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Sparker in lakes; reflection data from Lake Iznik

Göllerdeki sismik uygulamalarda Sparker enerji kaynağı kullanımı; Iznik Gölü uygulaması

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Abstract

The success of a sparker, a marine seismic energy source, would mainly depend on the physical characteristics of the water. In fresh or quasi-fresh lakes, some extra technologies are needed. For the basic and fresh waters of Lake Iznik, we have designed and tried a special sparker container and also some new electrode array configurations. The results and some technical problems encountered will be discussed. Single electrode transducer case, which means that the energy discharging through it will be many times higher if compared to the multi-electrode case, was found to be most practical for this particular expedition. It was in fact rather successful even the vertical resolution decreased about 2.5-3 times. Obtained shallow seismic profiles are used to image the stratigraphic and tectonic setting in the lake. Two unconformable main seismic units, which are separated by a major eroded surface 30-35 m below water surface, could be detected in the sub-surface fluvio-lacustrine sediments.

Keywords: Lake Iznik, sparker, seismic, lakes, geology

Introduction

Lake Iznik with its 313 km^2 areal coverage and 12.2 billion m^3 volume is the biggest lake in southern Marmara region to the eastern part of the Gemlik Gulf (Figure 1), irrigating about 12,000 ha agricultural area. The maximum depth of this fresh water lake is about 73 m. Its elevation from the mean present sea level is 0 m (Budakoğlu, 2000).

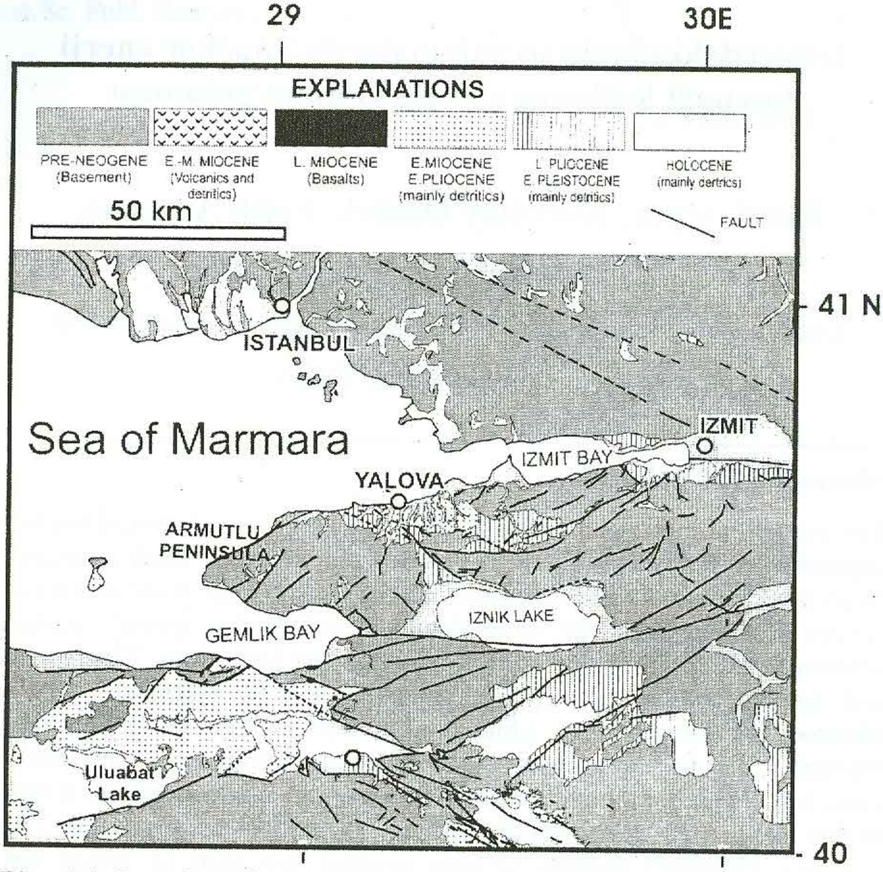

Figure 1. Location of Lake Iznik (modified from Yaltırak, 2002).

