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# Pingos and old sub-permafrost water at Svalbard

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Permafrost covers about 25% of the northern hemisphere land. Sub-permafrost hydrology is complicated, in particular in continuous permafrost terrains. Pingos are positive structures, the result of sub-permafrost groundwater discharge. Basically, pingo is a small hill, which builds up from below by the accumulation of ice due to near-surface freezing of upwelled groundwater. There are closed-system pingos and open-system ones. The closed-system pingos are produced by local permafrost thawing (thermo-karst), usually associated with continuous permafrost landscape, while the open-system ones are fed by meteoric water of recent recharge, and are usually associated with discontinuous permafrost.

Pingos at Svalbard were traditionally considered of the open-system style, owing to the scarcity of thermo-karst features and due to their location in valleys surrounded by high topography, believed to be the source for the sub-permafrost water. The continuous nature of the permafrost and the lack of wet-based glaciers led Hornum et al.[1] to challenge this view. They alternatively suggested that the pingos are of the closed-system style, and that the pingo-related groundwater is local, probably old sub-permafrost water, which is being pressed by the permafrost active downward aggradation.

We studied radium isotopes and $^{3}H$ in artesian water discharging at five pingos at the valley of Adventdalen, Svalbard. $^{3}H$ data suggest that all water include old (older than 60 years) component. While in one pingo, the old component is ~50% of discharge, in two other pingos it is ≥90%, and in two pingos there is no young water at all. Close to equilibrium ratios of $^{226}Ra/^{223}Ra$ in most samples suggest that the old water is at least several hundred years old, which is supported by high ratios of $^{226}Ra/Cl$ and $^{226}Ra/Ca$. This further supports the paradigm of closed-system pingos, although the exact age of discharging water should be further studied.

[1] Hornum, Hodson, Jessen, Bense & Senger (2020), *The Cryosphere* 14, 4627–4651