

# Soils of abandoned industrial wastes disposal sites: properties, processes, functioning

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## Introduction

Soils formed at once abandoned and recultivated industrial waste dumping sites are key research objects both as models of soil-forming processes in underdeveloped soils and indicators of persistent or potential environmental hazards of dumps themselves. Our studies of technogenic surface-like soil formations (TSF) and soils were conducted on a closed and recultivated landfill and two sugar waste treatment systems from sugar factories in Kursk region, central part of European Russia, forest-steppe landscape zone.

## Methods

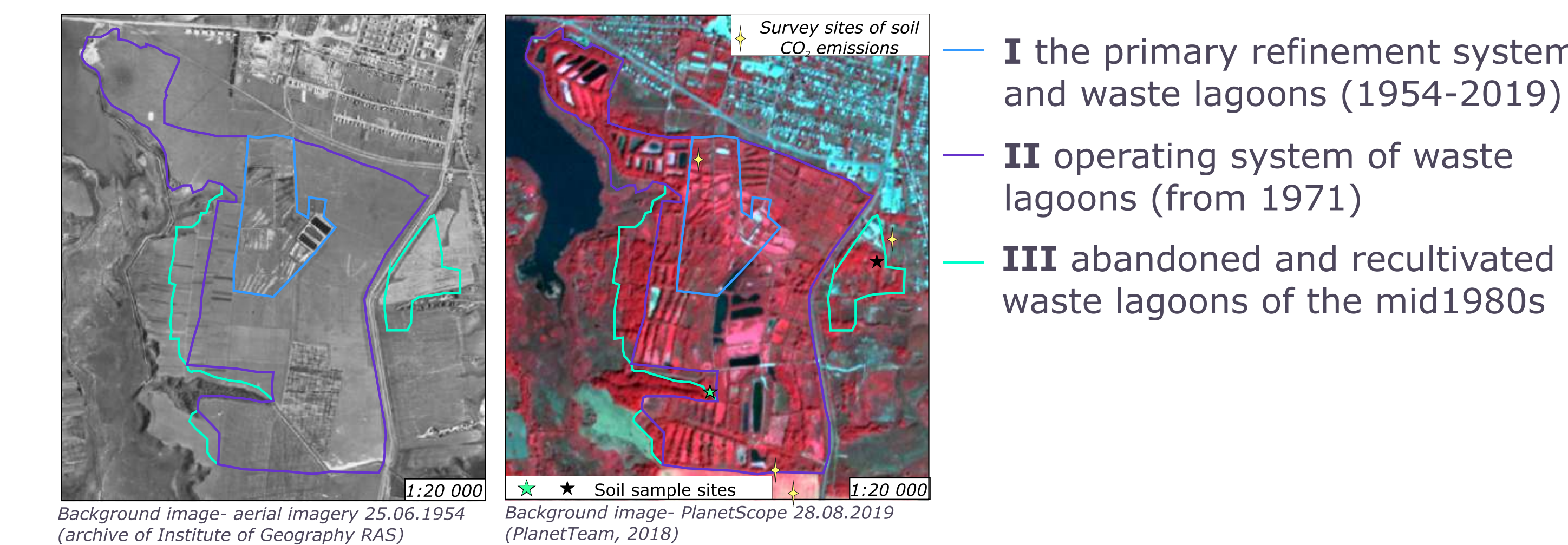
Key properties of TSF and soils were defined with the assessments of their ecological, microbiological state and gas-geochemical condition. Set of methods (mesomorphological and micromorphological analysis, soil chemical and physic-chemical analysis, comparatively geographical method) was used for the detection of current elementary soil processes. Main used methodology is a research of sustainable properties of soil solid-phase ("soil memory") together with soil functioning.

Seasonal dynamics of carbon dioxide emissions from soils to the atmosphere was also under consideration. From March 28 to April 06, 2020 in the period before the start of vegetation, but after the snow melt, a spatial survey of soil CO<sub>2</sub> emissions was carried out on the most representative elements of the landscape of chernozem forest-steppe in the vicinities of Kursk and L'gov cities. For elements of sugar waste treatment systems and surrounding landscape survey of soil emissions was conducted from 22 to 26 May, 2019. The field estimates were made by the closed chamber method, with the total number of measurements made 245.

