:ish J. Marine Sciences 9(3): 195-206 (2003)

›parker in lakes; reflection data from Lake Iznik

Göllerdeki sismik uygulamalarda Sparker enerji kaynağı kullanımı; Iznik Gölü uygulaması

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tract

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

words: 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).

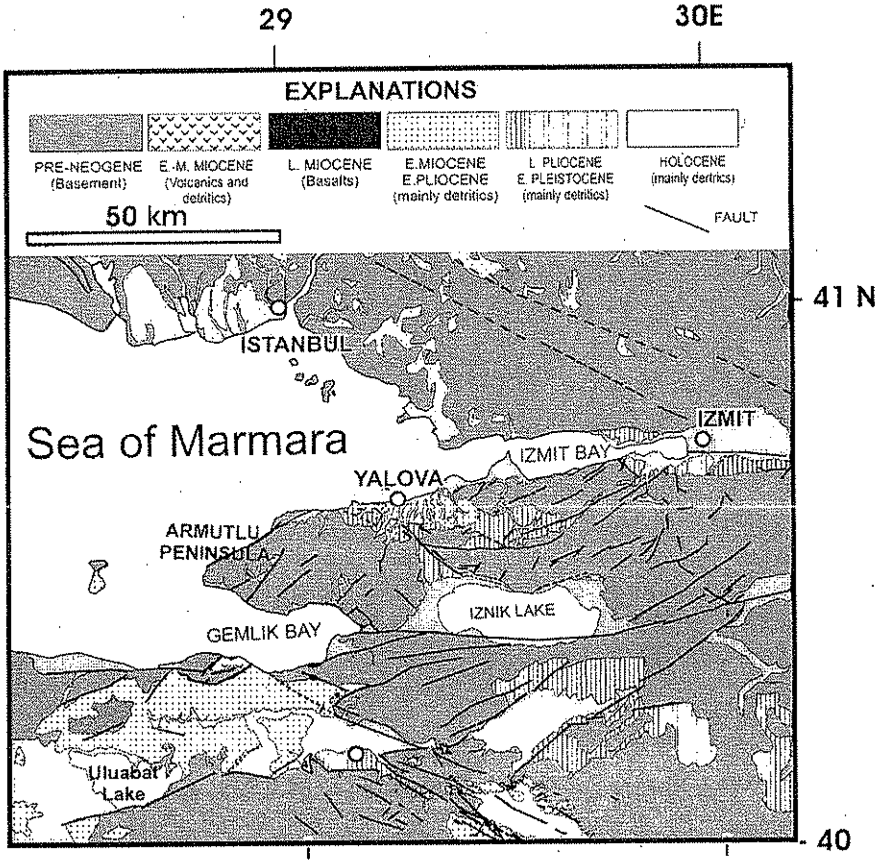

Figure 1. Location of Lake Iznik (modified from Yaltırak, 2002).

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 us
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
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 achie
at towage of a source and the receiver on the depth equal t
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 prevai
period of the generated waves, but this influence is not so str
Therefore, by defining the prevailing period in formulas (2) or
it is possible to use assumed values of depth. For example, for
most high-frequency variants of sparker (W=10-20 J on
electrode) h may be assumed as zero, and for the low-freque
variants (W=2000-5000 J) h is about 5 m.

Problems in Data Collection

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

Multielectrode Case

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

Meanwhile, from the Mohr-Knudsen method (Strickland and Parsons, 1972) applied by titration with a $AgNO_3$ solution using a K_2CrO_4 end point, we have found that the salinty as 0.25 psu (in thousand), which is a quater of ‰. This was same for all depths; from surface to bottom. In addition, we have measured pH of the surface water as 9.05 with a WTW 526 pH-meter equipped with a temperature-compensation (it corresponds to 110 mV on the equipment monitor). Our findings support previous work by Başar et al. (2002) who gave the pH values between 8.85 and 9.26. The authors also reported HCO_3 content was close to its limit values, while B, Cl and SO_4 contents were in normal values. So the water of the lake is basic.

So, to reach our aim, either we had to take extra precautions or some extra apparatuses should be designed; such as special sparker containers and sparker arrays. Therefore, we first decided to design a sparker container.

