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Strike-slip faulting in the West Siberian Platform: Insights from 3D seismic imagery

Formation de décrochements dans la plate-forme Ouest-sibérienne : données de l'imagerie sismique 3-D

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ABSTRACT

The 3D seismic exploration, actively deployed in recent years on much of the West Siberian Platform – one of the world's largest oil and gas bearing basins – has brought out extensive development of a system of strike-slip faults within the basement. The fault system causes local structural and fluid flow anomalies within the Jurassic-Cretaceous sedimentary section, which is known to accommodate a multitude of large oil and gas deposits. This article will show the distribution geography and the scale of the basement strike-slip tectonics, and explain why this phenomenon, so clearly highlighted by 3D seismic, was not discovered earlier. The article will also consider how strike-slip faults are detected in the sedimentary cover and how they impact the characteristics of oil and gas fields located in their vicinity.

RÉSUMÉ

L'exploration sismique 3-D, activement déployée ces dernières années dans une grande partie de la plate-forme Ouest-sibérienne, – l'un des plus grands bassins de pétrole et de gaz au monde, – a mis en évidence le développement extensif d'un système de décrochements au sein du soubassement. Le système de failles produit la genèse conjuguée d'anomalies de structure et de dynamique des fluides dans les séries sédimentaires du Jurassique-Crétacé, connu pour accommoder nombre de vastes dépôts de pétrole et de gaz. Cet article se propose de montrer la répartition géographique et l'échelle de la tectonique de décrochement du soubassement et d'expliquer pourquoi ce mécanisme, si bien mis en lumière par l'imagerie sismique 3-D, n'a pas été découvert plus tôt. Cet article se propose aussi de considérer comment les décrochements sont détectés dans la couverture sédimentaire et quel est leur impact sur les caractéristiques des champs de pétrole et de gaz localisés dans leur domaine.

1. Introduction

The West Siberian sedimentary basin is one of the world's largest oil and gas bearing basins. Hundreds of oil

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and gas fields have been discovered here, and several billion tons of oil and several trillion cubic meters of gas produced. In the West Siberian basin area, over 200,000 wells have been drilled and millions of seismic line kilometers shot. It should seem that the sedimentary cover geology of this basin is already well studied. However, 3D seismic surveys have allowed one to reveal a wide spread of a special type of tectonic dislocations – a system of relatively low-relief strike-slip faults within the basement section – that are the cause of complex folding and faulting in the overlying sedimentary cover holding hydrocarbon deposits. Strike-slip faults are well known and thoroughly described in hundreds of publications. However, we are not aware of any other linear strike-slip fault systems such as those encountered in West Siberia, practically similar to physical models, where they are indeed numerous. It is obvious here that the basement itself, in addition to the sedimentary cover, is impacted by the strike-slip motion. Therefore, we believe that observations highlighted in this article would be of interest to the specialists of tectonics and tectonophysics, as well as to geologists involved in the search for, exploration and development of hydrocarbon deposits.

2. General characteristic of the study area

The West Siberian oil and gas bearing basin (Fig. 1) covers an area of over 2.6 million sq. km. The basin geology is highlighted in numerous publications, but in discussing the issues of this article special mention should be made of fundamental works by Kontorovich et al. (1981), Skorobogatov et al. (2003), Surkov and Zhero (1981) and Vyssotski et al. (2006). The crystalline basement of the West Siberia Basin is overlain by a severely dislocated and partly metamorphosed Paleozoic sedimentary pile intersected by effusive rocks. This series is in turn overlain by a platform-type perfectly persistent Meso-Cenozoic clastic cover, which is hundreds of meters thick at the basin edges and up to a 2–5 km in thickness at the central part of the basin. The sedimentary cover thickness increases from south to north. The Jurassic-Cretaceous part of the sedimentary cover hosts most if not all hydrocarbon accumulations discovered so far.

The study area is located in the central part of the basin outlined with a dashed rectangle in Fig. 1 where numbered black-color spots indicate geologic highs (oilfields) under discussion in this article. A thorough paleostructure analysis shows that numerous highs of the 1st, 2nd and 3rd order have a complex development history and are classified as two types – old structures with intermittent growth episodes inherited from the basement, and newly-formed inversion features in the sedimentary cover horizons.

3. Strike-slip fault structures (SSFS)

3D seismic surveys completed on a large number of structures helped to identify deformations in the sedimentary cover that suggested the presence of strike-slip faults in the underlying basement. The strike-slip faults are

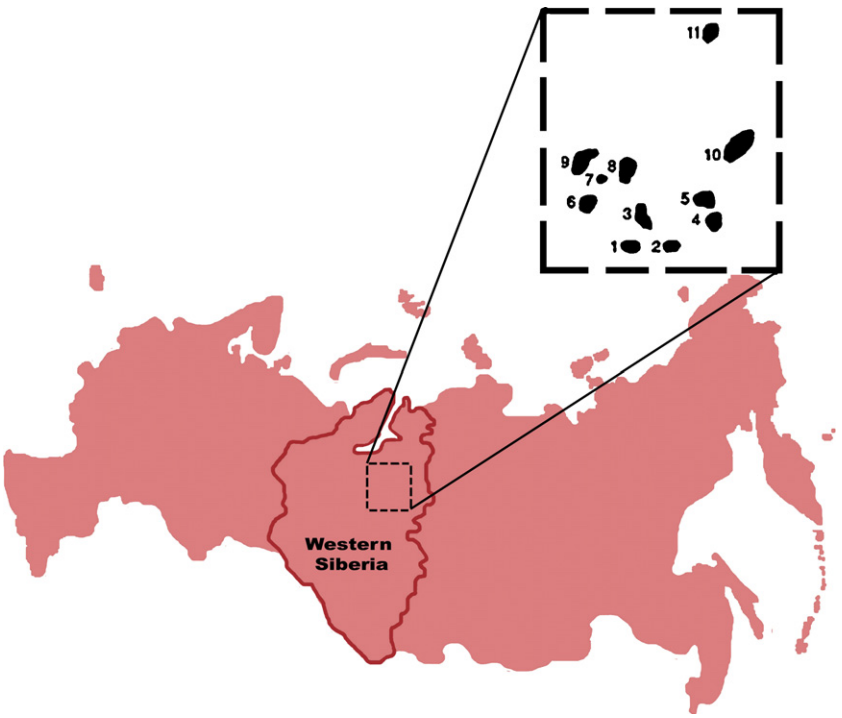

Fig. 1. West Siberian oil and gas bearing province. Dashed rectangle outlines the study area. Fields discussed in this article are numbered as follows: 1. Novogodneye. 2. Yarayner. 3. Yetypur. 4. Kharampur. 5. North-Khrampur. 6. Komsomol. 7. Metelnoye. 8. Gubkin. 9. North-Komsomol. 10. Chasel. 11. Russkoye.

Fig. 1. Province de Sibérie occidentale renfermant pétrole et gaz.