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ASASE2021

International Workshop on Active Tectonics and Seismicity of the Aegean Region with special emphasis on the 30 October 2020 Samos Earthquake

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Book of Abstracts

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PREFACE

Located on the Alpin-Himalayan mountain belt, the Aegean region is one of the most seismically active regions in the world, which had suffered many destructive earthquakes in the historical and instrumental period, bounded by the North Anatolian Fault from the north and the Hellenic subduction zone from the south. The last devastating earthquake that occurred in this region was recorded as the Samos earthquake of 30 October 2020.

This earthquake caused two causalities in the island of Samos and 117 in Bayraklı district of Izmir, more than a thousand injured, and damage to more than five thousand buildings. In addition, after the earthquake, a tsunami occurred both on the southern shores of Izmir and on the northern coasts of Samos island and therefore significant property damage occurred. In this workshop, in the light of the latest scientific studies conducted in the region, it was aimed to discuss the studies carried out on identifying the earthquake hazard seismic sources of the countries with a coast to the Aegean Sea, and determining the risks that these seismic hazard sources may pose. Within the framework of this aim, scientists working in the region were invited and as a result, an online workshop on Active Tectonics and Seismicity of the Aegean Region with special emphasis on the Samos Earthquake struck on 30 October 2020 was organized with 30 oral and 5 poster presentations. The workshop will cover a wide range of topics related to earthquake studies, such as active tectonics, geodynamics, seismic, tsunami, Global Positioning System (GPS) and Interferometric Synthetic Aperture Radar (InSAR) applications. After the workshop, a special issue of the Turkish Journal of Earth Sciences (Turkish J Earth Sci) will be published. We would like to thank all the speakers, public institutions and organizations that contributed to the workshop.

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ORAL PRESENTATIONS

TÜBİTAK

Turkish Journal of Earth Sciences
http://journals.tubitak.gov.tr/earth

Turkish J Earth Sci
(2021) 30: MA-1

Meeting Abstract

Active Tectonics of the broader Aegean region. An overview and new challenges

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Abstract

An overview of the active fault pattern of the Aegean region will be discussed in brief, while emphasis will be given on the active fault geometry of Northern Greece mainland and especially the North Aegean Trough (NAT). Complex tectonic processes produce intense lithospheric fracturing and the formation of many active faults. The main active faults of mainland Greece which are characterized as possible seismogenic sources have been documented in detail in the Greek Database of Seismogenic Sources (GreDaSS) and other Active Fault Maps. Their pre-instrumental activity and Palaeoseismology including Archeoseismology will be discussed, too.

The causative faults of Lesbos 12 June 2017 Mw=6.3, Kos-Bodrum 20 July 2017 Mw=6.6, and Samos 30 October 2020 Mw=7.0 strong earthquakes will be also presented. Based on the physical properties of the main shocks and the corresponding focal mechanisms, a stress change analysis has been performed using the best fit fault model. Several neighbouring active faults have been considered and the stress changes have been examined for all of them. Furthermore, a comparison between modelled surface displacements and the recorded ones (i.e., from GPS stations) has shown an adequately good correlation.

Lastly, the greatest achievements in Earthquake Geology Science during the past century will be presented and an overview of the remainder and future challenges will be discussed.

Key words: Aegean tectonics, North Aegean Trough, Active faults, fault modelling

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TÜBİTAK

Turkish Journal of Earth Sciences
http://journals.tubitak.gov.tr/earth

Turkish J Earth Sci
(2021) 30: MA-2

Meeting Abstract

Slab dynamics and seismicity distribution in the Hellenic Arc

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Abstract

It is well established that slab dynamics at depth affect the distribution of seismicity along the main plate interface as well as in the overriding and down-going plates. We refined the geometry of the Nubian slab down to 160–180 km, using well located hypocentres from global and local seismicity catalogs, to investigate the relations between subduction processes (i.e., rollback, tearing, segmentation) and the distribution of seismicity in the Hellenic Subduction System (HSS). The western termination of the HSS is defined by an abrupt termination of intermediate depth seismicity beneath northern Greece, where oceanic lithosphere transition to continental lithosphere subduction towards north. The Kefalonia Transform Fault marks the northernmost extent of the seismically active oceanic slab and as such is confirmed to represent an active Subduction-Transform-Edge-Propagator (STEP) fault. A vertical tear, at shallow depths, is likely to exist between the two slab segments. Beneath Peloponnese, the maximum depth of the Wadati-Benioff Zone seismicity is controlled by the amount of subducted oceanic lithosphere. The eastern termination of the HSS is defined by a tear in the slab beneath SW Turkey. Hypocentral locations suggest a V-shaped geometry of the tear at least down to 160-180 km. The distribution of seismicity from local networks indicates the presence of a NW-dipping subducting slab beneath Rhodes-Nisyros which is not compatible with the existence of a NE-SW striking STEP fault in the Pliny-Strabo trenches region. Furthermore, a vertical offset in the intermediate depth seismicity suggests the segmentation of the slab between Crete and Karpathos, with a less steep and laterally wider slab segment to the west and a steeper and narrower slab segment to the east. Slab segmentation affects the upper-plate deformation, that is more intense above the eastern slab segment, and interplate seismicity, that is stronger above the western slab segment.

Key words: Hellenic arc, seismicity, segmentation, slab dynamics, Aegean region

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TÜBİTAK

Turkish Journal of Earth Sciences
http://journals.tubitak.gov.tr/earth

Turkish J Earth Sci
(2021) 30: MA-3

Meeting Abstract

Offshore geomorphology and seismic profiling data indicate active extension, transtension and strike-slip tectonics in the Aegean Region

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Abstract

Detailed review and integrated re-interpretation of geomorphological, geological, geophysical, seismological and geodetic data show a major change in the style of deformation of the overriding Aegean microplate since Early Pliocene. Widespread, arc-perpendicular, back-arc extension in Miocene has been replaced by extensive shearing and transtensional deformation in Plio-Quaternary. The Aegean crust "flows" toward SSW, confined between the northern (North Anatolian and Kephallinia Faults) and the southern boundaries (East Hellenic Trench), and undergoes extension predominantly accommodated by strike-slip tectonics. Dextral shearing along major NE-SW strike-slip zones associated with conjugate NW-SE sinistral and WNW-ESE normal faults dominates over most of the Aegean Region since Late Pliocene – Early Pleistocene and imposes a complex pattern of localized transtension, oblique rifting and formation of new basins along with local transpression and uplift. Sinistral NE-SW to ENE-WSW shearing prevails in the southeastern Aegean, parallel to the left-lateral shear zones of the Pliny and Strabo Trenches. This deformation pattern may be the result of the interaction of the North Anatolian Fault with the ongoing Hellenic subduction and slab roll-back.

Key words: Active tectonics, Aegean region, extension, transtension, strike-slip tectonics

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TÜBİTAK

Turkish Journal of Earth Sciences
http://journals.tubitak.gov.tr/earth

Turkish J Earth Sci
(2021) 30: MA-4

Meeting Abstract

3D Rheological modelling in the Aegean Region and its implications for the seismotectonics of the area

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Abstract

This research dealt with the thermo-rheological modelling of the broader Aegean Region, for the purpose of seismotectonic and seismic hazard characterization. For the modelling two dominant deformation mechanisms have been considered, namely the frictional sliding and the power-law creep representing, respectively, the brittle and the ductile behaviours. Literature data have been collected in order to define the proper range of values for most of the input parameters in the rheological constitutive equations. Then, a detailed sensitivity analysis on the variability of the input parameters and their influence on the main thermo-rheological modelled properties has been carried out. The results of the sensitivity tests indicate that thermal-related parameters are the most influential ones for the BDT depth and strength. Dedicated and specific scripts have been developed in a Matlab environment for the purposes of the thermo-rheological modelling. In a first stage, 1D strength envelopes have been realized for specific test sites in the Aegean Region and have also been compared with the depth distribution of relocated seismicity, in order to test the precision and reliability of the correspondence between the BDT depth and cutoff depth of seismicity. In a second phase, 2D rheological pseudo-sections have been reconstructed along several selected transects, belonging to different geodynamic settings. Particular care has been devoted to the comparison between continental and oceanic subduction settings. The results highlighted the occurrence of a deeper brittle layer below the shallowest BDT in the continental collision sectors, differently from the oceanic subduction setting.

