Note

A Discussion on Pingos in Mellemfjord, Disko, Central West Greenland

Stephen D. Gurney and Peter Worsley

Open system, or more correctly, hydraulic pingos, are genetically poorly understood. A continuing problem concerns their need for a perennial groundwater supply (intra- or sub-permafrost). This has to be maintained despite the existence of continuous permafrost in many areas where they are located. Recent work on Disko Island has suggested a new type of hydraulic pingo developing only in a "marsh environment". It is argued that the marsh setting is not relevant to the formation of these features and that they are simply hydraulic pingos.

Keywords

Hydraulic pingos, permafrost, Greenland, Disko.

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This discussion intends to highlight problems with the hypothesis proposed by Christiansen (1995) concerning the pingos of Mellemfjord. Christiansen´s work appears to be part of a larger ongoing study as outlined by Humlum et al., (1995), therefore, discussion at this stage may prove particularly useful. It should be noted that the pingos in this region were first discussed by Donner (1978).

Pingos are one of the few periglacial landforms which are true indicators of permafrost conditions and take their name from the Inuit for conical hill which was first introduced by Porsild (1938). The current global classification scheme recognises two types of pingo: the hydrostatic pingo (closed system) and the hydraulic pingo (open system). Fritz Müller (1959) originally proposed this genetically based classification and Mackay (1979) extended its use. Indeed Mackay´s long term monitoring work concerning the hydrostatic pingos of the Mackenzie Delta and Tuktoyaktuk peninsula area, N.W.T., Canada, has done most to characterise pingo processes (e.g. Mackay, 1973; 1977; 1987; 1994). Despite this large body of work, the understanding of hydraulic pingo genesis has advanced little since the early 1980´s with important contributions from Liestöl (1977) and Hamilton & Obi (1982). The basic processes involved with hydraulic pingos involve the generation and movement of groundwater under artesian pressure which forms a perennial sub-surface supply to the pingo ice-cores. The type-area for hydraulic pingos is east Greenland particularly northern Jameson Land and the Karup Valley area of Traill Island (e.g. Müller, 1959; Cruikshank & Colhoun, 1965; Lasca, 1969; O´Brien, 1971; Allen et al., 1976; Worsley & Gurney, 1996). The other areas where hydraulic pingos occur include Alaska and Spitsbergen (e.g. Liestöl, 1977; Hamilton & Obi, 1982).

The region of central Alaska in question represents an area of discontinuous permafrost and is therefore one in which recharge and movement of groundwater does not represent conceptual difficulties. Spitsbergen and east Greenland, on the other hand, are areas of continuous permafrost and hence present problems for the accepted genetic hypothesis. In order for a continual supply of groundwater to be achieved over considerable periods (and hydraulic pingos require considerable periods in which to grow) zones of groundwater recharge and groundwater pathways must be maintained. It may be argued that the groundwater is sub-permafrost in nature and this avoids the necessity to maintain conduits within the permafrost, yet the question remains as to how the groundwater supply is replenished at altitude since this is required to generate the artesian pressures required. In the context of Spitsbergen, recharge of groundwater beneath glaciers has been suggested by Liestöl (1977), however, at many of these localities glaciers are either not present or are small in size. That is, warm-based glaciers with sufficient thickness to introduce a reasonable volume of water into the subsurface. Traill Island which has classic examples of hydraulic pingos forms an extremely useful case study of these problems (see Worsley and Gurney, 1996).

Discussion

Turning to the genesis proposed by Christiansen (1995) for the Mellemfjord pingos, a continuous permafrost setting and a typical valley bottom location is described for what are termed "open system pingos", the genesis described, however, is more closely related to that of hydrostatic (closed system) pingos. That is, it involves surface frost penetration of newly exposed sediments following marine regression. This freezing eliminates any taliks and expels pore water from their sediments which, in turn, supplies the pingo ice-cores. This is not the genesis of hydraulic pingos. Either these features are the result of the elimination of taliks formerly sustained by marine waters (following aggradation of the area), and represent a type of hydrostatic system, or they are related to an hydraulic (artesian) groundwater supply and are therefore hydraulic pingos. Whichever is the case, Christiansen appears to have incorrectly classified these features.

It is here postulated that these features represent true hydraulic pingos sustained by perennial intra- or sub-permafrost groundwater as are the pingos of east Greenland. Their location at the valley mouth is merely a confusing factor and is not significant in their origin. Hydraulic pingos could easily progress through a growth and decay cycle within the 2,700 years which Christiansen states is the period that this lowermost section of the valley has been exposed following marine regression. The concentration of pingos in this area does not represent a problem either, since on Traill Island, east Greenland complexes of hydraulic pingos numbering up to 10 have been documented (e.g. the Zurich group: Worsley & Gurney, 1996).

Of obvious importance, to the comprehension of pingos in Mellemfjord is the work of Humlum et al., (1995) which documents landscape evolution in the Mellemfjord area. This work includes a geomorphic map of the valley in question (Figure 3, page 31) which locates the 5 pingos documented by Christiansen (1995) as well as another pingo, 5 km up valley from the mouth by the sea. This feature appears to be located just above the valley floor. Whilst the pingos at the valley mouth are discussed in Humlum et al., (1995) the pingo further from the coast is not, probably because it is not interpreted as belonging to the "marsh initiated group". This solitary pingo is important since it is likely to represent an hydraulic pingo and provides evidence for groundwater upwelling at a locality which cannot be related to the elimination of taliks following marine regression. Furthermore, Christiansen´s map (1995, Figure 2, page 43) shows an icing (naledi) which again provides independent evidence of perennial groundwater upwelling unrelated to the marine regression. Thus, if groundwater systems are operative throughout the area their absence at the valley mouth requires explanation.

It is salient to note that other workers have attempted to subdivide hydraulic pingos, for example, Yoshikawa and Harada (1995). It is, perhaps, not surprising since hydraulic pingos are so poorly understood that meaningful generalities are difficult to substantiate in all cases. This accounts for why particular groups are often credited as forming a separate species of the general genus. Nevertheless if this is to be attempted it must be made certain that the genesis proposed conforms firstly to true pingo genesis as follows:

(i) The mounds are true pingos in that they are perennial, exist within a permafrost environment and rely on a pressure system (as opposed to cryosuction) to deliver water to their core where it is frozen;
(ii) The mounds belong to one of the two sub-groups i.e. the origin of the pressure system is either hydraulic (artesian) or hydrostatic.

Where the above criteria have been proved to determine hydraulic pingos, only then can a sub-division of this group be made, however, any such sub-division must conform to the criteria set for hydraulic pingos. It is, of course, possible that some pingos may be identified which cannot be readily assigned to either hydraulic or hydrostatic groups due to the paucity of data regarding the groundwater movement within permafrost beneath the features. Here the features may be termed mixed or polygenetic in origin (see Gurney and Worsley, in press).

Conclusions

It would appear that whilst the work of Christiansen (1995) and Humlum et al., (1995) documents the existence of at least 5 more pingos to add to the growing list for west Greenland (e.g. Yoshikawa, 1991) no good evidence for a new type of hydraulic species have been presented. Whilst the location of the majority of these features adjacent to the valley mouth does much to constrain the maximum age of these features it does not indicate that these features are unique to this environment. If they are, then their processes of formation owe more to hydrostatic pingo genesis than to hydraulic pingo genesis because they involve the elimination of taliks which progressively forces water out of the sediments and into the pingo core. Therefore, it is concluded that these features merely represent hydraulic pingos in an unusual setting.

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