An assessment of the geotemperature conditions of Bazhenov oil generation (Koltogor mezodepression and its framing structures)

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Abstract. The thermal history of oil source rocks of Bazhenov deposits was reconstructed in 8 cross-sections of representative wells of Koltogor mezodepression and the structures framing it. The tectonic history and geotemperature were reconstructed for well profiles, some located in the depression zone and others in the positive structures. A comparative analysis of the geotemperature conditions accompanying the generation of Bazhenov oils was performed.

1. Introduction

The Bazhenov oil source rock formation (J_3bg) is the main source of hydrocarbon deposits formation in Upper Jurassic and Neocomian traps [1]; it is the prominent [2] shale formation in oil and gas regions in South-East Western Siberia. The key factor in the realization of oil generation potential of a source rock is its thermal history [3] defining the starting time and the intensity of oil generation.

In the reviewed paper, the geological time of deposits' entrance into the main oil zone formation was assessed, based on the reconstruction of the paleotectonical and geotemperature modes of the Bazhenov formation in the Koltogor mezodepression and its framing structure (south-east Western Siberia). Also, the conditions under which Bazhenov oils had been generated were determined.

2. Characteristics of the researched territory

The Koltogor mezodepression is a 2nd order negative structure in the south-east Western Siberia (Figure 1). The high oil generation potential of Bazhenov deposits is stipulated by their ubiquitous spread, organic carbon content (Corg up to 12%) and the catagenetic transformation of MC_1^1–MC_1^2 graduations.

The Upper Jurassic oil and gas complex (OGC) consists of Callovian-Volgian deposits of the Vasyugan, Georgiev and Bazhenov formations. The Vasyugan formation was formed in littoral conditions and consists of lower (especially argilliceaous) and upper subformations, in terms of its lithological composition.

The deposits of *Neocomian OGC* in the south-east part of the West Siberian basin were examined with less detail. Neocomian deposits' studies were a research "byproduct" at best.

The eight representative wells have been selected for the analysis (see Table), some of them located in the depression zone while others within the positive structures (Figure 1).

