CAPILLARY EFFECTS ON FAULT-FILL SEALING MECHANISMS AND RATES

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Fault fills have a pore-size distribution, so capillary properties influence seal behavior where they are water-wet. Sealing behavior changes with height above the free-water surface (FWL) as capillary pressure increases up-section in petroleum accumulations. Conceptually, homogeneous fault-fill sealing behavior can be divided into three zones. (1) The lowest zone is membrane sealing, because capillary pressure is less than the fault-fill, capillary-threshold pressure. (2) The intermediate zone is a hydraulic resistance seal, because capillary pressure exceeds threshold pressure, but it is too low for high effective oil permeability. (3) The upper zone is not a seal because capillary pressure is sufficiently high for high effective petroleum permeability and leakage rates. The transition between hydraulic resistance sealing and leakage depends on the threshold leakage rate acceptable for preservation of the petroleum accumulation over geological lengths of time.

The relative magnitude of hydraulic resistance vs. membrane sealing can be evaluated by comparing the height of the zones of membrane sealing vs. hydraulic resistance sealing. The heights of the membrane- and hydraulic-resistance-sealing zones were modeled for standardized fault-sealed structural geometry. Effective petroleum permeability was calculated from mercury-injection, capillary-pressure test data by a modification of the Jennings (1987) method. Flow was numerically integrated with height to determine cumulative leakage rate as a function of height above the FWL.

Height of the membrane-sealing part of the fault and height of the hydraulic-resistance part of the fault increase with increasing threshold pressure. However, the ratio of the height of the hydraulic resistance sealing to the height of the membrane sealing is constant for a given threshold leakage rate and capillary curve shape factor for a petroleum with constant viscosity and density. Over a range of reasonable threshold leakage rates, hydraulic-resistance seal height is about 10% or less than membrane seal height. This indicates that hydraulic-resistance sealing is less important than membrane sealing over geological lengths of time except in settings where petroleum charge equals or exceeds leakage rates.