Geophysical Research Abstracts
Vol. 13, EGU2011-13169, 2011
EGU General Assembly 2011

Pingo remnants as recorders of Late Weichselian climate and environmental change

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Pingos are known from present day permafrost regions in Alaska, Canada and Siberia and occur under permafrost conditions with sufficient groundwater, leading to the formation of ice lenses. In the Netherlands, the remains of hundreds of pingos have been recognised over the last decades. These pingos presumably originated as a result of hydrostatic pressure, under conditions of discontinuous permafrost during the Weichselian Pleniglacial. As temperature rose at the onset of the Lateglacial interstadial (GI-1, round ca. 12,500 14C BP or 14,700 cal BP), permafrost most likely started to disappear from that time onward resulting in the development of pingo remnants – isolated depressions with or without a rampart. The presence of these pingo remnants with a diameter of 50 to 300 meters and in depth varying between 5 meters in the southern Netherlands to 20 meters in the northern Netherlands indicates a minimum thickness of permafrost in the order of those values. Melting of the permafrost layer that was several meters thick presumably lasted several hundreds of years. Implications for the disappearance of permafrost during the Lateglacial in The Netherlands are given by the basal organic infilling of pingo remnants, dated to begin between 12,500 and 11,900 14C BP. The fills of the pingo remnants in the Netherlands form a unique record of environmental change since the last deglaciation containing for instance pollen, aeolian sand, chironomids, tephra. Some of these depressions are filled with calcareous gyttja, implying that hydrostatic pressure and groundwater exfiltration continued after the decay of the ice-body. Others show clear water level changes and can e used to reconstruct effective precipitation. The fills of clusters of pingo remnants that are closely together can be used to estimate variation within and between the basins.