Sparker Containers

What we needed was to produce a special container filled with saline water and put the transducer inside this container. The diameter of this 2.5 m-long container was 7.5 cm. It was filled with saline water with a salinity of 35 psu. We knew that, following some period of functioning, the water inside the container spoils and stops functioning because it deteriorates and some gases accumulate. This condition requires opening the container to change its water. Even the container had got such certain disadvantages, we were expecting that our multi-electrode sparker would function readily. Unfortunately, it did not. There were no spark at all. In addition, it was rather complicated if not impossible to tow such a container without placing it under a suitable catamaran. In practice, it is known a small boat, catamaran or raft can be used, attaching the container and small streamer (1-2 m long) to the bottom of it in about 0.5m depth. The catamaran or raft was towed in some distance from the research vessel. The same towing equipment may be used with boomer.

The reason of this sparking failure might be the dimensions of the container, especially its diameter. In general, the bigger the container's volume, the longer it functions without changing its water. However, it becomes inevitably heavier. In order to increase the life of container, it can be applied some special scientific principles such as making special valves for removing gases, providing additional saline water supply and so on. But this becomes a complicated technical device problem.

Finally we designed a single-electrode sparker.

Single-electrode sparker

As seen, containers are complicated and heavy, making operation difficult. However, it is possible to manage without such a special container by using another shooting device. It is a special single electrode transducer.

It is also known that single electrode sparkers were operated in boreholes satisfactorily. The behaviour of a sparker inside a borehole is similar to that in a container. However, in lakes it is somewhat different. Unfortunately, the resolution and stability of the produced waveform will be much lower.

Knowing all these deficiencies, we have manufactured a single electrode transducer from the same sparker high-voltage cable. We left the metal pipe intact, inserted on the outer screen of cable (the ground electrode). But what we needed was to extend the ground electrode till the end of cable (1-2 m), using a steel spring, 1-2 m in length and inner diameter, equal the outer diameter of cable (outer insulation and screen removed). So, the cable should be inserted into the spring, the front end of the spring should be fixed on the ground electrode and must have good electric contact with it.

The free end of the cable (outer insulation and screen removed) must be the same length, as the spring, or a bit shorter, and must be cut at right angles. So, electric discharge happens between the central electrode of the cable and the nearest coil of the spring.

The distance between the electrodes is no more than several millimetres, so an electric discharge in fresh water may occur. But each discharge uses up some part of central electrode, so gradually a hole builds in place of central electrode, and discharge stops. In order to avoid this effect, we have done some cuttings on the central electrode insulation, before inserting it into the spring.

Our experiments indicated that the cuttings should be done approximately every one cm in distance. The depth of each cutting should be approximately the half of the thickness of the insulating layer. Because of these cuttings, after several shots, the part of insulation will be thrown out, clearing the central electrode and so on. The preliminary cutting must be done very accurately, if one of the cuttings will be too deep, the discharges will start to happen in this place and the further end of cable will be thrown out.

Data Collection

A small fishery boat, the biggest we could find in the lake, was used. The average boat speed was held at 4 knots. We used the Geont Sparker seismic system (Alpar et al., 1997) with 11-element 10 m-long surface-towed single-channel hydrophone streamer.

The sparkarray and streamer were kept floating about one metre below lake surface. The shots were fired every 2 seconds (~4.1 m), and return echoes were recorded for 250 ms (two-way-travel time, twt). The sampling interval was ¼ ms.

These parameters provided details on sedimentary deposits up to 50 m below the lake bed. Positioning was carried out by using an integrated GPS with an accuracy of ±20 m. The database consists of bottom samples and 30 km-line of high-resolution digital seismic profiles (Figure 2).

Even the signal distortions due to amplification were somewhat high, conventional data processing methods such as trim-statics, filtering and multiple suppression have contributed in better definition of the seismic data (Figure 3).

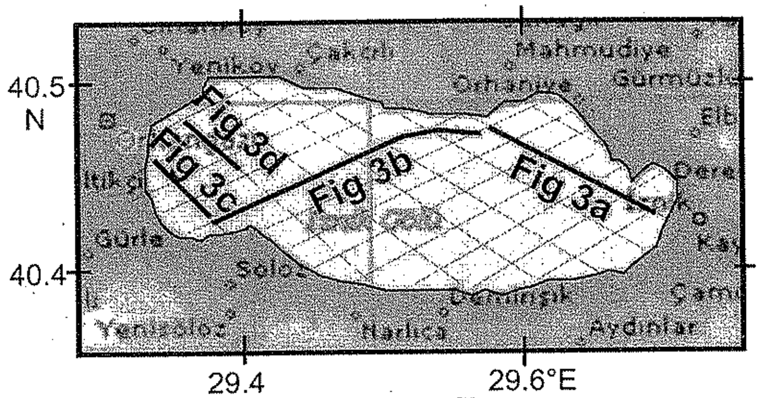

Figure 2. Location of the seismic profiles.

