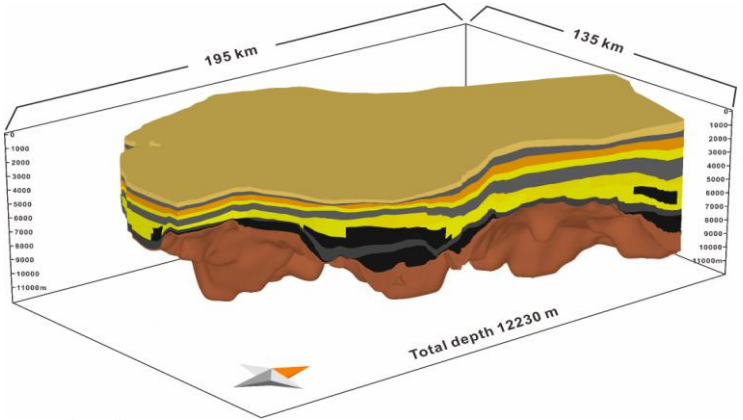
Brief workflow

1. **Establish the model**
2. **Determination of boundary parameters**
3. **Calibration of the model**
4. **Simulation and analyze the results**
5. **Discussion and promotion**

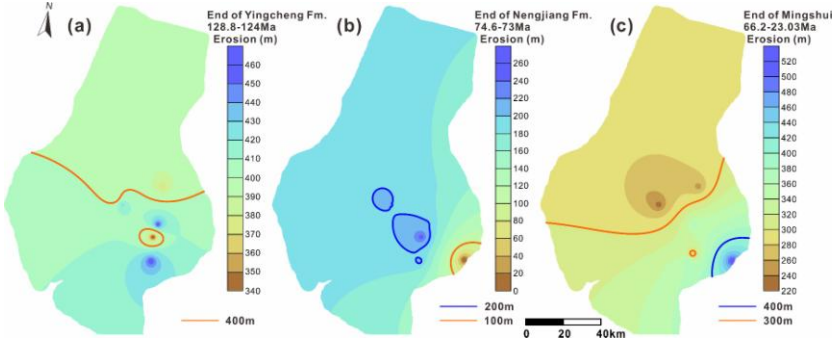
1. Establish the model

Layer Name	Color	PSE	Lithology
Cenozoic		OR	Siltstone (organic lean)
Mingshui Fm.		OR	Siltstone (organic lean)
Sifangtai Fm.		OR	Sandstone (clay rich)
Nenjiang Fm.		OR	Siltstone (organic lean)
Yaojia Fm.		OR	Sandstone (clay rich)
Qingshankou Fm.		OR	Sandstone (clay rich)
Quantou Fm.		RR	Sandstone (typical)
		SeR	Shale (typical)
Denglouku Fm.		RR	Sandstone (typical)
Yingcheng Fm.		SR	Shale (typical)
		RR	Sandstone (typical)
		None	Igneous rocks mixture
Shahezi Fm.		SR	Siltstone (organic rich)
		SR	Coal (silty)
Huoshiling Fm.		SR	Siltstone (organic rich)
		UR	Conglomerate (typical)

