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The investigation of shale dynamical spontaneous imbibition with hydration damage and its influence on mechanical property

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Shale gas development is relied on long horizontal drilling. But shale is typical formation that wellbore instability often occurs, restricting long horizontal drilling in shale reservoir. Hydration damage is a major trigger of borehole collapse in shale. During drilling process, spontaneous imbibition (SI) is one of main methods of water phase entering into shale. After this invasion, hydration between water and clay happens, forming damage effect. Currently, there are plenty of works about shale hydration mechanism, but research of connection between SI and hydration is rare. The understanding of shale hydration evolutionary law during SI is not deep enough, restricting the improvement of drilling quality in shale reservoir.
Therefore, in combination with SI test and rock mechanical test, based on damage mechanical theory, characteristics of shale SI and hydration damage evolutionary law during SI have been clarified. The dynamical model of shale SI has been established considering hydration damage. Also, constitutive model of shale hydration damage during SI has been built. The analysis of shale SI process and energy response law in loading have been conducted. Results indicate that shale has strong SI in earlier stage, and the imbibition gradually becomes stable at later stage. Due to the influence of hydration, driving forces of SI (capillary force and osmotic pressure) are both in dynamical process. Resistance of SI gradually declines due to hydration damage, which is beneficial for shale SI. Besides, compared to conventional model, dynamical model of SI is more consistent with test results, proving hydration is a major factor of shale SI. In addition, shale damage degree is consistent with degree of SI. During SI process, hydration crack starts to propagate, decreasing mechanical strength and leading to the change from brittleness to plasticity. With increasing imbibition time and hydration degree, total energy, elastic energy and dissipated energy all show decline, indicating the decreasing mechanical stability. Outcomes improve the understanding of shale mechanical behavior, offering theoretical support for high efficiency and safety of long horizontal drilling technique in shale gas reservoir

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