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PALEOENVIRONMENTS OF THE LAKE BALATON AREA

Research Project (2003-2005) Supported by the Hungarian National Science Foundation (OTKA)

2003. April

1. PROJECT OVERVIEW

The Geophysical Department of the Eötvös University, Budapest has received a remarkable fund from the Hungarian National Science Foundation to carry on a R&D Project in the area of the Lake Balaton, western Hungary. The primary aim of the fund is to support "Scientific Schools" with the proven potential to develop modern research methods, and apply them to address scientific problems of national and international interest.

The main goal of technological development is to improve individual geophysical surveying methods and integrate their results to arrive at a best characterization of the shallow subsurface environments.

The selected test area is the Lake Balaton and its surroundings, which is the Transdanubian Range on the North and Neogene basins elsewhere (Fig. 1.). In the framework of the Project, the Late Pleistocene through Holocene environmental conditions, paleoclimatic changes, tectonics and landscape evolution are to be understood.

The Project is open and participation of academic groups are welcome in any related field of environmental research. Interested groups of experts are requested to contact one of the following scientists in charge of the execution of the Lake Balaton Project.

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- Prof. Frank Horváth
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- Tamás Lipovics
  Project Secretary
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2. TRADITIONAL RESEARCH IN THE LAKE BALATON REGION

The study of the lake and its environment has been the object of the Hungarian geological research since the end of the XIXth century. The first geological map of the lake and its wider area was prepared by Lóczy, in 1913, using the data of boreholes and the result of geological mapping in the area. Lóczy thought that the lake was formed by tectonic subsidence which initially lead to several smaller depressions. These proto-lakes were enlarged by the erosion of wind and abrasion, and eventually they became one single water mass. Fig. 2. shows the initial extent of these proto-lakes.

In 1934 another traditional model was elaborated by Cholnoky, shown in Fig. 3. He thought that the lake was basically formed by normal faulting in the Pliocene. The ENE-WSW oriented normal faults resulted in the formation of a trough. In this depression, aeolian erosion created N-S directed valleys. From his field observations, he outlined the maximum extent of the lake, which can be seen in Fig 4. According to later palynological data from core samples, the lake reached its maximum size in the Atlantic (5000 YBP).

From 1981 the Geologic Institute of Hungary investigated the lake by borehole studies, seismo-acoustic surveying and mapping of the region. The stratigraphic column of Fig. 5. shows a summary diagram of their results. The base of the lake sediments is generally formed by Late Miocene strata. It is overlain unconformably by latest Pleistocene and Holocene soft sediments. The unconformity can be explained in term of uplift and strong erosion of the entire western part of the Pannonian Basin.

From 1997 the Geophysical Department of the Eötvös University carried out several ultra-high resolution seismic surveys on the lake. Early and more recent boreholes were analysed and correlated with seismic sections. (Fig. 6. and 7.)

3. ENVIRONMENTAL GEOPHYSICAL MEASUREMENTS

There are several geophysical methods that we plan to apply in the research project. The aim of the technological development is to arrive at an integrated geophysical acquisition technology that can be used most successfully in Quaternary environmental researches.

1. Magnetic susceptibility

Magnetic susceptibility is the most frequently and widely used physical parameter for the determination of climatic changes during the Quaternary. Our intention is to determine the magnetic susceptibility of the samples from boreholes – both on land and in the lake – with the highest possible resolution and accuracy. With our Bartington instruments both field and laboratory measurements will be carried out.

2. High-resolution magnetic measurements

Since the induced magnetic field of the geological formations is the function of their magnetic susceptibilities, high-resolution magnetic measurements can ideally complete the above discussed magnetic susceptibility determinations. Our magnetic measurements have been used for archeological purposes for more than a decade, therefore our inversion algorithms and magnetic models have been tested several times by excavations. In the present project we intend to integrate the magnetic measurement with different age dating methods.

3. Geoelectric tomography

The method utilizes the differences in the resistivities of the geological units – similarly to the classical geoelectric methods. However, if several electrodes are positioned along a section and the measurements are made with all the possible electrode configurations, thus a practically continuous resistivity image of the subsurface can be acquired.

4. Ultra-high resolution water seismic survey

This method has a very shallow penetration – a few tens of metres –, but an outstanding (appr. 10 cm) resolution. Our former surveys on Lake Balaton have revealed that the apparently homogenous sequences of the Holocene mud are characterized by acoustic impedance contrasts (see Figures 8 and 9). We believe that these contrasts can be explained by differences in the rate of compaction, which is, in turn, a function of depositional rate, and thus, a function of the climatic and other environmental conditions. Systematic mapping of these seismic surfaces can reveal important information on the changes of a lacustrine environment, and tectonic features associated with the formation and evolution of the lake.

5. Penetration test and coring

With the help of cone penetrometers the uppermost layers of the subsurface can be tested. The basis of the method is a measuring equipment which is pushed into the soil. The tool records the resistance of the cone, the pressure on the tip of the cone, natural gamma intensity, gamma-gamma activity, apparent electric resistivity, neutron-neutron activity and porosity etc. These parameters, completed with continuous cores from shallow boreholes will form a fundamental data set in the integrated interpretation of the geophysical data.

