EG Geosciences

Geologie • Geophysik • Archäologie
Einstein-Gymnasium Kehl

Project 2010

Investigation of the Kehl military tunnel system (1882–1945) using geo-electrical methods

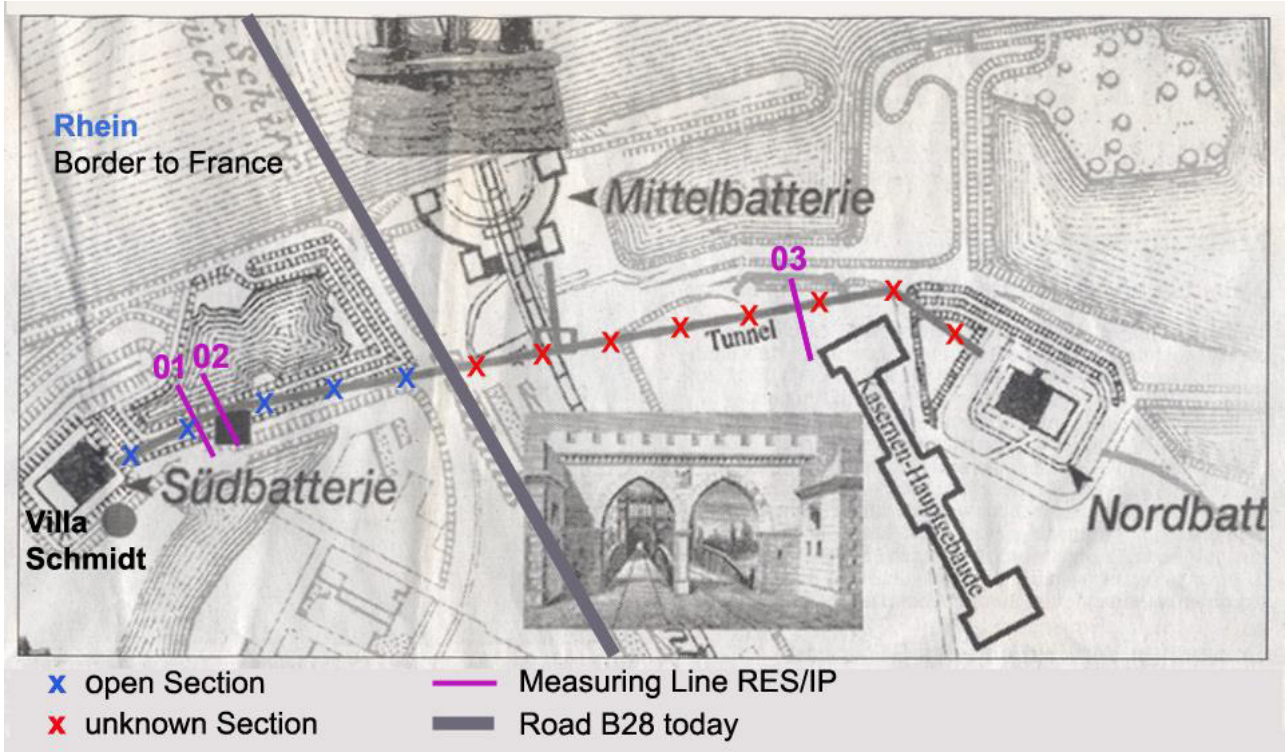
Beneath the city of Kehl, where our school is located, stretches an underground military installation consisting of bunker rooms and an approximately 700-meter-long tunnel.

The installation was built in 1861 and served during the World Wars to move soldiers of the gun batteries along the Rhine River without being seen. It also functioned as a shelter for soldiers.

Project Phases

1. Surveying the known, still accessible sections of the underground installation: Test measurements using Electrical Resistivity Tomography (ERT) and Induced Polarization (IP) were conducted to ensure that the underground chambers can be detected and to optimally calibrate the measurement setup (Profiles 01 and 02).

