Angewandte Geophysik

Modelling geoelectrical measurements on a roman villa

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Method

Geoelectrical measurements serve to investigate the spatial distribution of the subsurface´s electric conductivity. An electrical current is injected into the ground by two electrodes. Then the electrical potential observed at the surface reflects the conductivity structure of the underground. The method is used e.g. to detect groundwater pollution, for geological prospecting or for the detection of buried walls in archaeology. It is rather fast and non-destructive.

Aim of Study

The object of investigation is a roman villa. It was built close to Frankfurt about 225 AD. Archeologists investigated the villa very intensively, however, the location of the doors in the building could not be determined and might be detected by geoelectric measurements. Thus the aim of this study is (a) the investigation of the resolution of the geoelectric method and (b) the optimization of the field set up in view of the envisaged target, both by laboratory and by numerical simulations.

The ground plan of the villa was rebuilt in a water tank downscaling by 1:35 and additionally the set up was modelled by COMSOL. The measurements were performed for different field set ups, resp. for different electrode configurations.

Field Set up

The usual field set up contains up to 250 electrodes equally spaced along a line resp. a grid with 0.1-5m separation between each electrode. The electrodes are interconnected and controlled by a remote device. Thus the position of the current injection and potential electrodes can be chosen automatically via a computer software. The distance between the electrode dipol of the current injection and that for the measurement of the potential difference determines the depth range of the estimated conductivity.

Measurements in the field and in the laboratory are performed using the multielectrode device Lippmann 4-point light HP. One measurement cycle takes approx. 10-20 minutes for 100 electrodes, whereas setting up the electrodes in field usually lasts 1 to 2 hours.

Results

The resistivity distribution is displayed in plan view for different depth sections.

The Lab measurements very clearly show that the openings in the walls of the bathing section of the villa can be well detected by the equipment. The numerical studies point out that the separation between adjacent lines of electrodes should not exceed a certain distance. On the other hand a denser electrode spacing will not improve the lateral resolution of the resistivity.

Conclusions

While laboratory studies show the principal applicability of the geoelectric method using the existing equipment, the numerical investigation serves to optimize the field configuration and thus improves the field performance.

Open Questions for COMSOL

Automatic determination of selected points in COMSOL Script for attributing physical properties?
Increasing of modelling performance in COMSOL?

