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The Self-Potential survey on marine environment: an example from the Strait of Çanakkale

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Abstract

The self-potential (SP) method based on the measurement of electrical potential changes occurring naturally in fresh and saltwater environments has become used as an auxiliary technique in marine geophysics research over the past few decades. Although the method is straightforward to apply on land, its application in aquatic environments requires a more precise dynamic measurement system for both data acquisition and processing. In this study, we present a self-potential data acquisition system design and demonstrate its applicability through measurements conducted in the laboratory and inshore areas of Kepez, Strait of Çanakkale. A gradient array was designed, with two silver-silver chloride (Ag-AgCl) electrodes towed by a floating platform (buoy) connected via a few meters of cable to a recording unit. The recorder was equipped with a GPS for position fixing, a high-sensitivity analog-to-digital converter, and a data storage unit. The buoy was horizontally framed with a 2-meter separation between the fore and aft tips to prevent sinking while being towed along the stern of the vessel. Chirp profiles were concurrently obtained at the self-potential target positions.

Post-processing and interpretation of the trial data demonstrate that the designed system is well-suited for marine research. The SP data allowed us to distinguish both morphological changes, verified by chirp sonar imagery, and freshwater inflow into the marine environment, corroborated by multi-parameter data collected at the initial points of the profiles. Future studies will focus on freshwater surveys to investigate the impact of these observed variations.

Objective

To demonstrate the adequacy and accuracy of a newly designed self-potential data acquisition system for aquatic environments, based on laboratory and field test results.The data presented were acquired along the inshore area of Kepez in Çanakkale.

Methodology

The design and experimental stages of the acquisition system were carried out in both laboratory and marine environments (Figure 1, Figure 2).

The SP Acquisition System (SAS), functionally equivalent to a gradient array as previously described, was configured using a floating platform (buoy) for marine research applications (Figure 2a,b).

In the demo mission conducted on 06.03.2020, the SP buoy was deployed into the water behind the RV Bilim-1 research vessel, which proceeded at a speed of 3.6 km/h along the inshore area of Kepez in Çanakkale(Figure 3).

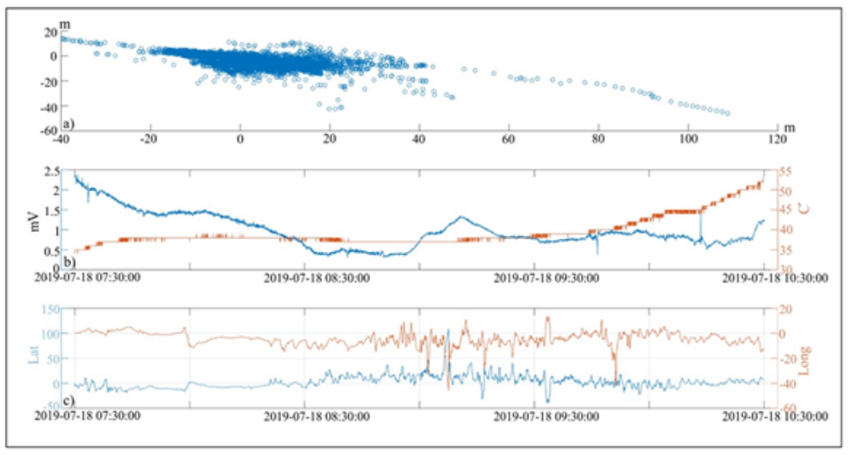


Figure 1- Experimental laboratuary measurements by using salt water (seawater) of the self-potential data acquisition system with a laboratory experiment. a) Drift in meter scale, b) The time-dependent variations of potential difference (mV) and temperature variation inside of the logger were shown in order of blue and red c) Time-dependent drift in meters according to latitude and longitude.