2. Surveying the tunnel in the currently inaccessible area, which was sealed off in the north in 1972 and partially filled in the south during the construction of the B28 road (Profile 03).



(Moll)

Using a self-built connection box, specific electrodes along the measurement line are activated. Hundreds of four-point measurements are carried out, with banana plugs being reconnected between each individual reading. The students take turns performing this highly focused task, and one student acts as a supervisor to ensure that no mistakes occur. In this way, the students manage within three hours to produce a dataset equivalent to that of an automated geo-electrical tomography system with 50 electrodes (Wenner array, 392 individual measurements). The data quality is comparable, since the manually operated single-channel instrument provides highly accurate readings.

Measurement_01: Electrical Resistivity Tomography and Induced Polarization – Data Acquisition
Jérome David, Sophie Mätz, Stefan Beck, Alper Altay (Moll)

Measurement Line 01

To perform measurements on the cobblestone surface without drilling or causing any damage, the students came up with an innovative idea: plastic tubes were set up, filled with cat litter and a small amount of salt water, with the electrodes placed inside.

The contact resistance between the electrodes and the ground turned out to be lower than that achieved by wrapping the electrodes in wet cloths — a method commonly used in scientific and industrial survey campaigns.

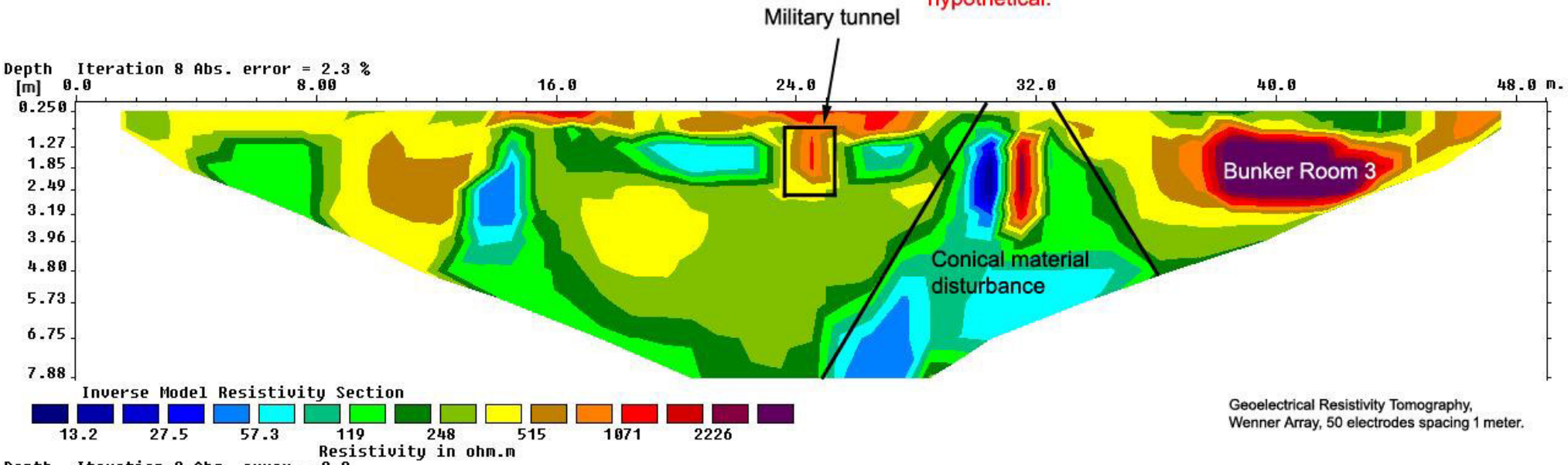
Measurement_01: Electrode Cable Setup (Moll)

