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Intra-ice and intra-sediment cryopeg brine occurrence in permafrost near Utqiagvik (Barrow)

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Cryopeg is a volume of permafrost with a significant amount of cryotic unfrozen water as a result of freezing-point depression by dissolved salt content. Cryopeg and saline permafrost have been reported for coastal areas of the Arctic seas, and their current distribution and future changes are a great concern for the warming Arctic, as the state of permafrost controls ground stability and the functioning of ice cellars in Arctic villages. To describe the distribution and segregation of cryopeg lenses, and to explore the origin and development of the cryopeg and associated brines found near Utqiagvik, we conducted extensive sampling campaigns in the Barrow Permafrost Tunnel during May of 2017 and 2018.

We found two types of cryopeg brines based on their distinctive spatial occurrences: (1) intra-ice brine (liB), entirely bounded by massive ice; and (2) intra-sediment brine (IsB), found in unfrozen sediment lenses within permafrost. While two examples of liB have been reported previously, they were each found within ice layers below ice-sealed lakes in the McMurdo Dry Valleys of Antarctica, geological settings very different from ours. In our study, the liBs were at roughly atmospheric pressure and situated in small pockets of ellipsoidal or more complex shape (dimensions of up to about 30 cm wide and 3 cm height) within 17–41 cm above the underlying sediment layer. Several individual liB pockets may have been connected by porous ice of low permeability. Radiocarbon dating suggests that, at the earliest, the liB was segregated about 11 ka BP from IsB-bearing cryopeg underneath. IsB lenses were interpreted as having developed through repeated evaporation and cryoconcentration of seawater in a lagoonal environment, then isolated at the latest when the surrounding sediment froze up and became covered by an upper sediment unit around 40 ka BP or earlier.

Considering the common characteristics among the cryopeg brines accessed from the tunnel and those found in brine-bearing marine sediment around Utqiagvik, all occurrences of cryopeg brine in the region may have experienced analogous development despite potentially contrasting salinities and estimated ages. An increase in permafrost temperature invariably will result in expansion of cryopeg lenses and may change movement of liquids within the permafrost, which potentially become threats to Arctic coasts, infrastructure, and food security.