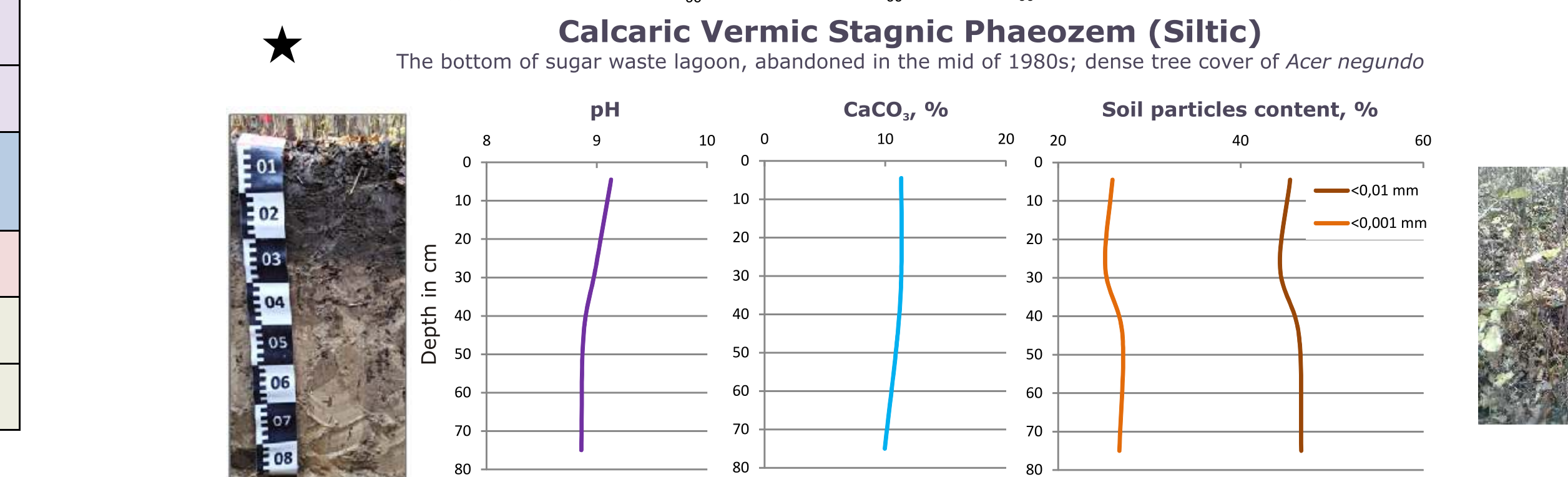
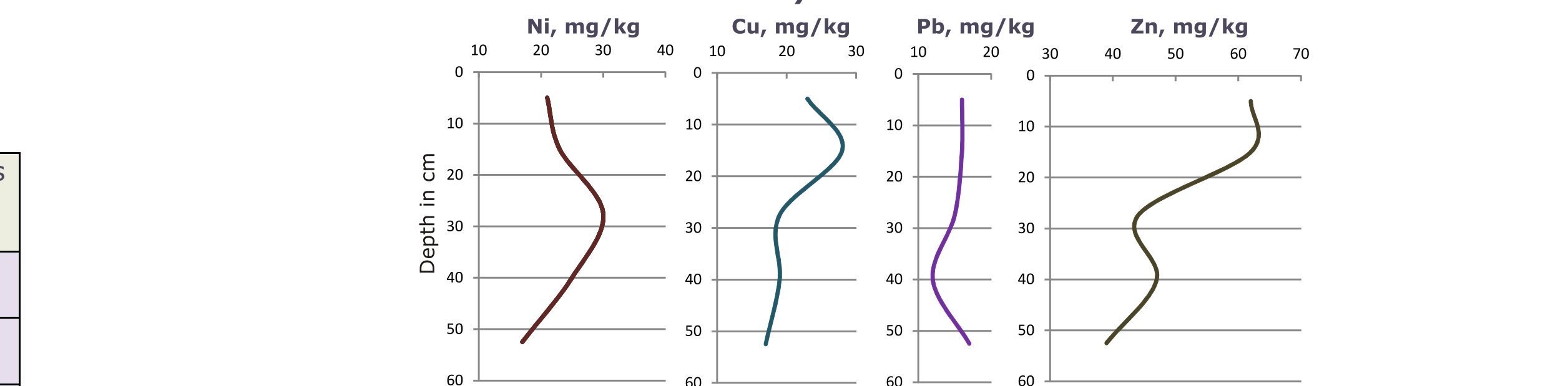
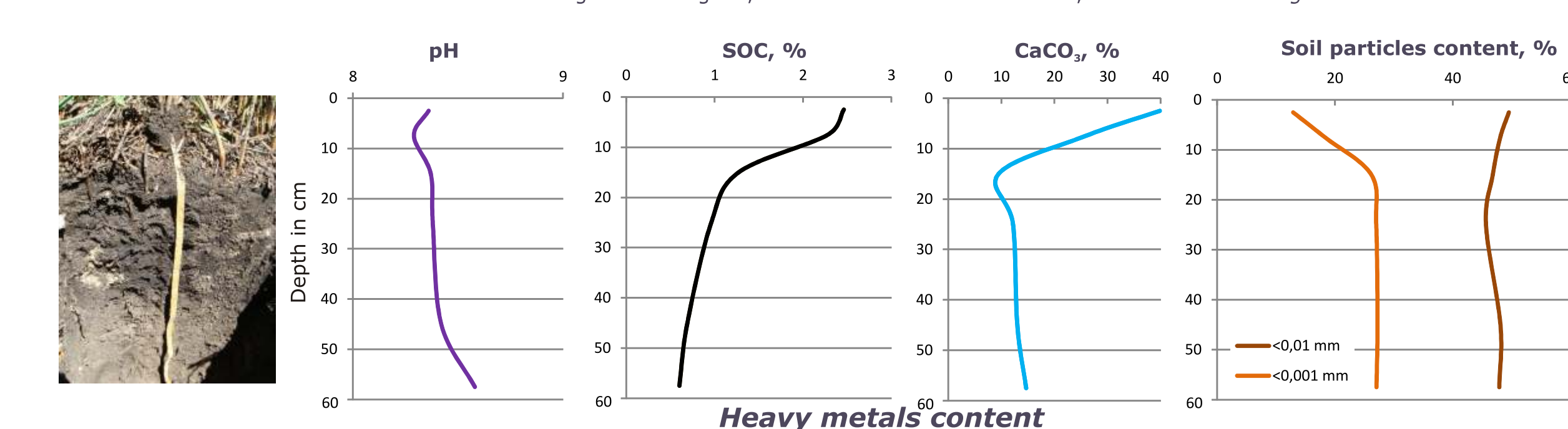
Multitemporal analysis of highly-detailed remote sensing data (from archive aerial photos of 1950s to current satellite images and UAV optical photogrammetry) provided the possibility for the retrospective and operating remote monitoring of the all abandoned dumps in study and reconstruction of their life cycles and land use/land cover changes.