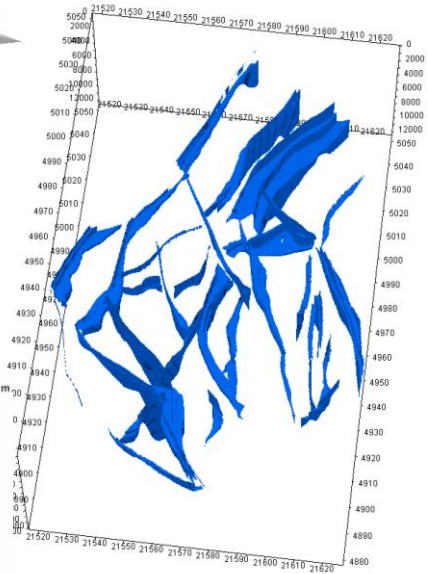
Lithology definition



Set up the layers using 3D seismic interpretation result



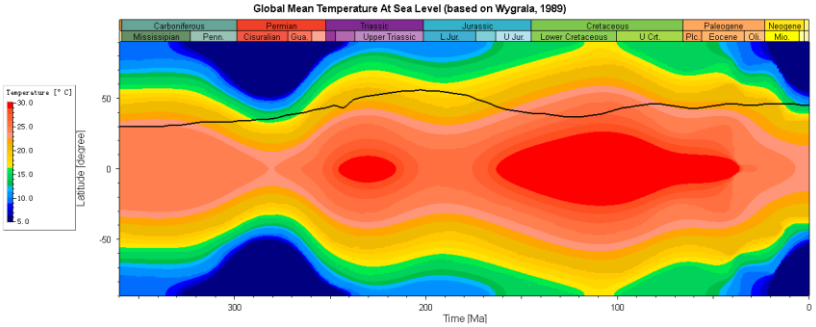
Erosion maps loaded for the three main erosion events



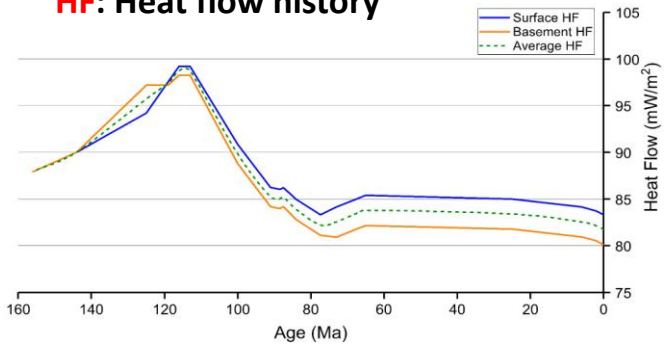
Build gridded faults

2. Determination of boundary parameters

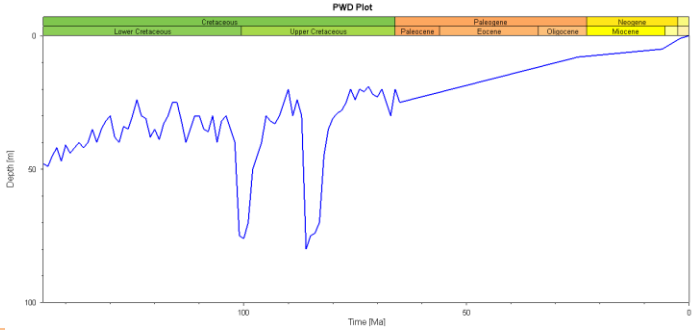
SWIT: Sediment water interface temperature



