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Detection and quantification of soil compaction in a post-mining landscape by geophysical methods

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Rhenish opencast mines located in the central west of Germany have used about 330 km^2 of land so far. Of this, some 230 km^2 have been recultivated, including 125 km^2 of arable land. After recultivation, the land is cultivated for at least seven years by the mining company before let to the farmers. Where new farmland is envisaged, the stackers spread pure loess mixed with soil material of the original Luvisols (loess loam) at the top of the refilled mining areas. After a certain settling time, this layer must be at least two meters thick. In a next step, the loess is levelled in a soil-sparing fashion using caterpillars with extra-wide rawler tracks. Even if care is taken that the loess layer will not be heavily compacted during levelling, local soil compaction is one of the major problems, as leveling often is performed during unfavorable moist soil conditions. These local compactions lead to reduced crop growth during either wet or dry growing seasons and result in yield losses over periods of many years. Localizing and evaluating such compacted field zones would enable the mining company to perform a physical soil melioration before handing over the land to a farmer.

To identify local soil compaction, a field study was performed in 2019 on a selected field with known variability in crop performance within the recultivated area of the Garzweiler mine in North Rhine-Westphalia, Germany. Over the course of 5 months, the field was intensively investigated using geophysical methods such as electromagnetic induction (EMI) and electrical resistivity tomography (ERT). Additionally, soil samples were taken to determine soil water contents, bulk density, penetration resistance, and soil texture.

The geophysical maps gathered, clearly show zones of higher electrical conductivities in the soil, which were associated to conventionally measured subsoil compaction. Regression of bulk densities with EMI data yielded good results allowing to map out compacted zones within the field and also to quantify compaction. Hence, geophysical methods provide a promising approach to plan soil melioration measures.