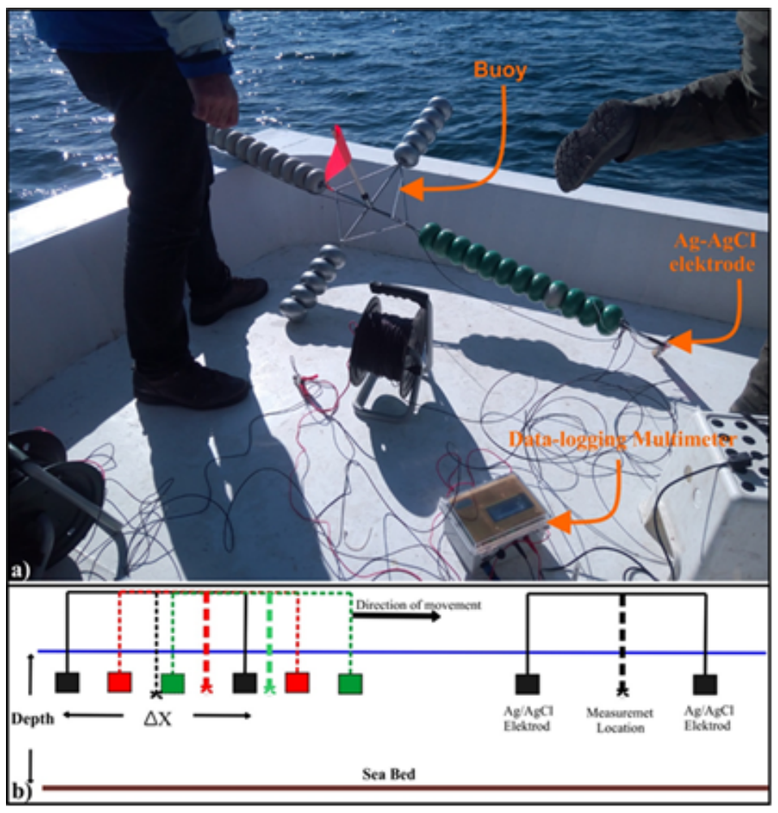


Figure 2- The acquisition system. a) Installed float system and the data-logging multimeter, b)measurement configuration of dipole buoy (modified from Ikard et al., 2018).

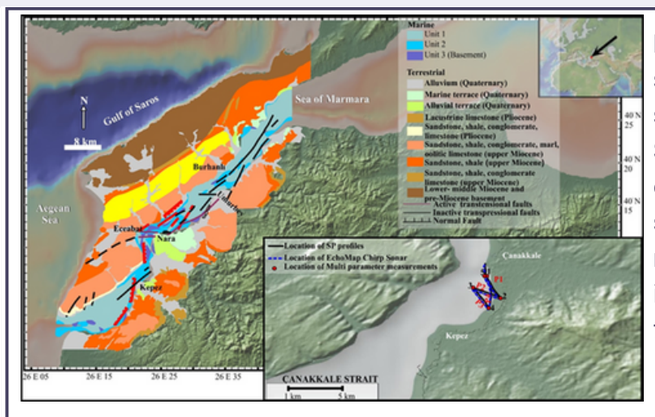


Figure 3- a) Geological map of the Çanakkale Strait and near surroundings (modified from Yaltırak et al., 2000; Gökaşan et al., 2008; Gökaşan et al., 2010). The base maps were prepared using the GeoMapApp software (http://www.geomapapp.org/). Framework in the inset. b) Ship tracts during the cruise. P1 to P4 show the location of both SP and Echomap Chirp Sonar profiles. Red hollow circles are water sampling locations.

During the measurements, an ECHOMAP Plus 72sv CHIRP sonar operating at a low frequency of 50 kHz was used to simultaneously image the seafloor morphology along the SP measurement profile lines (Figure 3). At the beginning of each profile, instantaneous conductivity–temperature–salinity (ICTS) values were measured using a portable multiparameter pH/Cond 340i Set 2 device in order to identify physical changes in the water column and verify their potential impact on SP variations (Table 1)

Results

The collected SP data, along with their corresponding geographical positions, are presented in Figure 4. Preliminary evaluations indicate that the system successfully recorded temporal data, internal temperature of the logger, positional information, and potential differences (Figure 4a, 4c, 4d, Figure 5)