The third and last stage of the modelling consisted in the reconstruction of a complete 3D thermo-rheological model for the whole study area. Taking as a reference the subduction zone, it can be observed that the BDT is much shallower (between 10 and 20 km, always in the upper plate) in the internal sectors with respect to the external areas, where the transition lies at ~40 km in the oceanic lithosphere of the lower plate, and at ~35 km in the continental sectors. Secondly, the strength and temperature at the BDT are generally well correlated with the BDT depth, meaning that strength values < 100 MPa characterize the internal sectors, while values up to 1 GPa are associated to the BDTs in the oceanic lithosphere. In terms of interpretation and explanation of the thermo-rheological results, all the models realized suggest that the main control on the BDT depth is exerted by the surface heat flow and the corresponding geothermal gradient.

The results of the modelling have been successively applied mainly into the fields of seismotectonics and geodynamics for: i) estimating the maximum possible magnitudes of the major seismogenic sources in the Aegean Region; ii) calculate the seismic strain rates for selected volumes and iii) estimate the values of the total integrated strength for the tectonic plates in the study area. To conclude, this research aimed at demonstrating how the rheological properties can effectively be linked to the seismogenic processes, thus representing a valid tool for improving the seismotectonic characterization and, finally, the seismic hazard assessment.

Key words: Thermo-rheology, 3D modelling, seismotectonics, seismic hazard, Aegean region

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TÜBİTAK

Turkish Journal of Earth Sciences
http://journals.tubitak.gov.tr/earth

Turkish J Earth Sci
(2021) 30: MA-5

Meeting Abstract

Earthquake Geology for SHA in the Aegean Region: single-event effects versus cumulative effects

Riccardo Caputo*
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Abstract

The earthquake is a natural phenomenon and it can be scientifically approached in several different ways because different are the sources of information, which are commonly grouped in four principal types/categories: i) instrumental records, ii) witnesses, iii) artifacts and iv) natural features. Accordingly, the more appropriate discipline for each category is Seismology, Historical Seismology, Archaeoseismology and Earthquake Geology. Even if in regions like the Aegean where historical and archaeological information is relatively abundant, in the last few decades, Earthquake Geology has rapidly grown and it is expected to become worldwide a pivotal discipline for Seismic Hazard Assessment (SHA) purposes. Indeed, the repeated 'surprises' in location and/or magnitude of recent earthquakes made the scientific community aware that SHA analyses cannot be solely based on instrumental and historical records: too short. Among the several motivations for searching alternative and complementary investigation approaches, most important is probably the fact that a recently reactivated fault (i.e. a fault that has generated an event in the last decades or few centuries) is unlikely to be reactivated again in the near future, say the next 50 years as commonly assumed in hazard maps. This is certainly the case for most of the Aegean region and other Mediterranean areas where slip-rates are relatively low and recurrence intervals relatively long. In contrast, tectonic structures which can be geologically recognised as active (especially those without instrumental or historical events) might be mature enough to rupture in the next future. For the finalities of any modern SHA estimate, the degree of maturity of an active fault in the frame of its seismic cycle would be indeed the most crucial aspect.

The importance of using geological information for better defining the principal seismotectonic parameters of a seismogenic source will be emphasized. In order to examine this issue, the information that can be obtained from the analysis of single-event effects or conversely from cumulative effects is analysed separately, and then compared. The quality and accuracy of the produced results from both sources of information are then discussed for defining the reliability of the outcomes and especially for calibrating the methodological approaches based on geological data, which have an intrinsically different degree of uncertainty and resolution, but also a greater potential exploitability.

Key words: Earthquake geology, seismic hazard, active fault, cumulative effects, Aegean region

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TÜBİTAK

Turkish Journal of Earth Sciences
http://journals.tubitak.gov.tr/earth

Turkish J Earth Sci
(2021) 30: MA-6

Meeting Abstract

Active tectonics and paleoseismology of seismic sources located on land in the vicinity of the city of İzmir, western Anatolia, Turkey

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Abstract

In the city of İzmir and its surroundings NE-SW trending strike-slip faults of the İzmir Balıkesir Transfer Zone (İBTZ) act with approximately E-W trending dip-slip normal faults. These active faults range in length from 12 to 70 km and are capable of producing earthquakes up to M_W 7 as indicated on active fault maps of Turkey. The Samos earthquake which occurred with the rupture of the submarine Samos Fault on October 30, 2020, caused severe damage to many buildings and the death of 117 people in the Bayraklı district of Izmir, 70 km away from the epicenter. The occurrence of this recent event suggests that the seismic sources of some destructive earthquakes that occurred in Izmir in the historical period may have originated from similar submarine faults located on the seafloor of the Aegean Sea. However, in earthquake catalogs, an important feature of the earthquakes that occurred in the historical period is shown by the active faults passing through the settlements of Izmir. In this context, active tectonic and trench-based paleoseismological studies were carried out on five faults (İzmir Fault, Tuzla Fault, Gülbahçe Fault, Seferihisar Fault and Yağcılar Fault) passing through Izmir city center and its immediate surroundings in order to reveal which faults caused historical earthquakes. We opened a total of fourteen trenches on these faults to decipher earthquake recurrence interval and the elapsed time since the recent earthquake for each fault segment.

Our findings show that the historic earthquakes that occurred in 47 AD, 177/178 AD, 688 AD, 1039/1040 AD, 1056 AD, 1389 AD, and 1688 AD in İzmir Province were generated by the aforementioned faults. Accordingly, our data indicate that the faults under the Aegean Sea were not a source of most of the historical earthquakes in Izmir province.

These results show that the investigated faults produce earthquakes in such a way that they trigger one another, and that on average there is a devastating earthquake in the region every 300 years. Considering that the last destructive earthquake in the region occurred in 1688, it is highly likely that a devastating earthquake will occur in the province of Izmir in the near future. This research is supported by TUBITAK (The Scientific and Technological Research Council of Turkey), project number of 117Y190.

Key word: Paleoseismology, İzmir Fault, Seferihisar Fault, Gülbahçe Fault, Yağcılar Fault, Tuzla Fault

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TÜBİTAK

Turkish Journal of Earth Sciences
http://journals.tubitak.gov.tr/earth

Turkish J Earth Sci
(2021) 30: MA-7

Meeting Abstract

Multi-hazard approach in managing earthquake emergencies amid evolving biological hazards: lessons from the 2020 Samos (Eastern Aegean) earthquake amid the COVID-19 pandemic

Spyridon Mavroulis[1,*], Asimina Kourou[2], Maria Mavrouli[3], Thekla Thoma[2], Maria Manousaki[2], Nikolaos Karveleas[2], Efthymios Lekkas[1,2]

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Abstract

In late October 2020, Greece was struggling with the second wave of the COVID-19 pandemic with the highest numbers of daily-confirmed cases and fatalities since its onset in late February of the same year. On 30 October, an Mw=7.0 earthquake struck the eastern part of Greece with its epicenter located offshore northern Samos Island and it was followed by a powerful tsunami. This seismic event was the most lethal worldwide in 2020 resulting in 117 fatalities in Turkey and 2 in Greece attributed to building collapse and the largest 2020 earthquake in Europe and Turkey. In Greece, the earthquake and its impact resulted in the largest mobilization of Civil Protection authorities in order to deal with the earthquake emergency. This emergency situation was unique, as almost all preplanned emergency response actions were incompatible with the COVID-19 pandemic mitigation measures. These contradicting issues are highlighted along with the adapted actions to the unprecedented conditions. Based on the study of the pandemic evolution on the earthquake affected North Aegean Region, it is concluded that the daily COVID-19 cases were not increased during the selected post-disaster period. We attributed this stability to several factors including the adapted emergency actions, which are considered as good practice and important lessons learned from the 2020 Samos earthquake emergency response. Based on the aforementioned, we also propose emergency response actions through a prism of a multi-hazard approach in disaster risk reduction and disaster management for future compound emergencies in areas with similar geoenvironmental and epidemiological characteristics.