Profile_01

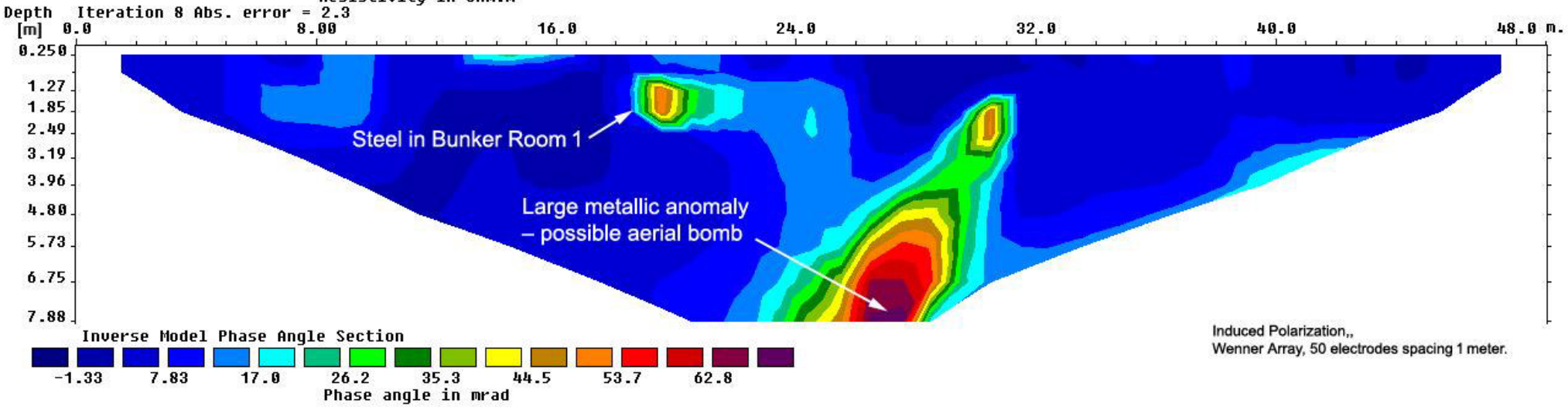
2D Resistivity/IP
EG Geoscience, 16.04.2010
Team: Sophie Mätz, Jérome David, Stefan Beck, Alper Altay, Philipp Moll

Tunnel_01

Resistivity Profile:Military tunnel, verified by on-site inspection; Bunker Room 3 hypothetical.IP anomalies: Steel scrap verified in Bunker Room 1; unexploded World War II aerial bomb (UXO) hypothetical.



Geoelectrical Resistivity Tomography,
Wenner Array, 50 electrodes spacing 1 meter.



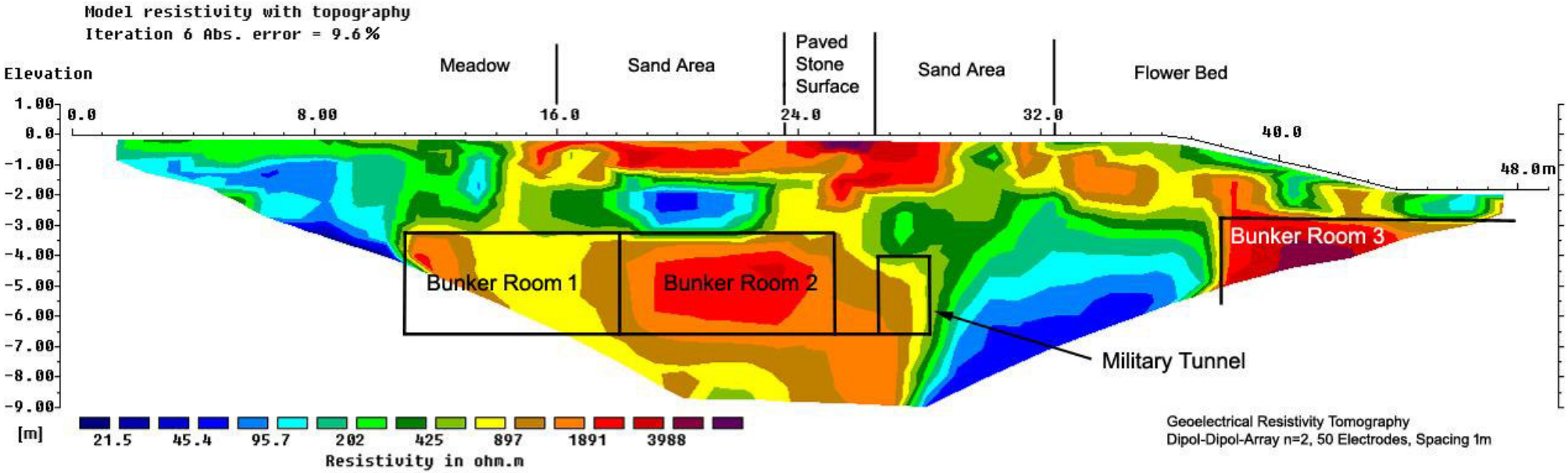
Induced Polarization,,
Wenner Array, 50 electrodes spacing 1 meter.

