

## Interactive comment on “Permafrost soils and carbon cycling” by C. L. Ping et al.

This review paper summarises concisely and (in general) clearly an eclectic literature on soils and carbon cycling in permafrost regions. This literature includes contributions from soil science, geocryology, biogeochemistry, periglacial geomorphology, Earth System modelling, Quaternary science, ecology and geology. Such breadth of coverage is a welcome contribution to help integrate our understanding of permafrost soils and carbon cycling, and the authors should be congratulated on bringing this together very nicely. I recommend that the review is published and suggest below some relatively small improvements that would help readers to place the work in the context of research questions, to understand more about the process(es) of cryoturbation, and to appreciate more clearly what the soil profiles look like. My only substantial criticism of the review is that it is structurally imbalanced: the narrative provides substantially more information than the figures, and I think with an appropriate call for photos amongst the five co-authors that it could make a visually important contribution to the literature, and balance the strong narrative impact.

### General comments

1. **Research questions:** I think the Introduction constitutes a later section and should instead stand back and summarise the main research questions that are driving recent research on permafrost soils and carbon cycling. These questions should lead readers into the subsequent sections of the review.
2. **Conclusions:** after providing a fine review of the literature the paper again needs to step back and provide readers with some key conclusions and priorities for future research. At present, the review seems to me to start and end abruptly, and lacks a context that the co-authors, with their wealth of experience, are very well placed to provide. Basically, the narrative reads like an incomplete draft.
3. **Cryoturbation:** this process (which is fundamental to carbon cycling) could be explained more clearly in mechanistic terms that relate soil thermal and hydrological conditions to the resulting movement of mineral soil and organic matter in the soil profile. Generally the literature on cryoturbation (with a few exceptions like Mackay 1980, and Hallet & Prestrud) seems to me to be pretty vague and I think this paper could make a valuable contribution that explains cryoturbation simply and concisely in process terms. Bockheim (2007; *Soil Sci. Soc. Am. J.* 71:1335–1342) provides a useful starting point in his review of cryoturbation, although detail on process is scant.
4. **Soil profiles:** a series of annotated colour photographs showing the main types of permafrost soil profiles (turbels, histels etc) developed on different substrates (clay, silt, sand) and associated with different permafrost types (epi- and syngenetic) and biomes (polar desert, tundra, boreal etc.) would be invaluable for readers. Remember that the paper is substantially aimed at the carbon community, and in my experience many ‘carbonites’ coming to work in permafrost settings are NOT very familiar with permafrost soils and find the soil nomenclature confusing.

### Specific comments

Note for the journal production: the absence of cumulative line numbers on the paper wastes reviewer time counting lines, and author time checking. The journal really ought to fix this problem.

1. Page 710, section 1, paragraph 1, line 5: I think you mean that the permafrost region occupies 24% of the exposed land surface; the actual area of permafrost is considerably less (see Zhang et al. 2000, 2008).
2. Page 710, section 1, paragraph 1, penultimate line: by ice free do you mean free of glacier ice or all forms of ice?
3. P. 711, last para, line 3: define IUSS
4. P. 712, last para, line 4: ‘notable’ in terms of carbon. But there is lots of relict epigenetic permafrost too.
5. P. 713, first para, line 9: I think you mean permafrost in non-glaciated regions. Permafrost probably degraded widely under thick glacial ice of the Laurentide Ice Sheet and other ice sheets.

6. P. 714, final para, third line up from bottom: 3 to 4 months is right at the maximum of the zero curtain; it more commonly lasts in the order of weeks. Better to cite research papers by e.g. Outcalt et al 1990 than Davis 1991.
7. P. 715, para 2, line 7: cryostatic pressures refers to ice pressure, whereas I think you're suggesting (through usage of 'saturated zone' either an artesian pressure (in last to freeze parts of the active layer near the base of hillslopes, with water flowing downslope through the active layer) or hydrostatic pressure (during 2-sided freezing of saturated non-frost susceptible material like sand or gravel on flattish ground). The cryostatic pressure hypothesis of involution formation (at least in frost-susceptible sediment on hummocky flattish ground) was debunked in 1976 and 1980 by Mackay, who failed to measure high porewater pressure during 2-sided freezing within earth hummocks. 2-sided freezing sucks water away from the last to freeze part of the active layer (some upward, some downward), consolidating it and increasing the shear strength of the central active layer, making cryoturbation of this part less likely at this time of year.
8. Page 715, penult para, line 5: 'create' (in singular) as contraction and expansion are plural.
9. Page 716, penult para, lines 3-4: Please clarify: frost jacking ejects elongate stones towards ground surface, with the long (a) axes vertical to subvertical (perpendicular to freezing front). That's why in Pleistocene periglacial sedimentary sequences, elongate stones are commonly oriented vertically to subvertically.
10. Page 716, last para, line 1: delete comma after 'formation'
11. 3 lines later: my understanding is that 'organic' is an adjective, not a noun, although it is commonly used incorrectly as a noun
12. P. 717, line 5: replace 'water' with 'volume'
13. P. 718, line 3: add 'and melting' after 'the formation'
14. P. 718, para 2, last few lines: are Mn nodules common in permafrost soils? Where in soils does the ferrihydrite tend to form?
15. P. 719: lines 1-3: usage of 'different' three times in a sentence is excessive
16. P. 719, para 2, line 1: please clarify usage of terminology: here 'transition layer' is used, whereas section 2.2 uses 'transient'.
17. P. 720, last para, line 1: I think you mean 'the formation of ice' (at the start of the para), because ice is not a process
18. P. 721, para 2, line 4: not sure I understand what you mean by 'thermal convection'. The process-based permafrost literature by Mackay, Peterson and others tends to refer to 'soil circulation' and 'differential frost heave' etc, but not 'thermal convection' as convecting heat has no direct impact on frost sorting and the water convection of Ray et al. is doubtful in all by coarse sand and gravel.
19. P. 722, line 5: Didn't Mackay identify in the 1950s a buried organic layer formed by hummocks moving downslope?
20. P.722, penult. Line: I'm not really clear from reading the narrative above exactly how cryoturbation redistributes SOC. Could you insert a sentence or two that explains this process mechanically in simple terms.
21. P723, para 2, line 1: 'was' (a series is singular)
22. P. 723, last line: what are these subzones? It is confusing having C (for carbon) and subzone C (for a soil layer?) in the same sentence; best use another way of describing the subzone.
23. P. 724: line 1: please explain this increased insulation effect in process terms. This whole paragraph is not easy to follow because it is not clear (to me at least) what all 5 the different subzones are. It would clarify things if the vegetation and land surface characteristics were specified, so changes from subzone C to D were explicit for the reader.
24. P724, para 2, 6 up from bottom: please explain why cryoturbation occurs beneath ridges but not beneath centres
25. P.724, para 2, 3 up from bottom: please explain why 'greater cryoturbation leads of formation of soils....'
26. P.725, penultimate line: prefix 'ice' with 'volumetric'