P2.4-068

# Vectorial Digitization and Re-Analysis of Turkey's Legacy Seismic Records: Four Major Historical Earthquakes

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## INTRODUCTION AND MAIN RESULTS

This presentation focuses on four important historical earthquakes occurred in Marmara Sea, examines them by digitizing analog seismograms using the vectorization method and shows seismic parameters re-determined by analyzing original waveforms through the modern techniques. The results clarify the region's seismotectonics by identifying likely locations and magnitudes of future large earthquakes.

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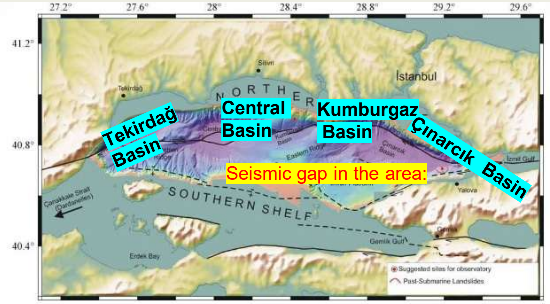
## Introduction

The Kandilli Observatory and Earthquake Research Institute (KOERI), established in the 1800s, began recording earthquakes in the 1880s and today operates 160 seismic stations across Türkiye.

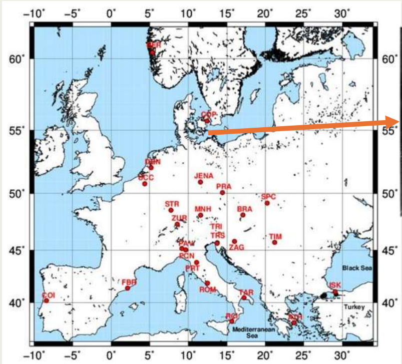
The Marmara Region is shaped by the westward motion of the Anatolian Plate along the North Anatolian Fault Zone, where the Main Marmara Fault remains a major seismic hazard with a seismic gap since 1766. KOERI's historical catalog includes ~600 earthquakes from 2000 BC to 1900 AD, showing the region's long record of destructive events. Studying historical earthquakes through seismograms is crucial for assessing future events in İstanbul and its surroundings, a megacity of nearly 20 million people. We re-evaluated the 1912 Şarköy–Mürefte, 1935 Erdek–Marmara Islands, and 1963 Çınarcık earthquakes by digitizing original seismograms and applying modern seismological methods on them, contributing to a better understanding of Marmara seismotectonics and future hazard.

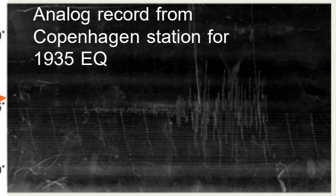



## Data/Method

### Data:

Collected analog seismogram data is mostly from the European Observatories and EUROSEISMOS Project 1912 Şarköy–Mürefte, 1935 Erdek–Marmara Islands, and 1963 Çınarcık earthquakes.



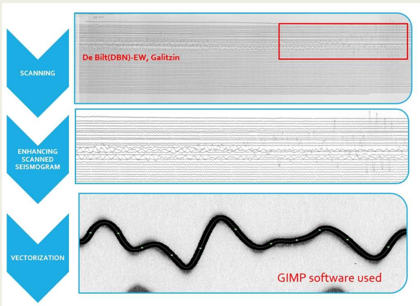


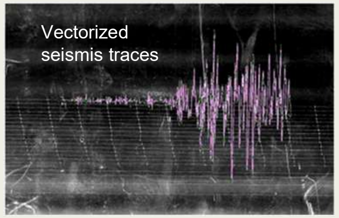
Analog record from Copenhagen station for 1935 EQ

### Old seismograms:

- Valuable records for seismology
- Hard to collect from old archives
- Poor quality (low dynamic range, response issues)
- Missing info for processing

### Vectorization Process:

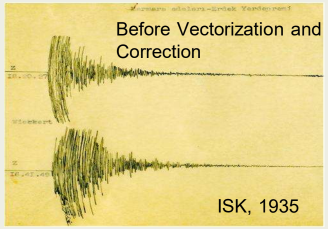


Vectorized seismis traces

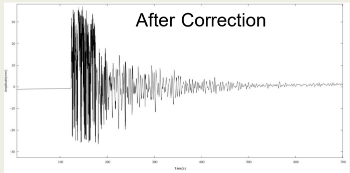
## Analysis After Vectorization

One of the main problem is the curvatures on seismic traces, which is a result of mechanism of the traditional instrument.



Before Vectorization and Correction

ISK, 1935

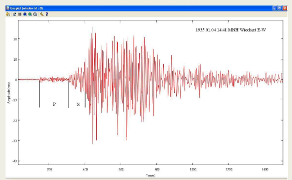


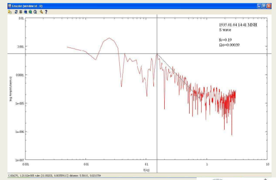
After Correction

- **Arm length** in mechanical seismographs
- **Curvature correction** varies by seismogram
- **Measured** using circles on max amplitude

## Spectral Analysis

After trace vectorization and corrections(skew, curvature), P-S interval was selected for spectral anaysis to find low-frequency level (Ω0) and corner frequency (fc).