Profile_02

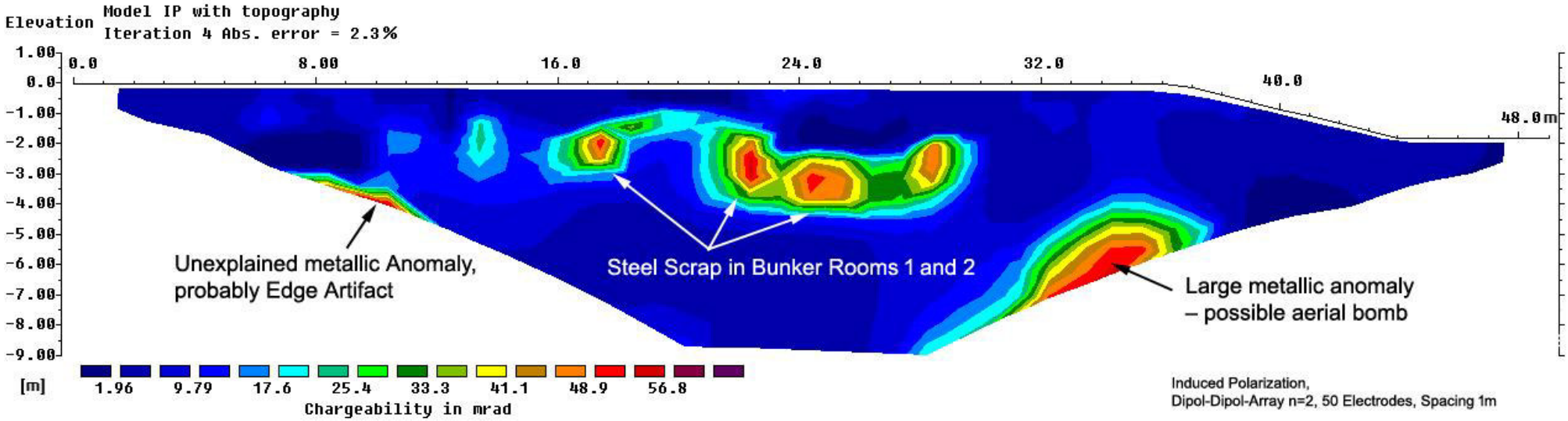
Bunker Rooms 1 and 2 as well as the military tunnel verified by on-site inspection.
Bunker Room 3 hypothetical, former entrance likely at 38.5 m along the profile

2D Resistivity/IP
EG Geosciences, 24.04.2010
Team: Johanna Eckstein, Stefan Beck, Jonathan Arnas, Philipp Moll

