Experimental Studies in Support of Protecting ANS Wells and Thermal Oil Recovery- Heavy Oil Development

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More than three decades of extraction of oil and gas from Alaska North Slope (ANS) subsurface formation has caused alterations of the surface and subsurface formation. The active layer is the surface layer of soil that thaws in the summer and freezes in the winter. Many researchers have reported observations that the active layer and permafrost are already responding to the Arctic warming. This degradation of permafrost has profound effects on mechanical stability of the ground, the landscape processes and the infrastructure (surface and subsurface facilities).

The recent emphasis on decreasing the footprint using directional drilling from closely spaced wells on the small well pads have contributed to thawing of annular region in the permafrost around a warm production well. In the process of drilling a well or extracting oil, natural gas or formation waters, fluid circulating through the wellbore transfers the heat from warm formations at deeper depths to colder formations near surface. The heat from the warm fluid is conducted radially through the casing, thawing the annular area.

During the early developments on ANS the well spacing was about 160 ft. apart. After decades of production the thawed areas were still relatively unconnected to each other, thus most permafrost remained intact and able to resist subsidence. With the modern designs, some of the wells are drilled on 10 ft. spacing, which is contributing to the fact that the thawed areas around wellbores could potentially be connected to each other, causing non-uniform subsidence.

Three major potential problems that could be result of annual thawing are: 1) Annular path to the surface- The thawed area is more permeable to fluids, thereby providing a possible path outside the casing, connecting it to the surface; 2) Stress on the well casing- The thawed area near wellbore could lead to two sources of stress on the well casing, a) caused by thaw settlement when annular region loses strength and settles against the casing adding vertical drag forces and radial pressures on the well pipe, b) caused by increased radial pressure as ice reforms during freeze back of annular area after drilling or production has stopped; 3) Surface subsidence- when ice-rich permafrost thaws, its volume typically decreases, leading to subsidence of the overlying formation and damage to structures above. If the thawed areas (due to closer well spacing) coalesce, it could cause very destructive differential settlement of well pads.

The subsidence problem affects two major issues on the ANS: 1) Protecting the infrastructure and wells for long-term operations for decades to come; and 2) The billions of barrels of heavy oil deposits, would need this infrastructure as well as potential use of thermal EOR technologies in the future will need better solutions to manage the subsidence challenge.