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Complex geophysical and geological study of the Balaton Highlands: inferences from magnetic and geoelectric surveys

Introduction

The Eötvös Student Chapter in SEG and the AAPG Eötvös Student Chapter of Eötvös Loránd University, Budapest, organized an international field camp between 10th and 16th of September, 2015 at the Balaton Highlands, Hungary. Geologist and geophysicist student participants arrived from 6 countries: Hungary, Brazil, Germany, Poland, the UK and the Netherlands. The aim of the field camp was to give an insight into solving geological problems with the application of near surface geophysical methods (Figures 1 and 2). During the week the participants attended lectures on the theoretical background of the applied geophysical methods, the geological settings of the area of our interest and the formation of the Pannonian Basin. We summarize the main results of our field camp by this contribution.

Geological background and research area

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<tr>
<th>STRATIGRAPHY</th>
<th>GEOLOGICAL TASKS</th>
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<tr>
<td><strong>Pleistocene-Holocene</strong></td>
<td>SEDIMENTARY INFILL IN SCORIA CONE</td>
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<td>Lake sediments were deposited in depressions of scoria cones and maar craters.</td>
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<td><strong>Miocene-Pliocene</strong></td>
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<td>From the Late Miocene to Pliocene a Basaltic Volcanic Field was developed in the area.</td>
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<td><strong>Miocene</strong></td>
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<td>Shallow marine to lacustrine sediments were deposited characterized by various lithologies.</td>
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<td><strong>Triassic</strong></td>
<td>BURIED BASALT BODIES</td>
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<td>Huge volume platform carbonates and marls deposited in shallow marine environments at the passive margin of the Neotethys Ocean.</td>
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<td><strong>Permian</strong></td>
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<td>Terrestrial, alluvial siliciclastic sediments make up the so called ‘New Red Sandstone’.</td>
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<td><strong>Variscan basement</strong></td>
<td>FRACTURED CARBONATES</td>
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<td>The crystalline basement is built up by phyllite, which metamorphosed during the Variscan orogeny.</td>
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Figure 1 Generalized stratigraphy and the addressed geological tasks.

Geophysical methods

**Geoelectrical measurements**

Direct current geoelectrical methods were used, since great contrast in the resistivity of the rocks was expected at both the sedimentary infill and the fractured carbonates measurement sites. Two direct current methods were applied: Electrical Resistivity Tomography (ERT) and Vertical Electrical Sounding (VES). The resistivity of the ERT surveys was evaluated with least-squares inversion from the apparent resistivity section with RES2DINV software.
Magnetic measurements
Magnetic methods were applied using Overhauser type GSM19 magnetometers in order to identify further, buried volcanic bodies. Basalt is generally made of 5-15 wt% FeO that causes the good magnetic perceptibility. Both the total field and the gradient were measured. Basaltic bodies near the surface can cause anomalies up to several hundred nT in the total field. Standard data processing procedures were followed for the evaluation, including diurnal correction based on the data of the Thany Geomagnetic Observatory, normal correction, despiking and filtering for low frequency anomalies. The data processing was implemented by a MATLAB code, written by ourselves.

Results and discussion
Geoelectrical measurements
Site 1: Scoria cone
On the Kopácsi Hill an ERT survey was measured in the crater of a scoria cone. Two electrically distinctive layers were detected by the ERT survey: the low resistivity layer (5-20 Ωm) represents the lacustrine sediments, while the high resistivity layer (>200 Ωm) represents the basaltic body. This value is in agreement with previous studies (e.g., 200-100000 Ωm, Milsom, 2003). The thickness of the low resistivity layer is 10-14 meters. Two medium (40-80 Ωm) resistivity bodies can be noticed on the sides of the survey. These are the slope sediments of the crater wall and are made of basaltic tuff. The geometry of the volcano was reconstructed based on the geoelectrical data and the cross section of Kereszturi & Németh (2012 and Figure 3).

Figure 2 The research area was located at the Balaton Highlands, Hungary. The different measurement sites are marked with rectangles.

Figure 3 The geometry of the volcano based on the ERT survey and the cross section of KERESZTURI & NÉMETH, 2012. Map: the red line indicates the measurement site, the black line the crater rim and the dashed line the tuff ring (modified after MARTIN & NÉMETH 2004).
Site 2: Fractured carbonates

The fractured carbonate zone near Nagyvázsony was investigated by both ERT and VES measurements. Three higher resistivity bodies indicated by the ERT survey are associated with fractured zones. Note the low resistivity body under a higher resistivity at 50 meters. It is a shadow effect caused on one hand by the high resistivity block and the other hand by the inversion process. A VES measurement was performed in order to achieve better penetration depth compared to the ERT survey. This VES measurement supports the results of the ERT survey that the subsurface is not built up by horizontal, homogenous layers. The result of the inversion for the first layer is 860 Ohm. However, the ERT survey shows 500-800 Ohm resistivity on the same point. The explanation of the higher resistivity is that, when the distance between the current electrodes is increased, one of the electrodes will be located above the aforementioned higher resistivity body and the average resistivity of that higher and lower resistivity body will be measured. The second layer of the VES corresponds well with the ERT measurement at the same depth. Probably the third, lower resistivity layer is highly saturated with water.

Figure 4 [ERT and VES survey image]

ERT and VES surveys were measured to find the fractured carbonate zone. Black circles indicate the higher resistivity bodies on the ERT survey. Map: Blue line is the ERT survey, red dot is the VES. The line crossing the dot indicates the direction of the VES cables during measurement.

Magnetic measurements

During the measurements two locations were investigated, one at Kab Hill and one near Vörööstö. Near Vörööstö, numerous basaltic outcrops were mapped by the famous Hungarian geographer and geologist, Lajos Lóczy in the early 1900s (Lóczy, 1918). However, recent geological mapping studies couldn’t confirm the existence of one of these basaltic bodies. Therefore magnetic measurements were performed over the questionable basaltic body and based on our data its existence can be confirmed.

Figure 5 [Geological map]

The measurement’s track on a geological map with the hypothetical and proven outcrops.

However, the peaks associated with the outcrops are separately cropped out between 3000 and 3500 meters, with a distance of ~200 meters, they are part of the same basaltic body which might need further investigations. This large volcanic body is indicated with the green circle on Figure 6. Note that due to the dumpiness of the surface, the anomalies width is slightly incorrect and also loaded with the deviation of the GPS error.
Conclusions

During our field camp at the Balaton Highlands the attending students performed geophysical measurements and visited the most important outcrops of the area. Every participant has been able to try all the methods and they also participated in the data processing. Our preliminary results have improved the understanding of a key area of the volcanic field: the thickness of the lake sediments in the crater of Kopácsi Hill has been determined and the existence of the basaltic body speculated by Lajos Lóczy has been confirmed. These preliminary results should be verified by further measurements. We do hope that such a successful field camp will be also implemented next year.

Acknowledgements

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Figure 6 The measured profile. It shows the already proven and the hypothetical outcrop. The green circle indicates that these outcrops are associated with major basaltic bodies.

Figure 7 Group photo of the participants of the field camp.

References:


