Mass Movement by Solifluction and Syngenetic Dynamic of Permafrost in the High Arctic, Ward Hunt Island, Canadian High Arctic

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1. Context

On Ward Hunt Island, Nunavut (Canada), many stone-banked solifluction lobes deform and entrain sediments downslope (Vincent 2011). Considering the recent deepening of the active layer due to the climate changes, the increase of material downslope may modify permafrost dynamics.

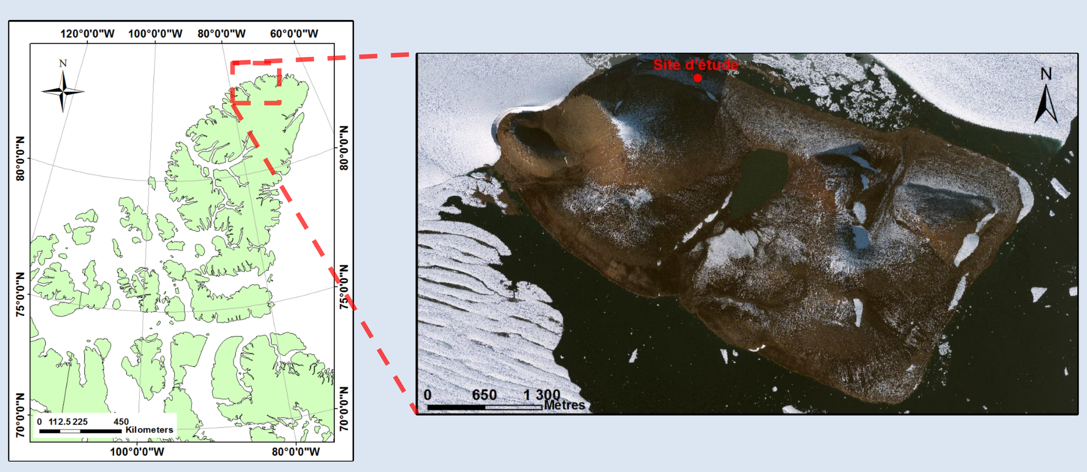

Figure 1 Location of Ward Hunt island and the study site in the extreme north of Ellesmere island (83°N, 74°O) (Sources : Image satellite NRCAN 2012; DMA 1992).

Figure 2 Studied solifluction lobe.

It is suggested that the movement of solifluction lobes entrain the syngenetic development of permafrost and the aggradation of ice downslope.

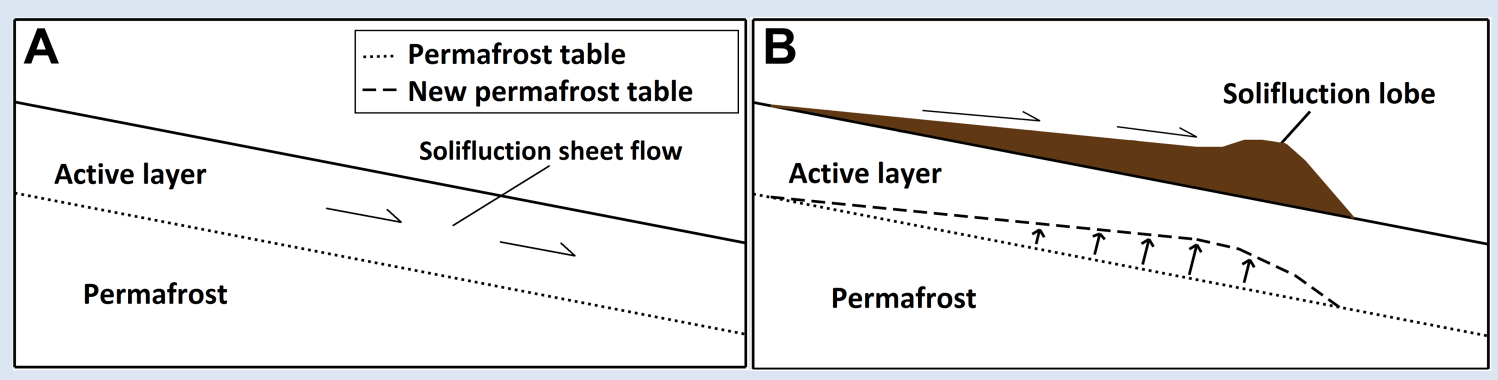

Figure 3 A) Absence of solifluction lobe; B) Presence of solifluction lobe : the accumulation of material on the surface permits, with an adjustment of the active layer to the local climat, rise of the permafrost table and aggradation of ground ice in the upper part of permafrost.