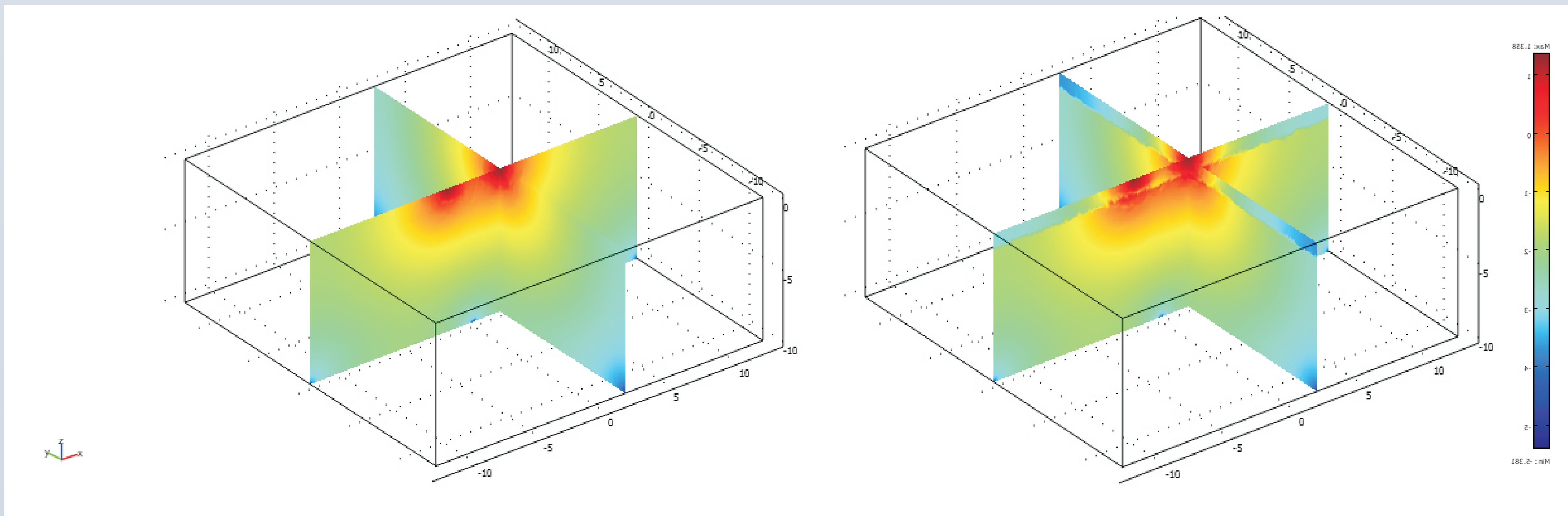
Literature

Felber, Markus (in Press): Geoelektrische Untersuchungen im Flusssystem des Rio Palancia, Spanien. Unpublished Diploma Thesis

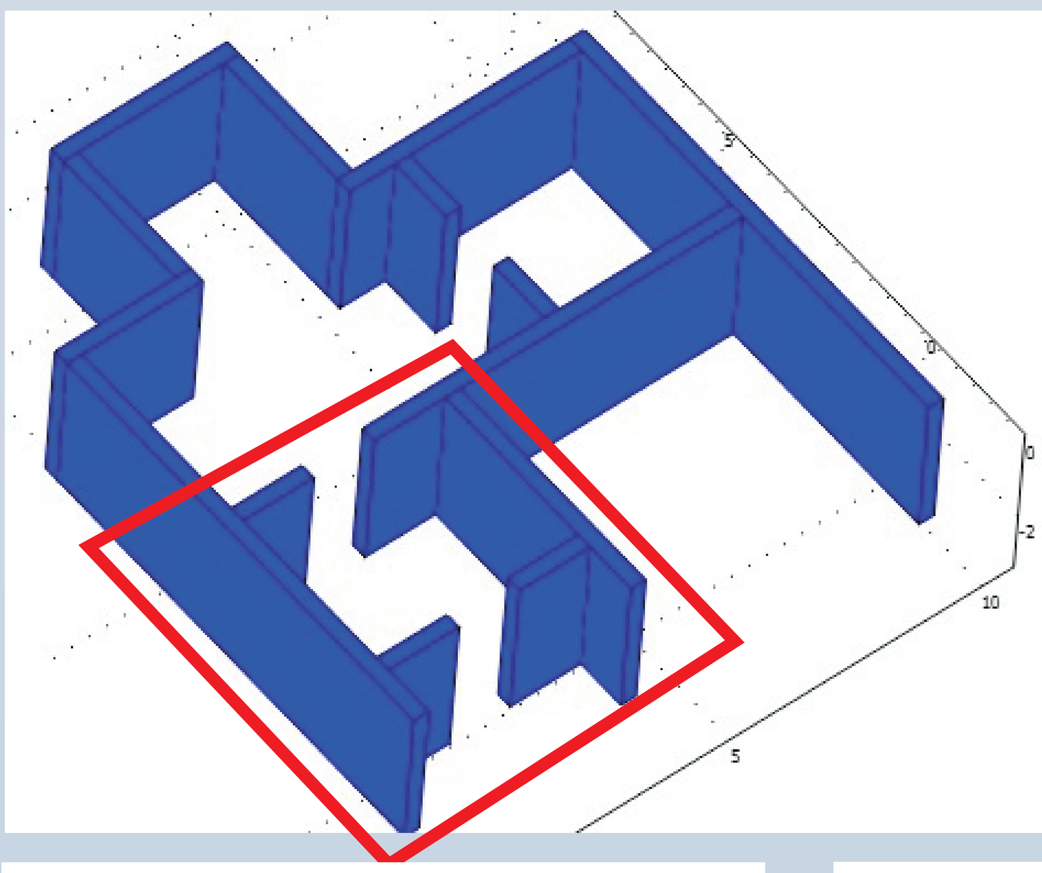
Herrman, F.-R. (1986): Führungsblatt Stand 1985 zu dem römischen Gutshof bei Hoechst-Hummetroth. Odenwaldkreis. In: Archöologische Denkmäler in Hessen 55

Electrode layout in field.