Preliminary Results of Geologic Setting

The seismic data indicate thick deposits probably made up of Quaternary and Pliocene fluvio-lacustrine sediments. Sites closer to sediment sources have more coarse-grained materials than sites in the center of the basin (e.g. NE part of Line-3 in Figure 3b). This overall appearance indicates high sedimentation rates mainly along the rims.

Two main seismic units separated by an enhanced reflector (ER) can be outlined for all sections (Figure 3). ER represents a major unconformity or an eroded surface placed below 30-35 m water depth and extending down to the central part of the lake.

For the shallow areas placed above 30-35 m water depth, the underlying acoustic turbidity (AT) or the lower unit outcrops, if it is not overlain by the topmost recent sediments which may be thinner than our seismic vertical resolution.

The upper unit *(Pleistocene-Holocene)* is at least 30 m thick towards the cenral basin. It is composed of parallel to sub-parallel reflectors, which are gently inclined basinward.

The lower unit or AT *(Pliocene)*, on the other hand, is made up of acoustically reflective strata, mainly dipping basinward. These fluvio-lacustrine sediments form the acoustical basement of the shallow seismic sections.

Discussion and Conclusions

In normal conditions, single electrode constructions must function in fresh water lakes. If it does not start to function in fresh water, it may be needed to make the spark gap shorter. This may be done by using a smaller diameter cable. In addition, it may be tried to make the distance between the carbon electrodes shorter in the high-voltage power unit. But, in any case, the vertical resolution and stability may be not good.

In our case the towage depth was about 1 m below surface. On the other hand, C=30 μF and U=5.5 kV. Therefore from equations (3) and (4) we obtain;

a) For our normal multi-electrode case (N = 15);

$W = (505.5^2 / 2) / 15 = 30$ J

$T \approx 30^{0.36}/(1 + 0.1*1)^{5/6} = 3.2$ ms.

$f_{max} = 317$ Hz.

b) For our single-electrode case (N = 1);

$W = (505.5^2 / 2) / 1 = 454$ J

$T \approx 454^{0.36} / (1 + 0.1*1)^{5/6} = 8.4$ ms.

$f_{max} = 120$ Hz.

Using a single electrode transducer instead of a multi-electrode one means that the energy discharging through it will be many times higher. According to theory, as well as encountered in practice, it leads to longer duration of the pulse (about 2.8-3 times), and lowers the vertical resolution (about 2.5-3 times). So, the expected resolution in fresh water with single electrode sparker will be 12-13 m, considering that the estimated vertical resolution on our marine records as 4-5 m. Depending on the water depth and other exploration purposes, such a resolution may not be sufficient.