Key words: Samos earthquake, tsunami, COVID-19, multi-hazard, biological hazard

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Turkish Journal of Earth Sciences
http://journals.tubitak.gov.tr/earth

Turkish J Earth Sci
(2021) 30: MA-8

Meeting Abstract

Analysis of Strong Motion Data recorded in Greece during the Samos Island Earthquake Mw7.0

Dimitris Sotiriadis[1,*], Zafeiria Roumelioti[2], Ioannis Kalogeras[3], Kiriaki Konstantinidou[4], Nikos Melis[3], Nikos Theodulidis[4], Panagiotis Pelekis[2], Basil Margaris[4]
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Abstract

The October 30th, 2020 Samos mainshock was recorded by numerous recording stations located at epicentral distances up to 600 km in Greece. The broader area around the epicenter is characterized by the continental part of Asia Minor to the east and the Aegean Sea to the west. Both, raw and processed versions of these records can be found in Cetin et al. (2020). In the present work, the strong motion data recorded by 11 stations within the Greek territory are presented and analyzed in terms of time-histories, Fourier amplitude and response spectra. Among the 11 stations, two are located on the Samos Island (near -field); one is operated by the Institute of Engineering Seismology & Earthquake Engineering (ITSAK) and the other one by the Institute of Geodynamics (NOA-IG). These two stations are installed in the Vathi town of Samos in different geological conditions. Their 30 meter-averaged shear wave velocities (VS30) were measured after the earthquake using the MASW geophysical method from Patras University. Uniform data processing was implemented to the raw accelerograms and some of the important period-independent ground-motion intensity measures (PGA, PGV and PGD) as well as the strong-motion durations were computed and were listed along with 5%-damped spectral acceleration comparisons of the Greek and Eurocode 8 design codes. The provided information also includes the VS30 site parameter for the strong-motion stations as well as the frequently used source-to-site distance metrics in Ground Motion Prediction Models (GMPMs). The Fourier acceleration spectra of the recorded accelerograms and macroseismic intensity distributions of the region struck by the earthquake compliment the conveyed information. Moreover, the set of available ground motions is utilized for the evaluation GMPMs which are widely applicable to this specific region. These local GMPMs from Greece, among which is the latest GMPM published for the region (Boore et al., 2021), as well as, some global models, are evaluated for PGA and 5%-damped PSA at T = 0.2s and 1.0s to observe their behavior in the intermediate-to-long distance range.

The analyses which were conducted lead to the observation that the spectral values computed from the ground motions of this earthquake are mostly lower than those provided by the design codes, as well as regional effects control the ground-motion attenuation towards long source-to-site distances. When the slower attenuation option of global models is implemented, the large-distance scaling of this model is less consistent with the recorded data when compared to the Average-Q (global) and Low-Q options.

Key words: Samos earthquake, seismicity, MASW, Strong motion data, Greece

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TÜBİTAK

Turkish Journal of Earth Sciences
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Turkish J Earth Sci
(2021) 30: MA-9

Meeting Abstract

Rapid Damage Assessments in and around the City of Izmir by using NASA-ARIA Damage Proxy Maps: Case Study for the 30 October 2020 Mw6.9 Samos Earthquake

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Abstract

On October 30, 2020, at 14:51 local time, an Mw6.9 earthquake occurred in the Aegean Sea, between Samos Island-Greece, and Izmir-Turkey. This earthquake caused significant losses of lives and properties in the City of İzmir, which is, economically and population-wise, the third biggest city in Turkey. After the Samos earthquake, The Advanced Rapid Imaging and Analysis (ARIA) team at NASA's Jet Propulsion Laboratory-California Institute of Technology released the Damage Proxy Map (DPM) showing likely damaged areas by the earthquake. The DPM image was derived from Synthetic Aperture Radar (SAR) images on October 30, 2020, by the Copernicus Sentinel-1 satellites operated by the European Space Agency (ESA). The pre-event images covering an area of 337 by 175 kilometers were taken before (October 18, 2020, and October 24, 2020) the earthquake. This damage proxy map was generated to use as guidance to identify damaged areas, such as in living environments and, with less reliable detection, over vegetated areas.

We obtained two versions (v0.3 and v0.7) of the DPM images analyzed by the NASA-JPL/Caltech ARIA team. We first clipped the images in the GIS environment for the damage assessment teams working in the area. We then validated the predicted damage areas (red spots) seen on the DPMs in the Bayraklı, Sığacık-Seferihisar districts of İzmir and Samos Island, Greece. We also gathered some relevant information that might be useful to provide along with the DPM images are ShakeMaps from NOA and ground maps (liquefaction and landslide prediction) from USGS. We provide these maps in a GIS environment to compare to other relevant data such as maximum peak ground accelerations (PGAs) and their ratio, ShakeMap intensities. We observed that DPMs show a good correlation with USGS ground failure prediction maps, specifically near the epicenter area (north of Samos Island and Seferihisar-Sığacık coastal areas in the south of Izmir). Also, DPMs showed some good correlations with the USGS liquefaction predictions in the Izmir bay area, but we had only one observation reported in this area. We found that DPMs are very reliable to detect the damage levels of high and collapsed buildings in densely populated areas, such as the Bayraklı district of Izmir, and to detect ground failure (liquefaction and landslide/rockfall) near the epicenter area. Finally, we expect the NASA-ARIA products along with the real and near-real-time earthquake information released by the local agencies (AFAD, NOA, and KOERI) and by the international agencies (EMSC and USGS) will be efficiently used in better-coordinated earthquake emergency response efforts at local and regional levels.

Key words: Earthquake effect, SAR, Damage assessment, Damage Proxy Map, Ground failure, Izmir, Samos

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TÜBİTAK

Turkish Journal of Earth Sciences
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Turkish J Earth Sci
(2021) 30: MA-10

Meeting Abstract

Seismicity Variations Preceding the Samos, 30 October 2020 (M_w=7.0) Earthquake at Eastern Aegean

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Abstract

We examine the seismicity variations that preceded the strong earthquake which occurred close to Samos Island (Eastern Aegean Sea) on 30 October 2020 (M_w=7.0). For this reason, we used a recently compiled, homogeneous (in respect to magnitude), earthquake catalog which gives information on all events that occurred up to 30 April 2019 in the broader Aegean area and Western Turkey. We applied the Decelerating-Accelerating Seismic Strain model (D-AS model), without any *a-priori* constraints ("blind-test"), over a broad region (± 4°) around the Samos mainshock epicenter, seeking to identify spatio-temporal Benioff strain release variations in its vicinity prior to the occurrence of the mainshock. The results show that a marked decrease in Benioff strain release took place in the epicentral area of the 2020 mainshock several years before its occurrence.

