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Structure and chronology of the Chocolate clays facies of the Lower Volga

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During the Late Quaternary dramatic changes in relative sea-level are known to have occurred in the Caspian Sea. However, all previous attempts at resolving the uncertainty associated with the timing of these transgressive/regressive events using standard dating methods have produced inconclusive or controversial results. In the Lower Volga River region, Early Khvalynian marine deposits are situated between the modern soil and Atelian subaerial strata (MIS 3-5), and are represented by readily identifiable marine silty-clays with clear specific characteristics: fissile mudrock, in general with a well-developed stratified fabric, consisting of interbedded sub-mm laminae of silt. These laminated layers break into small blocks, which, together with a red-brown colour, gives the material a characteristic 'chocolate' appearance – hence the widely-used name "Chocolate Clays". In general, this type of facies in the Northern Caspian is found in topographic depressions of various configurations and size, the largest of which is the Lower Volga River valley. As a result, the relative position of Chocolate Clays in the Lower Volga River sequence may vary: in the northern part of the region, close to Volgograd, they are underlain by subaerial loess-soil sequences (Yanina et al. 2017) with a clear erosional contact. For the first time a reliable Late Pleistocene chronology has been derived using optically stimulated luminescence (OSL), and post-IR IRSL290 analysis of quartz and K-feldspar grains extracted from 20 sediment samples collected along the Lower Volga River. Analyses were conducted on multi-grain aliquots of the

sand-sized fractions of loessic sediments, marine clays and the overlying modern soils from three exposed sections ~50km downstream of Volgograd. The signals from all quartz samples were dominated by the fast component; there was no significant IR sensitivity, and no significant dependence of De on preheat temperature. The post-IR IRSL290 signals from the 5 samples examined also met all laboratory-based criteria for a reliable estimate of equivalent dose. Resetting of the luminescence signals was investigated based on the differential bleaching rates of quartz OSL and K-feldspar signals; we conclude that all signals were sufficiently reset prior to deposition (Kurbanov et al, 2021). Our results show unambiguously that the Early Khvalynian marine Chocolate Clays present at all three sections were deposited post-LGM, between ~13.5ka and ~17 ka ago. These ages are further constrained by the overlying Kastanozem soils (0.7 to 9.1 ka) and underlying loess-soil series (19-30 ka). Relative (Caspian) sea-level during the Early Khvalynian must have been well above the sampling altitude of 9.33 m (Srednyaya Akhtuba), 8.51 m (Raygorod) and 6.98 m (Leninsk) to explain the absence of significant alluvial sand and to allow the deposition of the clay-sized particles of the Chocolate Clays marker horizon. Using luminescence dating, we have obtained, for the first time, an unambiguous age for the Caspian Sea Early Khvalynian Chocolate Clay marker horizon. The Chocolate Clay horizon is widespread throughout the Lower Volga River, and has previously been most recently dated using 14C to both before and after the LGM; our ages clearly place this important unit at the end of MIS 2, after the LGM. It seems very likely that OSL has the potential to resolve many of the outstanding chronological questions in the Ponto-Caspian basin. In particular, the young (17-13 ka) age for this unit, deposited by the largest Late Quaternary transgression, now provides a foundation for further research into the broader Eurasian palaeogeographical mechanisms and implications of such an extreme sea-level rise (from about -150 to > +40 m) in just a few thousand years. Research was supported by the Russian Science Foundation, project 19-77-10077.

Key words: Chocolate clays, Khvalynian transgression, Late Quaternary, OSL dating.

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