6. Age dating

Only a few methods can determine reliably ages within the time period of the last few hundred thousand years. Within the project we intend to improve the $^{234}U/^{230}Th$ method and calibrate with more standard dating methods (e.g. ^{14}C).

Budapest, 23 April 2003

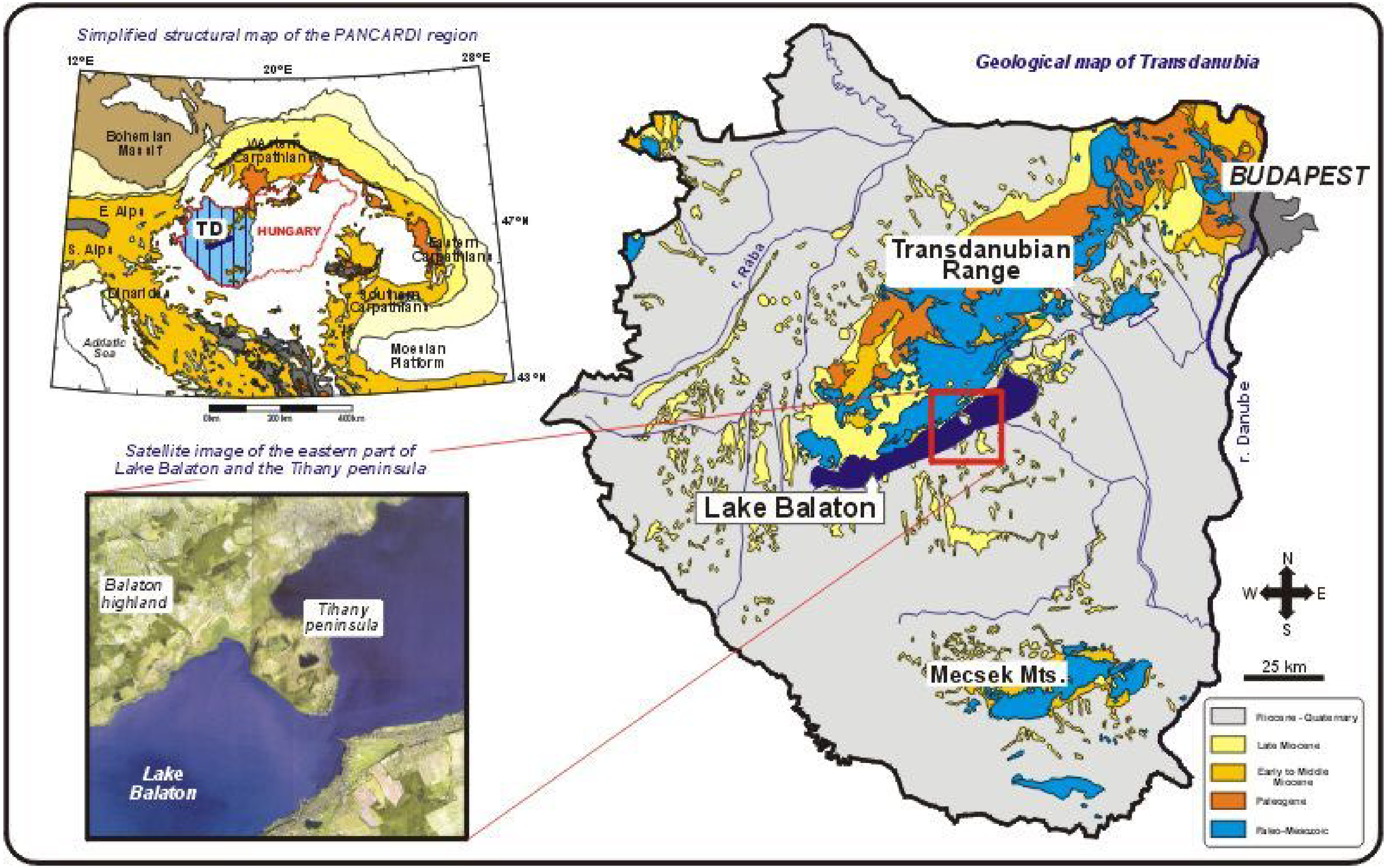


Figure 1: Geological map of Transdanubia (TD - W. Hungary) and its wider geological environment, the PANCARDI region.