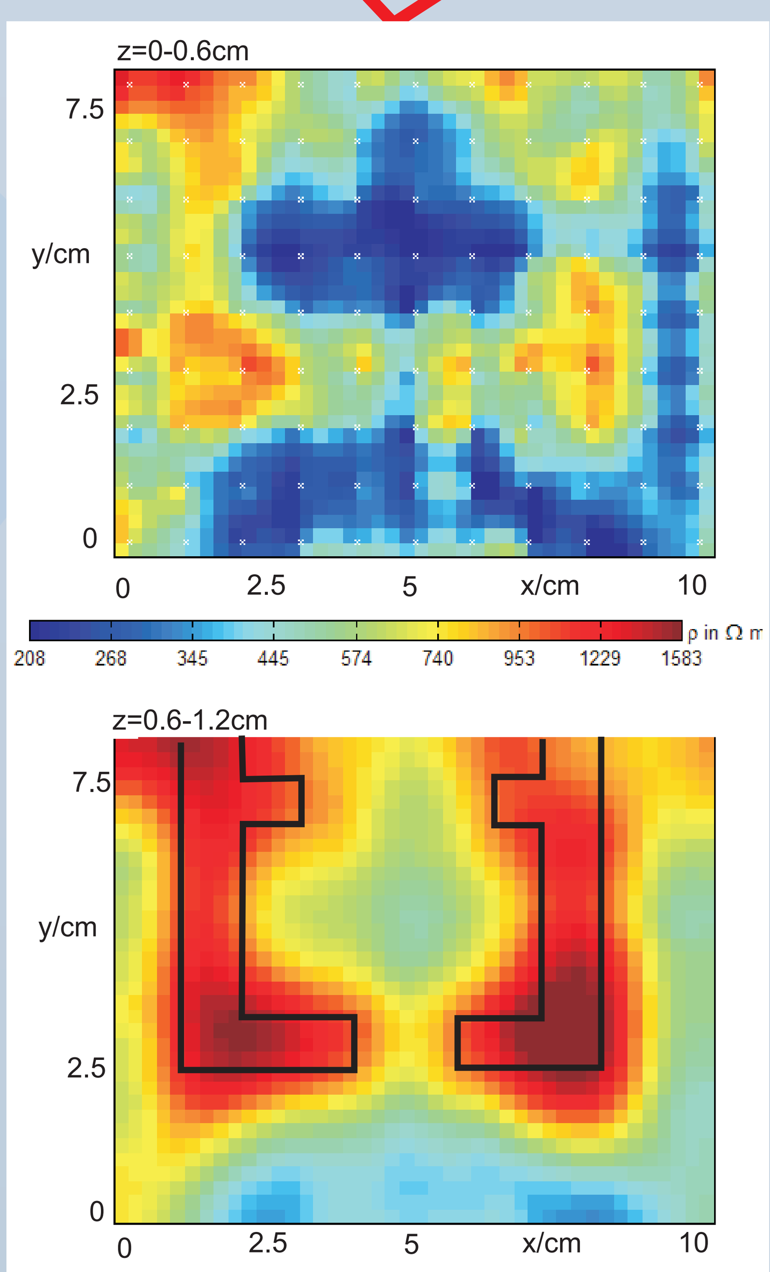
Remote control via Lippmann device to the right of the laptop