KANDİLLİ RASATHANESİ VE DEPREM ARAŞTIRMA ENSTİTÜSÜ 1868

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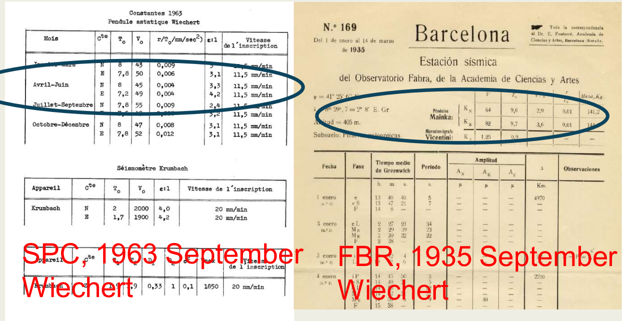
## Collected Bulletins

The instrument constants have been collected from various sources to carry out spectral analysis to deal with instrument response.




Bulletin of National Research Council ,INGV Website. European Observatories have been consulted.

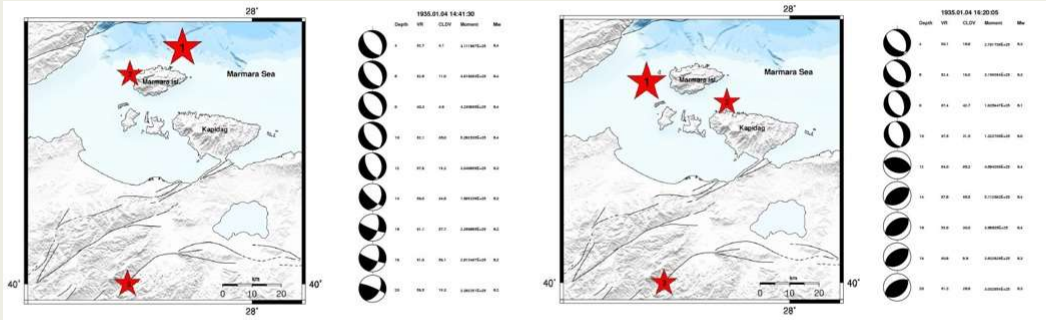
## Epicenter Calculation and Moment Tensor Inversion

For epicenter, Hypocentre 3.2. software (Lienert, 1994) by using velocity model of KOERI. Zsac software was used to run TDMT-INV algorithm produced by Dreger (2002).

## Seismic parameter Calculation

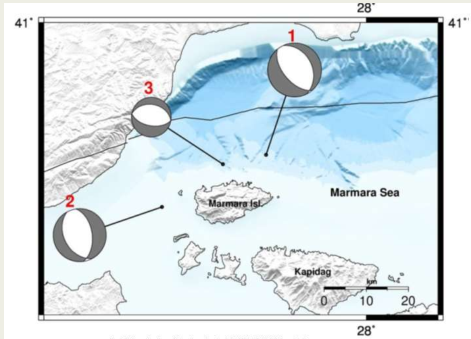
Seismic Moment(Mo), Moment magnitude(Mw), Radius of the circular Source Zone and Stress Drop have been estimated for the historical events.

## Results for 1935, 14:41 and 16:20 Earthquake: Epicenter and Fault Types



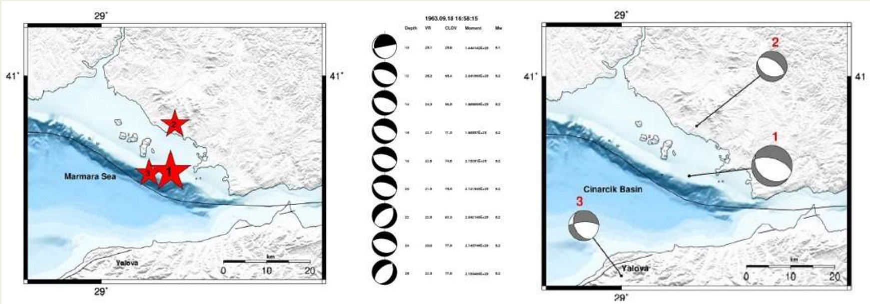

**14.41 Earthquake: 1: this study**, *2:* by Ambraseys (1988) and 3: by ISS Bulletin

**16:20: Earthquake: 1 this study**, 2 by Ambraseys and Jackson (2000), 3 by ISS Bulletin




1: **This study:** 1st shock at 14:41(GMT) Ms=6.4
2: **This study:** 2nd shock at 16:20(GMT) Ms=6.3
3: Nalbant et al.,(1998)

## Results for 1963, Earthquake : Epicenter and Fault Types




**1: This study**, **2:** by Ambraseys and Jackson (2000), **3:** ISS Bulletin

**1: This study**; **2:** Taymaz et al. (1991), **3:** Jackson and McKenzie (1984)

## Results for Seismic Parameters

| Result | 1912 | 1935 14:41 | 1935 16:20 | 1963 |
|---|---|---|---|---|
| Mo [Nm] | 8.3E+19 | 1,77E+18 | 1.46E+18 | 1.579E+18 |
| Mw | 7.13 | 6,06 | 5.99 | 5.95 |
| R [km] | 41.6 | 15,17 | 15.19 | 13.32 |
| Δσ [bar] | 26.09 | 9,47 | 10.12 | 17.28 |

## Conclusions

The 1912 earthquake had Mw 7.13, R = 41.6 km, Mo = 8.26×10[19] Nm, and a 26-bar stress drop. The 1935 events (Mw 6.4 & 6.0) had ~15 km fault radii, Mo = 1.77×10[18] Nm and 1.46×10[18] Nm, with moment tensor inversion revealing normal faulting at 4 km and 10 km depths—determined for the first time in this study (Ambraseys, 1988; Ambraseys & Jackson, 2000). The 1963 quake (Mw 6.2) had a 13 km fault radius, normal faulting at 12 km depth, and was ~10 km off from Taymaz et al. (1991). Despite challenges, analyzing historical seismograms remains vital for interpreting seismic sources, hazards, and nuclear test impacts.