## Soils of sugar waste lagoons from abandoned and operating sugar factories

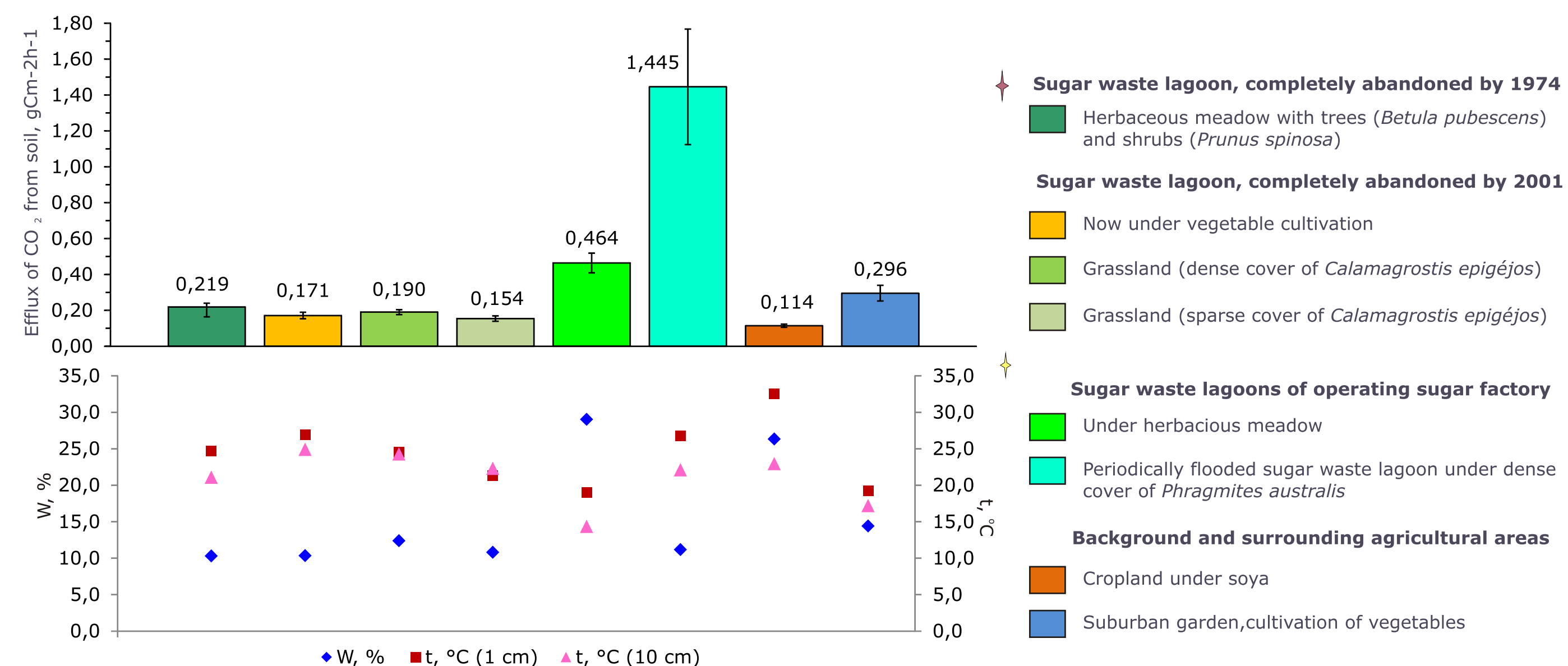
### Chrono-functional zoning of waste treatment system from an operating sugar factory