3. Research methodology

The reconstruction of the tectonic and thermal history of Bazhenov formation was done using a software suite for paleotemperature modeling [5]. The method of paleotemeratures calculation is provided in paper [6].
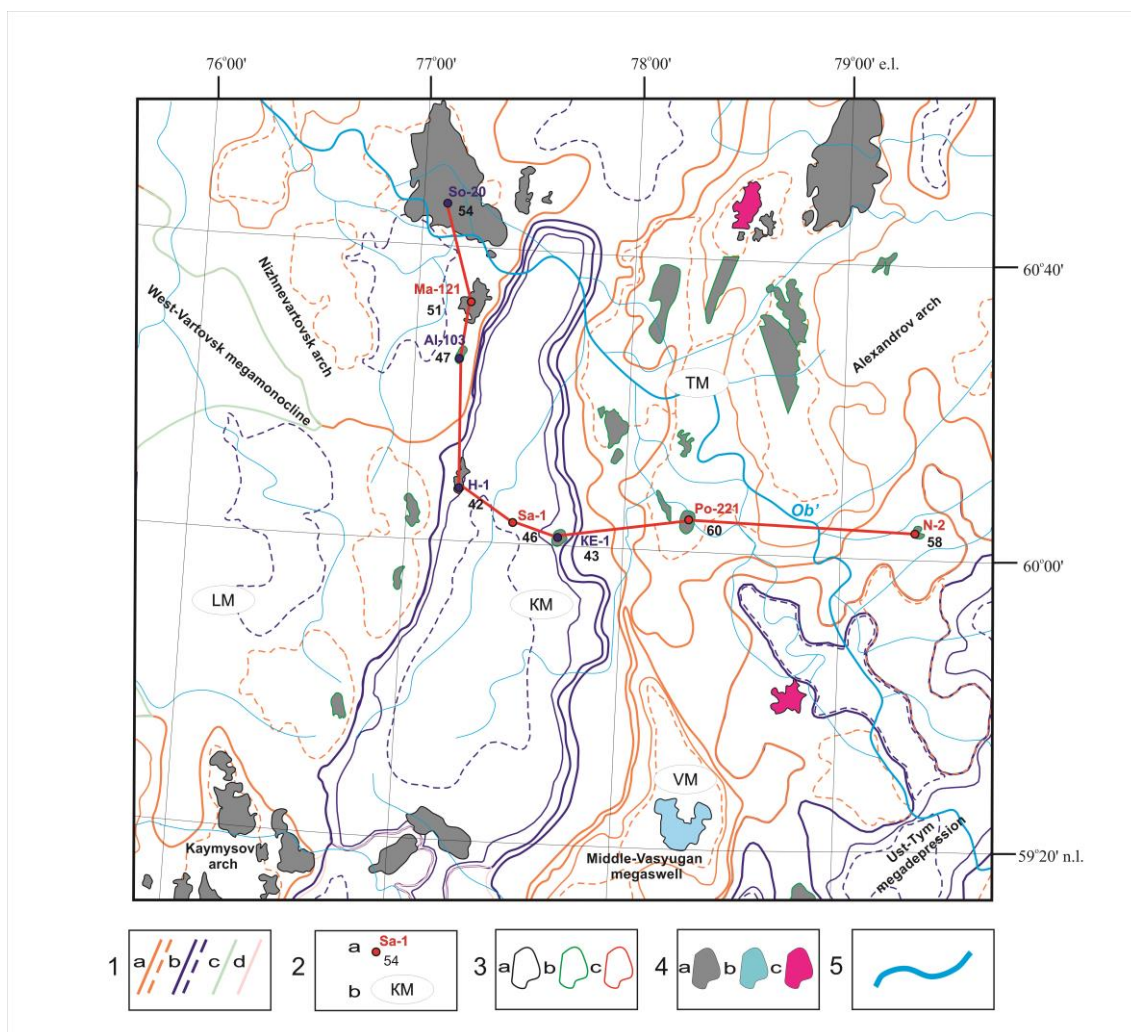
Figure 1. Overview diagram of the oil and gas potential of the Koltogor mezodepression and its framing structure (based on the tectonic foundation [4]): *1* – the contours of the tectonic elements: *a* – positive; *b* – negative; *c* – mezosaddle; *d* – megamonocline; *2* – *a* – the research well, its index and the estimated value of the heat flow density, mW/m^2; *b* – the index of 2nd order structures; *3* – the contours of the fields: *a* – production; *b* – exploration; *c* – ready for production; *4* – the type of hydrocarbon field: *a* – oil; *b* – gas condensate; *c* – oil and gas condensate; *5* – river system. 2nd order structures: VM – the Vasyugan mezoswell; KM – the Koltogor mezodepression; LM – the Ledyansk mezosaddle; TM – the Traygorod mezoswell.

Table. Characteristics of the research wells (see Figure 1 for well index).

Field	Sovetskoe	Malorechenskoe	Alenkinskoe	Hvoynoe
Well	**So-20**	**Ma-121**	**Al-103**	**H-1**
Characteristics	Values			
Downhole, m	2759	2664	2800	3207
Downhole deposits	Paleozoic (Pz)	Paleozoic (Pz)	Paleozoic (Pz)	Paleozoic (Pz)
Top of Bazhenov formation, m	2451	2430	2501	2673
Thickness of Bazhenov formation, m	13	14	15	10