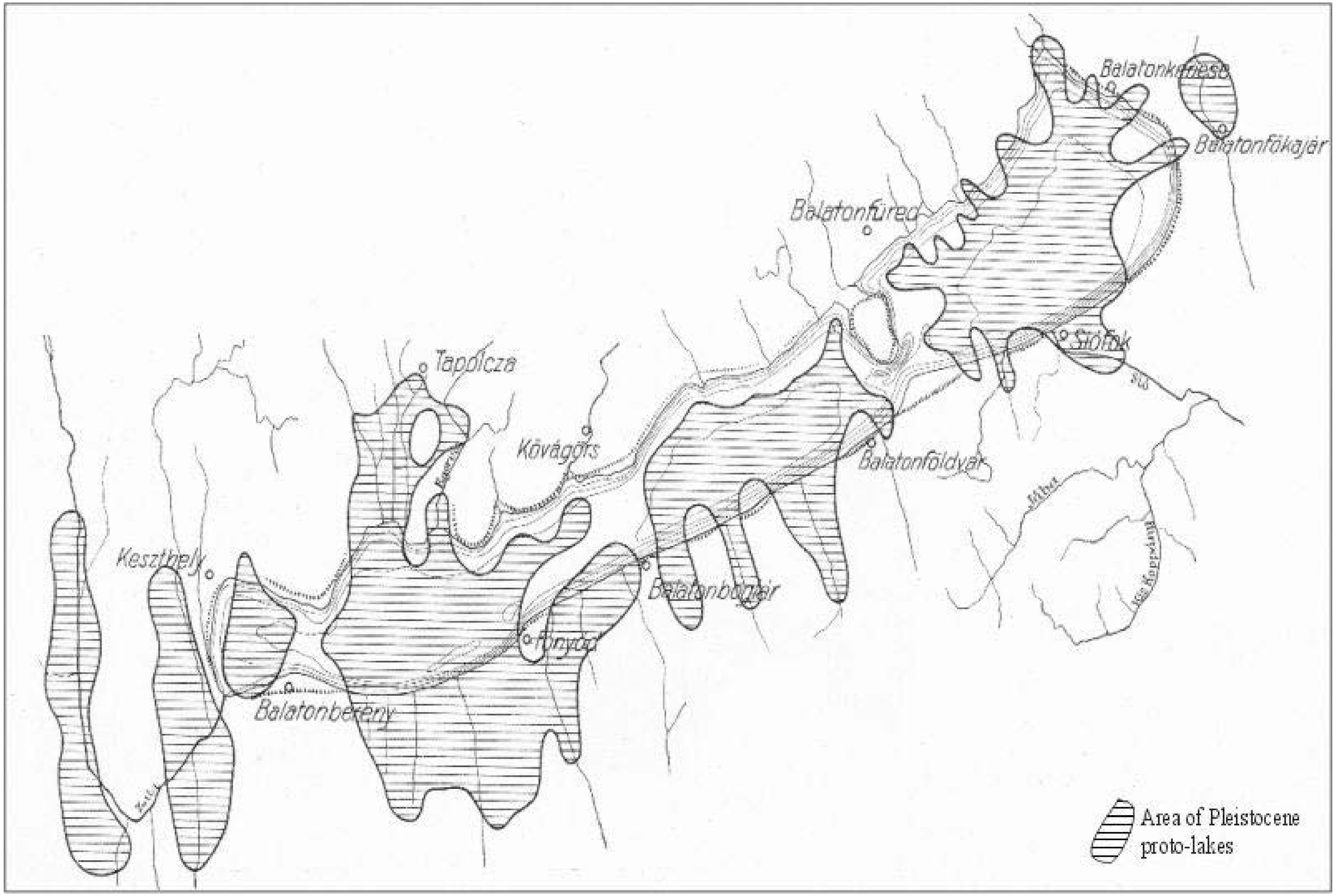
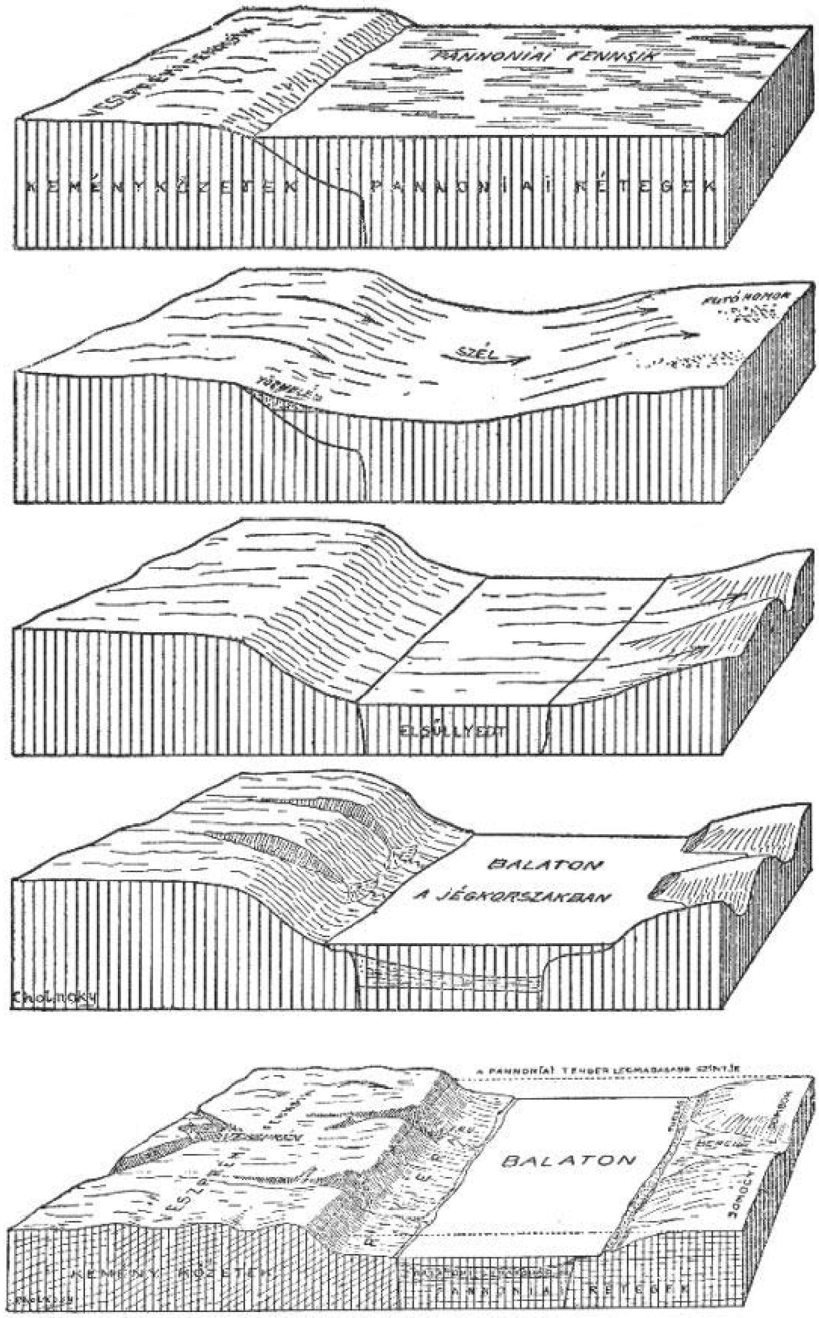


