

## ***Interactive comment on “Pingo development in Grøndalen, West Spitsbergen” by Nikita Demidov et al.***

**Go Iwahana (Referee)**

giwahana@alaska.edu

Received and published: 27 June 2019

The paper “Pingo development in Grøndalen, West Spitsbergen” by Demidov et al. presents very rare data set about internal structure and ice geochemistry of a pingo in West Spitsbergen. The paper discusses possible water sources and freezing conditions of the core ice, then growth history the pingos in target area. Especially, the cryolithological information with geochemistry of entire pingo core ice (with underlain sediment) is a paramount value for understanding frozen ground on Earth and other planets. This paper should be published ultimately with additional information after some clarifications of information provided and revision of discussion. (Major comments) The title of paper is too broad, and it indicates overall study on pingo distribution and development history in Grøndalen. However, the focus of this paper, to me, is

C1

unveiled internal structure of this particular pingo and interpretation of geochemistry of pingo ice and surrounding water. Could you revise the title so that reader can easily understand the contents of the paper more specifically?

Discussion about water source of pingo ice is not clear mainly because the definition of precipitation is vague in the text. I encourage authors to reconstruct the discussion considering time and area of the precipitation and groundwater. I think the confusion came from the fact that the water sources of pingo ice and sources of groundwater (and river) are different concepts (groundwater can be a source of pingo ice, but the groundwater itself has its water sources.).

Section 5.3 should be rewritten and revise thoroughly to clearly present authors' discussion. Its paragraph structure does not match discussion flows. It was very hard to follow the logic of authors' idea and some statements don't sound to me as pointed in minor comments below. Authors discussed hydrologic conditions and history of pingo growth comparing to Yoshikawa and Harada (1995) model; however, explanation, evidence and reasoning to suggestion of non-marine sedimentation are weak and discrepancy points between researches are unclear. This can be improved by describing more details about Yoshikawa and Harada (1995)'s development model and their reasoning if you intend to include this comparison in the conclusion. Please make it clear about discrepancies and discussion in occurrence of sea regression at the target pingo location, timing of the regression, interpretation of sedimentation history at the site, and judgment of marine or non-marine sediment.

I think it is important to show photo of obtained cores for judgment of integrity, and also to capture cryolithologic properties of the target pingo as authors indicated as one of the purposes. Recovery of the entire massive ice core of a pingo is a dominant value of this study, however, cryolithological description and discussion of the obtained core is poor. Aim (1) can be more developed by comparing to other pingos on Spitsbergen (and in other regions?).

C2

(Specific minor comments) P2, first paragraph: please provide some references for these descriptions. P2, L25: What are the unresolved questions relevant to this paper? P3, L23: I assume 5.5 m depth is the height difference between the crater rims and bottom, but it could mislead to be understood as water depth. What is the water depth? And did you drill through the ponding water (ice in May, right?) into the pingo core? P4, L3: Showing photos of cores will provide necessary information to judge stratigraphic integrity and possible contaminations. P4, L4: "Drill diameters", are these borehole's or core's diameters? What is the upper parts thickness? P4, L15-: Please provide information about subsampling interval for each measurement. P4, L27: This sentence indicates water was extracted from sample cores, but the following sentence obviously tells the cores were dried first, then added DI water. Probably, the water extraction is after the drying and DI water adding procedure? Please clarify. P5, L24: It is important to know how transparent and perfectly free from any inclusions (materials and bubbles) to understand formation of the massive ice. Could you show close-up photos of the ice? The next sentence mentions about 10P5, L25: Is the dimension 1-2 -10-20mm thickness or length of the flakes? What is 0.5 P5, L26: most air bubble should be rounded. Could you provide more information about the bubble shape? Oriented? Trained? Spherical other shape? What is 10 P5, L27: "well defined lower contact to the basal deposits", Please provide photo and describe more about characteristics of the boundary ice and sediment. P5, L27-28: "From 22.2 . . . is underlain by dark. . ." Ambiguous sentence. The layer 22.2-25m is the dark grey clay? Or within this layer the pingo ice is underlain by clay? P5, L29: Clear ice doesn't necessarily mean segregation ice. The word "clear" is vague in this case. Do you mean just color, bubble-free or no inclusions? P6, L1: "top of the pingo" could indicate entire pingo-top crater. Do you mean top of the crater rim? Highest point? P6, L2: What is "modern top soil" and "buried soil formation"? How did you differentiate them? "plant organic material" is terrestrial? P6, L6: 1.2m (4.7 -5.9m) thick clear segregation ice? This is interesting data to understand the formation of this kind of frost mounds. Including photos of these cores is really helpful also for relevant researchers to understand de-