Results of well testing (formation; reservoir; fluid type; flow, m3/day)	Alym; AV_{1-1}; oil; 156.0.	Vasyugan; J_1; gas; 13,2. Vasyugan; J_1; oil; 124.7.	Tara; B_{10}; oil; 20.3.	Vasyugan; J_1 oil; 8.1.
Estimated reservoir temperature (formation; measured depth; reservoir temperature)	-	Vasyugan; 2452 m; 90°C.	-	-
"Estimated" temperature by vitrinite reflectance (formation; sampling depth; (R_{vt}^0); temperature)	Tyumen; 2746 m; (0.76); 115 °C	Tyumen; 2470 m; (0.67); 103°C Tyumen; 2515 m; (0.67); 103°C Tyumen; 2620 m; (0.70); 106°C	Tyumen; 2700 m; (0.67);103°C	Tyumen; 2867 m; (0.64); 99°C Tyumen; 2939 m; (0.64); 99°C
Field	**Saymovskoe**	**Kul'-Eganskoe**	**Poludennoe**	**Nickol'skoe**
Well	**Sa-1**	**KE-1**	**Po-221**	**N-2**
Characteristics	Values			
Downhole, m	4008	3112	2448	2816
Downhole deposits	Paleozoic (Pz)	Paleozoic (Pz)	Paleozoic (Pz)	Paleozoic (Pz)
Top of Bazhenov formation, m	2832	2648	2207	2424
Thickness of Bazhenov formation, m	19	13	19	12
Results of well testing (formation; reservoir; fluid type; flow, m3/day)	Bazhenov; J_0; oil; 0.6.	Vasyugan; J_1; oil; 1.5.	Vasyugan; J_1; oil; 3.2.	Vasyugan; J_1; oil; 7.8.
Estimated reservoir temperature (formation; measured depth; reservoir temperature)	Bazhenov; 2844 m; 98°C.	-	Vasyugan; 2239 m; 94°C.	Vasyugan; 2445 m; 91°C.
"Estimated" temperature by vitrinite reflectance (formation; sampling depth; (R_{vt}^0); temperature)	Bazhenov; 2882 m; (0.67); 103°C Tyumen; 3437 m; (0.85); 124°C	Bazhenov; 2680 m; (0.62); 94°C	Tyumen; 2335 m; (0.70); 107°C	Tyumen; 2652 m; (0.76); 115°C

In the cross-sections of the 8 wells, the paleoreconstructions of the tectonic history and geotemperature for 17 key geological times were done, for the start time and end time of each formation (Figure 2).

The conditional integral index R [7] was calculated for assessing the density value of the generated Bazhenov oil which allows for cumulatively taking into account the geotemperature dynamics of the main oil generation zone of the source rocks [8].

4. Results

The thermal history analysis of the Bazhenov formation in well cross-sections (Figure 2) has shown that the deposits entered the main oil formation zone, having "overstepped" the threshold temperature of 85°C due to the dispersed organic matter of the sapropel type. The conditions that are favorable for Bazhenov oil generation persist at present, both in the most loaded and in the elevated parts of the researched territory.

The conclusions can be made by analyzing the time when the Bazhenov formation entered the main oil formation zone. The earliest time of entrance was around 92 million years ago on the territory near wells Sa-1 and Po-221. The Bazhenov formation escaped the main oil formation zone under the

