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Editorial: Lost circulation control during drilling and completion in complex formations

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Editorial on the Research Topic
Lost circulation control during drilling and completion in complex formations

Well drilling is a common method for Earth exploration, underground mineral resource extraction, and geological storage of nuclear waste and carbon dioxide. Drilling fluid circulates in the well during drilling, cooling the drill bit, transporting rock cuttings, preventing wellbore collapse, and balancing formation pressure. Lost circulation occurs when less fluid returns from the wellbore than is pumped into it, resulting in economic losses due to drilling fluid wastage and nonproductive time. Untreated losses can cause well control issues, poor hole cleaning, pack-offs, and stuck pipe, impairing normal drilling. Lost circulation incidents are more likely to occur with the increasing share of difficult wells (deep-water, deviated, horizontal, high pressure, high temperature) in the drilling portfolio. It is one of the most troublesome drilling problems.

Lost circulation is a longstanding challenge in drilling that worsens under extreme conditions. To prevent and cure losses, we need to understand their causes, locations, and control methods. This entails elucidating four physical science issues: 1) multiphase flow in the drilling assembly-wellbore-formation system; 2) geomechanics, rock mechanics, and fracture mechanics during fracture initiation and propagation; 3) material and granular mechanics of the sealing zone formed by physical or chemical lost circulation materials; 4) fluid-structure interactions between multiphase fluid and rock. We present a Research Topic on lost circulation control during drilling and completion in complex formations that addresses these issues. This Research Topic aims to fill the gaps among fundamental theories, applied technologies and field practices, reporting recent innovations and advances related to lost circulation control during drilling and completion in complex formations.

We received 14 papers for this Research Topic and selected 9 for publication after careful review. The papers cover materials, experiments, mathematical models, and numerical simulations for lost circulation control.

The paper "*Study and application of temporary plugging agent for temporary plugging acid fracturing in ultra-deep wells of Penglai gas field*" by Wang et al. developed a temporary plugging agent based on polyemulsion-modified polyvinyl alcohol resin for multi-stage acid fracturing. The agent, composed of fiber and granular resin, had an experimental fracture plugging strength of over 20 MPa. The paper "*Experimental studies on the performance evaluation of water-soluble polymers used as temporary plugging agents*" by Wu et al. tested a new temporary plugging agent made of degradable water-soluble polymer. The agent showed good temporary plugging performance due to its high plugging strength, temperature-controlled water degradation, stable reflux, and effective self-supporting after degradation. These two papers present two new lost circulation materials (LCMs) for enhancing temporary lost circulation control, especially in pay zones.

The paper "*Composite stimulation technology for improving fracture length and conductivity of unconventional reservoirs*" by Wang and Lv visualized ceramic proppant migration in vertical fractures. They found that non-uniform sized ceramic particles formed smoother sand dikes and migrated better to the fracture tip than uniform sized ones. The paper "*Study on migration law of multiscale temporary plugging agent in rough fractures of shale oil reservoirs*" by Wang et al. examined the effects of morphology, concentration, and combination of temporary plugging agents, as well as fracture width and roughness, on fracture plugging performance. Particles alone plugged fractures more effectively than fibers did, whereas a mixture of fibers and large and small particles yielded the best performance. Increasing fiber concentration in the mixture enhanced plugging pressure and reduced plugging time. Higher overall concentration of temporary plugging agents also increased plugging pressure. Rough fractures were easier to plug than smooth ones. These two papers offer insights for improving the placement and sealing efficiency of LCM slurry in fractures.

The paper "*An experimental evaluation method of drilling fluid lost control efficiency considering loss types*" by Zhang et al. quantified the main factors controlling lost circulation efficiency and proposed a new experimental method to evaluate it in fractured formations with different loss types. Their results showed a better agreement between indoor experimental lost circulation efficiency and on-site data. The paper "*Optimization of degradable temporary plugging material and experimental study on stability of temporary plugging layer*" by Chen et al. measured permeability under various confining pressures to optimize the temporary plugging material formula, and assessed the stability and degradability of the temporary plugging layer. They found that a mixture of hyperfine $CaCO_3$ and walnut-shell particles formed a tight and stable plugging layer under increasing confining pressure, resulting in the best temporary plugging performance. These methods bridge the gap between experimental and real downhole conditions and improve the guidance of indoor experiments for on-site operations.

The paper "*Bridging performances of lost circulation materials (LC-LUBE and mica) and their blending in 80/20 and 60/40 oil-based drilling fluids*" by Belayneh and Aadnøy compared 80/20 and 60/40 oil-based drilling fluids (OBMs) on LCMs bridging performance, filtrate loss, barite sagging, and shale stability. They found that a mica and LC-LUBE blend had the best bridging performance, and that 60/40 OBM had better bridging stability, sagging, and filtrate loss than 80/20 OBM. The paper "*Plugging efficiency of flaky and fibrous lost circulation materials in different carrier fluid systems*" by Alhaidari et al. demonstrated the effect of carrier fluid on the plugging efficiency of flaky and fibrous LCMs. Carrier fluid exposure changed the particle size distribution, shape, specific gravity, fluid loss, and fracture plugging of LCMs, depending on the type of LCM and carrier fluid. These two papers highlight the importance of carrier fluid type for LCM and provide experimental evidence for selecting specialized LCM based on carrier fluid.

The paper "*Finite element study on the initiation of new fractures in temporary plugging fracturing*" by Xing et al. compared the stress field around the artificial fracture before and after production, and determined the mechanical conditions for new fracture initiation during temporary plugging fracturing. They discovered that stress field and pore pressure variations induced new fractures in re-fracturing processes, accounting for the increased loss circulation and difficulty in control in pressure-depleted formations.

Author contributions

CL: Writing–original draft. AD: Writing–review and editing. CX: Writing–review and editing. ZY: Writing–review and editing.

Conflict of interest

Author CL was employed by the company CCDC Drilling Production Technology Research Institute.

The remaining 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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