Microfabrics of Buried Soils in Loess Sediments of the Lower Volga Basin

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Introduction

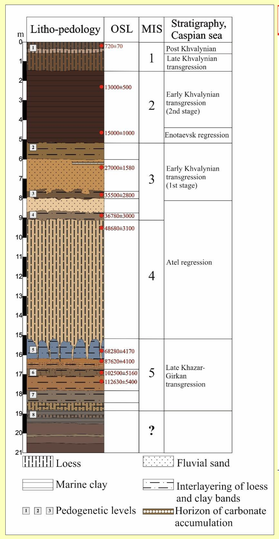
Soils develop under the direct influence of climatic parameters, and they retain environmental information in their features (soil memory: Targulian and Goryachkin, 2008). Micromorphological features have their own soil memory, which makes it possible to distinguish between the results of pedogenetic processes under different environmental conditions and to specify the genesis of sedimentation processes. Buried soils provide an excellent opportunity to reconstruct paleoenvironments preceding their burying. The Lower Volga basin experienced considerable changes due to fluctuations in the Caspian Sea level together with other responses to glacial-interglacial cycles in the Quaternary. Numerous horizons of buried soils have been recorded in sedimentary sequences, and they have been used for stratigraphic correlations and paleogeomorphic reconstructions in the area (Konstantinov et al., 2016). However, the study of paleosols as a paleoenvironmental proxy has not been performed until now.

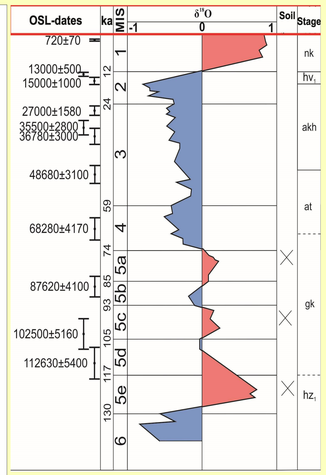
The height of the section is 20 m. 7 levels of paleosols (MIS 1 to MIS 5)

Method and Object

Micromorphological studies of a section of soil–sedimentary sequence were performed for the natural escarpment 1 km from Volgograd - Lower Achtuba paleosol-sedimentary sequence

(48.7005277 N, 44.89330709 E, 16 m asl).



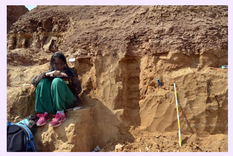


The study was supported by the Russian Foundation for Basic Research, project no.18-04-00638a.

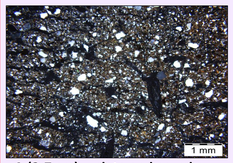
Modern surface soil Kastanozem are underlined by marine chocolate clays

MIS1 (720±70) Kastanozem typical for dry steppe areas.

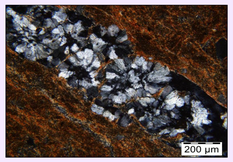
MIS2 15.02±1.02 marine chocolate clays



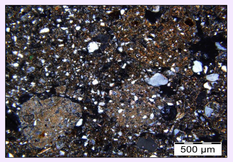
Microfeatures



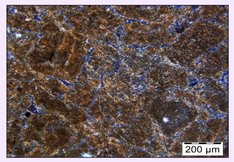
A (2-7 cm) – plate and crumbs peds , circular sand orientation



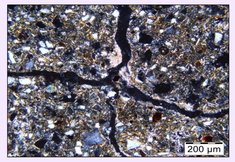
130-135 cm - gypsum infilling, parallel striated b-fabric



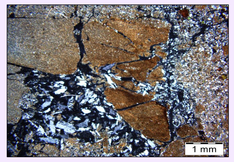
Bm (15-20 cm) - crumbling fragments of clay, typic CaCO3 noduls



130-135 cm - degradation of chocolate clay with the formation of crumbs



Bt (35-40cm)-thin clay coatings



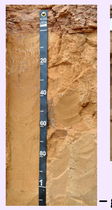
BC (107-112cm) - fragments of clays and gypsum pedofeatures

Kastanozem

is underlined by marine clays of (120-520 cm). OSL dates, for the middle part (13000±500 yrs) and lower part (15000±1000 yrs) bracket marine clays to Atel-Achtuba Late Khvalynian transgression of Caspian Sea (Arslanov et al., 2013).

Weak pedogenesis in marine chocolate clays: vertical cracks; sub angular structural units; gypsum roses in chocolate clays.

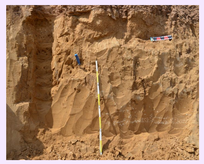
Pedogenetic level 2 26.99±1.58



Polygenetic features – gypsum accumulation, gleyic (Fe-Mn) cutans

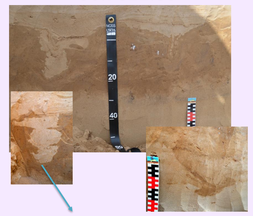
MIS3

Pedogenetic level 3 35.58±2.80

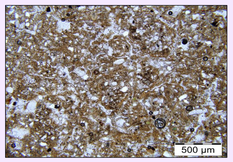


Loess intercalation with signs of pedogenesis

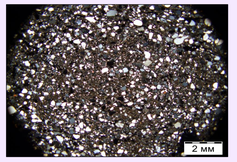
Pedogenetic level 4 36.78±2.80



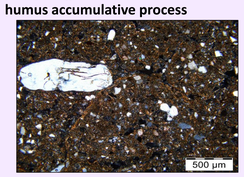
Intermixture of fluvial and aeolian accumulation. Weak pedogenesis disturbed by alluvial sedimentation and cryogenisis.



