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Sediment move into the 3.6 Mya old El'gygytgyn Crater Lake, NE Russian Arctic, as recorded by frozen alluvial fan deposits

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The El'gygytgyn Meteorite Crater in Chukotka holds the unique chance to trace frozen ground conditions back to the Pliocene. The basin was not glaciated in Quaternary time and terrestrial deposits accumulated on the slopes and continuously in a central lake basin. Drilling into sedimentary permafrost at the shore of the El'gygytgyn Crater Lake recovered a 141 m long core of frozen coarse-grained deposits, which belong to an alluvial fan setting entering the central lake basin from the west. The retrieved permafrost core contains ground ice throughout and largely consists of sandy gravels with volcanic clasts embedded in a sandy matrix. Pollen assemblages, ground ice hydrochemistry (i.e. stable water isotopes, major ions) and mineralogical proxies of cryogenic weathering are used as paleoenvironmental indicators for reconstructing late Cenozoic climate, landscape and permafrost dynamics. This aids understanding permafrost history on longer time scales in NE Siberia, an area yet underexposed in permafrost research.

Permafrost conditions through time are inferred from proxy data of cryogenic weathering based on studying the mineral debris. The peculiar weathering features (i.e. quartz grain enrichment in the fine fractions, single grain quartz micromorphology) originate from frost weathering on the exposed crater slopes and in the active layer. Mineral grains are transported subsequently downslope and accumulate in the subaerial and subaquatic parts of the alluvial fan. They are now traced along our core. These two indicators reflect the continuity of thaw and freeze dynamics in the catchment and which drives the production of the mineral debris in the area.

The pollen stratigraphy in the core suggests that the upper 9 m represent a discontinuous record back to the Allerød period. According to the pollen assemblages the Holocene is restricted to the upper 1.8 m where organic matter can occur in amounts of >1 %. Below, where organic matter decreases to negligible values, the Younger Dryas is represented by the interval 1.8 - 2.5 m and sediments at $\sim$20 m depth were probably formed during interglacial MIS 5.5 or 7 as inferred from the pollen assemblages, which can be correlated with other regional records. Whilst the pollen assemblages at $\sim$36 m and $\sim$ 51 m depth still indicate cold Pleistocene environmental conditions, those at about 62 - 65 m depth may belong already to the warmer Pliocene epoch based on high pollen counts of pine, larch, fir, spruce, and hemlock.

The inferred climate oscillations for the transition from the Pleistocene into the Holocene are also suggested in the water isotope record of the ground ice. There, d18O minima and maxima support the inferred vegetation history as indicated by the pollen record. Below 9 m (potentially Allerød), the d18O of the ground ice shows less variation and tends towards lighter isotopic composition. From ancient lake terraces surrounding the present shore line at higher altitudes in the crater it is known that the coring site was flooded during Pleistocene epochs before lake shrinking in the Late Pleistocene gave way to the modern outline of the alluvial fan setting. Thus, the d18O values of ground ice observed lower than 10 m core depth must be discussed in the frame of lowering lake level involving a basinward migration of the freezing front.
A marginal lake environment prior to the Allerød is also indicated by the occasional occurrence of distinctly rounded pebbles, suggesting shore-line processes, and well sorted sandy layers, possibly deposited on the upper lake slope.