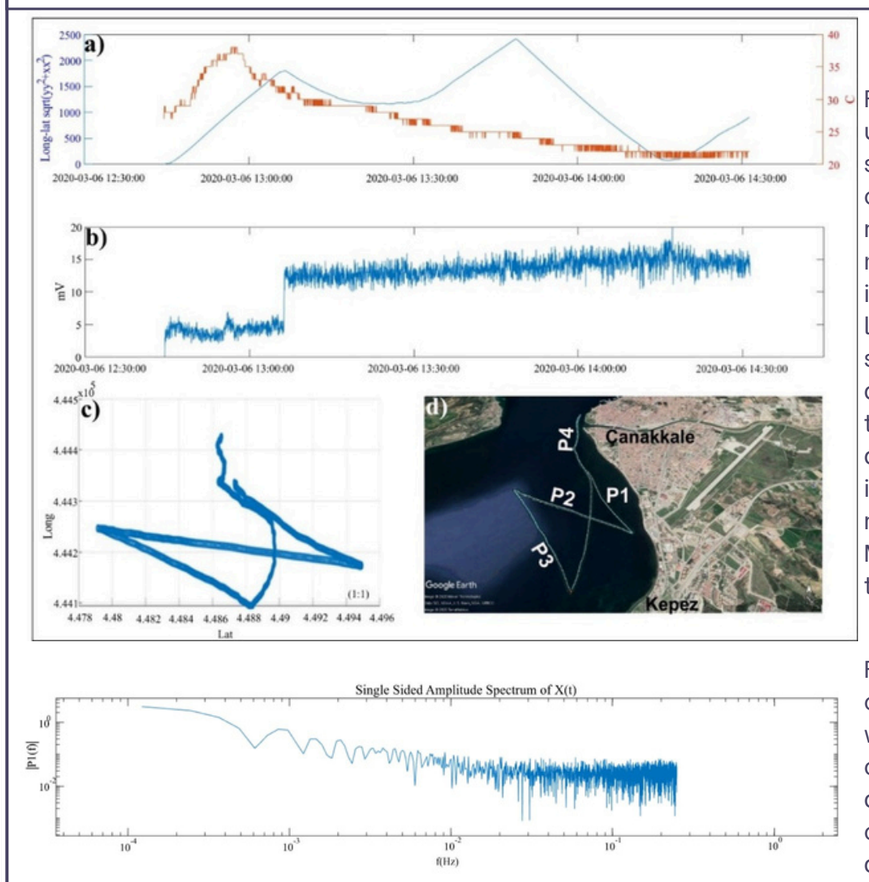


Figure 4 – Demo measurements obtained using the SP acquisition system. a) Graph showing the variation of geographic coordinates and corresponding distances recorded as a function of time at each measurement point. Red lines indicate the internal temperature values recorded by the logger during measurements. b) Graph of self-potential (SP) measurements plotted as a function of time. c) Distribution graph of the distance and geographic coordinates associated with SP measurements collected in the marine environment. d) Ship track recorded during the demo mission. Measurement profiles are labeled as P1 through P4.

Figure 5 – Single-sided amplitude spectrum of the SP measurement data. The spectrum was computed to analyze the frequency content of the self-potential signal. It displays the contribution of each frequency component to the overall signal energy, allowing for identification of dominant frequency ranges and noise characteristics in the marine environment.

Conclusion

Within the framework of this study, the capability of the designed system to successfully acquire self-potential (SP) measurements was tested, along with an assessment of its ability to detect potential anomalies. The collected SP data demonstrated the system's effectiveness in identifying both morphological variations–verified through CHIRP sonar imaging–and freshwater inflows into the marine environment, supported by multi-parameter measurements taken at the initial points of the profiles. The study area is situated in a region where the freshwater discharge from Kocadere (north) interacts with the northeastward-directed horizontal current regime.

Table 1- Multi-parameter values measured at the initial points of the profiles at the date of 06.03.2020.

Measurement	Time	Conductivity (mS/cm)	Temperature°C	Salinity(mS/cm)
1. Point	15:44	48,5	12,6	30,6
2. Point	16:07	48,3	12,4	30,9
3. Point	16:28	48	11,2	30,5
4. Point	16:52	48,8	11,3	31
5. Point	17:17	48,2	10,7	30,6

Related Literature

Ikard, S. J., States, U., Survey, G., ve Springs, H. (2018). New Insights on Scale-dependent Surface and Groundwater Exchange from a Floating Self-potential Dipole New Insights on Scale-dependent Surface-Groundwater Exchange from a Floating Self- potential Dipole, (June). https://doi.org/10.2113/JEEG23.2.261.

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