Figure 2: Initial extent of Lake Balaton in the Pleistocene (after Lóczy, 1913)



Late Pannonian
The Pannonian Lake

Early Pliocene
Arid climate, and strong erosion by northern wind

Late Pliocene
- Tectonic subsidence
- Aeolian erosion creates N-S oriented valleys

Pleistocene and Holocene
Glacial climates
Formation of the lake at the beginning of Holocene

Present Landscape

Figure 3: Traditional model for the evolution of Lake Balaton: aeolian erosion combined with normal faulting (Cholnoky, 1934)

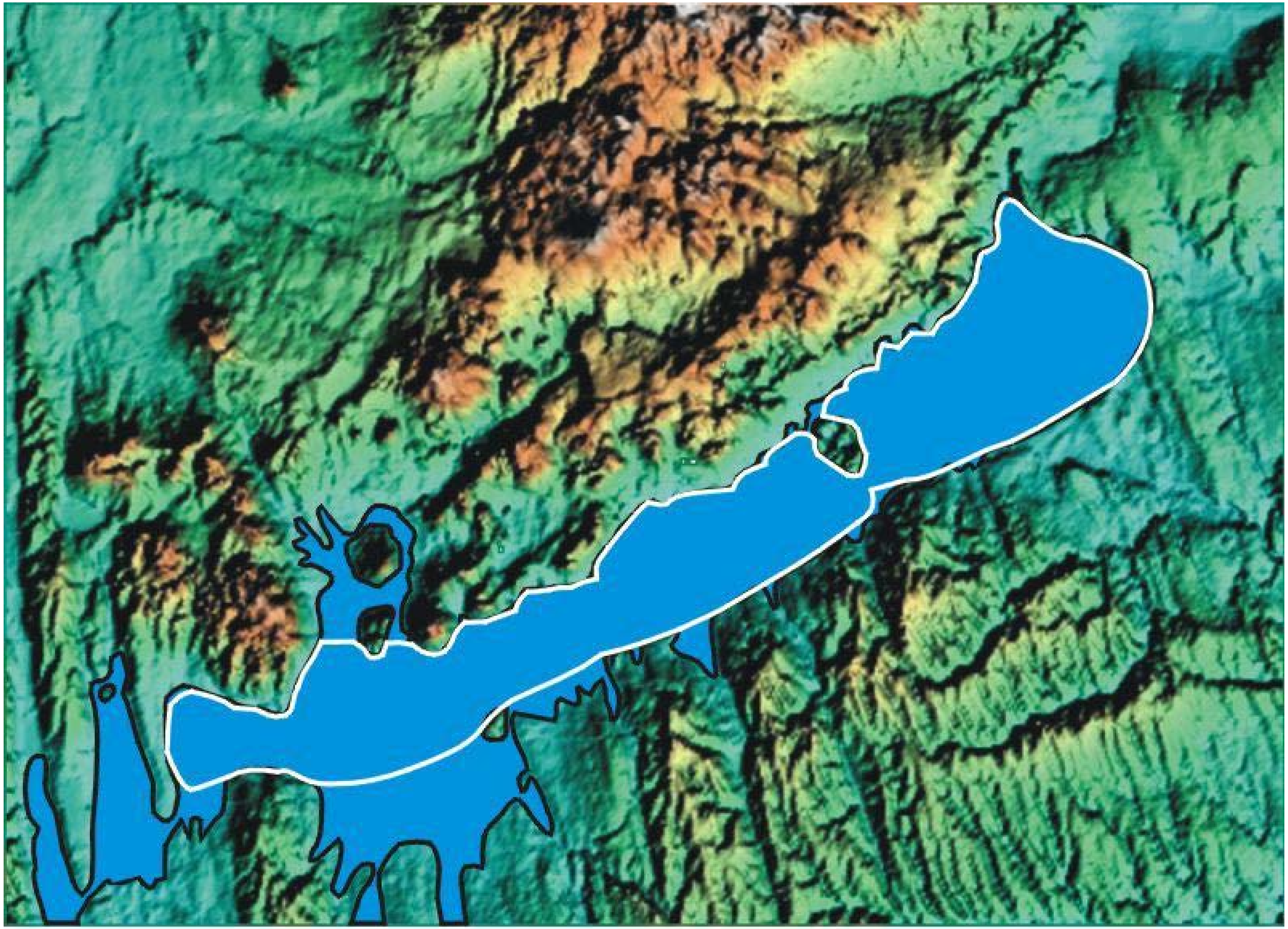


Figure 4: The largest extent of Lake Balaton. White line indicates the present extent of the lake.

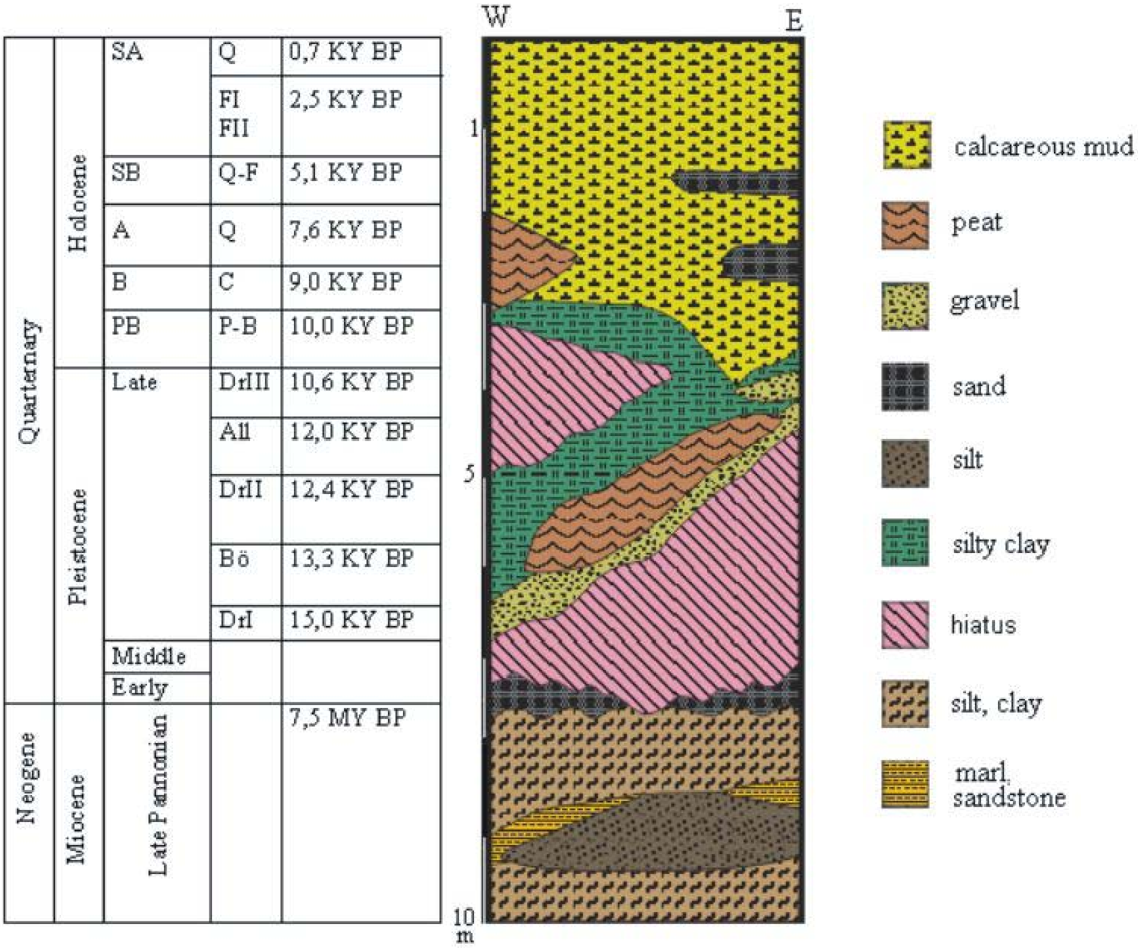


Figure 5: Stratigraphic column of Lake Balaton sedimentary fill and the uncoformably underlying Late miocene strata(Cserny and Nagy-Bodor, 2000)