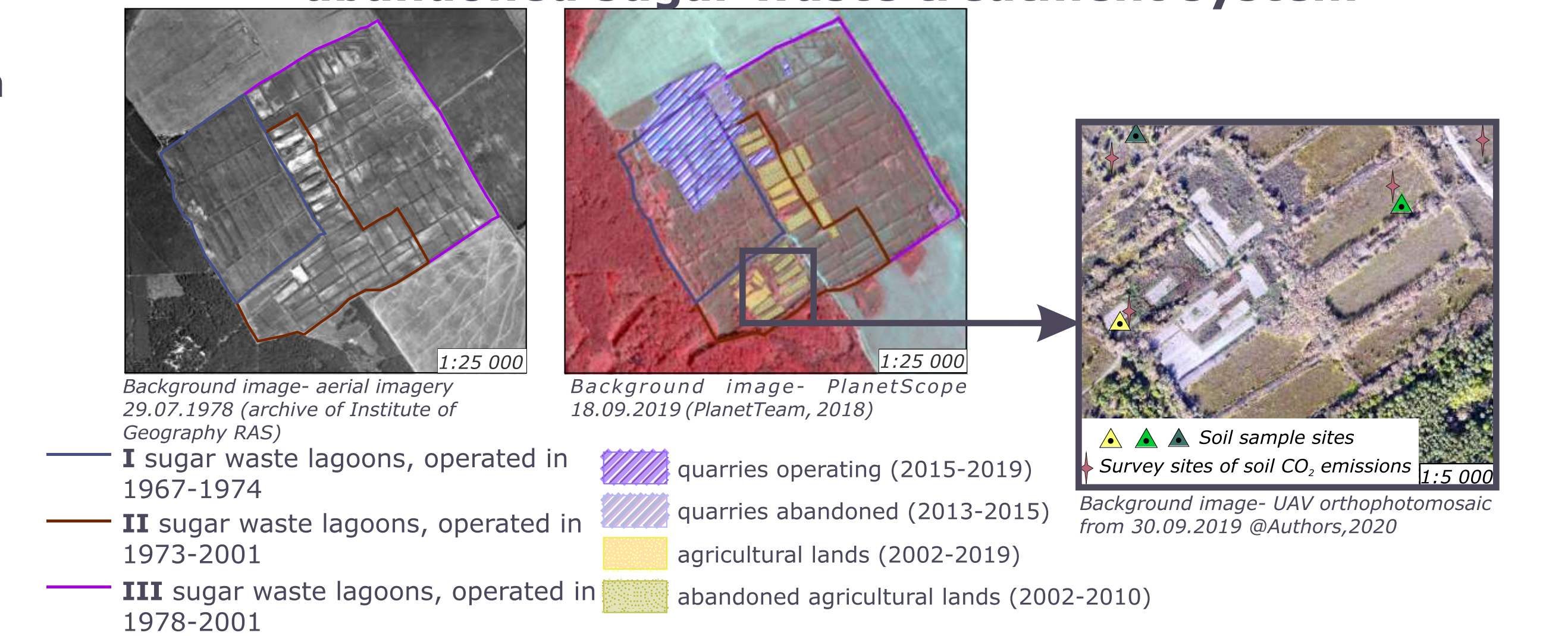
### Garbic Technosol (Siltic, Calcaric, Stagnic) / Calcaric Stagnic Phaeozem (Siltic)



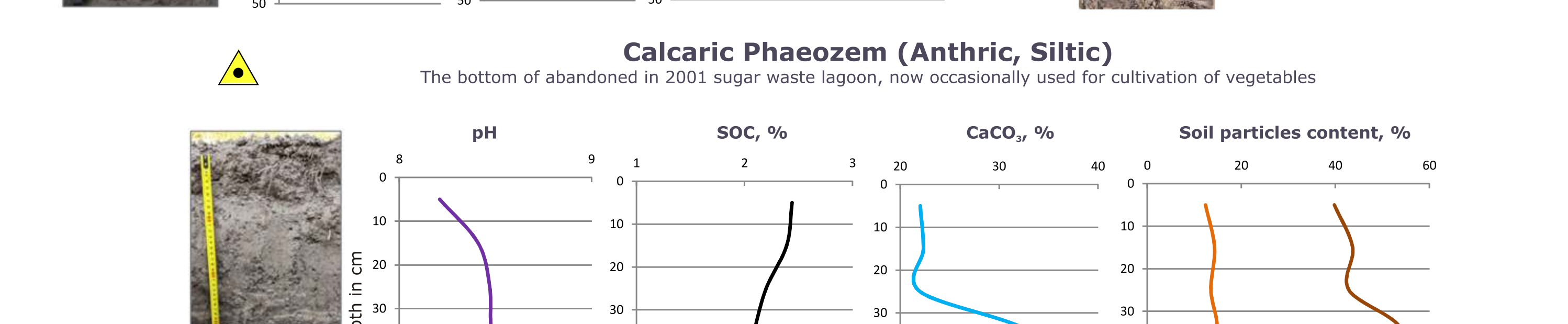
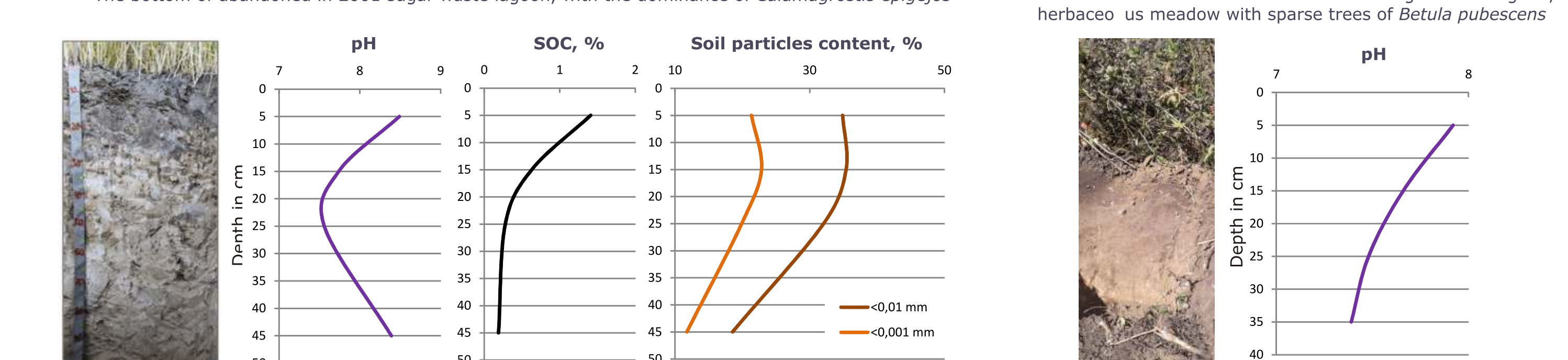
### CO<sub>2</sub> soil efflux from sugar waste lagoons with different age of abandonment and land use types in Chernozem forest-steppe (Kursk region, Russia, 22- 26 May 2019)



