

# Relict Pingos and Permafrost

## A comparison between active landforms in the Canadian Arctic and relict permafrost features in the Netherlands and adjacent Germany



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### Introduction

Pingos are periglacial landforms which currently are present in permafrost areas in Alaska, the Canadian Arctic, Greenland, Svalbard and Siberia. In permafrost areas with a continuous water supply, ice lenses can form and from these pingos can grow. Isolated circular and most often ramparted depressions are left behind when pingos degrade. In the Netherlands, especially the provinces Friesland, Groningen and Drenthe, hundreds of isolated circular, most often ramparted depressions are regarded as being remnants of these periglacial landforms. According to previous research, these pingos formed during the cold Weichselian Pleniglacial, when discontinuous permafrost conditions caused increasing hydraulic groundwater pressures in the partially frozen upper aquifers. During the warmer Late Glacial Interstadial when the permafrost gradually started to thaw, these landforms collapsed, and the depressions started to fill (see poster R. de Bruijn et al.).



Figure 1: Pingo remnant in the Mackenzie Delta (above) and in Germany (left).

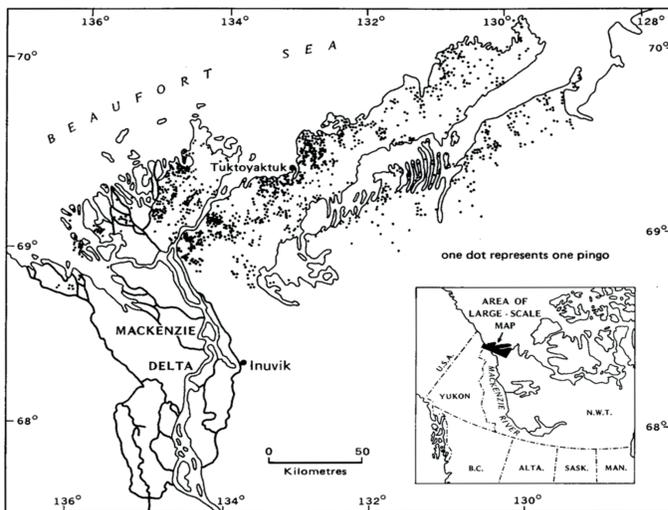
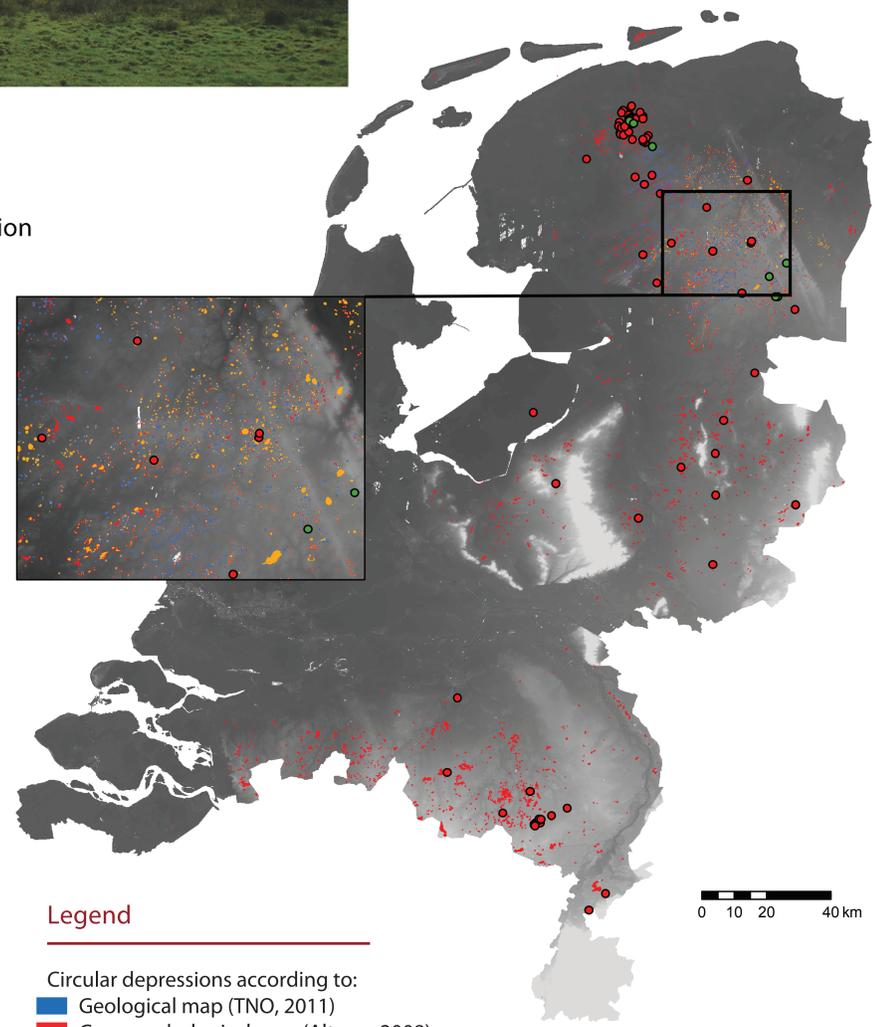