influence of secular climate and temperature trend [9] (wells H-1 and KE-1). It can be noted that the thermal history is less favorable for oil generation in well cross-sections on the margins of the Koltogor mezodepression (Figure 3).
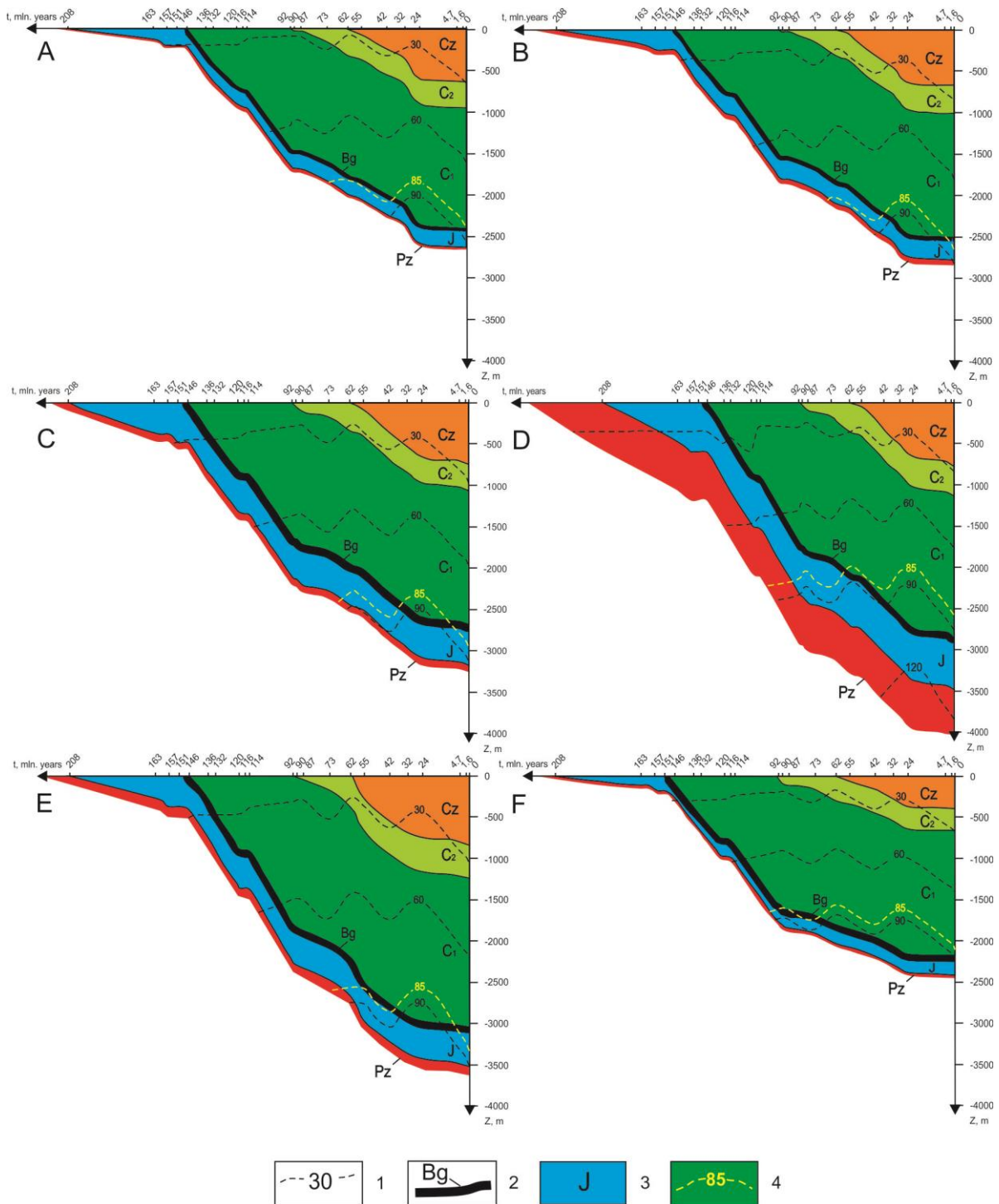