Key words: Samos earthquake, D-AS model, Benioff, Eastern Aegean

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Turkish J Earth Sci
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Meeting Abstract

Possible precursory anomalies in groundwater level and geothermal resources associated with before and after the October 30, 2020, Samos Earthquake

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Abstract

October 30, 2020, the Samos earthquake (Mw 6.6) affects the Aegean Sea and its surroundings, causing destruction and loss of life in the city center of İzmir, which is approximately 70 kilometers away from the earthquake epicenter. Before the earthquake, cold and hot groundwater resources were monitored in the Bayraklı district, Gülbahçe, and Seferihisar geothermal fields. Ten groundwater monitoring wells were drilled in Bayraklı Region, where groundwater level, temperature, and electrical conductivity changes have been monitored at 1-hour intervals with divers placed in 5 wells. Also, groundwater and geothermal fluid were observed in terms of their physical and chemical properties.

It was found that the Samos earthquake caused responses in the groundwater level before, during, and after the earthquake, provided new resources and temperature-flow increases in geothermal fields. The result shows that groundwater water level changed before the earthquake, and it took about 7 to 10 days for the water levels to recover their former static levels.

In addition, geothermal fluids are observed along NE-SW trending Gülbahçe and Tuzla faults, far away from the Samos earthquake epicenter, about 50 to 20 km, respectively. The most crucial anomaly was observed on the Gülbahçe and Seferihisar geothermal fields. After the mainshock and tsunami event, new geothermal sources emerged with having the same fluid characteristics as the Gülbahçe and Seferihisar hot springs.

With this study, the importance of monitoring groundwater and geothermal resources before and after the earthquake has been shown with the findings in İzmir and its surroundings.

Key words: Groundwater monitoring, Samos earthquake, Bayraklı, Geothermal fields

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TÜBİTAK

Turkish Journal of Earth Sciences
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Turkish J Earth Sci
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Meeting Abstract

Impacts of the 2020 Samos earthquake in the modeling of ancient seismic events

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Abstract

Earthquakes with magnitude in the range 6.8-7.2 (seismic moment of the order of 10**19 Nm) are expected to produce both short-period and long periods waves, reflected in potential for serious damage to near field high-frequency constructions and, under certain conditions, and for damage to rather distant low-frequency structures.

The 2020 Samos earthquake was a striking example of rather far-field damage, essentially concentrated in a part of Izmir. However, in the near field, it produced limited structural damage but much fear, mainly because of the sense of oscillation produced. In fact, structural damage in the northern coast of Samos, very close to the modeled fault, was limited, even for traditional, old houses in unfavorable foundations conditions (on thin layers of unconsolidated sediments). One problem hence arising is that this earthquake was characterized by a deficit of near-field destruction potential.

This article focusses on another problem: If earthquakes of Samos 2020-type are not uncommon, modeling of ancient earthquakes, based on very limited historical information, needs to be revisited. Existing evidence indicates that the epicenter of ancient earthquakes was close to their macro-seismic epicenter. Still, if the Samos earthquake had occurred in ancient times, and a long-period structure in the Bayrakli area of Smyrni (ancient Izmir) was damaged, a biased epicenter would have been derived, or better, a mixture of different events, in Izmir and in Samos would have been inferred.

This is a realistic scenario, because another recent, large seismic event in the NW Aegean, the 2014 Samothraki-Gokceada M6.9 earthquake, produced a disproportional impact of near-field and far-field effects, though at smaller scale.

Key words: Samos earthquake, ancient seismic events, historical information, Aegean region

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Turkish Journal of Earth Sciences
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Turkish J Earth Sci
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Meeting Abstract

The strong Samos earthquake (M_s6.3) of 11 August 1904 and its aftershocks revisited

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Abstract

The recent disastrous M_w7.0 earthquake that ruptured the eastern Aegean Sea area near Samos on 30 October 2020 attracted increased interest regarding the historical seismicity in the area. One of the strongest past earthquakes was recorded on 11 August 1904. Strong aftershocks occurred on 18 August 1904 (aftershock 1) and on 10 October 1904 (aftershock 2). We re-examined the macroseismic effects of the three earthquakes, based on several contemporary reports, and in addition, we re-determined their magnitudes and epicentral locations.

The main shock of 11 August 1904 hit the island of Samos causing damage to several buildings and the collapse of about 60 houses in several villages, while 10 persons were killed and 20 injured, as it comes out from the unpublished "Book of Earthquakes:1899-1913" of the National Observatory of Athens (NOA), from Press reports (16.8.1904, Old Style calendar) as well as from the scientific Bulletin of NOA (1905). However, no important damage was reported after the strong aftershocks. Focal parameters of the three earthquakes are listed in various earthquake catalogues. However, parameters inserted in some catalogues are copied from previous ones. On the other hand, in some catalogues it is not always clear how the parameters have been determined. Unfortunately, in the ISC-GEM (2021) worldwide catalogue, which is based on a standard methodology for the earthquake parameters determination, one may find only hypocentral determination of the mainshock, while the aftershocks are not listed in that reference catalogue. In other catalogues the mainshock surface-wave magnitude, M_s, or the moment-magnitude, M_w, varies greatly from 6.0 to 6.9, while M_s or M_w magnitudes calculated for the aftershocks 1 and 2 range from 5.9 to 6.0 and from 5.7 to 6.0, respectively. Although all catalogues are consistent in that the three earthquakes were shallow, some differences exist in the epicentral locations listed in the various catalogues for each one of the three earthquakes. The recalculation of magnitudes of these earthquakes is part of a research project focusing on the magnitude redetermination of 52 moderate and strong earthquakes that occurred in Greece and surrounding regions in the time interval from 1901 to 1910. To this aim we utilized for the first time seismic wave trace amplitudes recorded at five Agamennone-type seismograph instruments that operated in Athens (ATH) and other four stations of NOA. Wave amplitude data from Agamennone records were utilized for the determination of magnitudes equivalent to M_s from the formulas (1) and (2) used at NOA for shallow (Papazachos and Vasilicou, 1966) and intermediate-depth earthquakes (Papazachos and Comninakis, 1971), respectively, and recorded in the period 1911-1963 by Mainka and Wiechert instruments, thanks to the fact that these instruments have been of intermediate natural period:

$$M = \log a + 1.42 \log \Delta + 0.2 \quad (1)$$

$$M = \log a + 0.18 (R/100) + 3.2 \quad (2)$$

Where Δ and R are epicentral and hypocentral distances, respectively. Since the Agamennone-type seismographs were also of intermediate natural period, the "Agamennone magnitudes" received for the period 1901-1910 were calibrated over M_s obtained at NOA for the post-1910 period. Finally we obtained magnitudes equivalent to M_s for the 52 earthquakes. The magnitudes calculated for the Samos 1904 three earthquakes are 6.3 for the mainshock, 6.2 and 6.0 for the aftershocks 1 and 2, respectively. Our mainshock magnitude is consistent with the magnitude M_s6.2 listed in nearly all catalogues but one which assigned Ms6.9 and later M_s6.8. Our magnitude estimation for the aftershocks 1 and 2 are close to previous estimations, i.e. M_s5.9 or 6.0 and M_s5.8 or 6.0, respectively. Magnitude determinations have been obtained for epicentral distances corresponding to mainshock epicenter located at the eastern side of Samos and aftershock epicenters offshore to the north of Samos near to the 2020 mainshock epicenter. The three epicenters are well controlled by P-S travel-time curves.