The lake is situated on the middle branch of the North Anatolian fault (Barka, 1996), a highly active tectonic region (Figure 1). Such a strategic position makes the sedimentary and tectonic processes in the lake explanatory for many geological problems. In order to understand the tectonic and sedimentary evolution in Lake Iznik, we carried out a seismic cruise. The energy source to be used and how it will be operated will depend on the goals of lake investigations. Unfortunately, the conventional seismic energy source we use at sea, sparker, was not designed for fresh waters (Urick, 1983). Using a sparker in a fresh or quasi-fresh lake deserves extra technologies. So we had to purchase a boomer source (e.g. uniboom or pinger) or design a new sparker configuration for freash water.

It may be good idea to use a boomer in fresh water, because a boomer performs the same way in both saline and fresh waters. The vertical resolution of boomers is higher but unfortunately their penetrations below the lake bottom are lower than we needed. Due to this and the lack of sufficient funding (about 7000 US Dollars) we preferred to use our sparker in this fresh water lake.

The Frequency of the "Sparker" Signal Spectral Maximum

The principle of acoustic signal generation by a "sparker" is that when high voltage electric energy, stored in capacitors, instantly discharge into water, it heats water to a very high temperature, building steam and gas. This cavity of high pressure steam and gas starts to expand very fast, then to contract. So, the pulsing cavity radiates acoustic waves in water. The more energy discharge instantly, the larger the cavity, the higher the amplitude of the radiated waves, and the longer their period, i.e. the lower the frequency.

The frequency of the "Sparker" signal spectral maximum (f_{max} in Hz) depends on the electric energy stored in capacitors and the towing depth. As a result of theoretical and experimental investigations the following formulas were obtained (Zverev, 1997);

$$f_{max} = 1000 / T \quad (1)$$

$$T = (1.15\, U^{0.5} \cdot C^{0.36}) / (1 + 0.1h)^{5/6} \quad (2)$$

where T is the prevailing period of waves (in ms), U is stored electric energy voltage (in kV), C is total capacitance of the energy storage capacitors, divided by the number of discharge electrodes (N) on the transducer (in µF) and h is the towage depth (in m).

For the fixed voltage U = 5.5 kV (our case) it is possible to use a more simple expression;

$$T \approx W^{0.36} / (1+0.1h)^{5/6} \quad (3)$$

where W is the electric energy stored in capacitors, divided by the number of discharge electrodes (N) on the transducer, in Joule.

$$W = (CU^2/2) / N \quad (4)$$

Optimal use of energy of a signal for seismic researches is achieved at towage of a source and the receiver on the depth equal to a quarter of prevailing length of a wave, i.e.

$$h = \lambda/4 \quad (5)$$

where λ is prevailing length of a wave, in m;

$$\lambda = TV \quad (6)$$

Here V is seismic velocity in sea water; approximately 1500 m/s.

The depth of a source below lake surface influences the prevailing period of the generated waves, but this influence is not so strong. Therefore, by defining the prevailing period in formulas (2) or (3), it is possible to use assumed values of depth. For example, for the most high-frequency variants of sparker (W=10-20 J on one electrode) h may be assumed as zero, and for the low-frequency variants (W=2000-5000 J) h is about 5 m.

Problems in Data Collection

The success of a sparker would mainly depend on the physical characteristics of the lake water. If the lake water is not completely fresh, possibly with a salinity more than 2 psu, it is possible to use the multi-electrode transducer, or a similar one possibly modernised somehow.

Multielectrode Case

At first attempt, we have just tried a 1.25 kJ multielectrode sparker array (5.5 kV and 30 mF) that we normaly use in marine realms for an energy source. However, due to physicochemical conditions of the lake, it failed.