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Coupled Thermal-Hydrological-Mechanical-Chemical Model For Reactive Dissolution and Wormhole Formation in Vugs Carbonate Rocks

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Vugs are very common presence in carbonate rocks. According to vugs interconnection, vuggy pore space can be divided into separate-vugs porosity system and toughing-vugs porosity system. Separate-vugs porosity system is also the target rocks for acidizing, in which the addition of vugs only increases the total porosity but has no significant increase of permeability. But few works have been conducted to study effect of vugs on acidizing process.

In this work, a novel two-scale continuum model coupled thermal-hydrological-mechanical-chemical processes is employed to study acidizing process in two typical core-scale separate-vug porosity systems, vugular carbonate rock and isolated vug carbonate rock. Naiver-Stokes-Darcy equation is used to describe fluid flow instead of using different equations in free flow region and porous media region. Continuity equation of fluid phase is modified to consider mass exchange between fluid and solid phases. Based on this model, many numerical cases are conducted to discuss a comprehensive vug parametric study on acidizing process and hydraulic behavior including shape, position, filling degrees, and diameter.

Results indicate that acid injection velocity still has an obvious influence on acidizing process when vug exists. Acid consumption volume of vugular carbonate rock and isolated vug carbonate rock are less than that of matrix carbonate rock, which is consistent with experimental observations. And typical dissolution patterns including ramified wormhole, wormhole, and conical wormhole can also be observed in vug acidizing process. Compared to dissolution patterns of matrix carbonate rock, the presence of vug induces wormhole to pass through vug. The difference of acid consumption mass is generally not obvious with different acid injection velocities both for vugular carbonate rock and isolated vug carbonate rock. Core porosity and permeability both increase as vug porosity and vug diameter increase. But the increasing of core permeability is limited. It further shows that the presence of vug in separate-vug porosity systems only contributes to more storage space but has little contribution for hydraulic conductivity. As for effect of vug porosity and vug diameter on acidizing process, increasing vug diameter and vug porosity can decrease pore volume to breakthrough both for vugular carbonate rock and isolated vug carbonate rock. While in general acid mass does not change a lot.

Vugs provides main storage space for vuggy reserves. However, modeling of vugs is still a challenge until now, which also limits studying of acidizing process in vugs carbonate reservoirs. In this work, a more fundamental two-scale continuum model is developed to study acid transportation and consumption during vugs carbonate acidizing process, which can avoid employing different equations in free flow and porous media regions and determining additional parameters such as material property in BJS condition.

Time Block Preference

Time Block A (09:00-12:00 CET)

References

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Primary authors: JIA, Cunqi; YAO, Jun

Presenter: JIA, Cunqi

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