

Fluid overpressure during liquid and gas hydrocarbon generation in shales

MIAO WANG AND YONG CHEN

School of Geosciences, China University of Petroleum (East China)

Natural bedding-parallel horizontal fractures are widely present in organic-rich shales, and their formation is generally attributed to fluid overpressure caused by hydrocarbon generation from organic matter. However, there are significant structural differences in the cementation of these fractures, indicating distinct formation processes of vein bodies and a notable variation in the coupling relationship between fracture opening and cementation. Currently, there is a lack of systematic research on the coupling processes of fracture opening and cementation indicated by different structures, as well as their roles in hydrocarbon accumulation and migration. This study compares the physicochemical conditions and opening modes recorded by two different cementation structures in organic-rich shales from the Shahejie Formation in the Bohai Bay Basin and the Wufeng-Longmaxi Formation in the Sichuan Basin. The results show that the former consists of bedding-parallel horizontal fractures cemented by fibrous structure minerals, representing crystal growth in restricted spaces occurring simultaneously with fracture expansion. The latter consists of bedding-parallel horizontal fractures cemented by blocky structure minerals, where crystal growth occurs unhindered in an open fluid space. Additionally, fluid inclusion PVT analysis reveals that the two types of cemented fractures represent different fluid overpressures at distinct hydrocarbon generation stages. The fibrous crystal-filled fractures form through initial hydraulic fracturing followed by crystallization, mainly during the liquid hydrocarbon generation stage (oil window), with moderate fluid overpressure occasionally exceeding static rock pressure. In contrast, blocky-filled fractures form through bedding-parallel fracturing during the gas generation stage (gas window), followed by blocky crystallization during post-gas generation uplift. In this case, methane-saturated fluid overpressure generally persists, actively expanding fractures and promoting cementation. This model of bedding-parallel fractures, supported by overstatic fluid pressure and filled with blocky crystallization, shares similarities with certain ore systems, such as orogenic gold deposits in metamorphic rocks and tungsten-tin deposits related to S-type granites.