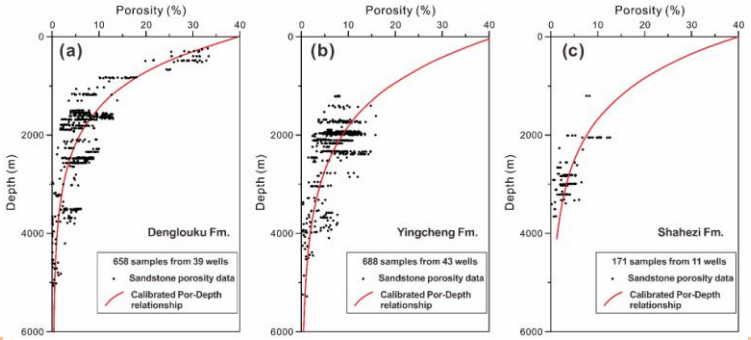
HF: Heat flow history



PWD: Paleo water depth



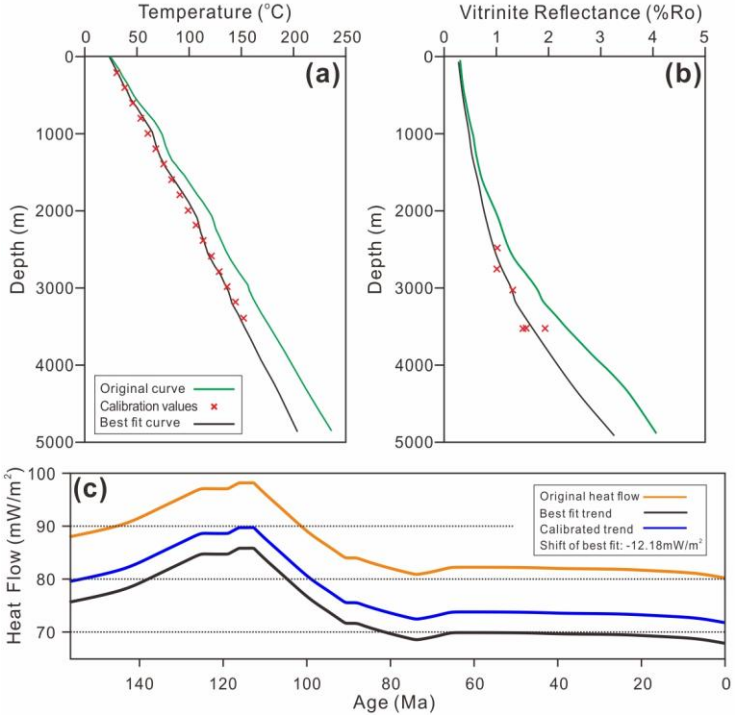
Lithology: porosity settings



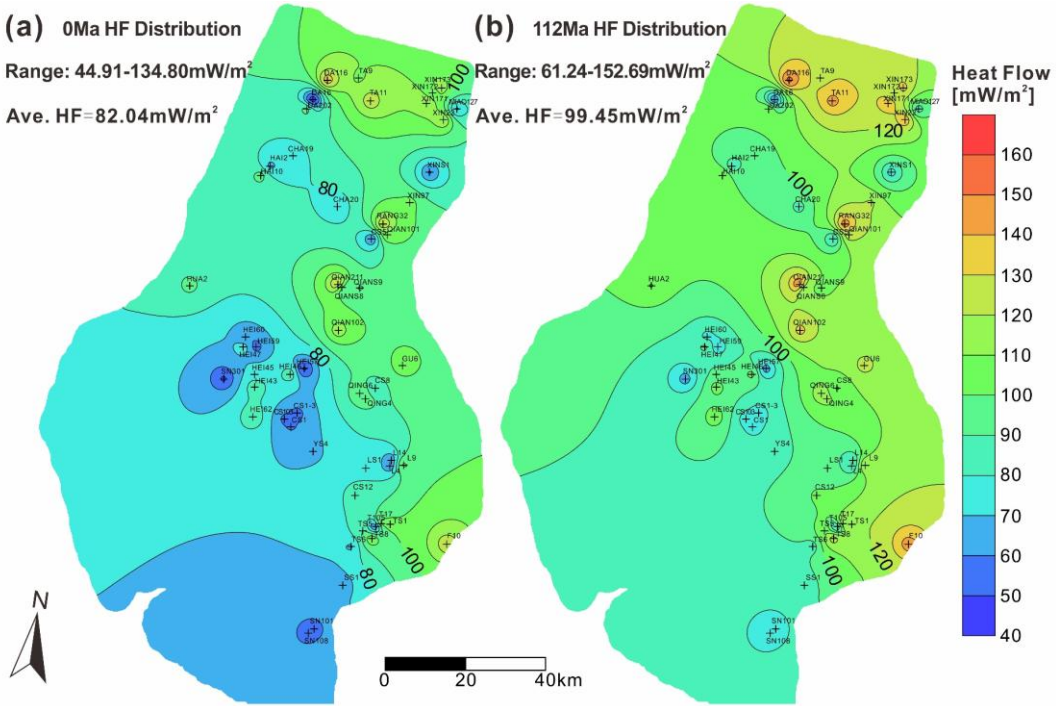
Others:

Source rock Properties, Permeability, Kinetics and so on.