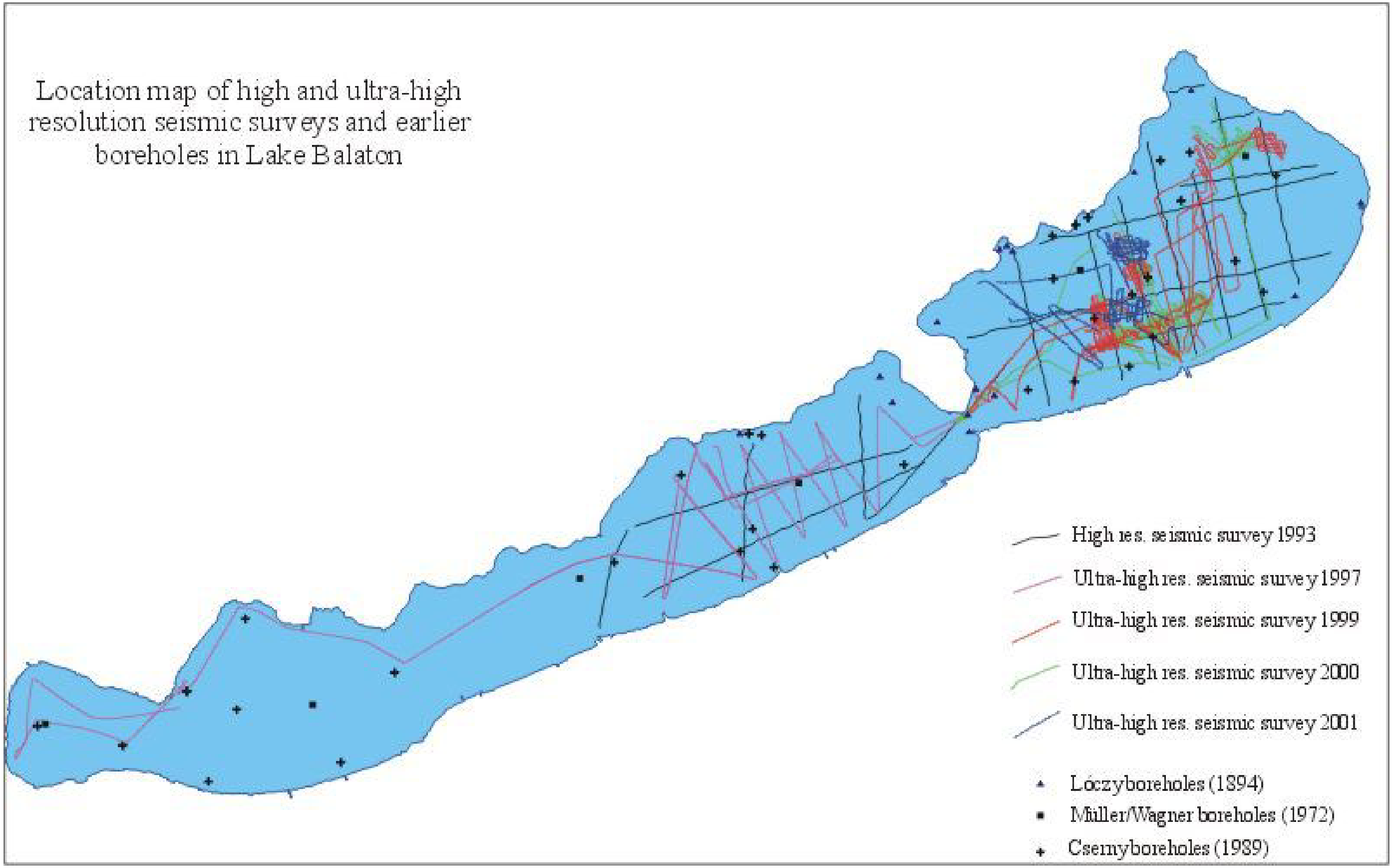

Location map of high and ultra-high resolution seismic surveys and earlier boreholes in Lake Balaton
High res. seismic survey 1993
Ultra-high res. seismic survey 1997
Ultra-high res. seismic survey 1999
Ultra-high res. seismic survey 2000
Ultra-high res. seismic survey 2001
Lóczy boreholes (1894)
Müller/Wagner boreholes (1972)
Cserny boreholes (1989)

