Note

Open System Pingos in Mellemfjord, Disko, Central West Greenland: A Reply to Gurney and Worsley

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Abstract

A group of marsh initiated open system pingo remnants from the Iterdlagssûp kûgssua valley mouth, in Mellemfjord, Disko Island, Central West Greenland was described in Christiansen (1995). Gurney and Worsley (1997) state that the location of this group of pingo remnants in the Iterdlagssûp kûgssua valley mouth is of no relevance to their genesis, and that they presumably were the result of an assumed late Holocene sea level regression, causing permafrost to be established in the valley bottom. In this reply the arguments by Gurney and Worsley (1997) on the Iterdlagssûp kûgssua valley pingos are commented, and it is argued by way of sea level information, frost penetration and water supply that the special setting must indeed have caused pingo initiation and growth. Furthermore, the area has experienced a relative sea level rise during the late Holocene.

Keywords

Open system pingos, Little Ice Age, Disko, Greenland.

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In my original paper (Christiansen, 1995) attention was drawn to a special geomorphological setting of some pingo remnants in the Iterdlagssûp kûgssua valley mouth in the Mellemfjord area, Disko Island, Greenland. It was argued that these pingos evolved during the Little Ice Age period. The investigated pingos were clearly classified as open system pingos, an opinion also shared by Gurney and Worsley (1997). The unusual topographic setting of the pingos on marsh flats along the upper tidal limit appears to indicate site-specific controls on their initiation and growth.

In the following I will respond to the comments by Gurney and Worsley on a case-by-case basis.

Donner (1978)

Gurney and Worsley (1997) notes that the pingos in the Mellemfjord region were first discussed by Donner (1978). It is correct that Donner (1978) reported pingos from the Mellemfjord area, as was noted by Christiansen (1995, page 46). However, he only mapped and described pingos from the innermost part of Mellemfjord, in the Kildedalen area (Donner, 1978 Figure 2, page 65). He did not mention the pingos in the Iterdlagssûp kûgssua valley, which were discussed in Christiansen (1995), and did not classify the pingos regarding their genesis.

The Single Pingo

The pingo located 5 km further up the Iterdlagssûp kûgssua valley, on tshe valley side (Humlum et al., 1995, Figure 3) is a classic open system pingo. This particular pingo has nothing to do with the described pingos in the valley mouth, as the geomorphologic setting is completely different, and it was therefore not discussed further.

Pingo Concentration

Gurney and Worsley (1997) argue that the concentration of the Iterdlagssûp kûgssua valley pingos does not represent a problem, and that their location at the valley mouth is merely a confusing factor and not significant to their origin. However, the unusual setting, as Gurney and Worsley (1997) admit that it is, in my opinion represents an interesting possibility for a direct combination of permafrost evidence with sea level variation, which was a key subject in my paper (Christiansen, 1995). According to Gurney and Worsley (1997) the concentration of the Iterdlagssûp kûgssua valley pingos is not a problem, as other complexes of hydraulic pingos likewise exist on Traill Island, East Greenland. These complexes, however, do not have a geomorphological setting equivalent to the Iterdlagssûp kûgssua valley pingos, as they are located far from the coast (Worsley and Gurney, 1996, Figure 2, page 251). Therefore these pingos can only, with great care be used in a direct comparison with the Iterdlagssûp kûgssua valley pingos.

Pingo Genesis

At one point, Gurney and Worsley (1997) suggest that what I described really were closed system pingos, and from this, criticise me for not having classified the pingos as open system pingos. The pingos in the Iterdlagssûp kûgssua valley mouth were clearly classified as open system pingos by me (Christiansen, 1995), however, they were probably initiated due to a particular favourable combination of 1) suitable glaciofluvial sand and fine-grained estuarine sediments, 2) sufficient frost penetration and 3) sufficient supply of water during the freezing season. This combination only exists on the highest parts of the marsh flats along the upper tidal limit. Here the immigration of vegetation during the accumulation of the marsh flats causes the highest sedimentation rates at exactly the location of the pingo group described (Christiansen, 1995). Therefore, this part of the marsh is slightly higher than the surrounding valley bottom, and thus more exposed to frost penetration.

Relative Sea Level

Gurney and Worsley (1997) interpret the pingos described as being developed in 'newly exposed sediments following marine regression'. Furthermore, they claim that I should have stated that the lowermost section of the valley has been exposed following marine regression within the last 2,700 years.

In my paper (Christiansen, 1995, page 44 and 47), it is, however, clearly explained that sea level was approximately 2 m below the present at 2,750 years BP (Bojsen and Jacobsen, 1979), and that the lowermost part of the valley therefore was transgressed sometime within the last 2,750 years BP. Recently, detailed studies close to the Iterdlagssûp kûgssua valley show that a relative sea level rise has occurred since 0.7 ka BP (Rasch et al., 1997). This rejects the basic perception on which the alternative interpretation suggested by Gurney and Worsley (1997) is founded.

Pingos in a Marsh Environment

The occurrence of the pingos along the interior and highest part of the marsh flats, and the rising relative Late Holocene sea level gives strong evidence as to their dependence on this particular environment. Enhanced frost penetration during the Little Ice Age (AD 1400-1900) and water supply from the glaciofluvial sediments up valley presumably established conditions required for pingo initiation and growth. Even though the area is located within the zone of continuous permafrost, obviously the substantial glaciofluvial summer discharge in the Iterdlagssûp kûgssua valley must cause the general permafrost thickness to be reduced along the valley bottom. A more or less continuous down valley flow of water through the sediments probably takes place, sufficient for pingo growth during the Little Ice Age at the mouth of the valley, on the highest parts of the marsh flats. This is also the location where an underlying wedge of marine salt water is expected to force fresh water, flowing down valley beneath the permafrost, towards the terrain surface. The precise location of the fresh water, being of supra-, sub- or intra-permafrost origin is, however, not known. The existence of a recurring icing in the Iterdlagssûp kûgssua valley bottom, slightly up valley from the pingos, signals water flow to the valley bottom during a large part of the winter season.

By this, high lying marsh flats in combination with a period of extraordinary cold climate during the Little Ice Age (AD 1400-1900), presumably was decisive for the initiation and development of the pingos, as suggested by Christiansen (1995).

Conclusion

In my opinion the concentration of the pingos in the Iterdlagssûp kûgssua valley mouth represents an interesting occurrence in an area otherwise devoid of pingos or with only a single or a few pingos in one location. Therefore it appears appropriate to consider why a significant group of pingos developed along the upper tidal limit, in this particular valley mouth, especially when the late Holocene relative sea level affords a means of age range determination.

As described in Christiansen (1995), the pingos now experiences lateral thermal erosion. Therefore their initiation and growth must represent a past period with an extraordinary cold climate. Today no new pingos appear in the area. During the Little Ice Age (AD 1400-1900) the average annual air temperature in the nearby Illulissat area was presumably at least about 2°C below modern values (Humlum, 1996), which, in combination with a rising relative sea level (Rasch et al., 1997) makes this period most likely for the pingo initiation.

References

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