Key words: Samos earthquake, seismicity, Agamennone magnitudes, mainshock

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TÜBİTAK

Turkish Journal of Earth Sciences
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Turkish J Earth Sci
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Meeting Abstract

The earthquake of 30th October 2020 at Samos: Relative sea level changes and impacts on the coastal zone

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Abstract

On 30th October 2020, the eastern Aegean Sea was shaken by a Mw = 7.0 earthquake. The epicenter was located near the northern coasts of Samos island. This tectonic event produced an uplift of the whole island as well as several cases of infrastructure damage, while a small tsunami followed the mainshock. Underwater and coastal geological, geomorphological, biological observations and measurements were performed at the entire coast revealing a complex character for the uplift. At the northwestern part of the island, maximum vertical displacements of +35 ± 5 cm were recorded at the northwestern tip, at Agios Isidoros. Conversely, the southeastern part was known for its subsidence through submerged archaeological remains and former sea level standstills. The 2020 underwater survey unveiled uplifted but still drowned sea level indicators. The vertical displacement at the south and southeastern part ranges between +23 ± 5 and +8 ± 5 cm suggesting a gradual fading of the uplift towards the east. The crucial value of tidal notches, as markers of co-seismic events, was validated from the outcome of this study. The co-seismic response of Samos coastal zone to the 30th October earthquake provides a basis for understanding the complex tectonics of this area.

Key words: Samos earthquake, tsunami, sea level changes, Aegean Sea

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TÜBİTAK

Turkish Journal of Earth Sciences
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Turkish J Earth Sci
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Meeting Abstract

Macroseismic and geotechnical observations after the October 30, 2020 (Mw6.7) Samos-Kuşadası earthquake

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Abstract

The destructive Mw6.7 earthquake with its epicentre offshore, few kilometres north, of Samos Island, caused several secondary ground deformation phenomena, such as rockfalls, landslides, etc., increasing the impact and the hazard on settlements and infrastructures. At three landslide sites on Samos Island (Avlakia, Stavrinides and Pythagorio), the local road network was cut off. The extended damages occurred on old buildings and temples built on loose geological formations and alluvial deposits. The tsunami invaded the northern shores for several metres.

In Aghios Nikolaos area and in the northern and central part of Samos Island, a series of ground ruptures were observed striking from N40° to N70°, demonstrating a small throw of 5-8 cm. They also transect the main road that connects Vathy and Karlovasi. These ruptures are related to the western tip of the seismic fault as a surficial exposure of the main fault plane.

Coseismic phenomena were also observed on Ikaria Island as well, several tens of kilometres WSW of the epicentre. Along an onshore ENE-WSW-striking active fault, where a significant geothermal field is developed, the outflow of the geothermal fluids was immediately increased after the mainshock. Scattered rockfalls and landslides occurred along the island and the sea in the harbour of Aghios Kyrikos showed a circular, turbiditic flow.

Key words: Samos- Kuşadası earthquake, macroseismic observation, natural hazard

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TÜBİTAK

Turkish Journal of Earth Sciences
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Turkish J Earth Sci
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Meeting Abstract

Urgency of building inventory studies for seismic risk prioritization towards hazard Resilient Izmir

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Abstract

In earthquake-prone regions, it is still a challenge to predict seismic resilience of existing building stock. This is especially true for mega-cities such as Izmir. This study presents some of the results from a pilot work titled "Seismic Risk Assessment of the Building Stock in Balcova and Seferihisar and Developing its Building Inventory." Balçova and Seferihisar were chosen for the pilot study and the work has been conducted with a collaboration among Izmir Metropolitan Municipality, Dokuz Eylul University, and Chamber of Civil Engineers at Izmir. Within the project, structural drawings of 10.550 existing buildings, comprised of reinforced concrete and masonry buildings, were retrieved from the archives, digitized, and evaluated. The archive work was enriched with data collected from field work performed by 84 trained civil engineers. City-scale risk assessment of buildings requires rapid screening methods to be used. This necessity arises from multiple reasons: the first one is being budgetary constraints and the other due to dealing with large number of buildings in a relatively short time. Rapid screening methods on the existing building stock take into account specific structural vulnerabilities indigenous to the construction practice in Turkey. Several different methods with varying complexities and reliabilities were used to process the building data. The results of different methods are combined within a framework called multiple-decision tree method to prioritize the studied buildings, i.e., to rank them, in terms of their seismic risk. Ranked buildings were given a color code depending on their seismic risk state and are shown on a map integrated with the Municipality's geographic information system. The results from this study can be used in the future to perform cost studies corresponding to different mitigation strategies, estimating loss of lives, as well as in guiding the pre- and post-preparation efforts after a damaging future earthquake, therefore contributing to the preparedness efforts for achieving a more resilient Izmir for natural hazards.

Key words: Seismic risk assesment, building stock, natural hazard, resilient, Izmir

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Turkish J Earth Sci
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Meeting Abstract

Japanese experiences on Tsunami Hazard from assessment to preparedness - role of Tsunami Engineering Laboratory (TEL) in Tohoku University

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Abstract

30 years passed since the Tsunami Engineering Laboratory (TEL) was started in 1991 in Tohoku University, Japan to contribute for the international society of the tsunami academia to improve the knowledge and technology as well as coastal community at the tsunami prone area for disaster risk reduction. Especially after the high probability of an earthquake and tsunami of 99 % within 30 years provided by the Japanese government in the area of Miyagi Prefecture at in 2010, the TEL initiated the collaboration among the residents, local government and experts on tsunami engineering to make action for countermeasure such as evacuation drill based on the hazard map, its planning, constructing structural defense and installing the tsunami observation offshore with the GPS sensors. Nevertheless, the eastern Japan particularly Tohoku region in 2011 was hit by a gigantic earthquake of M=9.0 and a huge tsunami which occurred off the Pacific ocean, causing huge damage on the eastern coast of the eastern Japan, including the Sanriku area which is one of well prepared for tsunamis disaster based on the damage experiences in the past.

Having experienced the catastrophic disaster in 2011, Tohoku University has founded the International Research Institute of Disaster Science (IRIDeS) with the interdisciplinary field in natural, human and social sciences including medical science for disaster in 2012. The research field of TEL is still one of major one at a new institute of IRIDeS. Together with collaborating organizations from many countries and with broad areas of specializations, the IRIDeS conducts world-leading research on natural disaster science and disaster mitigation. Based on the lessons from the 2011 Great East Japan (Tohoku) earthquake and tsunami disaster, IRIDeS aims to become a world centre for the study of the disasters and its mitigation, learning from and building upon past lessons in disaster management from Japan and around the world. The lessons learn on tsunami engineering are summarized;

- Appropriate risk evaluation and its transfer for the disaster mitigation at community level
- Prior construction of the emergency operation system at the time of the disaster
- Importance of emergency correspondence, information in the restoration and the communication management including the tsunami warning system with the monitoring in real time
- The new disaster culture for the 21st century compiling the tradition of memorial stone, oral story such as tsunami-tendenko - Japan leaving the lesson from a past disaster shows

Key words: Earthquake, tsunami hazards, disaster risk, early warning system

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TÜBİTAK

Turkish Journal of Earth Sciences
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Turkish J Earth Sci
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Meeting Abstract

European fault-source models for seismic hazard and tsunami hazard applications: a focus on the Eastern Mediterranean

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Abstract

In the last two decades, several active fault compilations have been developed in Europe to provide input primarily to seismic hazard analyses and secondarily to tsunami hazard analyses.

At the continental scale, the European Seismic Hazard Model 2013 (ESHM13; Woessner et al., 2015, Bull. Earthquake Eng.) was the first to extensively use fault sources, followed by the NEAM Tsunami Hazard Model 2018 (NEAMTHM18; Basili et al., 2021, Front. Earth Sci.). Earlier seismic and tsunami hazard models mainly adopted area sources (also called zonation models). Meanwhile, diverse hazard analysis initiatives used fault sources at the national or regional/local scale.

Recent understanding of earthquake source complexities and technological advancements on simulating at least some of these complexities call for renewed views and strategies on collecting and organizing fault data to improve fault-source models, thereby enhancing the results of hazard analyses that use such input.