Figure 2. Paleoreconstructions of tectonic and thermal history in well cross-sections (index of wells in Figure 1): A – Ma-121; B – Al-103; C – H-1; D – Sa-1; E – KE-1; F – Po-221. *1* – the isotherms; *2* – the Bazhenov formation; *3* – the stratigraphic confinement of the deposits; *4* – the threshold temperature of the main oil formation zone.
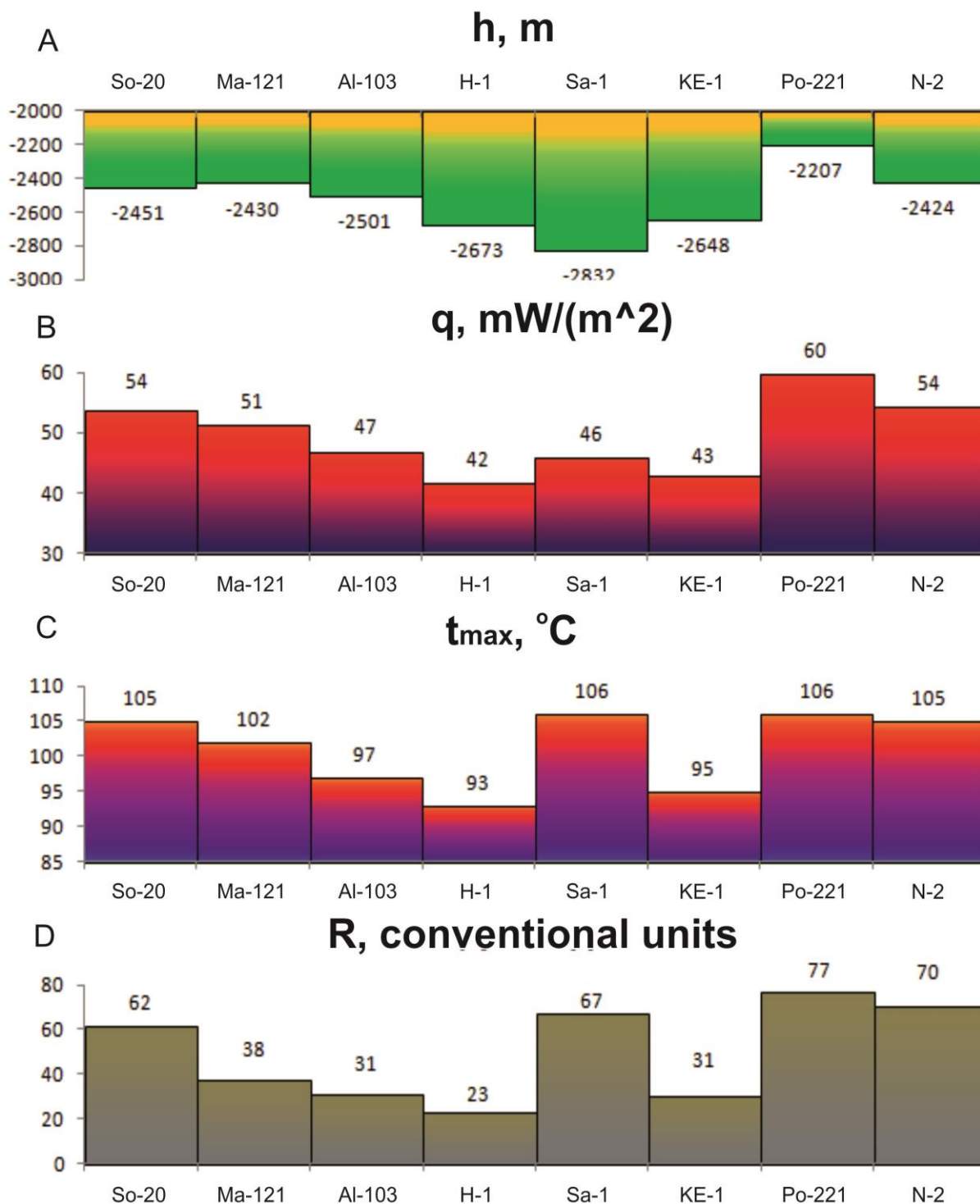
Figure 3. Correlation graphs along the line of the research wells (Figure 1): A – the thickness graphs of the deposits above the Bazhenov formation; B – the values of calculated heat flow density from the base of the sedimentary cover; C – the maximum geotemperature of the Bazhenov formation; D – the estimated resource density of the generated Bazhenov oil.

5. Conclusion

Oil generation for the researched profile of wells is confirmed by well testing results. Production and non-production oil inflows were mainly obtained from the Upper Jurassic reservoir J_1. In the Saymovskoe field, a non-production oil inflow was obtained from the Bazhenov formation during well testing results of well Sa-1. In the Alenkinskoe oil field in the Neocomian reservoir B_{10}, production oil inflow was obtained from well Al-103. In the Sovetskoe field, a production oil inflow was obtained from the Neocomian reservoir AV_1.

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