Tunnel_02

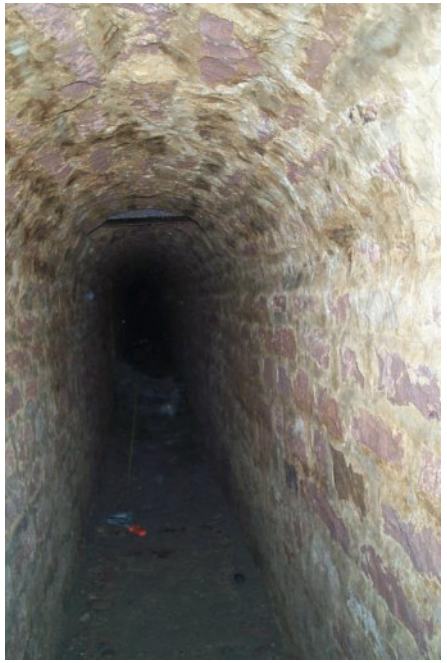


Geoelectrical Resistivity Tomography
Dipol-Dipol-Array n=2, 50 Electrodes, Spacing 1m



Induced Polarization,
Dipol-Dipol-Array n=2, 50 Electrodes, Spacing 1m

Bunker Rooms Today (Moll)



Tunnel Today – Accessible Section (Moll)

Northern End of Tunnel in Basement of Pioneer Barracks
– sealed off since the 1970s (Gras)

Exposed Section of Tunnel during Construction of the B28 in 2002 (Gras)

Kehler Stadtanzeiger 24.03.2010

Mit Stromflussfeldern den Untergrund durchleuchten

Archäologie AG will die Lage und Beschaffenheit des Kehler Tunnels erforschen

Kehl (gro). Mit dem Kehler Untergrund beschäftigt sich in den nächsten Monaten die Archäologie-AG des Einstein-Gymnasiums. Seit einem Jahr haben sich elf Schüler mit ihrem Leher Philip Moll der Erforschung der Kehler Geschichte verschrieben. Eine Alemannensiedlung haben sie schon vermessen, nun widmen sie sich der neueren Kehler Geschichte.

In Zusammenarbeit mit dem Historischen Verein Kehl wollen sie den Tunnel entlang des Rheins erforschen und vor allem mittels eines geophysikalischen Messverfahrens den Verlauf und Zustand des Bauwerks aus der Zeit des deutsch-französischen Krieges ermitteln.

Klaus Gras vom Historischen Verein ist gespannt auf die Ergebnisse: „Wir wissen vieles nur vage durch Zeitzeugenberichte. Es ist interessant zu erfahren, wie oft der Tunnel unterbrochen wurde und wo er auf der anderen Seite der Europabrücke verläuft." Denn derzeit gibt es nur einen Zugang und nur ein kurues Stück Tunnel, dass man begehen kann. Knapp zwei Meter hoch und 1,50 Meter breit diente der Verbindungsgang in der ehemaligen Garnisionsstadt den Soldaten. Nach dem zweiten Weltkrieg wurde er durch Betonmauern unterbrochen, als die Europabrücke in den 50er Jahren gebaut wurde, wurde ein Teil zerstört.

Der zweite Teil des Tunnels endet beim „Wachhiesel" an der Großherzog-Friedrich-Kaserne. „Wir wollen nicht nur theoretisch arbeiten", so Moll. „Wir wollen auch graben", stimmen ihm die Schüler zu. Sie träumen davon, den Eingang an der Kaserne freizulegen und mehr von dem Tunnel der Öffentlichkeit und Forschung zugänglich zu machen. Das Equipment bringt Moll, der mit Freunden schon in Kanada nach Bodenschätzen suchte, mit. „Wir arbeiten mit einer Elektrodenkette. Durch Stromflussfelder können wir die Beschaffenheit des Untergrunds erkennen", erklärt Moll. Am Ende steht eine zweidimensionale Karte von dem Tunnel, seinem Verlauf und den Unterbrechungen.

Wollen mehr über die Kehler Geschichte erfahren: Die Archälogie AG des Einstein-Gymnasiums. Foto: gro

Auch theoretisch wird das Projekt aufgearbeitet. Der Historische Verein hat den Schülern Quellenmaterial überlassen, sie hoffen auch im Stadtarchiv Hilfe und Informationen zu finden. Unterstützt werden sie von Arne Beckmann, Geschichtslehrer am Einstein-Gymnasium. Die Ergebnisse bekommt der Historische Verein.