Figure 2: Pingo distribution in the Mackenzie Delta. (Mackay, 1962)

### Discussion

In the Mackenzie Delta plain, active pingos occur, associated to high groundwater levels. In the Netherlands and adjacent Germany the fossil pingos were located >100 m above past sea-level. A mechanism that could explain the formation of pingos could be groundwater pressure related to the occurrence of a confined aquifer. During permafrost degradation in the Netherlands, water sources could have formed. The combination of permafrost on glacial till (present in large parts of the Netherlands) both acting as an aquiclude might explain the occurrence of pingos in the Netherlands during the Lateglacial. Pingos in this area have therefore most probably been open system pingos, fed by a water supply from below the aquiclude.



#### Legend

Circular depressions according to:  
■ Geological map (TNO, 2011)  
■ Geomorphological map (Alterra, 2008)  
■ Geomorphological map (Provincie Drenthe, 2009)

● Pingo remnants (this study)  
 ● Pingo remnants (Hoek, 1997 and others)

Figure 3: Pingo distribution in the Netherlands.

| Region                              | Reported density (per km <sup>2</sup> ) | Source                   |
|-------------------------------------|---|--------------------------|
| Alaska                              |   |                          |
| Interior Alaska                     | less than 1                             | Holmes et al, 1968       |
| Alaska Coastal plain (Beekey Point) |   | Walker et al, 1985       |
| Flat thaw lake plains               | 0.096                                   |                          |
| Gently rolling thaw lake plains     | 0.286                                   |                          |
| Floodplains                         | 0.012                                   |                          |
| Hills                               | 0.027                                   |                          |
| Siberia                             |   |                          |
| Yamal Peninsula                     | 0.13                                    | Grosse and Jones, 2011   |
| Gydan Peninsula                     | 0.21                                    |                          |
| Taymyr Lowland                      | 0.12                                    |                          |
| Khatanga-Anabar Lowland             | 0.13                                    |                          |
| Lena River Delta                    | 0.06                                    |                          |
| Central Yakutian Lowland            | 0.28                                    |                          |
| Yana River Delta                    | 0.08                                    |                          |
| Indigirka Lowland                   | 0.14                                    |                          |
| Kolyma Lowland                      | 0.12                                    |                          |
| Anadyr River Valley                 | 0.28                                    |                          |
| NW Canada                           |   |                          |
| Yukon region                        | less than 1                             | Hughes, 1969             |
| Mackenzie region                    | less than 8                             | Stager, 1956             |
| Greenland                           |   |                          |
| Traill Island                       | less than 11                            | Worsley and Gurney, 1996 |
| Netherlands                         |   |                          |
| Drenthe                             | 0.74                                    | This study               |
| Friesland                           | 0.26                                    |                          |
| Groningen                           | 0.05                                    |                          |

Table 1: Pingo densities (after: Grosse and Jones, 2011)

### Conclusions

The pingo density analysis of the Netherlands (based on figure 3) is a method which shows that a comparable spatial distribution is found elsewhere (table 1). However, the amount of pingo remnants is strongly dependent on the amount of research done in this area, which differs considerably. An uniquely high concentration of open system pingo remnants is present in the Netherlands.

### References

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