3. Calibration of the model

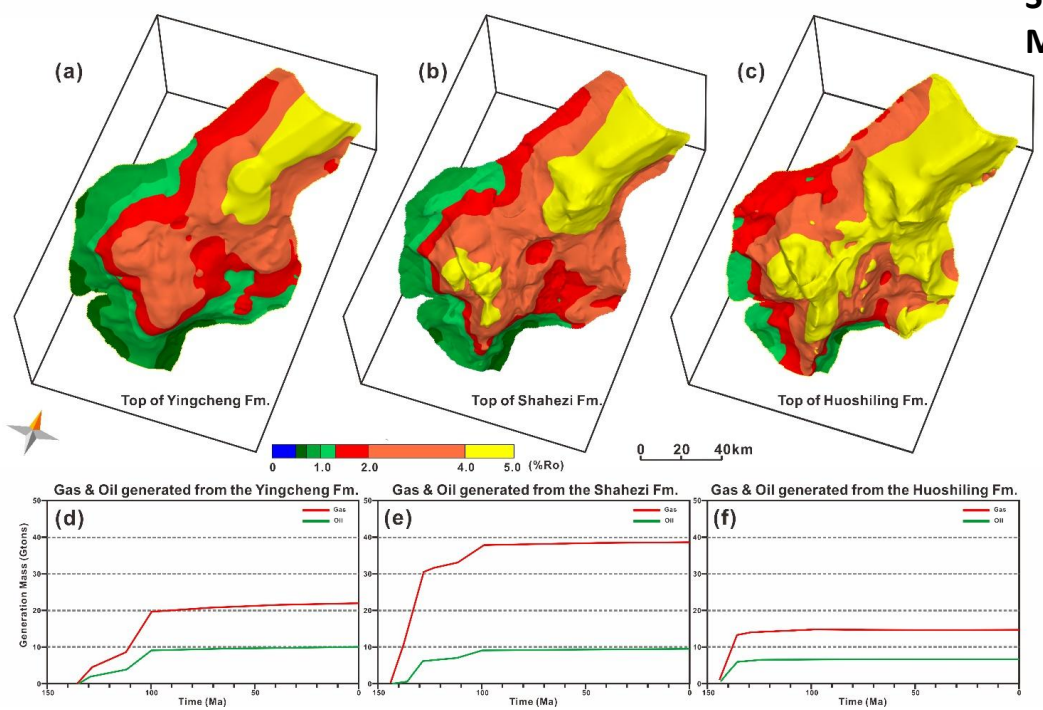


Result of heat flow calibration (single well)