Nowadays, subduction sources and crustal fault sources are already treated in different ways. For example, the geometry of the subduction interface is commonly reported as a complex 3D surface. Conversely, the crustal fault geometries are often more simplified, typically using a down-dip planar surface. Such planar surfaces are usually obtained through geometric extrusion based on geologic information collected at the surface or very shallow depth. Simplifications are also adopted for fault behaviour parameters. In particular, fault slip rates are often averaged over long fault sections or even the entire fault length. Fault slip rate down-dip variations, instead, are very rarely considered.

This presentation will summarize the characteristics of the main European active fault databases and how they were, and are being, used as fault-source models in European-scale hazard projects with a focus on the eastern Mediterranean which is Europe's most active sector. Then, using a few examples from recent studies, the importance of introducing complexities into individual earthquake ruptures will provide insights on how seismic and tsunami impacts are affected.

Key words: Tsunami hazard analyses, active fault, seismic hazard, Eastern Mediterranean

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TÜBİTAK

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Turkish J Earth Sci
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Meeting Abstract

Realities, achievements and requirements for Tsunamis in the Eastern Mediterranean and Aegean Regions

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Abstract

Eastern Mediterranean and the Aegean Sea experienced numerous strong earthquakes, volcanic activities, and associated tsunamis in history. The massive tsunamis generated by the historical eruption of the Santorini volcano is the oldest known event in the region and caused a major impact on the ancient civilizations in the Mediterranean. Tsunamis occurred in 365 and 1303 are the two major ones that caused extensive damage and loss of lives in the coastal regions of the region. Three normal-faulting events have been recorded since 2017, confirming the tsunami threat in the area. The June 12th, 2017 (Mw 6.3) and July 20th, 2017 (Mw 6.6) events in the Eastern Aegean affected the nearby coastal areas and served as reminders, the latter causing remarkable loss of property and boat damage in Bodrum, Turkey and Kos Island, Greece. On October 30th, 2020, a strong earthquake (Mw 6.6, AFAD, 2020; Mw 6.9 KOERI, 2020) caused substantial structural damage at ~75 km epicentral distance in the Bayraklı region resulting in 117 casualties. A tsunami was also generated, causing very strong motion in the nearshore shallow areas and small craft harbors along 130 km shoreline from Alaçatı (North) to Gümüldür (South) in Seferihisar and Çeşme districts of İzmir Province. The maximum runup was observed as 3.8 m in Akarca, which is one of the most impacted areas together with Sığacık and Zeytineli. The tsunami caused one casualty and several injured people and remarkable boat and property damage to coastal structures and facilities along İzmir coast as well. The tsunami also resulted in significant impact on the northern coast of Samos Island especially in Karlovasi.

There have been about 20 moderate-size earthquakes in the central (Eastern) Aegean Sea from 496 BC to 1949 AD. Among these earthquakes, the ones on 20 March 1389, 13 November 1856, 19/22 January 1866, 3 April 1881 and 23 July 1949 caused tsunamis and somehow affected the coastal settlements of the Aegean Sea. The earthquakes and associated tsunamis of October 6, 1944 and March 7, 1867 in the Northern Aegean Sea are other important events in the region.

In the light of lessons learned from the most recent Aegean tsunamis and the experience gained in our field surveys in recent destructive tsunamis, with the support of findings from international scientific researches, the essential requirements for the tsunami risk assessment, increasing awareness, development of mitigation strategies and societal/structural preparedness and tsunami action plan for the coastal communities will be discussed with the examples of new achievements in this direction from megacity İstanbul and the importance of high-resolution numerical modeling of tsunamis are presented with discussions.

Key words: Tsunami, Samos earthquake, action plan, Aegean Sea

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Turkish Journal of Earth Sciences
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Turkish J Earth Sci
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Meeting Abstract

Tsunami hazard, warning, and risk reduction in Italy and in the Mediterranean Sea

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Abstract

The 2004 Indian Ocean tsunami and the 2011 Japan tsunami that caused the subsequent nuclear disaster were both initiated by large magnitude subduction earthquakes, the most common cause for the largest tsunamis. We cannot exclude that comparably large events will occur also in the Mediterranean Sea, characterized by high vulnerability and exposition of coastal settlements. Historical catalogues document evidence for more than 400 tsunamis in European coastal waters since 1600 BC, and tsunami hazard models like the NEAMTHM18 providing the probability of future earthquake-induced tsunamis are available; yet tsunami risk is sometimes overlooked, A recent wake-up calls came from the 2020 Samos-Izmir earthquake and the moderate tsunami that followed.

Five accredited Tsunami Service Providers run by IPMA (Portugal), CENALT (France), INGV (Italy), NOA (Greece), and KOERI (Turkey), and several national centers provide tsunami alerts in the framework of the NEAMTWS. Seismic and coastal sea level networks provide the necessary data (e.g., the sea level data provided by VLIZ on the behalf of IOC/UNESCO).

Some countries in our region have produced, in the last years, intense efforts for the protection of their coastlines from the tsunami threat both through long-term coastal planning and the design of emergency response plans, for example for the capillary distribution of tsunami warning messages, and for the preparation of evacuation of the population in case of a potentially impending tsunami.

However, there are several essential drawbacks, which characterize this rich scientific and operational landscape, resulting in gaps affecting the understanding of tsunami hazards and the efficiency of tsunami DRR, including:

✓ lack of interoperability among the TSPs and of sufficient instrumental coverage along the southern Mediterranean coasts and of modern, cost-effective, and sustainable monitoring networks such as GNSS and deep-sea networks;

✓ lack of understanding of the so-called tsunami earthquakes (1992 Nicaragua; Java, 1994, 2006; Mentawai Island 2010), and of response to tsunamis by non-seismic events, such as volcanoes, landslides, and meteotsunamis (e.g., 1994 Flores Island, t1998 Papua New Guinea, 2018 Palu bay and Anak Krakatau);

✓ lack of a multi-hazard approach and of a full vulnerability and risk assessment; and of consistent planning and awareness-raising actions across different NEAM countries.

In this talk, I will highlight the response of the NEAMTWS to some recent earthquakes and tsunamis, and I will then focus in particular on the approach to tsunami risk reduction and coastal planning that Italy has been implementing. I will also discuss some of the above-mentioned gaps, to emphasize the need for better preparation, and full implementation of the tsunami warning "last-mile" to foster the creation of a more integrated, interoperable, and sustainable risk reduction framework.

Key words: Tsunami hazard, risk reduction, Samos earthquake, Mediterranean Sea

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TÜBİTAK

Turkish Journal of Earth Sciences
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Turkish J Earth Sci
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Meeting Abstract

Development of disaster prevention platform in coastal resilient community

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Abstract

Urban planning that integrates both hard and soft measures based on the precondition of inundation has just begun, and the methods and techniques are still in the process of development, and it is essential to establish such methods through repeated discussions with the government and residents. In addition, in order to bring about a change in evacuation awareness, it is necessary to change the culture to one in which residents themselves take responsibility for city planning and think carefully about the height of levees and evacuation plans, rather than simply leaving it to the national and local governments as has been the case in the past. In order to achieve this goal, it is necessary to have a tool that can be easily understood by everyone and that allows everyone to consider the issues on the same platform.

Therefore, in this project, we aimed to build such a consensus-building tool and develop a platform that contributes to urban planning for disaster adaptation. Specifically, we will create a flood and tsunami inundation database, structural vulnerability, evacuation behavior, population forecasts, and laws related to disasters and build a platform that allows free and convenient access to these data. In addition, building a city that can adapt to disasters is one of the major issues in Japan and other countries, and we aim to build a platform that can be applied worldwide, the Coastal Disaster Prevention Platform, in cooperation with various countries.

