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Editorial

New Advances in Oil, Gas, and Geothermal Reservoirs

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Abstract: The most significant geo-energy sources in the world today continue to be oil, gas, and geothermal reservoirs. To increase oil and gas reserves and production, new theories are constantly being developed in the laboratory and new technologies are being applied in the oilfield. This Special Issue compiles recent research focusing on cutting-edge ideas and technology in oil, gas, and geothermal reservoirs, covering the fields of well drilling, cementing, hydraulic fracturing, improved oil recovery, conformance control, and geothermal energy development.

Keywords: drilling and completion; oil well cement; fracturing; tight gas; shale gas; enhanced thermal recovery; enhanced geothermal system

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1. Introduction

The most significant geo-energy sources worldwide in recent years continue to be oil, natural gas, and geothermal resources. As conventional fossil energy resources, oil and gas still play an irreplaceable role in industrial production and human life. In addition, with the continued recovery of the global economy and increasing energy consumption, the development of oil and natural gas is still very important.

The development of crude oil and natural gas mainly comprises the stages of drilling, completion, well cementing, fracturing and acidification, and improving oil recovery (IOR) [1]. With rapid developments in experimental technology and numerical simulation technology, drilling speed increases and drilling becomes safer, and the quality of well cementing gradually increases. Fracturing and acidification are two main measures to increase the production for low- and ultra-low-permeability reservoirs [2]. The stimulated reservoir volume (SRV) has been continuously improved, and the proppant placement scheme can be continuously optimized. An eternal theme of the development of oil fields, IOR technologies are gradually applied to unconventional reservoirs, such as heavy- and tight-oil reservoirs [3]. In addition, new types of plugging materials have been developed to overcome the low sweep efficiency of the displacement agent caused by reservoir heterogeneity [4–6].

Geothermal resources, a kind of renewable thermal energy inside the Earth with huge reserves, are considered a feasible alternative to achieving global dual carbon goals. The key issue to resolve is the use of science and technology to improve the recovery efficiency of geothermal resources.

This collection, which accompanies the Special Issue of *Energies*, places an emphasis on fundamental innovations and compiles 11 current publications on original applications of new ideas and methodologies in oil, gas, and geothermal reservoirs.

2. Review of Research Presented in This Special Issue

The papers published in this Special Issue describe recent advancements in oil, gas, and geothermal reservoirs. These studies are divided into five categories.

The first category is the efficient and high-speed drilling and completion technology of complex hydrocarbon formations. In response to the situation where the cuttings removal mechanism of the current pulsed jet is unclear, Zhao et al. [7] established a pressure-flow-rate fluctuation model and discussed the impact of the displacement, drilling fluid viscosity, well depth, and flowing area of the pulsed jet tool on the instant flow characteristics at the bottom hole. The findings indicated that flow velocity fluctuations can improve the mechanical status of the cuttings, and help cuttings to tumble off the bottom hole.

The quality of well cementing also determines the quality of the later development process. As the main material for well cementing, oil well cement has been widely studied in recent years. Qi et al. [8] used low-field pulse nuclear magnetic resonance (LF-NMR) technology to examine the impact of the addition of concrete retarders on T_2 distribution, cement thickening characteristics, and paste strength. According to studies, retarders can slow the rate at which cement particles hydrate by weakening the van der Waals force and the electrostatic absorption force between water and cement grains. The early strength of cement slurry can be enhanced by appropriately increasing the cation content of polymeric ion retarders.

The second category is the low-cost and highly efficient development of low/ultra-low permeability hydrocarbon reservoirs. Due to the low matrix permeability, these reservoirs are generally required to employ a fracturing method to increase the flow volume of oil and gas [9]. The purpose of the fracturing process is to pump the proppant into the fractures, causing the oil and gas in the low penetration substrate to easily flow out [10]. Wu et al. [11] examined proppant transportation and placement in narrow curving channels. The dune height and covered area of the proppant in the curving fractures are smaller than in linear fractures. Additionally, curving sections hinder the distribution of the proppant, making the location of the dunes closer to the inlet.

For the hydraulic fracture technology in glutenite reservoirs, the geometric heterogeneity of the embedded gravel affects its serious stress and strength heterogeneities. Tang et al. [12] used the discrete element method (DEM) method to simulate the macro mechanical behavior of gravel samples. Results showed that gravel embedded near the wellbore can cause stress and strength heterogeneities, which further increase the local initial point and form a complex fracture network nearby.

