Permafrost & climate change in northern Finland

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Introduction

- In Finland permafrost is only found on the northern fells and in palsa cores
- The permafrost here is ‘warm’ so it is very sensitive to climate change
- Most Finnish palsa cores appear to be in decay
- Palsa decay may lead to greater methane (CH₄) emissions from northern mires (methane is a ‘Greenhouse Gas’)}
Permafrost
“Earth materials (soil, sediment or rock) that remains at or below 0°C for a period of at least two years”

Palsas
“Perennial mounds in a peat bog with a frozen core containing segregated ice”
Finland

- Large country at 338,145 km²
- Relatively low lying
- About 25% mires (>30% before drainage)
- Has a ‘seasonal frost’ climate
- Permafrost occurs on fells & in palsa cores in the north only
Permafrost in Finland

Discontinuous - on fells (tunturi)

Sporadic - in palsa cores
Geomorphology, including palsa distribution, northern Finland
Climate of northern Finland

- Winters are moist & cold
- North of the arctic circle the m.a.a.t. is often <0°C
- Drier than the south at about 400-600 mm per annum
- The uplands (fells) of Finnish Lapland have a specific microclimate
Mean annual temperatures in northern Finland 1931-1961
Seasonal Frost Climate

- The climate and substrates in northern Finland mean that seasonal frost is an important geomorphological factor.
- Seasonal frost has created:
  - stone stripes
  - stone polygons
  - earth hummocks (pounu)
  - palsas (perennially frozen core)
Palsa mire landscapes of northern Finland
Mires in Finland

- Before mire drainage in the 20th century, mires occupied >30% of the land area in Finland.
- Finnish mires can be divided into three zones: Raised Bog, Aapa and Palsa.
- Mires can be ombrotrophic (rain-fed) or minerotrophic (stream-fed).
Palsa mires

- Basically these are a periglacial form of mire and contain ‘permafrost’
- Instead of the ‘strings’ and ‘flarks’ of aapa mires, palsas (up to 7 m high) along with pounus (< 0.5 m high) form the microtopography
- Only found in northernmost Finland where the MAAT is < -0.5°C
Mire classification in northern Finland
Palsas in northern Finland

- From the Lapp for a ‘mound in a peat bog’
- Contain a segregated ice core (in the peat)
- Occur in clusters in palsa mires
- From 0.2 to 7 m high and 4 to 100 m long axis
Palsa types in northern Finland

Peat palsa

Mature peat palsa

[Diagram showing different types of pallas, with labels for peat, silt, segregated ice, and permafrost boundary]
Palsa requirements

• MAAT between -0.5 to -3°C
• Relatively thin winter snow cover
  – Wind may redistribute snow
• Thermal properties of peat:
  – Insulates the ground in summer (if dry)
  – Enhances the cooling of underlying materials in winter
• Peat cools readily and thaws only slowly
Palsa growth & decay cycle (process = cryosuction)
Palsa formation - 1

• Snow cover removal hypothesis
  – Seppälä
  – Finland
  – Tested experimentally
  – Snow is a good insulator
  – Snow removal leads to deep frost penetration
Palsa formation - 2

• Vegetation change hypothesis
  – Railton & Sparling
  – Canada
  – Based on albedo changes associated with vegetation changes
Palsa formation - 3

• Buoyancy hypothesis (USA)
  – Nelson et al (computer model)
  – North America
  – Idea that a parcel of peat with included ice is more buoyant than the surrounding mire and rises up
Palsa core temperature measurements -1.1°C
Coring in a palsa mire (Kaktsavárjeäggi)
Palsa Mire Vegetation

- Flarks
  - Cotton grass (*Eriophorum* species)
  - Sphagnum moss (*e.g.* *Sphagnum lindbergii*)
  - Sedges (*Carex species*)

- Palsas
  - Crowberry (*Empetrum nigrum*)
  - Labrador Tea (*Ledum palustre*)
  - Cloudberry (*Rubus chamaemorus*)
  - Dwarf Birch (*Betula nana*)
  - Reindeer moss (*Cladonia* species – lichen)
Betula nana
Rubus chamaemorus
Ledum palustre
Empetrum nigrum
Palsa Decay

- Natural process (may be accelerated)
- Dilation cracking in the peat due to volumetric increase leads to:
  - Thermokast (ice core melt)
- Thermal and mechanical erosion by adjacent pools (flarks)
- Deflation of the peat surface by wind
- Thermal contraction cracking
Collapsing palsā (Kaktsavarjeäggī)
Palsas & climate change

• Palsas may be useful indicators of climate change
• Current palsa distribution may only be a small remnant of the previous distribution
• Increasing summer precipitation may be more damaging to palsas than increasing air temperatures (wet peat)
• Palsa decay may contribute to climate change (through methane release)
Measuring pH, temperature & redox potential in the surface waters and peat at depth in a palsamire (Kaktsavarjeäggi)
Conclusions

• Warmer winters or summers may lead to a lower incidence of embryo palsas
• Increased summer precipitation and temperatures may lead to a more rapid decay of mature palsas
• Ultimately, palsas may decay completely in Finland and the northern aapa mire zone will simply extend further north
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