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Editorial: Multiphase flow behavior in the deep-stratum and deep-water wellbores

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Editorial on the Research Topic
Multiphaseflow behavior in the deep-stratum and deep-water wellbores

In recent years, the exploration and development of hydrocarbon energy, such as crude oil, natural gas, and natural gas hydrate, has come to deep-water and deep-stratum regions. The field engineers must face challenges resulting from the multiphase flow of complex fluids under elevated temperature/pressure conditions. These challenges require developing in-depth understanding of multiphase flow in porous media under conditions that typically are not studied in a conventional setting. For example, the temperature and pressure of a 24,000 ft deep wellbore can reach over 200°C and 100 MPa in the Tarim oilfield. In deep-water wells, the wellbore temperature can vary from 4°C to 120°C, while the wellbore pressure can range from 10 to 30 MPa. As the phase state, heat/mass transfer between gas and liquid, and fluid hydrodynamics in the wellbore depend highly on the temperature and pressure conditions, the *Multiphase flow behaviors in deep-stratum and deep-water wellbores* become much more complicated. Different from the conventional oil and gas exploitation, the production of oil and gas from the and deep stratum deep-water regions involves multiple complex physical phenomena, such as phase transition (gas-liquid-solid-supercritical), particle deposition (wax, hydrate, water scale, asphaltene, etc.), changes of heat/mass transfer induced by phase change, and so on. It is, therefore, of high importance to discuss the *Multiphase flow behavior in the deep-stratum and deep-water wellbores*.

This Research Topic aims to explore recent developments in this area and focused on the following two aspects: 1) Numerical simulations of gas-liquid or liquid-solid two-phase flow in porous media, 2) Experiments and simulations of multiphase flow in the pipelines and wellbores. There are a total of 12 articles under this Research Topic.

The following articles report results related to the experiments and simulations of multiphase flow in the pipelines and wellbores. Ge et al. conducted dynamic liquid-carrying experiments and evaluated the performance of some foam discharge agents. The agent ZHY-01 had a better resistance to high temperatures and condensate oils than the agents MA/AA and PESA. Wang et al. creatively developed a multiphase flow model to analyze the gas-liquid two-phase flow behavior in a novel deep-water closed-cycle riserless drilling system. Their study provided a theoretical foundation for the selection of subsea pumping power and optimization of gas injection sites and gas displacement. Zhang et al. developed a theoretical model to calculate the temperature profile of the deep gas well by considering the coupling relationship among the temperature, pressure, and gas properties. Their results help mitigate the trapped annular pressure (TAP) caused by thermal expansion which is one of the serious challenges for the safe production of a deep gas well. Xu et al. numerically studied the erosion of hydraulic fracturing nozzle in deep wells induced by sand-liquid two phase flow. A three-dimensional model was developed to analyze multiple influencing factors on the nozzle erosion, such as multiphase flow field distribution, flow rate, sand diameter, etc. Their findings help engineers to select proper nozzles in hydraulic jet fracturing applications.

The following articles report results related to the numerical simulations of gas-liquid or liquid-solid two-phase flow in porous media. Gong et al. conducted experiments to study the permeability jail range of tight gas reservoirs through conducting gas-water relative permeability experiments. They showed that the Byrnes model showed a good performance in predicting the permeability jail range of tight gas rocks. Shi et al. developed a numerical two-phase flow model to study water-sediment seepage characteristics in rough rock fractures. Their study revealed the effects of the smooth and rough fracture surfaces on multiple parameters, including sediment volume concentration, sediment particle size and sediment particle mass concentration. Their findings help reveal the disaster-causing mechanism of water-sediment inrush in mining and deep-ground engineering. Zhao et al. conducted a series of foam flooding experiments in core samples to evaluate the impact of foam quality and permeability on foam performance. Considering the effects of foam quality and core permeability, they also developed a mechanistic model to describe the dynamic foam performance. The mechanistic model was applied to match foam flow experimental results in the absence and in the presence of oil. Their model captured the high-quality and low-quality foam regimes observed in previous oil-free foam flow experiments. He et al. developed a comprehensive multiphase flow model to study the flow characteristics of CO_2-containing natural gas streams that are invading a wellbore during the drilling process. Their model considered the effect of gas solubility in water/brine solutions. They found that gas solubility has a significant impact on the monitoring of gas invasion in low permeability reservoirs. Wang et al. proposed an improved multiphase flow model to simulate the complicated gas-liquid-solid multiphase flow that will occur during a deep-water drilling process due to the invasion of formation gas into the wellbore. Their results help detect kicks in deep-water wells and develop effective well-control measures accordingly. Miao et al. proposed a mechanistic model to study the behavior of bubble migration and pressure build-up during a dynamic shut-in procedure in the deep-water drilling process. This study helps quantitatively characterize the hydrate growth behaviors and interphase mass transfer rules of gas bubbles during a dynamic well shut-in procedure. Cao et al. established a model to analyze the changing law of the temperature profile inside a production string. The established model considered the frictional loss caused by a high production rate as well as the variations in gas properties. This model is useful in simulating the temperature profile inside a production string in a high-pressure/high-temperature gas well.

Author contributions

WF was a guest associate editor of the Research Topic and wrote the editorial. JZ, ZW, and HL were guest associate editors of the Research Topic and edited the editorial.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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