Implications of the Pore-Scale Distribution of Frozen Water for the Production of Hydrocarbon Reservoirs Located in the Permafrost

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Reduction of 23.3% and 35.1% was observed in relative permeability to oil by Baptist, 1960 between 75 0F to 26 0F over two Umiat core samples respectively.
The present study investigates the reasons behind reduction in relative permeability to oil and put forth the best production technique for permafrost grounds. The main reason investigated is freezing of interstitial water with in pores and its dependency on changes in temperature and water salinity.
Core flood experiments were performed on two clean Berea sandstone cores to determine the sensitivity of the relative permeability to oil (kro) over a temperature range of 740F to 140F and for connate water salinities ranging 0 to 6400 ppm. For core 01, from 740F to 140F, kro is reduced by 43.2% with deionized water and 33.3% with 6400ppm saline water. Similarly, as salinity drops from 6400ppm to 0ppm, kro is dropped by 10.3% at 740F and 10.6% at 140F. Similar results are observed for core 02.
An alternative Kozeney-Carman equation is used to find the radius of ice formed in the center of the pore by assuming the present system as a cube with 'N' identical parallel pipes embedded in it. With obtained values of kro as input to KC equation at 140F, Radius of ice is dropped from 0.16μm to o.o8μm when flooding water salinity increased to 6400ppm. From this, we can conclude that the presence of salt water in the pore space causes less reduction in relative permeability compared to the presence of pure water in frozen ground.
Deionized water, saline water and antifreeze (mixture of 60% of ethylene glycol or Propylene glycol with 40% of water) are tested to find the best flooding agent for frozen grounds. 9% more recovery is observed with antifreeze over saline water at 320F. Antifreeze has 48% recovery even at 140F where the rest have produced nothing.