Paleopedological cryotrassology: Tracers of former permafrost – the cases from the Late Pleistocene paleosol/sedimentary sequences of Europe and western Siberia

Vladimir Sheinkman[1], Sergey Sedov[2], Vladimir Melnikov[1], Birgit Terhost[3], & Aleksey Rusakov[4]

[1] *Tyumen State Gas and Oil University; Tyumen State University Earth Cryosphere Institute, Russian Federation*

[2] *Departamento de Edafología, Instituto de Geología, UNAM; Mexico;Tyumen State Gas and Oil University; Tyumen State University*

[3] *Institute of Geography and Geology, University of Würzburg, Germany*

[4] *Institute of Earth Sciences, Saint-Petersburg State University, Russia*

Identification and reliable interpretation of the witnesses of the past permafrost development (proposed as a special branch of geosciences – cryotrassology) is of major important for reconstructing past terrestrial environments of the former cold periods. Such indicators/tracers of those events as pseudomorphs after repeated ice wedges, cryoturbations in sedimentary layers, solifluction features, lenses of segregation ice etc. are reliable but not ubiquitous markers.

Therefore, we propose to use the cirtain indirect pedological indicators/tracers of past and former permafrost in order to complete the information about its spatial distribution and chronostratigraphic occurrence. The certain pedogenetic processes, also not necessarily linked to permafrost, are strongly influenced or modified in its presence. In particular icy permafrost layers could cause water saturation and thus switch on the hydromorphic soil forming processes: accumulation of peat and gleyzation in the mineral horizons, in the geomorphic positions and substrates where otherwise well-drained non-gleyic soils are formed.

We have interpreted some of Late Pleistocene gleyic soils as indirect tracers of ancient permafrost. Their characteristics consist in the next:

1). Recently well-developed paleosols formed during the late Marine Isotope Stage (MIS) 3 were discovered to the north from the Eurasian Loess Belt – in the Center-North area of European Russia (Upper Volga basin) (Fig. 1) [Rusakov and Sedov, 2012] and North-Western Siberia (Middle Ob basin) [Sheinkman et al., 2016].

The paleosols are developed within the Late Pleistocene alluvial and lacustrine sequences and produced radiocarbon dates from its organic materials within the time interval of 50 – 25 Ka BP. They represent hydromorphic profiles with Histic horizons or materials and gleyic colour pattern; in thin sections numerous specific ferruginous pedofeatures (concentric nodules, mottles, strypes). These paleosols demonstrate contrasting difference as well as from synchronous Cambisols and Chernozems formed within loess sequences to the south. Conspicuously they are developed in the well-drained geomorphic positions, where modern soils (Podzols and Luvisols) have only weak surficial redoximorphic features.

2). In the Late Pleistocene loessic sequences of Germany and Austria strongly gleyed soils (known as Tundragley or Naßboden) correspond to the strata, developed during MIS2 including MIS3/MIS2 transition [Terhorst et al., 2015]. Again, they are formed in the elevated landsurfaces providing good drainage on porous calcareous loess which hampers gleyzation. Indeed earlier (MIS3) and later (Holocene) soils of the same sequences are non-gleyic Cambisols and Luvisols. Additional evidences of permafrost in these soils are provided by morphological features of horizon fragmentation and mixing by cryoturbation and solifluction. Also in thin sections signs of cryogenic structuring, grainsize sorting, mixing of organic and mineral materials and deformation of plant debris and pedofeatures by frost processes are observed. As far as in both cases we attribute gleyzation to water-logging by permafrost, we classify these paleosols as Reductaquic Cryosols. From the described spatial/temporal occurrence of the cryogenic gleyic paleosols we deduce the shift of permafrost several hundreds of km to the southwest during the MIS3-MIS2 transition.

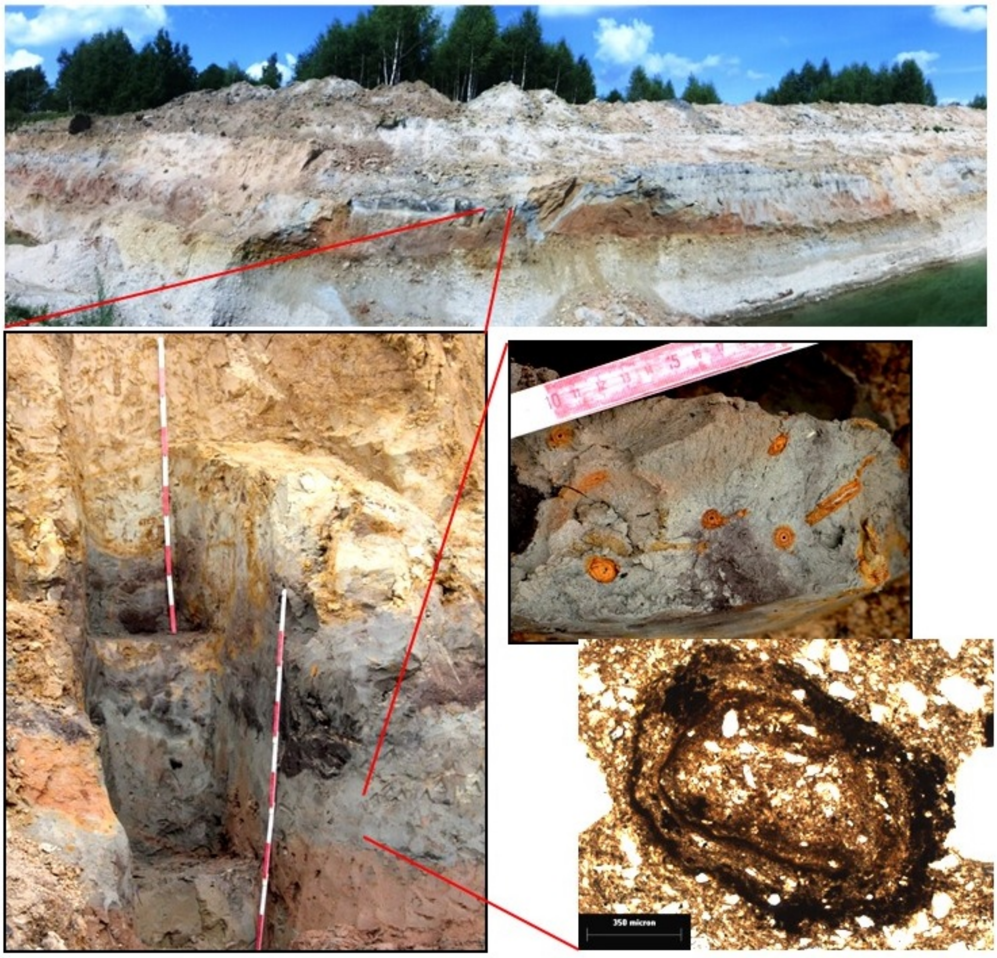

Figure 1: Gleyic cryogenic paleosols of the Upper Volga Basin: section Koskovo, paleosol macro-, meso- and micromorphology (photos by Alexey Rusakov)

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