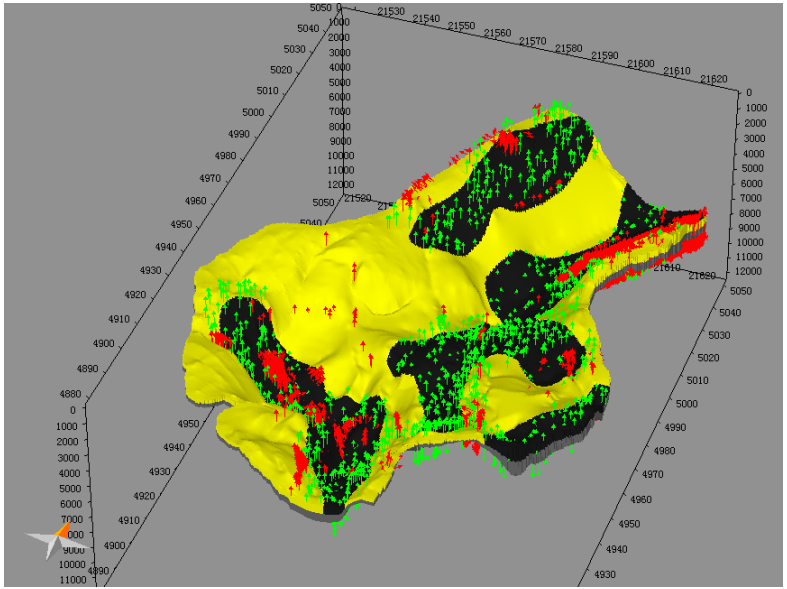
Heat flow distribution definition

4. Simulation and analyze the results



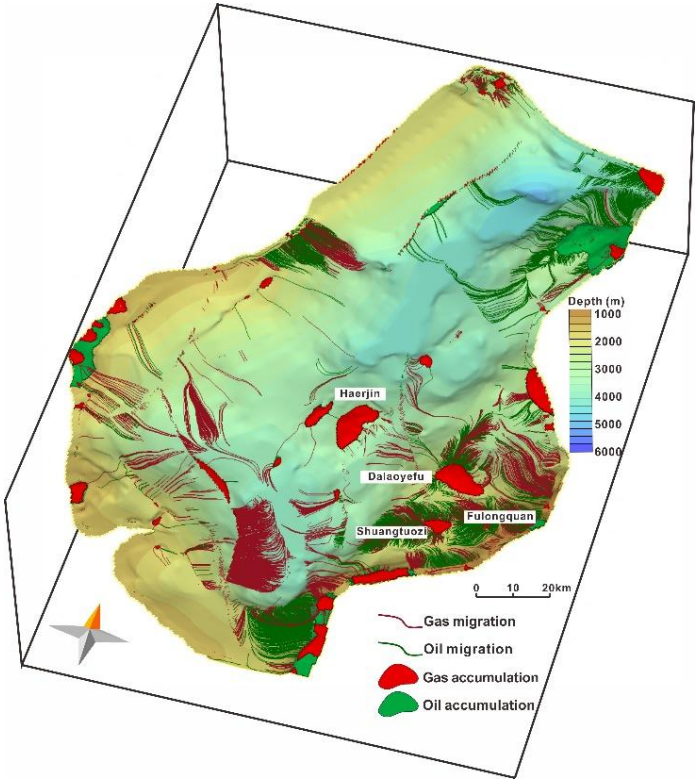
Source rock maturation and hydrocarbon generation

Sampling 2×2 grid size (400 m^2 per cell);
Migration method: Hybrid (Darcy flow and Flowpath)

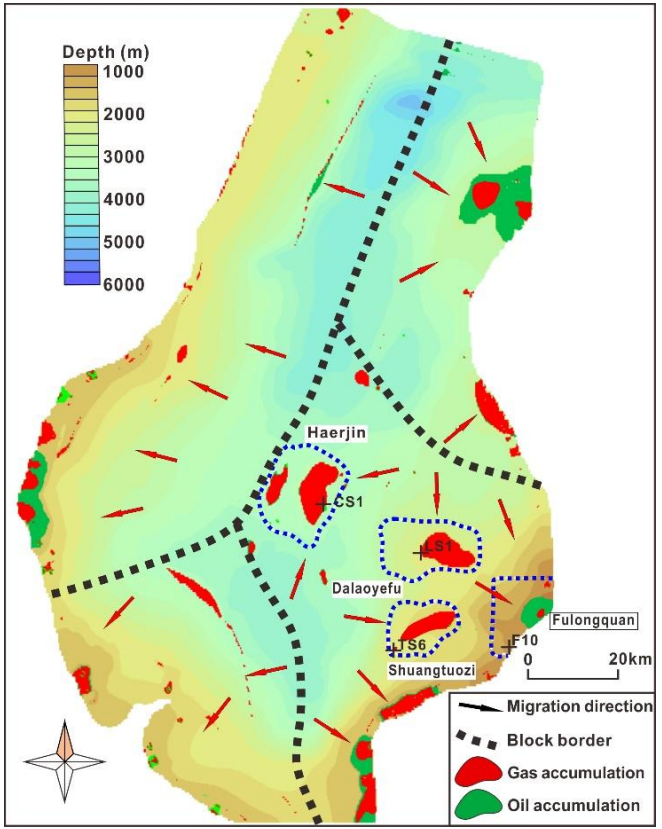


Gas & oil expulsion directions(Shahezi Formation)

