Detecting and Evaluating Hydrodynamic Sealing by Faults

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Hydrodynamic sealing may cause petroleum-water contact (PWC) variations across minor faults that do not significantly compartmentalize reservoir production. Fault hydrodynamic sealing is analyzed as an extension of classical hydrodynamic sealing theory. Hydrodynamically-sealed faults show two identifying characteristics: (1) water pressure difference across the fault (after correction for the weight of the water), and
(2) tilted petroleum-water contacts. Maximum height of pure hydrodynamically sealed petroleum columns can be predicted from the cross-fault pressure difference. If the petroleum accumulation extends across the barrier, the pressures form a single pressure-depth trend, but the PWC will have different elevations. If petroleum pressures on different sides of the barrier fall on different trends, then another mechanism must be active in addition to hydrodynamic sealing, such as membrane sealing or hydraulic-resistance sealing. The relative contribution of hydrodynamic sealing can be interpreted from pressure differences, PWC differences, and filling history. These data also help distinguish membrane sealing from hydraulic-resistance sealing.

The potentiometric gradient in hydrodynamically trapped accumulations is calculated from the PWC dip and fluid densities. Hydrologically averaged permeability is interpreted from the cross-fault pressure change, reservoir potentiometric gradient, and assumed fault width. The membrane sealing capacity of the fault is estimated from average permeability using empirical trends.

In four field examples, the theoretical relations successfully predicted properties of the accumulation or the barrier. In some cases, hydrodynamic theory guided recognition of tilted fluid contacts that were previously unrecognized. These case studies substantiate the importance of hydrodynamic sealing by faults in hydrodynamic regimes.

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