In addition, imbibition or gas flooding methods are usually used after fracturing. Deng et al. [13] used a microfluidic platform based on a visual circular capillary tube to monitor the entire imbibition process. Studies found that when analyzing the mathematical models of the imbibition process, the impact of the collected liquid ejecting from the capillary tube on the imbibition must be considered. This effect is more obvious in the imbibition process of lower viscosity (e.g., water) liquid displacing higher viscosity liquid (e.g., oil). The imbibition behavior in the capillary was described using additional force, and a revised Poiseuille mathematical model was developed. The model can make excellent predictions on the water imbibition process.

The third category is the effective development of tight gas and shale gas reservoirs. Research on the existence and flowing characteristics of natural gas (mainly methane) in tight or shale reservoirs is essential for the reserve assessment and production prediction of tight and shale gas. To explore the effects of methane's adsorption dynamics on gas shale rocks, the methane adsorption dynamic law on gas shale powder was described by Zhang et al. [14]. Most methane molecules are adsorbed during the early stage, and low temperature is conducive to the adsorption of methane on shale powder.

The inorganic nanopores in the matrix of shale form irreducible water on their inner surfaces due to strong hydrophilicity. By establishing a corrected shale gas apparent permeability model, Zhao et al. [15] analyzed the impact of the existence of irreducible water on natural gas flow behavior. Studies showed that the rate of bulk phase transportation replacing the surface diffusion of natural gas slowed down because of the existence of irreducible water. However, with the increase in formation pressure, the impact of irreducible water on the apparent permeability of gas decreases. Under low-pressure conditions, the irreducible water in the small pores can accelerate the flow of natural gas.

The fourth category is the further improving oil recovery (IOR) technology of the mature oil fields. Although they gradually entered the post-development period, and the efficiency of water injection gradually decreased, there is still a large amount of remaining oil in the formation [16]. Therefore, novel IOR technology for old oilfields has always been a hotspot for oil companies and researchers. Cyclic supercritical multithermal fluid stimulation (CSMTFS) is a new type of technology for the development of heavy oil reservoirs. Tian et al. [17] conducted a simulation experiment on its heating efficiency, production, and heat loss through a three-dimensional (3D) experimental system. Results indicated that CSMTF had less heat loss than conventional thermal fluids, and the enthalpy values are significantly increased compared to multithermal fluids; therefore, it can improve the heat-carrying ability of the multithermal fluid. Tang et al. [18] discussed the characteristics of supercritical multithermal fluids and their potential in enhanced thermal recovery. The experimental results show that the oil-to-water ratio of the reactant has a more significant impact on the specific enthalpy and displacement efficiency compared with the initial temperature and pressure. With a low gas-to-water ratio, the supercritical multithermal fluid had a higher crude oil displacement efficiency and oil recovery in the beginning and enlarged the supercritical area; therefore, later channels can be formed in the oil layer.

Aiming at the problems caused by low steam sweep efficiency in heavy oil reservoirs, Cheng et al. [19] used flour ash as a plugging material to evaluate its controlling steam channeling in the two-dimensional (2D) displacement experiment. It has good anti-flush ability, stable plugging performance, and excellent improved heavy oil recovery effects.

The fifth category is the efficient development of geothermal resources. Due to the continuous increase in geothermal resources in recent years, and the growing difficulty of conventional fossil energy development, the efficient utilization of geothermal resources is increasingly valuable. To improve the recharge efficiency of geothermal resources, Yu et al. [20] proposed an unblocking and permeability enhancement method using a rotary water jet for low recharge efficiency wells in sandstone geothermal reservoirs. This technology can solve the problem of low efficiency in the reinjection processes of cooled thermal waters back into geothermal reservoirs.

3. Conclusions

Many academics from a variety of fields, from the natural sciences to engineering, have been conducting research into drilling and completion, the development of conventional and unconventional oil and gas reservoirs, IOR technology of mature oil fields, and the development of geothermal resources. New theories and technologies are proposed in this Special Issue. The new experimental methods, numerical simulation technology, and pilot cases in this Special Issue can help readers and researchers to better understand and be inspired by the cutting-edge technologies in the field of oil and gas and geothermal.

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