Translation:

Illuminating the Underground with Electric Current Fields

Archaeology Club aims to investigate the location and condition of the Kehl tunnel

Kehl (gro). The Archaeology Club at Einstein Gymnasium in Kehl has been exploring the city's underground in recent months. For about a year, students under the guidance of their teacher Philipp Moll have been studying the history of Kehl. After already surveying an Alemannic settlement, they are now turning their attention to more recent chapters of Kehl's past.

In cooperation with the Historical Society of Kehl, the group intends to explore the tunnel running beneath the Rhine and to determine its condition using geophysical measurement methods.

Klaus Gras from the Historical Society is eager to see the results:
"We hope to learn a lot about the tunnel's structure and age. It will be interesting to find out how often it was interrupted and where it runs on the other side of the Europe Bridge."

Currently, there is only one access point and just a short stretch of tunnel that can be entered. The passage is about two meters high and 1.5 meters wide, and originally served as a connection between military facilities in the former garrison town.

During the Second World War, parts of the tunnel were interrupted by concrete walls when the Europe Bridge was built in the 1950s, and parts were destroyed. Another section of the tunnel ends near the "Wachhiesel" at the Grand Duke Friedrich Barracks.

"We don't just want to work theoretically," says Moll. "We also want to dig!"

His students agree enthusiastically. They dream of uncovering the entrance at the barracks and making more of the tunnel accessible to the public and for research.

The equipment is provided by Moll, who previously searched for mineral resources in Canada with friends.
"We work with an electrode array. Using electric current fields, we can detect the condition of the underground," explains Moll.

The end goal is to create a two-dimensional map showing the tunnel, its course, and any interruptions.

The project also includes a theoretical component. The Historical Society provides the students with archival material, and they hope to find additional information in the city archive. The final results will be handed over to the Historical Society.