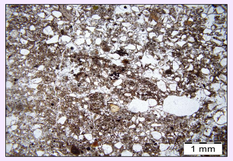
520-525 cm - granules and crumbs peds, organic matter - feature of humus accumulative process



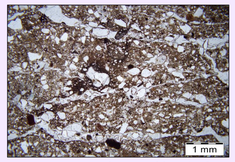
770-800 cm – layered separation of sand and silt particales



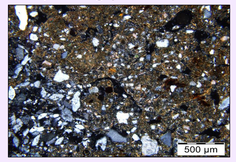
520-525 cm - circular striated b-fabric, cracking quartz



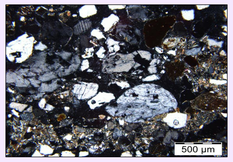
770-800 cm – layered separation of sand size grains



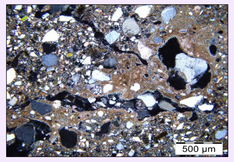
880-910 cm - platy and lenticular peds



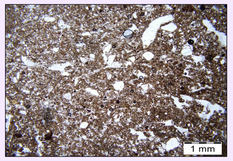
535-540cm - gypsum pedofeature, circular striated b-fabric



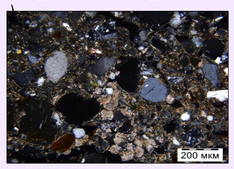
770-800 cm - microfeature of cryogenesis (shattering quartz)



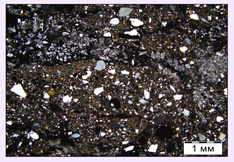
880-910 cm – local area with crystallitic calcite b-fabric



550-555 cm - loess material with close c/f related distribution and channel voids



770-800 cm – sparite calcite crystals, granostriated b-fabric



880-910 cm - gypsum pedofeature

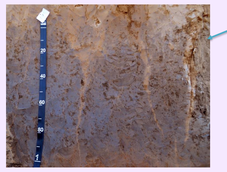
Interstadial paleosols (MIS3) – polygenetic.

Sedimentary environment: **Intermixture of fluvial and aeolian sedimentation, soils have been formed during short periods of mesomorphic pedogenesis coinciding with loess sedimentation, interrupted by increase of fluvial activity.**

Paleoclimatic features: **cold arid environment, frost wedges and involutions, carbonate and even gypsum neoformations.**

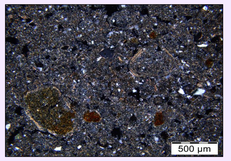
MIS5

Pedogenetic level 5 68.28±4.17

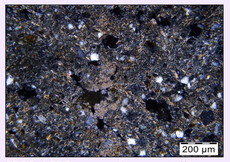


Pedogenetic level 6 87.62±4.10 – 102.5±5.16

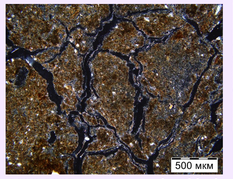
Pedogenetic level 7 112.6±5.40



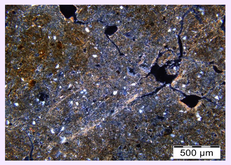
1530-1630 см – rounded fragments of brown clays, Fe- micronodules, circular striated b-fabric



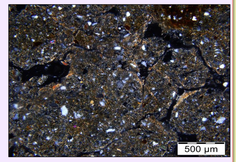
1530-1630 см – microcrystalline calcite nodule, mono- and granostriated b-fabric



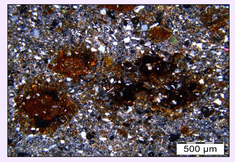
1690-1695 см – angular blocky microstructure, internal hypocoating and dense groundmass – vertic paleosoil



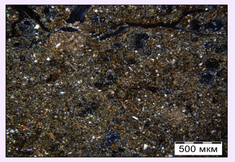
1800-1832 см – clay coatings, monostriated b-fabric



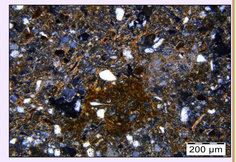
1832-1843 см – laminated clay coatings, open porfyric c/f related distribution



1630-1680 см – clay-Fe-Mn nodules and dendritic



1730-1735 см – crystallitic and b-fabric



1843-1858 см – monostriated b-fabric, some micritic and microsparitic calcite crystals

1635-1680 см -needle carbonate microcrystals

1770-1775 см – loess with some fragments of clays

>1858 см – loess with large quantity weathered minerals

The whole MIS5a-e **- Late Khazarian transgression and includes three distinct soils formed in loess. The presence of pedogenetic levels indicate that the area was beyond Late Khazarian transgression of Caspian Sea. Formed paleosols are separated by loess layers.**

It was found that the buried soil had been formed under subaerial conditions with loess sedimentation alternating with the periods of fluvial and marine sedimentation. The soil–loess sequence (MIS1–MIS5) includes seven paleosol layers separated by sediments of different compositions and geneses. Longer periods of interruption of sedimentation processes predetermined the formation of better developed soils. All the soils are polygenetic and contain contrasting sets of macro- and microfeatures reflecting different stages of pedogenesis: (1) steppe pedogenesis marked by well-shaped humus horizons with biogenic aggregation, diverse carbonate pedofeatures, and mole tunnels; (2) hydromorphic pedogenesis marked by gleyed mottles and Fe–Mn nodules that could be formed under conditions of long floods; (3) cryogenic pedogenesis under the influence of syngenetic (MIS3) and epigenetic (MIS5) cryogenesis marked by frost cracks, ring-shaped arrangement of coarse fractions, fissuring of quartz grains, and specific aggregation.