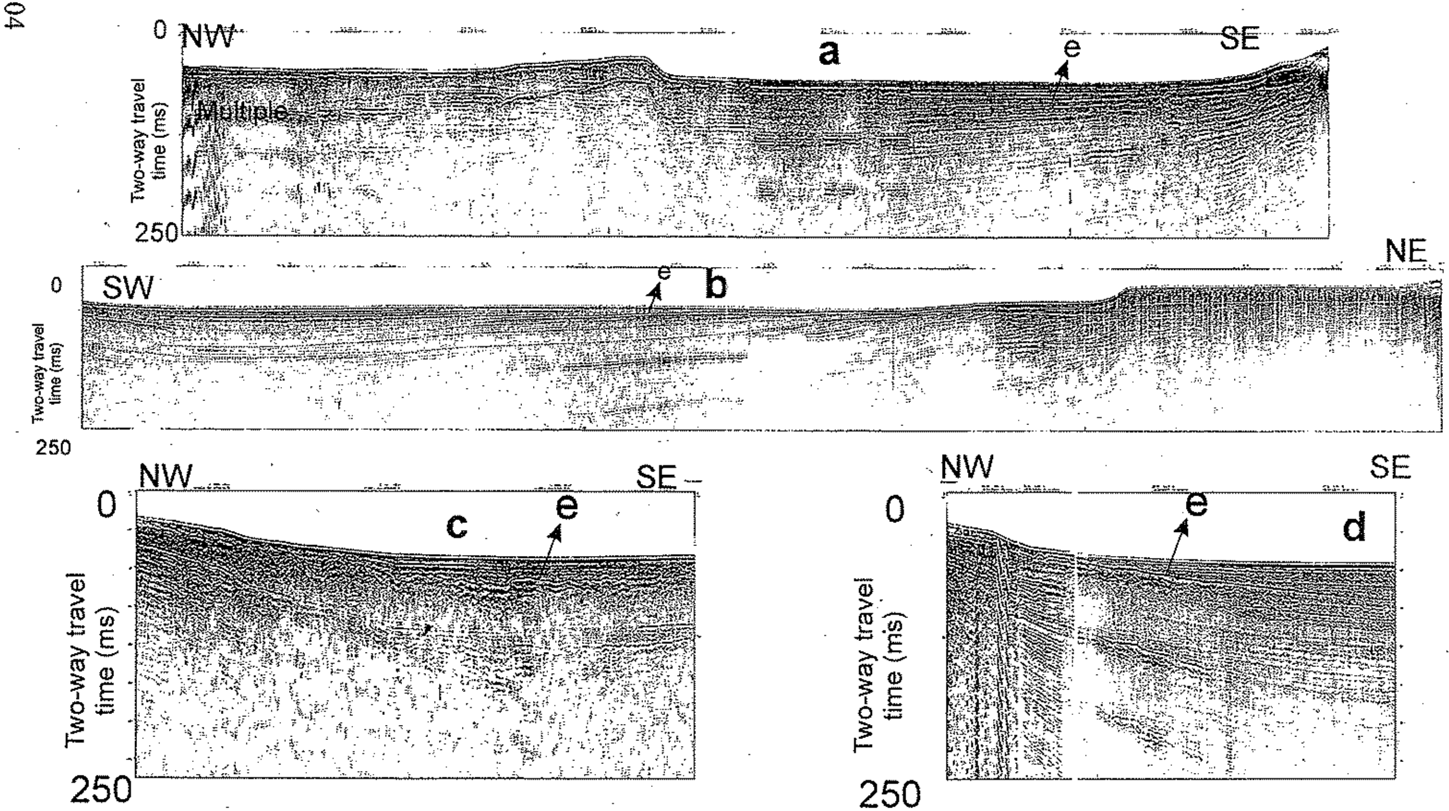

Figure 3. Seismic data. See Fig. 2 for location.

Electric discharge in fresh water has another nature, than in saline water. It is faster, and the current is higher. It may cause a heavy electric interference on the receiving system. For these reasons, it is preferable to use the multi-electrode sparker in a suitable container, and reduce energy as much as possible (e.g. 300 J). This will enable to collect seismic data of much higher resolution and better quality, though technologically it may be more difficult. Designing and developing a reliable construction may take time.

Beyond technical problems and solutions mentioned above, further seismic and other complementary works will provide an opportunity for the reconstruction of paleoclimatic factors in the region. Accurate geochronology must be undertaken through complementary dating methods applicable to paleoseismology.

Özet

Denizlerde sıkça kullanılan bir sismik kaynak olan sparker yeterli derecede iletken olmayan tatlı su ortamlarında doğrudan kullanılamamaktadır. Bu amaçla sparker ya içine tuzlu su doldırılmış bir muhafaza kutusu içinde çalıştırılır veya elektrot aralıkları daraltılarak değişik kaynak tasarımları yapılabilir.

Bu çalışmada İznik Gölünde yapılan böyle bir uygulamada kazanılan deneyimler ve ilk jeolojik bulgular verilmektedir. Tek elektrot kullanılarak yapılan uygulamada düşey çözünürlük 2.5-3 kez azalmasına rağmen, göl yüzeyinden 30-35 m derinde yer alan bir erozyon düzlemi ile ayrılmış birbirleri ile uyumsuz iki sismik birim belirlenebilmiştir.

Acknowledgements

This work has been supported by TÜBİTAK (Project 102Y109 allocated to FA). The authors wish to express sincere thanks to Mr. Sabri Bal for his efforts during data collection.

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Received 24.10.2003

Accepted 11.11.2003