C3

velopment mechanism. P6, L11: "structure less cryostructure" can be displayed by photo. P7, L3: "sedimentary water extracts" indicates you measured extract water from the original samples. See my comment on P4, L27. P7, 23-25: Why this points to the non-marine origin. Could you explain this in detail? This relates to one of your important conclusions. P9, L2: "on the mounts of valley sides. . ." P9, L10: Is the source water exclusively from sub-glacial melt? Is there any contribution from rain or snow melt? P9, L19-20: I could not understand the logic of this sentence and the previous explanation. P9, L21: Do you have any information of discussion about how stable or variant geochemistry of the spring water seasonally and inter-annually? P10, L3-5: As you discussed earlier, the source water came from glacier melt in the upper area of the valley. Past precipitation (rain and snow) in the ground water source area would also be a probable water source for the pingo ice? "precipitation" in this paper should be well-defined because there are many types depending on time-scale, season, and precipitated area (if you discuss about groundwater source, precipitation in the recharge area might be different from that in your sampling area of precipitation and river data.). P11, 10-11: "Generally. . ." I cannot understand this sentence. Please revise it and provide some references. P11, L22-24: This is a long sentence and it's hard to understand. It is not clear to me why authors need to state this. It is better to bring comparable observations of internal structure of other pingos. P11, L28-30: Hard to understand. Please explain about "step-wise massive ice growth". P11, L33: I could not understand this logic. Do you mean the massive ice started to grow when freezing front reached at 15m depth and most of the upper sediment layer was lost by solifluction? P12, L10-12: I don't find the first half of this sentence is general fact. The second half seems to be too obvious to state. P12, L12-13: Please explain why Yoshikawa and Harada (1995) concluded this. P12, L16: Is the presence of gravelly sand and loam the only reason for non-marine deposit? It is unclear if authors suggestions are contradicting to marine deposits only or pingo growth after sea regression as referred by Yoshikawa and Harada (1995). P12, L18: This sentence doesn't sound to me because heaving amount that forms current pingo height could advance any moment of freezing

C4

of intruding water. Are you assuming intrusion of groundwater into the pingo bottom started when the ground was frozen down to 15m? Is there any possibility the intrusion happened earlier, and advance of entire ground freezing and intrusive ice core development happen at the same time? P12, L34: Please explain and define "warm-based" and "cold-based" glaciers. P13, L2: What is "rare locations"?

P13, L10: active layer depth → active layer thickness, or in this case maximum thaw depth would be suitable. P13, L11: "fast" degradation → temporal degradation rate are not discussed in this paper. Authors should provide evidence of ongoing fast degradation and strong solifluction (against degraded in the past but stabilized) if they want to conclude this. P13, L18: It was hard to understand this sentence. Characteristics of what? Non-marine character of the pingo deposits indicate fault-related groundwater discharge and ground-water origin from warm-based glaciers are unlikely? But I couldn't understand why. P13, L22-24: This sentence needs to be rephrased or edited.

Table 1: What the "v" indicates? Fig 1: Provide contour lines information. Fig 1: Could you add information of geological faults location/direction? Fig 2: Why the sample intervals of stable isotopes and ions are so different, especially in the unit II? Fig 4 (a): One more value should be in the y-axis. Fig 2-5: Use different symbols for different components in same figures so that readers can distinguish them in blackwhite printouts. Fig 6: Please revise this image so that it can display difference between authors' and Yoshikawa Harada (1995) development models.

Please also note the supplement to this comment:

<https://www.the-cryosphere-discuss.net/tc-2019-76/tc-2019-76-RC2-supplement.pdf>

---

Interactive comment on The Cryosphere Discuss., <https://doi.org/10.5194/tc-2019-76>, 2019.