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Editorial: Advances in the study of natural fractures in deep and unconventional reservoirs

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Editorial on the Research Topic
Natural fractures in deep and unconventional reservoirs

As the global oil and gas demands continue to grow, deep and unconventional reservoirs have become the main areas for increasing reserves and improving production, and are increasingly valued by various countries and oil companies. However, deep and unconventional oil and gas reservoirs often have poor matrix physical properties, development of natural fractures, and strong heterogeneity. Natural fractures at different scales and types are the main storage space and important seepage channels of these tight reservoirs, which control the migration, accumulation, preservation, and single-well productivity of oil and gas, and affect fracture propagation mode and fracturing performance.

The study of natural fracture distribution is of great significance for guiding deep and unconventional oil and gas exploration (such as selection of high-quality reservoir, evaluation of the integrity of cap rock, evaluation of gas storage safety) and development (such as fracture propagation, drilling, and completion methods, etc.). In recent years, the development of deep and unconventional reservoir research has produced innovations in methods and technologies. Many advances have been made in the quantitative characterization and predictive modeling of fracture systems, which have improved our understanding of formation mechanisms and the dynamic evolution processes of natural fractures. A total of 28 manuscripts were received for this Research Topic, covering rock types such as shale, tight sandstone, carbonate, and bedrock.

Shale oil and gas reservoirs have been a research hotspot in recent years (Gale et al., 2014; Gong et al., 2021a; Salem et al., 2022). Natural fracture system plays a key role in the enrichment and high production of shale reservoirs (Zeng et al., 2016; Gong et al., 2021b). Zhang et al. analyzed micro-nano fractures and pore types at organic matter in shale rocks, and discussed their evolution behaviors controlling factors using X-ray diffraction, scanning electron microscopy, nitrogen adsorption and other experiments. Zhou et al.

analyzed and discussed development characteristics and main controlling factors of fractures at Niutitang shale in northern Guizhou area, as well as impact of fractures on natural gas enrichment based on detailed fracture description. They pointed out that the strong tectonic movement developed throughgoing fractures and faults, destroying overpressure environment and losing shale gas. It was beneficial to shale gas enrichment in the positions where small-scale fractures were developed with no throughgoing fractures and faults.

The analysis of fracture effectiveness evolution and quantitative prediction of fracture distribution are critical to investigate fractures at deep and ultra-deep tight sandstone reservoirs (Ju et al., 2015; Gong et al., 2019; Zeng et al., 2022). Wang et al. firstly evaluated static parameters quantitatively based on the fluid production profiles, e.g., fracture density, opening and filling behaviors, and then established fracture effectiveness evaluation method for ultra-deep tight sandstone reservoirs from three aspects: fracture activity, fracture opening and fracture connectivity. Xu et al. used the volume-based structural framework modeling technology to construct a three-dimensional heterogeneous rock mechanics field, and predict fracture distribution in deep tight sandstone reservoirs with finite element numerical simulation method. They analyzed fracture effectiveness and stability in different directions through studying the current stress field. Liu et al. analyzed fracture distribution at deep tight sandstone reservoirs from different structure units, and evaluated fracture effectiveness. They pointed out that multi-stage tectonic movement led to fracture development at the study area, especially developing a large number of tensile fractures at the top of anticlines, which effectively improved reservoir seepage capacity and was the primary oil and gas channels.

Exploration activities in recent years have confirmed that fault-controlled paleokarst reservoir was an important type of fracture-vuggy carbonate reservoirs (Burberry and Peppers, 2017; Liu et al., 2021). Geng et al. systematically investigated deformation mechanism and internal structures of overthrust fault belts in carbonate rocks based on detailed outcrop data, discussed their impact on reservoir property. They believed that damage zones were "sweet spots" for oil and gas enrichment at carbonate rocks, which were distributed along faults with a strip pattern. Zhang et al., classified structures of fault-controlled paleokarst reservoir in Tahe Oilfield based on multi-scale data, and put forward a modeling framework called "constrained by structure classification, controlled by genesis, and modeling step by step".

Paleostress inversion is an important approach to investigate crustal deformation history and dynamic mechanism. The paleostress determination is of great significance for restoring regional tectonic history, predicting fracture distribution, explaining fault nature, and clarifying control of fractures on fluid flow (Ju and Sun, 2016). Ping et al. proposed to use seismic interpretation data to invert the paleostress of Xicaogu structure belt at Shulu sag during subsidence periods based on sliding trend algorithm. This paper put forward a new stress inversion method based on seismic data, which is expected to become a new and independent stress evaluation method. It has universal practicability and popularization in oil and gas industry, and can provide a solid foundation for fracture prediction and oil and gas exploration and resource evaluation.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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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.

Publisher's note

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