2. Objectives

- Caracterize the cryostratigraphy of a solifluction lobe
- Determine if the displacement and the accumulation of material lead to the aggradation of ground ice and the development of syngenetique permafrost downslope.

3. Methodology

1. Cryostratigraphy : GPR profiles and permafrost coring
2. Permafrost composition: Micro-computed tomography
3. Geotechnical properties : Laboratory analyses
4. Isotopic geochemistry : $^{18}O/^{16}O$, H, ^{2}H, ^{3}H
5. Solifluction lobe geomorphology : 3D laser scanning and total station survey

4. Results and discussion

1) The incidence of the solifluction lobe on permafrost cryostratigraphy varies in function of the morphology of the lobe.
2) The accumulation of material on the lateral and front ridges of the lobe (composed of coarser material) permits the aggradation of permafrost. However due to water drainage (high hydraulic conductivity of the material), the permafrost is ice-poor. In the central portion of the lobe, the accumulation of material saturated with water and the presence of vegetation creates a shallower active layer and permits the creation of ice-rich lenticular cryostructures.
3) The adjustment of the active layer in response to the accumulation of material on the surface, causes the aggradation of syngenetic permafrost.

3D scanning

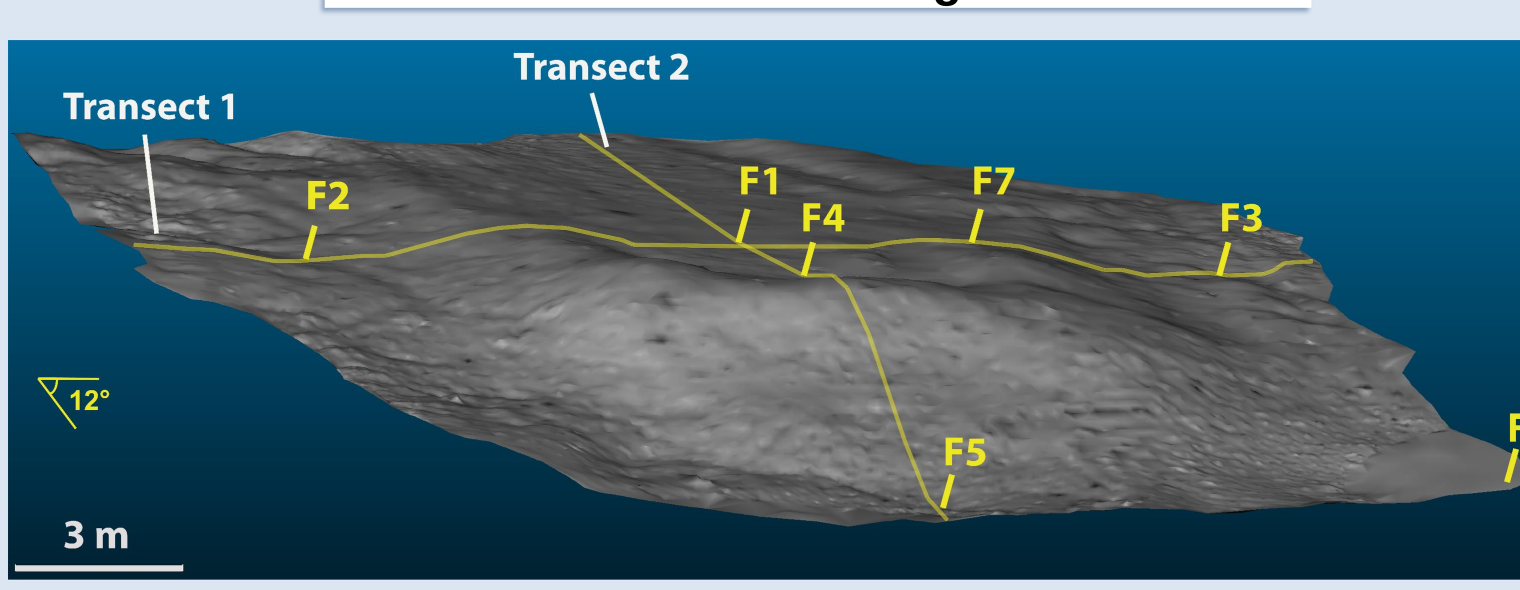

Figure 4 3D scanning of the solifluction lobe, Location of the seven coring sites and of 2 GPR transects.