Figure 6

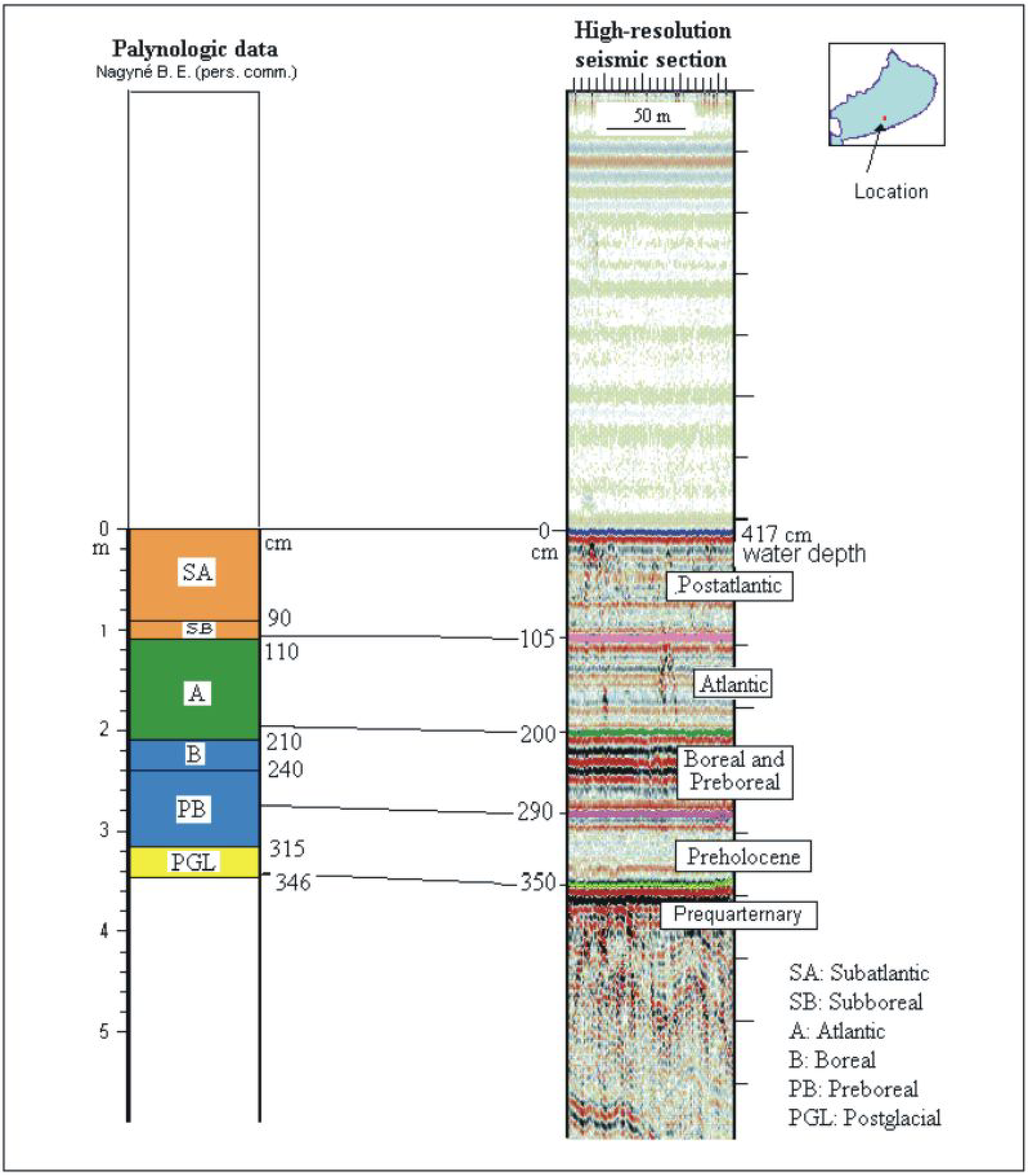


Figure 7: Correlation of Holocene biozones and seismic reflectors

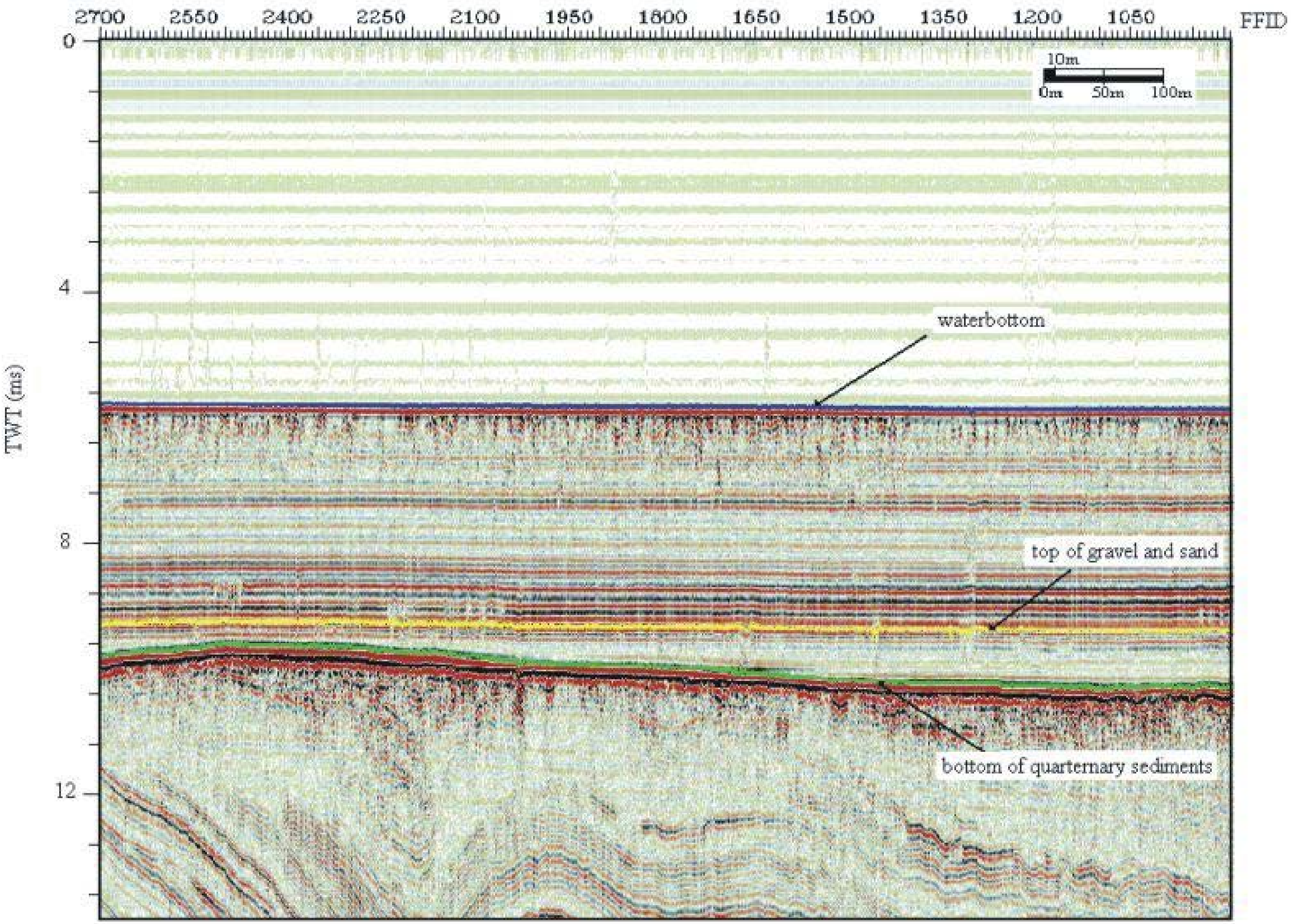


