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The permafrost glacial hypothesis: Is permafrost carbon the black box between insolation forcing and global climate?

R. Zech
Geological Institute, ETH Zurich, Switzerland (godotz@gmx.de)

Global climate is tightly correlated with and controlled by the amount of CO_2 in the atmosphere, and both show frequencies of orbital insolation on glacial-interglacial timescales. However, the 'black box', i.e. the mechanisms that control atmospheric CO_2 and climate, remain enigmatic.
Soil organic carbon pools in northern permafrost regions have long been extremely underestimated and may exceed 1670 Pg – more than twice the atmospheric carbon pool. The reason for this large 'permafrost carbon' storage is that cold and waterlogging conditions are favorable for the preservation of soil organic matter, which more than compensates for low biomass productivity. Recent findings of increasing CO_2 and methane emissions from warming and thawing permafrost ecosystems have fueled concerns about strong positive climate feedbacks, but the potential role of permafrost carbon dynamics for atmospheric CO_2 levels and global climate on glacial-interglacial timescales has largely been ignored.

I propose a conceptual model – the permafrost glacial hypothesis – to explain the rhythm of the Pleistocene ice ages based on the strong positive climate feedback related to insolation-driven permafrost carbon dynamics:
1. Obliquity is the dominant mean annual insolation signal at high latitudes, and obliquity forcing of permafrost carbon dynamics can thus readily help explaining the '40 ka world', i.e. the pronounced 40 ka cyclicity of the ice ages, during the early Pleistocene.
2. The long-term Pleistocene cooling trend led to an expansion of permafrost areas to lower ($\sim$45°N) latitudes at $\sim$1 Ma. Here, integrated annual insolation is no longer controlled by obliquity, but by eccentricity. As a consequence, obliquity cycles (glacial terminations) were skipped, unless they coincided with increasing eccentricity, resulting in $\sim$80 or 120 ka glacial cycles and marking the Mid-Pleistocene Transition. The characteristic saw-tooth pattern of the $\sim$100 ka ice ages during the Late and Middle Pleistocene could be readily explained with slow accumulation of permafrost carbon, and rapid release once substantial thawing set in.

It should be emphasized that most studies and models today assume a net transfer of terrestrial carbon into the ocean during glacials based on 13C measured on foraminifera shells. This would obviously be inconsistent with the permafrost glacial hypothesis, yet the carbonate ion effect provides a viable alternative interpretation of the measured 13C signals in the ocean.