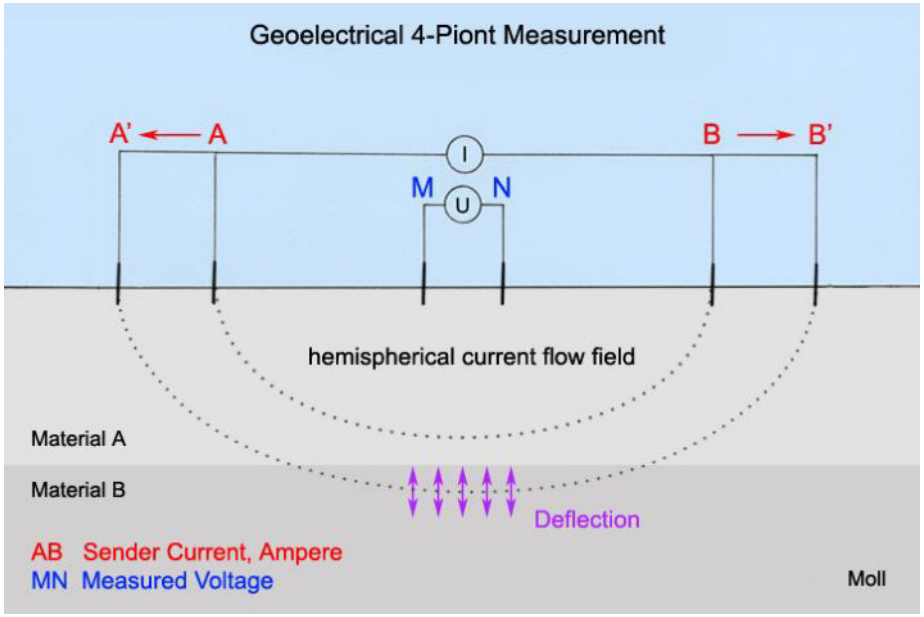
Geoelectrics

Methods Used

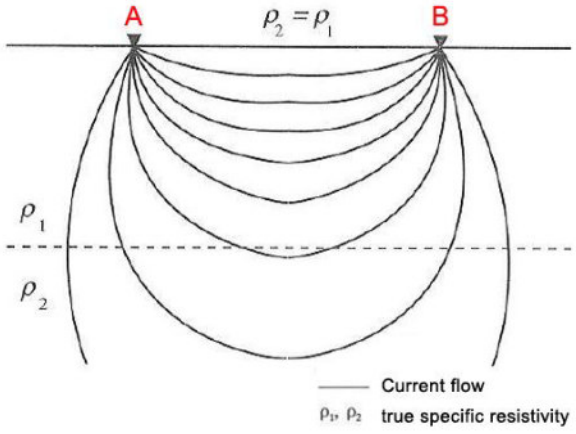
Electrical Resistivity Tomography (ERT):
ERT determines the spatial distribution of electrical resistivity in the subsurface by injecting current and measuring the resulting voltage response. Differences in resistivity allow conclusions to be drawn about lithology, porosity, water content, and structural disturbances of the Earth's crust.

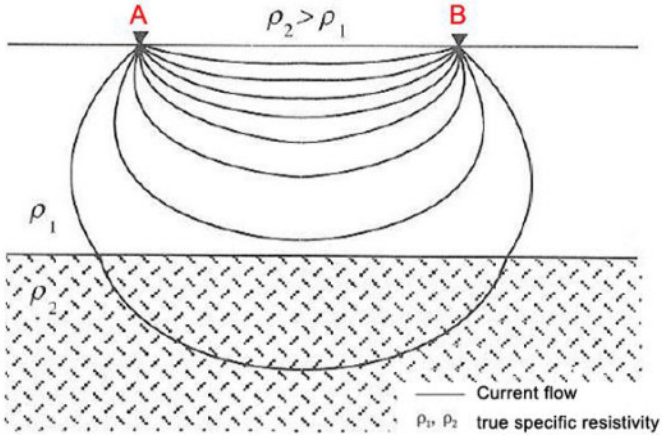
Induced Polarization (IP):
IP measures the delayed decay of the electric field, capturing the ability of rocks to store electrical charges. This behavior is typical of clay-rich or sulfide-bearing zones and is specifically used for mineral exploration and the characterization of fine structural features.

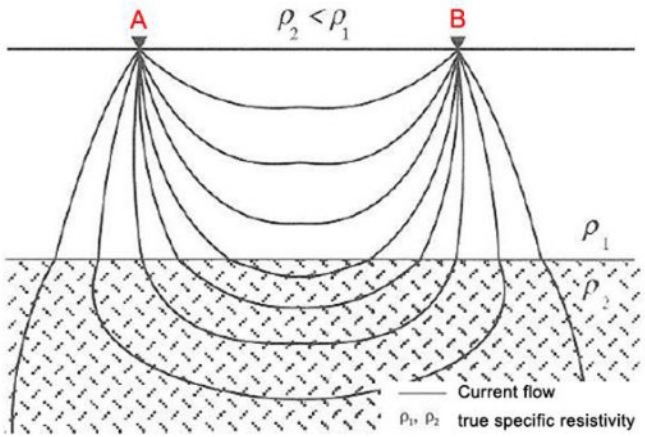
Both methods are measured **simultaneously** and provide a complementary electrogeophysical model of the subsurface.