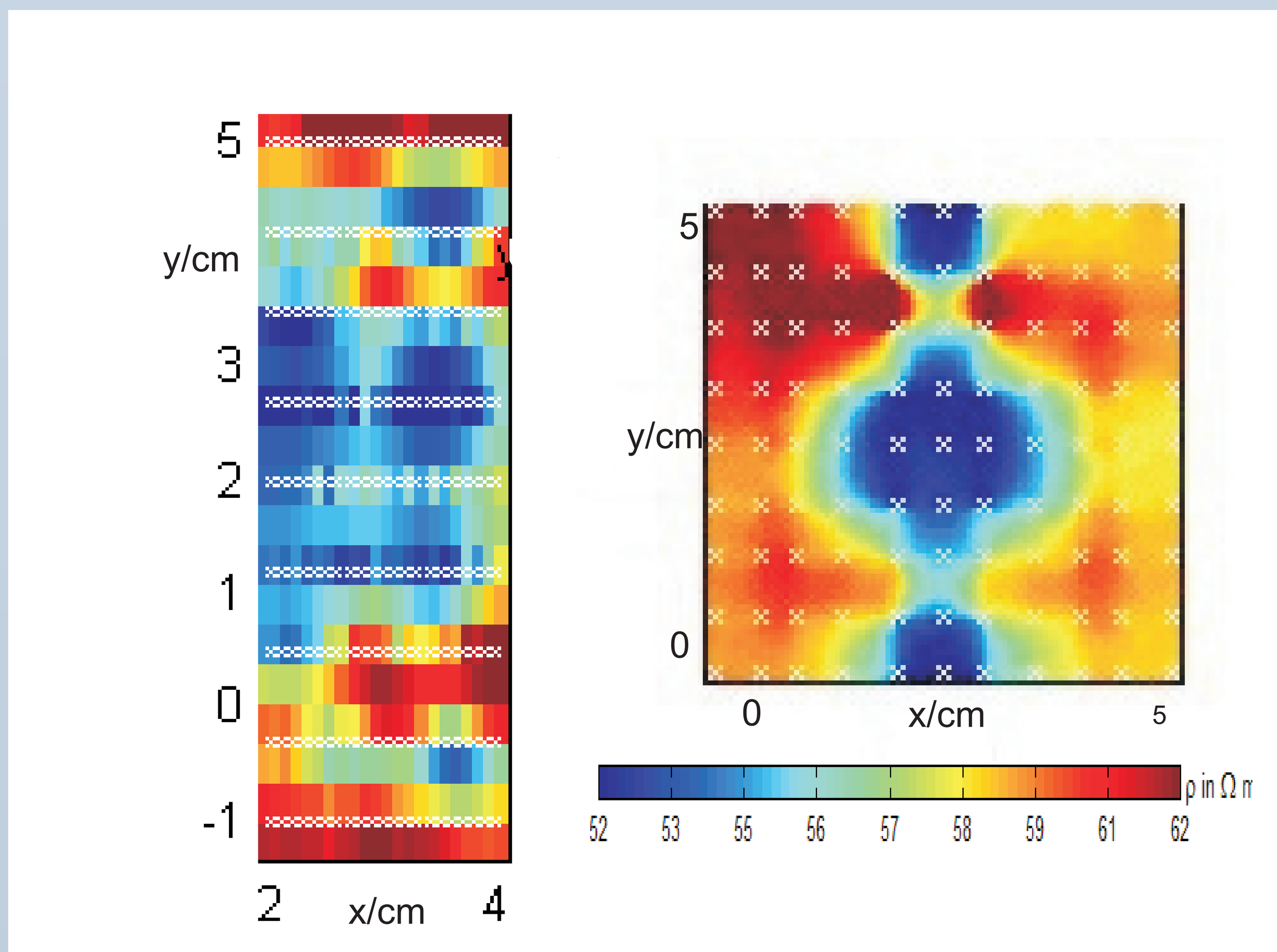
Distribution of the total current density for dipol current injection at the surface of a conducting halfspace. Left: Homogeneous halfspace, resistivity 100 Ωm. Right: Top layer 100Ωm, halfspace 1000 Ωm



Ground plan of the bathing area. The area is about 10x10 m^2 . The modelling and the laboratory measurements (scale 1:35) are restricted to the area within the red square.



Lab measurements - plan view of resisitivity distribution at different depth levels. White crosses show electrode positions.
Openings in the walls are resolved.



COMSOL modelling - plan view. White crosses show electrode positions. Colours represent the distribution of the resistivity.
Left: Subsection (x=2-4 cm) with large line separation.
Right: Small electrode separation.
A smaller electrode separation than that in the laboratory experiment does not give more information (right), increasing line distance causes the loss of details (left).

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