The core of the coastal disaster prevention platform is constructing a database using simulators and water tank experiments. As a simulation tool, we develop a "hierarchical multiphase coupled simulator" that can calculate inundation, structural failure, and evacuation from a meteorological model in a coordinated manner. We call it the Multiphysics Multiscale Integrated Simulator (MMI). In addition, we are constructing a coastal disaster simulation tank that can perform various experiments on the danger to humans and the vulnerability of structures, which are difficult to reproduce by numerical calculations alone, which will ensure the validity of the numerical calculations. The MMI will be equipped with various GIS information, such as the vulnerability of the land, and the calculated and experimental results will be compiled into a database to build a platform. The ultimate goal of this project is to develop decision support tools for evacuation and urban planning based on the platform and then to construct an academic system for adapting to disasters (disaster adaptation science).

Although evacuation behavior in natural disasters has been studied, many people may encounter a disaster such as a tsunami only once in their lives. Although floods have also occurred frequently in recent years, the probability of encountering such a disaster in one's life is low in terms of personal experience. Given this, it is highly likely that an actual encounter with a disaster will be the first time in an individual's life. For this reason, we believe it is crucial to develop a system that displays specific evacuation locations and routes. In our laboratory, we are considering using AR to present the information to the residents, and we have applied it in the field. Although there are still many issues to be solved, some of the system residents said it could be a helpful tool.

Key words: Disaster prevention, coastal disaster, resilient, MMI

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TÜBİTAK

Turkish Journal of Earth Sciences
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Turkish J Earth Sci
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Meeting Abstract

Coseismic deformation field retrieval from Satellite SAR Interferometry for offshore (nearby coastline) earthquakes: hints from recent case studies in the Eastern Aegean Sea

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Abstract

In the last three decades SAR Interferometry (InSAR) technique has increasingly become an effective tool for Earth Sciences, and Seismology in particular.

InSAR deals with pre- and post- earthquake phase difference of "complex" SAR images, corresponding with satellite-to-ground distance change due to surface displacements. Moreover InSAR is able to provide a comprehensive picture of surface "changes" and "displacements" within the image frame.

Since the 1990s two Earth Observation missions of the European Space Agency (ESA), namely ERS1-2 and ENVISAT, have provided fundamental SAR data for these applications. Today, Sentinel 1-a and 1-b missions have been designed to continue and improve the SAR data acquisitions till now and along the following years.

Today capabilities and limitations of InSAR are well known. Since the first applications to earthquake studies in 1992 InSAR demonstrated its great capability to detect and measure with centimetric accuracy the coseismic displacement field caused by moderate to strong earthquakes at depth.

Offshore earthquakes can be only partially imaged by InSAR if the epicenter is nearby the coast and surface effects reach land while, on the contrary, no signal can be detected whereas offshore earthquakes do not provoke any on land surface movements.

The aim of this talk is to focus on the effectiveness of InSAR to study offshore, near coastline, earthquakes and to provide hints for fault ruptures inversion and slip distribution at depth. Although, on the contrary, the inherent limitations of InSAR technique offshore hamper the retrieval of the coseismic field, thus providing a fragmented view (on land portion) of the overall displacement.

Particular emphasis has been devoted to the earthquakes in the Aegean Region occurred since 1992. Among the most relevant the July 20, 2017, M 6.6 Kos-Bodrum Earthquake and the October 30, 2020, M 7.0 Samos Earthquake, both affecting the Greek islands of Samos and Turkey's western coast. Seismic source models and InSAR coseismic displacement fields are showed and related outcomes discussed.

Key words: Deformation, INSAR, seismicity, Samos earthquake, Aegean Sea

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TÜBİTAK

Turkish Journal of Earth Sciences
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Turkish J Earth Sci
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Meeting Abstract

How can geodetic data help identify regional and local crustal deformation patterns? Examples from the broader Aegean area

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Abstract

Geodetic data have long been used to identify active crustal velocities in respect to specific "stable" points of reference. In the Aegean area, it is well established that the area south of the North Aegean Trough (NAT) is moving towards the SW with significantly larger velocity than the area north of NAT. The current velocities have been also used to infer the active stress field trend in the broader area, including the areas that are affected by major active tectonic structures, such as the North Anatolian Fault Zone (NAFZ), the West Anatolia Graben System (WAGS), the Hellenic Arc, etc. In this paper, we describe the results of a detailed analysis of a 7-year campaign and its implication for active deformation in the Aegean area. The GNSS time series of 159 stations have been collected and analyzed for the period 2008 – 2014. Observation rate was 30 seconds on a 24-hour basis and the reference frame used is the ETRF2000 - European Terrestrial Reference Frame 2000, considering Eurasia stable. A variable set of parameters was extrapolated, using several methods and critical reviewing: 1) Maximum (MAHE) and Minimum (MIHE) Horizontal Extension, 2) Total Velocity (TV), 3) Maximum Shear Strain (MSS), 4) Area Strain (AS) and 5) Rotation (Rot). The structural interpretation of the results shows that several well-known fault systems are being deformed without significant earthquake activity, verifying their active status. An interesting result is that apart from those evident areas, there are several more ones of small to moderate size that present similar behavior (i.e. deformation pattern) without having any large fault zones within them. They are interpreted as a result of the activity of deep-seated fault or shearing structures, which is reflected to the surface as a disperse and not well bounded deformation area. This observation indicates that the actual active structural pattern of the broader Aegean area is potentially more complex than previously thought. The implications of such a complexity raise new questions about the possible linkages of fault segments and fault zones, as well as their input for seismic hazard assessment.

Key words: Deformation, GNSS, seismic hazard, fault zone, Aegean area

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Turkish J Earth Sci
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Meeting Abstract

GPS Derived Finite Source Mechanism of the 30 October 2020 Samos Earthquake, Mw6.9

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Abstract

Greek-Turkish boundary near the cities Samos-Greece and Seferihisar-Turkey has been shaked on October 30, 2020 by a Mw 6.9 earthquake. The observed coseismic displacements at 62 sites were inverted for the fault geometry and the slips. The mainshock did not generate an on-land surface rupture. However, the uniform slip modeling shows a finite source of 43.1 km long and 16 km wide rupture which slips 1.42 m along a north dipping normal fault extending from the Aegean see floor to a depth down to ~13 km. While the uniform slip model is consistent with the seismological solutions and provides a sufficient fit to the far field coseismic offsets, a distributed slip model is necessary to account for the near field coseismic displacements.

Key words: Samos earthquake; GPS; co-seismic; earthquake; slip; rupture process

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TÜBİTAK

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Turkish J Earth Sci
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Meeting Abstract

Field observations and InSAR analysis for mapping environmental effects induced by the October 30, 2020, Mw = 7.0, Samos (Eastern Aegean Sea, Greece) earthquake

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Abstract

On October 30, 2020, an Mw=7.0 earthquake struck the eastern Aegean Sea. Its epicenter has been determined offshore northern Samos, along an almost E-W-striking and N-dipping fault. It triggered earthquake environmental effects (EEE) in Samos Island detected by field surveys, relevant questionnaires and Interferometric Synthetic Aperture Radar (InSAR) analysis. The primary EEE detected in the field comprised surface deformation including permanent coseismic uplift detected on several coastal sites of Samos Island and coseismic surface ruptures in its northern part. Secondary EEE were mainly generated in the northern part of Samos and include slope failures comprising rockfalls and landslides, liquefaction phenomena including sand boils, ground cracks and lateral spreading at coastal sites, hydrological anomalies in springs and ground cracks due to local failure of coastal road embankments. With the contribution of the Satellite Radar Interferometry (InSAR), subsidence was also detected at coastal areas and slope movements identified in inaccessible areas of Kerketeas Mt. Moreover, the type of the surface deformation detected by InSAR is qualitatively identical to field observations. As regards the spatial distribution of primary and secondary EEE, it is concluded that effects were generated in all fault blocks of Samos Island. Based on the guidelines of the Environmental Seismic Intensity scale (ESI-07), intensities were assigned to all affected localities. The maximum intensities were observed in northern Samos. Taking into account the aforementioned results from post-event field surveys and InSAR analysis, it is suggested that the northern and northwestern Samos constitute an almost 30-km-long coseismic deformation zone with extensive primary and secondary EEE. The surface projection of the causative offshore northern Samos fault points to this zone indicating a depth-surface connection and revealing a significant role in the rupture propagation.

