Study predicts thawing of gas-saturated permafrost around oil and gas wells of Russian Arctic

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Skoltech scientists and their partners from Sergeev Institute of Environmental Geoscience of RAS, with support from the R&D unit of

TotalEnergies, have predicted how oil and gas wells heat up the permafrost around them. Presented in *Geosciences*, the new model encompasses 30 years of well operation and accounts for not just the melting of ice in frozen soil but also the gradual release of methane locked up in it. Understanding these processes is becoming increasingly relevant for accident-proof extraction and greenhouse gas emission monitoring as oil companies shift their attention to deposits in the Arctic region.

Oil and gas deposits in the Arctic region lie beneath a 100-to-500-meter layer of permafrost. As comparatively hot hydrocarbons rise up along the well shaft drilled in the frozen soil, it heats up. This causes the surrounding permafrost to thaw, compromising its ability to support structures, including the well itself. Moreover, if the frozen soil is saturated with methane, which is typical for the northern part of Western Siberia and the Yamal Peninsula in particular (Russia's major oil and gas companies such as Gazprom and Novatek are active there), the thawing permafrost releases methane—a potent greenhouse gas and a fire hazard.

The first author of the study, Skoltech Leading Research Scientist Evgeny Chuvilin commented on the findings that they "modeled thawing around a production well that operates on the Yamal Peninsula, but similar processes can occur elsewhere and on other types of oil and gas wells, because by definition, hydrocarbons rising up from the depths carry heat: Every time you go 100 meters deeper, things heat up by about 3 degrees Celsius. With extremely deep drilling, oil can get as hot as 100 C or more."

The model proposed by the team shows how the permafrost surrounding an active well gradually heats up and thaws, but there's more to it. Chuvilin added that they "looked at the case with permafrost that is more complexly structured: At the depth of between 60 and 120 meters, it contains gas hydrate inclusions—icelike solids made up of frozen water and natural gas locked up in it. They are stable within a certain range of temperatures and pressures, but when these conditions are disrupted, they decompose, releasing about 170 liters of free gas per liter of solid gas hydrate. We have shown that operating one gas well for 30 years may melt the surrounding permafrost in a 10-meter radius, releasing up to 500,000 cubic meters of methane into the atmosphere."

The team stresses that correct predictions of the well-permafrost thermal interactions are necessary for preventing critical ground depressions and cave-ins, which in turn may result in flooding and disrupt well shaft stability, potentially resulting in major repair costs. As for the emission of methane, that aspect is important for two reasons. First, that combustible gas may create the risk of fires or explosions, which might ruin the well and lead to substantial economic loss. Second, methane is a potent greenhouse gas whose release into the atmosphere needs to be monitored so that researchers could understand global and regional climate change better.

More information: Evgeny Chuvilin et al, Simulating Thermal Interaction of Gas Production Wells with Relict Gas Hydrate-Bearing Permafrost, *Geosciences* (2022). DOI: 10.3390/geosciences12030115

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