Cryostratigraphic profiles

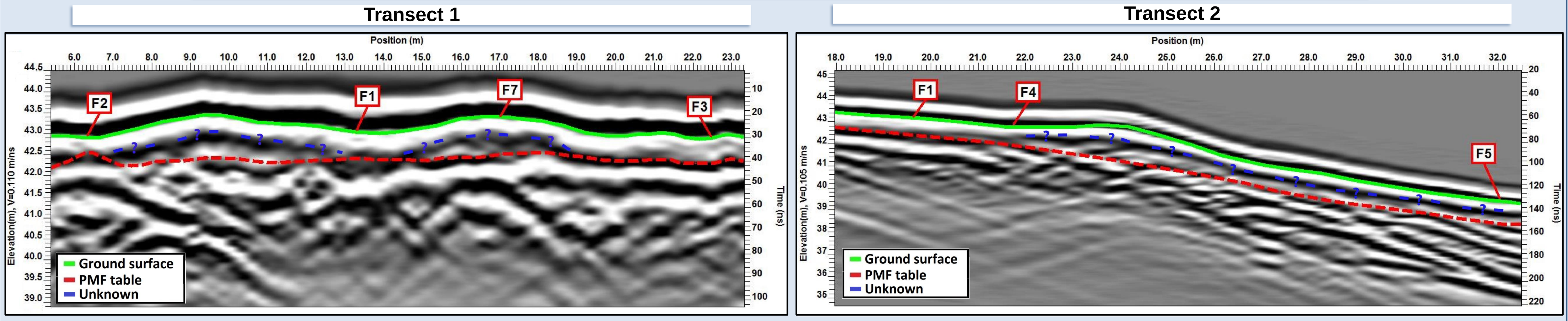

Figure 5 GPR profiles of the two transects presented in figure 4. Antennas of 100 Mhz. These profiles shows reflections that are caused by the contrasts in the dielectrical properties of the material. The presence of ice in permafrost changes the electrical properties of the soil and then ables us to have an estimation of the active layer's depth.

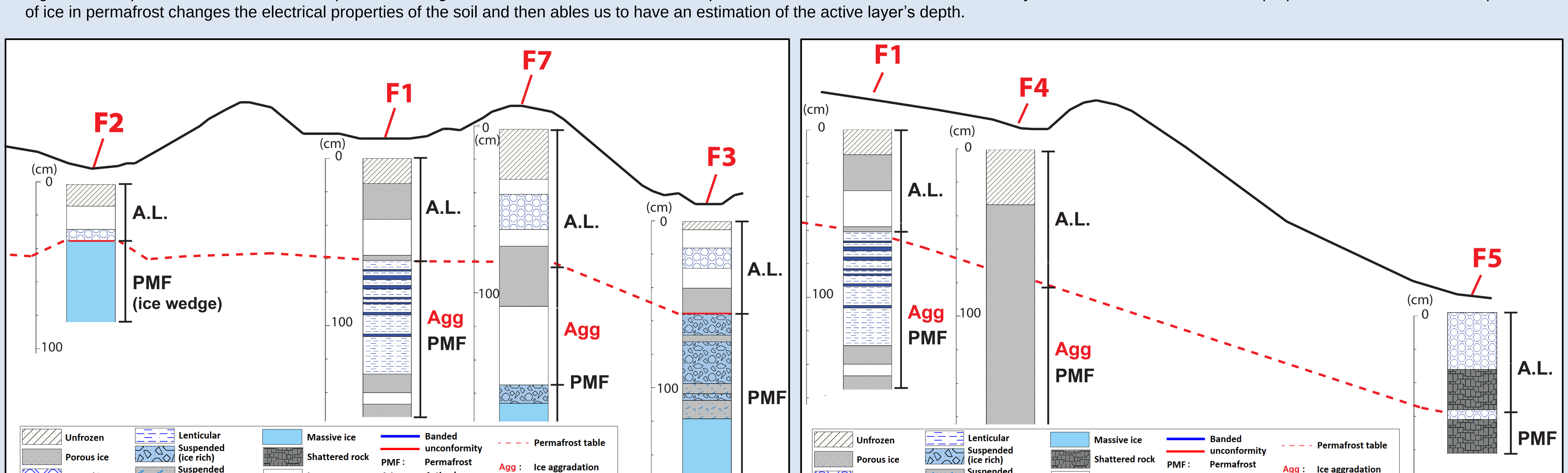

Figure 6 Cryostratigraphic profiles of different coring sites in function of the surface's topography for the two transects shown in figure 4. The coring site F3 is the reference ground profile of the area. The latter shows the permafrost table which marks the junction between the active layer and the ice-rich permafrost. The permafrost in coring site F1 isn't of the same origin than the reference coring site (F3). The latter shows lenticular and banded cryostructures, which support the hypothesis of an aggradation of ice in response to a sedimentary input of material downslope.