Figure 8: Representative ultra-high resolution seismic section in Lake Balaton

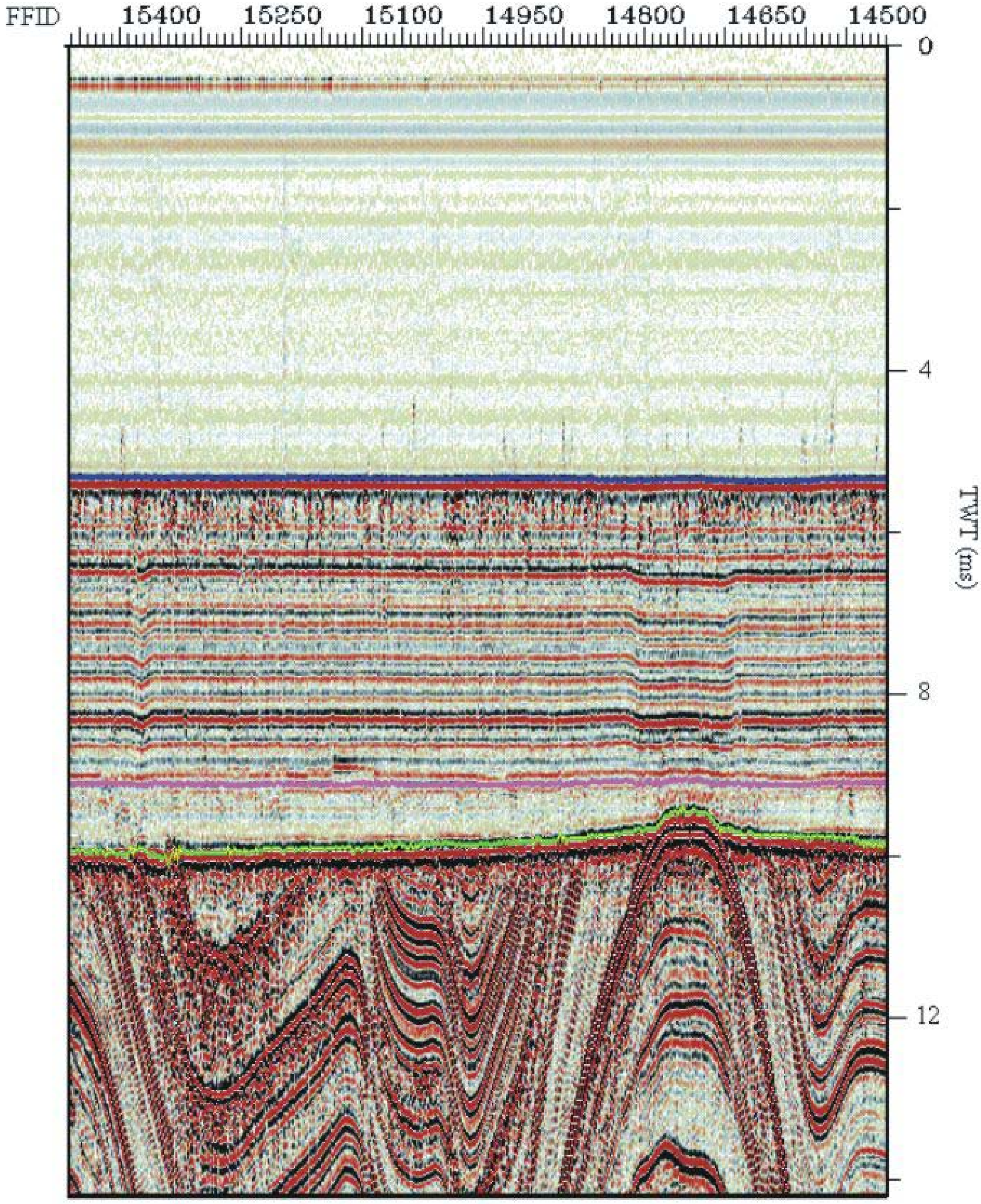


Figure 9: Ultra-high resolution seismic section showing tectonic activity during the Holocene.