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Reconstructing the paleotopography at the beginning of the Weichselian glacial stage using electromagnetic induction

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The loess belt of Central Europe extends from the Atlantic coast, through central Belgium, to Eastern Europe. During the Weichselian glacial stage of the Late Pleistocene (80 ka- 10 ka), the periglacial undulating landscape of central Belgium, formed in surfacing Tertiary marine sands and clays, was covered by niveo-aeolian loess with a thickness ranging from only a few decimeters on hill tops up to several tens of meters in valleys. As a consequence, the paleotopography was strongly smoothened by the loess pack, and more recently by slope processes. So the present topography does not reflect the underlying paleotopography. Reconstructing the paleolandscape at a detailed scale is almost impossible by the conventional invasive methods due to the expense and labour associated with augering. Therefore, non-invasive geophysical tools were used to map the depth to the Tertiary clay substrate. While numerous geophysical investigations are effective to investigate the stratigraphy over relatively large depths (20-80 m), knowledge about the applicability in shallow ($<$ 3 m) subsurface exploration for geomorphologic purposes is still incomplete. Therefore, the use of the electromagnetic induction sensor, EM38DD (Geonics Ltd., Mississauga, ON, Canada), was evaluated as an alternative for mapping the depth to the Tertiary clay substrate at shallow depths. In our 2.7 ha study site located in the loess belt of central Belgium, two transects were laid out in such a way that both highest and lowest apparent electrical conductivity (ECa) measurements were sampled equally. A strong

non-linear relationship (R^2 = 0.86) was found between ECa, measured by the vertical dipole orientation of the EM38DD and the depth to the Tertiary clay substrate. These predictions were validated by independent observations of the depth to the Tertiary clay and a correlation coefficient of 0.83, with an mean error of 0.22 m, was found. So, our dense ECa measurements (2 by 2 m resolution) allowed to model a three dimensional surface of the depth to the Tertiary substrate, reconstructing the paleotopography at the beginning of the Weichselian glacial stage. This paleotopography revealed distinct erosion patterns on the surface of the Tertiary clay. These gullies combine into one major gully which ends in what seems to be a wider valley. The continuity of these gullies was confirmed by an analysis of surface flow patterns conducted on the reconstructed paleotopography. The non-invasive, time- and cost-effective electromagnetic induction sensor was found to offer new perspectives to reconstruct and analyse in detail the Quaternary paleotopography at shallow depths beneath the loess cover.