### Chrono-functional zoning and current land use of the abandoned sugar waste treatment system



### Calcaric Someric Phaeozem (Siltic, Densic, Transportic)



### Calcaric Phaeozem (Anthrisc, Siltic)

The bottom of abandoned in 2001 sugar waste lagoon, now occasionally used for cultivation of vegetables



## Conclusions

Since the cease of industrial waste dumping in the early 1990s shallow Technosols and Phaeozems have formed on the major part of abandoned landfill. Surface soil layers are characterized by very high contamination level with heavy metals (especially cadmium, nickel and lead). However, the comparison of CO<sub>2</sub> efflux from these soils, made between dominant ecosystems and land use types, was found that the landfills rehabilitated in the late 1990s in the area of Kursk, do not significantly differ in average CO<sub>2</sub> emission rate from the control habitats (Mann-Whitney test), being intermediate between nearby old fallows (over 60 years) and unmanaged overgrown slopes of beams and ravines. Thus, it can be considered that by this ecosystem indicator, the rehabilitation of the landfill in study has reached its goal.

For waste lagoons of sugar waste treatment systems studied soils can be divided into 4 groups according to the peculiarities of soil forming processes and the age of waste lagoons abandonment. The first group is presented by Garbic Technosols (Siltic, Calcaric, Stagnic), forming on filtration sludge (defecate) in overwetted lagoons bottoms with the dense cover of *Phragmites australis*. For these habitats we fixed the unusually great soil CO<sub>2</sub> efflux above 1,4 gCO<sub>2</sub>m<sup>-2</sup>h<sup>-1</sup> : 10 times as high as surrounding agricultural areas.

In the absence of waterproof layers in the underlying rocks and after more 30 years of abandonment and tree overgrowth the Calcaric Vermic Stagnic Phaeozem (Siltic) formed, not always with morphological signs of gleization in the profile. As a result of agrogenic transformation of the long-term unflooded sugar waste lagoons (they often used for cultivation of vegetables) the Calcaric Phaeozem (Anthrisc, Siltic) developed with the 30-40 cm depth of organic layer. The fourth group unites soils formed at the completely abandoned and recultivated sugar waste treatment system. According to the age of abandonment and recultivation with successive overgrowth by grasses, shrubs and trees we distinguish Calcaric Someric Phaeozem (Siltic, Densic, Transportic) after 20 years of abandonment and Calcaric Phaeozem (Siltic, Transportic) at the bottom of lagoons unused from the mid 1970s.

## Funding and acknowledgement

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