AAPG Annual Meeting
March 10-13, 2002
Houston, Texas

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Fault Reactivation, Leakage Potential, and Hydrocarbon Column Heights in the Northern North Sea

We evaluated the stress and pore pressure acting on the major faults in four oil and gas fields in the northern North Sea. Many of the faults bound hydrocarbon reservoirs. Our goal was to test the hypothesis that faults reactivated in the current stress field are permeable and tend to leak, whereas inactive faults are likely to seal. We test this hypothesis by utilizing detailed measurements of the principal stresses along with information on pore pressure to resolve the shear and normal stress acting on distinct ~100 m x 100 m elements of individual fault planes. By comparing the stress state resolved on each fault element to expected stress at failure we created color-shaded maps showing the proximity to fault slip (and hence leakage) along each fault. Fault reactivation and hydrocarbon leakage in this area appears to be caused by two factors: (1) locally elevated pore pressure due to buoyant hydrocarbons in reservoirs abutting the faults, and (2) fault orientations that are nearly optimally-oriented for frictional slip in the present-day stress field. We demonstrate that these factors may have induced fault slippage and gas leakage along sections of previously sealing reservoir-bounding faults in some fields, whereas in others, the stress and pore pressure are not sufficient to reactivate faults. We show that only in cases where reservoir-bounding faults are not potentially active, the pore pressure difference across faults can become quite high. Hence, the leakage potential of reservoir-bounding faults appears to exert an important influence on potential hydrocarbon column heights.