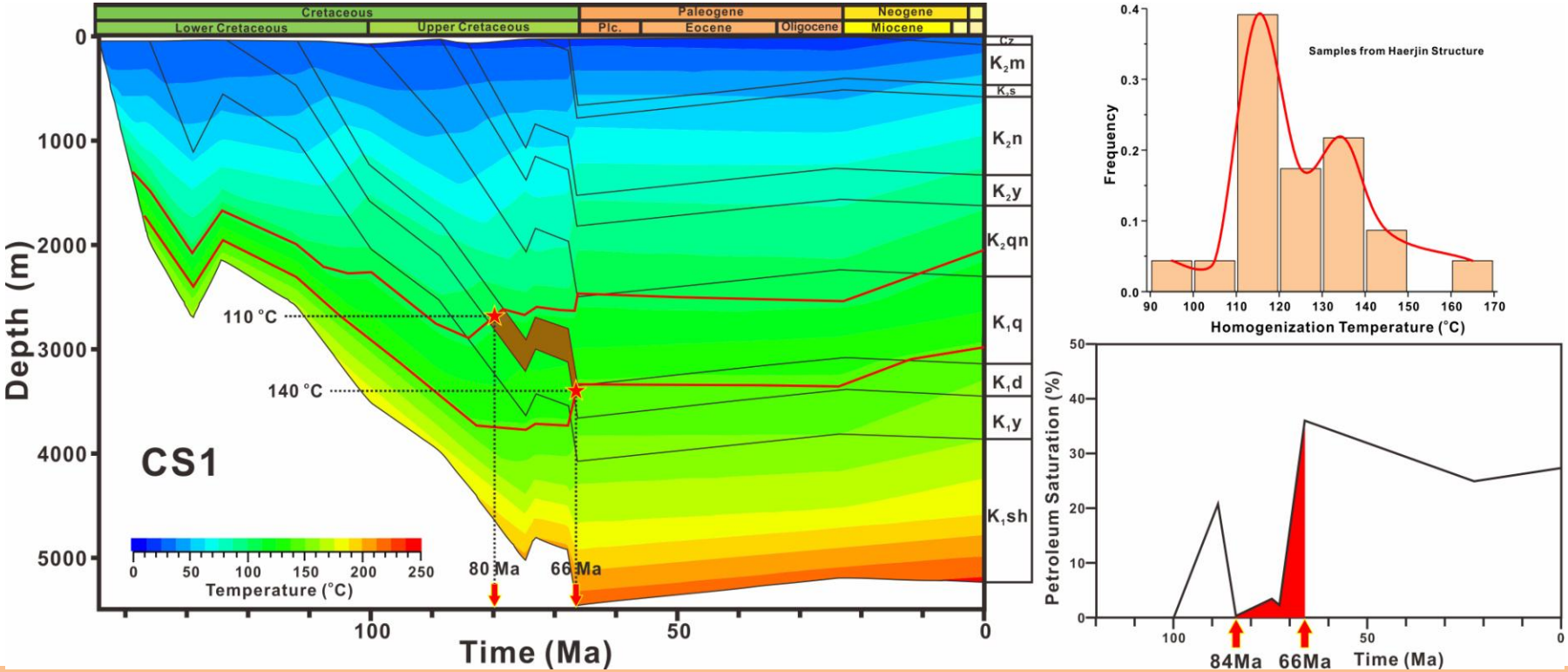
4. Simulation and analyze the results



Four main oil and gas bearing structures:
Haerjin
Dalaoyefu
Fulongquan
Shuangtuozi



5. Discussion and promotion



THANKS

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