Cryostratigraphy

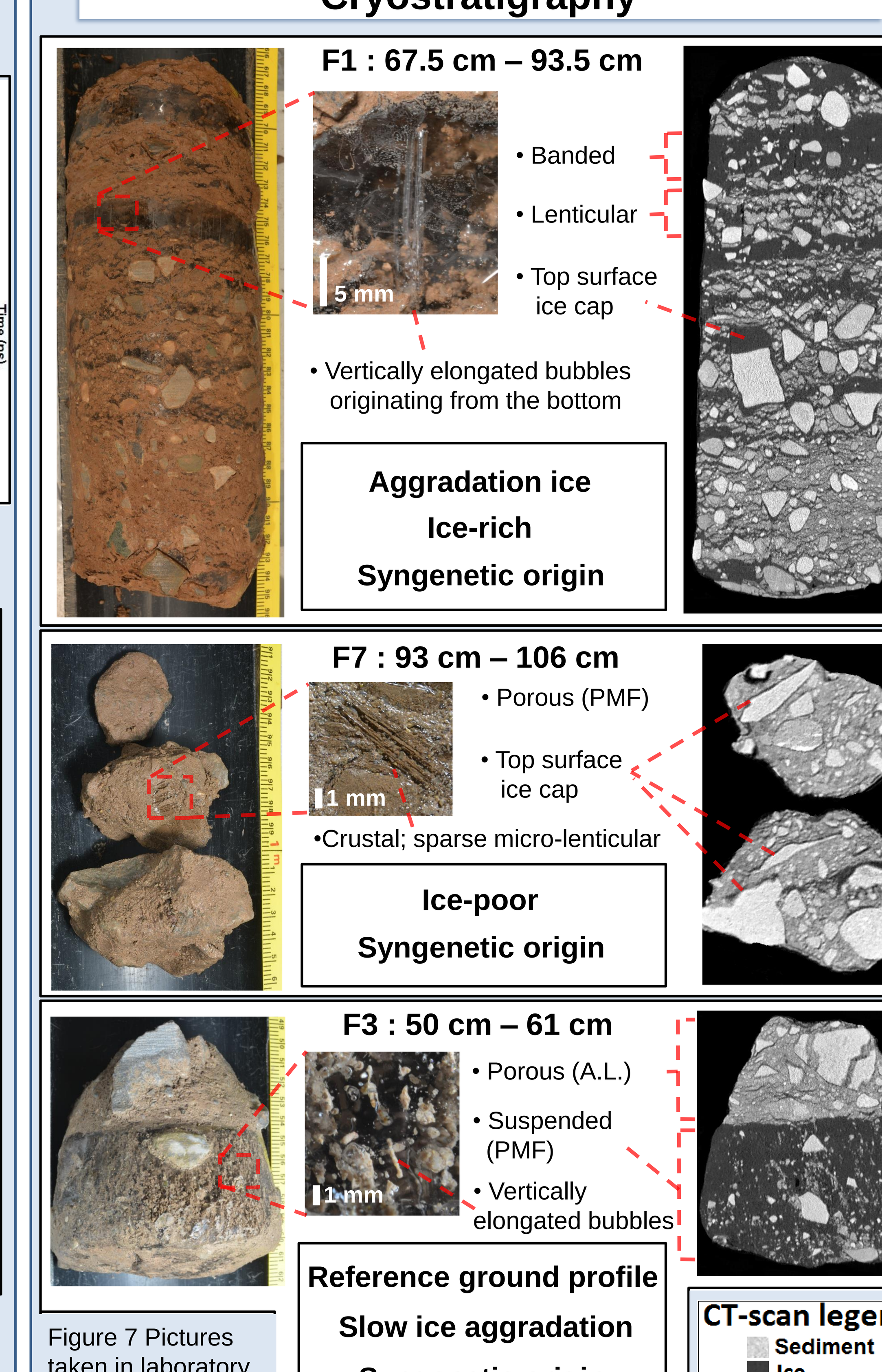

Figure 7 Pictures taken in laboratory (credit : K. Larrivée).

5. Implications

- In a climate change context, deepening of the active layer increases mass movement and the formation of an ice rich zone in the upper part of permafrost downslope.
- Due to the important latent heat of this ice-rich zone, permafrost thaw is slowed down (negative feedback).
- This buffer zone would allow, in this context, differential thawing in the solifluction catchment.
- More studies need to be done to understand the impacts on lake sedimentology.

References

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Acknowledgments

ADAPT
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