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Darcy based models for oil generation and expulsion from source rock

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Oil industry is resorting more and more often to mathematical and numerical modeling to locate new oil and gas reservoirs, and to exploit the existing ones at their best. The numerical simulation of generation and migration processes can support geologic analysis in tracking hydrocarbons “from source to trap” and therefore reduce the risk in oil exploration. This work deals with the mathematical modeling and numerical simulation of the generation of hydrocarbons, and their expulsion from the source rock, with the aim of predicting the amount and quality of oil and gas generated in a region during million years. The chemical reactions of generation are strongly coupled with selective retention processes which act as filters altering the chemical composition of the oil, and with the fluid flow in the rock. We model the flow of water and oil in the rock as a two phase multicomponent Darcy flow. The numerical approximation of the problem relies on a time splitting approach to decouple the equations. Mixed hybridized finite elements are employed for the Darcy problem for an accurate velocity field in presence of strong inhomogeneities in the permeability. The degenerate parabolic equation for the oil phase saturation is solved with an advection-diffusion-reaction splitting, employing the Godunov method for the advective part and expanded mixed finite elements for the degenerate diffusion part. Integration schemes that preserve that are conservative and preserve the positivity of the solution are proposed for the integration of chemical reactions. Moreover, the retention processes introduce a discontinuity in the system that requires a special treatment from the analytic and numerical point of view. The result of monodimensional and bidimensional simulations show that generation, retention and fluids flow strongly influence each other and in particular, the inclusion of retention processes delays the expulsion and enriches the expelled hydrocarbons in gas and saturates, in agreement with typical experimental data collected at the wells.