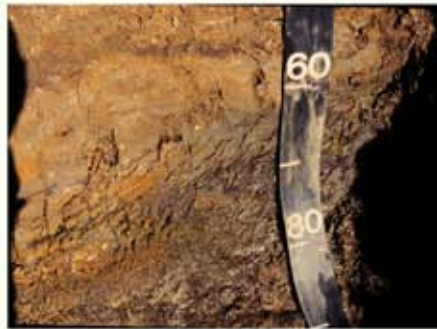




Active cryoturbation of mineral and organic soil throughout the entire active layer by seasonal frost heave and thaw settlement, as postulated in most existing explanations of frost-boils formation, have never been evident in our field observations.



Organic intrudes under boil along melting ice lenses at the contact of active layer and upper permafrost. Note developing of aggradational ice and ceasing of organic in ice-rich intermediate layer



Active layer - permafrost contact in the frost boil near inter-boil area. Note orientation of ice inclusions. Barrow, Alaska



Vegetation in the inter-boil areas triggers formation of the intermediate layer with aggradational ice



Organic ceased in the intermediate layer of the upper permafrost has been penetrated by aggradational ice. Barrow, Alaska



Aggradational ice of the intermediate layer intruded into organic horizon in the base of frost boil. (Barrow, Alaska)



Hummock formed from frost boil due to perennial frost heave by accumulation of aggradational ice in the intermediate layer of permafrost in response to vegetation development (Coldfoot, Alaska) Scale in inches



Buried frost boil. Colville River Delta, Alaska Inter-boil area is the source of organic at the bottom of the boil.



Organic intrusion into boil from inter-boil area Note absence of cryoturbations. (Banks Island, Canada)



Boil-hummock transition. Note intrusion of organic under the boil from inter-boil areas. (Inuvik, Canada)

Conclusion

Formation of frost boils and hummocks is usually considered as related to processes in the active layer. Permafrost impact is limited only by thermal impact. Changes in the active layer are important but they are reversible. Seasonal frost heave always follows by thaw settlement. Important features of frost boils and hummocks cannot be explained by seasonal reversible changes. Development of the intermediate layer of the upper accompanied by three-dimensional perennial frost heave is the driving force of frost boils and hummocks formation.