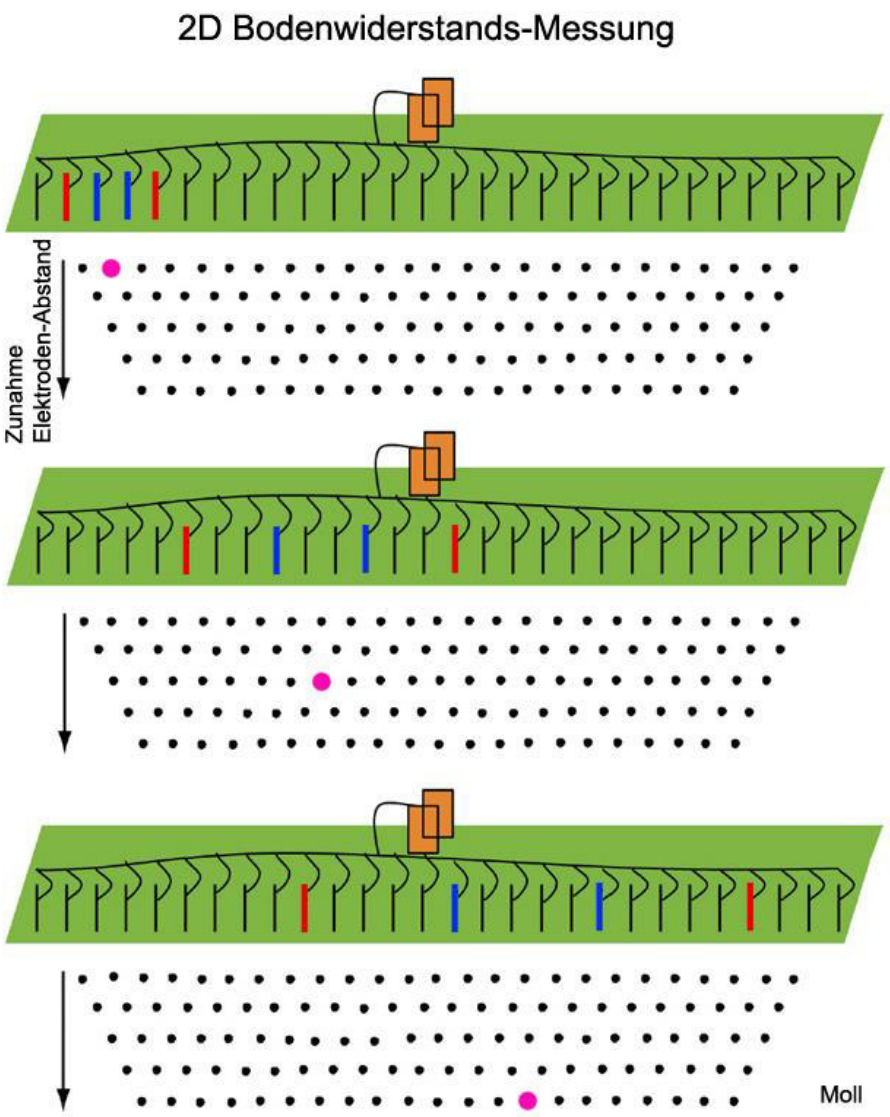
Deformation of Geo-Electrical Current Fields Depending on Changes in Ground Conductivity:[1]







[1] Script "Geophysik", Prof. Dr. A.Henk,



In **2D ground resistivity measurements**, the four-point electrodes are gradually shifted horizontally and their spacing is increased. This produces a dataset that captures both horizontal and vertical variations of the subsurface. Using forward-modeling software, a two-dimensional resistivity profile of the subsurface is calculated.
The resulting, differently sized hemispherical current flow fields are simultaneously used to detect zones of varying chargeability (inducibility) and to compute a **2D IP profile**.

Measured Quantities and Derived Units for the Profile

During **resistivity measurements**, current (I) and voltage (U) are recorded. From these values, the **apparent specific resistivity [Ohm·m]** is calculated, since the ground acts as an inhomogeneous conductor, and the measured data represent averaged conductivities of different layers.

In addition, during **IP measurements**, the chargeability is determined — the phase shift between current and voltage in **milliradians (mrad)**, which describes the delayed discharge of stored electrical charges.

Measuring Equipment:
Student-built system: 370 m serial cable, 75 stainless steel electrodes, connection box.
Loan from Lippmann company: 4-Point Light measuring device, maximum transmission current 50 mA (Moll)

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