Key words: Samos earthquake, INSAR analysis, deformation, Aegean Sea

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Meeting Abstract

Source modelling and stress transfer scenarios of the October 30, 2020 Samos earthquake: Seismotectonic implications

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Abstract

On October 30, 2020, a strong earthquake (M_w6.6-7.0) occurred offshore, just north of the Samos Island, causing life losses, injuries and damages, especially on the Turkish side. The broader area is characterized by a complex geodynamic setting with both rich seismic history and numerous active faults of different direction and kinematics. The first aim of this study is to define the seismic source of the mainshock, based on seismological and geodetic data (GPS measurements and originally processed GNSS records), as well as our field observations on Samos Island few days after the mainshock. The integration of this information leads to a N-dipping normal fault (Kaystrios fault) that controls the central-northern coast of Samos Island. We modelled the seismic source and calculated the theoretical dislocation (using the Okada formulae) on the surrounding GPS/GNSS stations, comparing it with the measured values. The results are very encouraging, especially on the station installed on the Samos Island, giving confidence to our source model. We then used our seismic source to study the spatiotemporal evolution of the aftershock sequence by exploiting published seismological data (focal mechanisms and two seismic catalogues, one of which with relocated hypocentres) and our calculated Coulomb static stress changes caused by the mainshock. This comparison suggests that more faults than the Kaystrios fault were involved in the aftershock sequence. In order to investigate possible triggering and/or delay scenarios of the mainshock on nearby faults, the Coulomb stress changes are also studied showing various results according to each receiver fault.

Key words: Samos earthquake, Kaystrios fault, Okada formulae, Coulomb stress

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Meeting Abstract

Seismotectonic implications of Karaburun Peninsula, Kuşadası Gulf and Samos Island

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Abstract

Microseismicity and fault plane solutions are used to determine the current seismotectonic characteristic of the region covering Karaburun (İzmir), Kuşadası Gulf, and Samos Island. In this study, the activation of adjacent faults in this complex strike-slip and normal fault system is investigated using several thousand earthquake locations obtained by applying the double-difference location method, using travel time picks and waveform cross-correlation measurements. The use of accurate location methods is especially required for complex areas where several faulting systems or relatively small seismogenic structures exist. In fact, even though routinely determined epicenters are capable of revealing the rough picture of the seismicity, they are not suitable for studies of the fine structure of the causative fault, as their location uncertainties are often larger than the source dimension itself.

Numerous fault plane solutions were determined by both teleseismic and regional moment tensor waveform inversions and also first motion polarities, revealing that the stress tensor is in agreement with the clear NS trending extension direction. Groups of microearthquakes show either strike-slip faulting with a NS extensive stress (T axis), whereas other groups show oblique normal faulting on EW striking fault planes with a strike-slip component, also under NS extension.

The significant contribution of this study is the detailing of the local active structures and their properties, identified by the microseismicity, to forecasting future locations of strong earthquakes. The hypothesis that underlies this approach is that the smaller earthquakes are delineating locations that are capable of generating larger earthquakes and is proved by the latest 30 October 2020 (Mw 7.0) Samos mainshock.

Key words: Seismicity, active faults, Samos earthquake, Karaburun Peninsula, Kuşadası gulf

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TÜBİTAK

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Meeting Abstract

Active faults of the İzmir Gulf using high resolution seismic data

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Abstract

The shallow sedimentary structure and active faults as well as submarine fluid flow structures along the faults of the İzmir Gulf have been investigated using high-resolution seismic datasets. For this purpose, Chirp sub-bottom profiler, single channel sparker seismic, and multibeam bathymetric data were collected in 2008, 2010 and 2012 during different cruises aboard the R/V K. Piri Reis of Dokuz Eylül University, Institute of Marine Sciences and Technology.

The gulf is sub-divided into three areas by means of its morphology: Inner gulf, outer gulf and the Gülbahçe Gulf. Whole İzmir Gulf has thick and unconsolidated sediment cover, the thickness of which increases from inner to outer gulf where northeastern part is quite shallow (e.g., less than 1 m) due to the deltaic sediments of the Gediz River.

The active faults of the İzmir Gulf is still debated, and there are a number of models suggested by different researchers, most of which is established by mapping the fault traces on land. The suggested active fault models of the gulf consist of N to S trending strike-slip faults. However, high-resolution seismic data from the outer gulf shows the existence of NW to SE strike slip faults with a significant vertical component. These are named Uzunada Fault which forms the western margin of the outer gulf and İzmir Central Graben which is located at the central part. The most significant fault within the outer gulf is Uzunada Fault trending as a single sinistral strike-slip fault at the eastern part of Uzunada and at its southernmost part. Then it bifurcates around Çiçek Archipelago and the northern part of the Uzunada where it displays a horse-tail splay geometry. The fault trends are in E to W direction for the eastern part of the outer gulf towards the Yenikale Strait and for the complete inner gulf. A significant fault distinguished in the southern margin is named Izmir Fault, which is a normal fault dipping through the north. In the inner gulf, sparker seismic data from southern margin indicate normal faults with downthrows towards the basinal area. The throws of these faults are relatively small and they form a geometry like a half-graben structure.

Considering the tectonic model of the western Anatolia, the tectonic structure of the İzmir Gulf can be explained with an anticlockwise rotational escapement model in which the gulf has been opening. Within this context, main faults can be considered as normal faults with the strike-slip components.

Key words: High resolution seismic data, active faults, Izmir Gulf, western Anatolia

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TÜBİTAK

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Turkish J Earth Sci
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Meeting Abstract

Beyond the historical records in western Anatolia: cosmogenic 36Cl as the direct tracker of normal fault activity

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Abstract

Fault scarps provide direct evidence of past earthquakes, whose seismic behavior beyond the historical and instrumental earthquake archives can be explored using cosmogenic ^{36}Cl dating, if built in carbonates. The episodic exhumation of the fault surface as a result of successive earthquakes forms differential distribution of cosmogenic ^{36}Cl versus height on the fault surface. Accordingly, this temporal distribution pattern as a vertical profile can be utilized to constrain the horizons of past earthquake events on the fault surface.

One of the most seismically active regions which accommodate well-preserved active normal faults is western Anatolia. There kilometer-scale normal faults with observable vertical crustal displacements occurred in carbonate bedrocks of major horst-graben structures. We studied the seismic history of western Anatolia using ^{36}Cl exposure dating with analysis of 584 samples taken from seven carbonate normal fault scraps within Gediz, Büyük Menderes and Gökova grabens to explore their seismic history, in terms of timing of major earthquakes, their magnitude, vertical displacement, and slip rates. At least 20 large seismic events, mainly as clustered earthquakes of magnitude 5.5 to 7.5 have been reconstructed over the past 16 kyr, in accord with several existing historical records. We introduce four phases of high seismic activity in western Anatolia, at ca. 2, 4, 6, and 8 ka indicating a regional recurrence interval of about 2000 years. This recurrence interval correlates well with those inferred from a number of normal faults of roughly similar size within the Aegean extensional region. Vertical component of slips of per seismic event are simulated to be in the range of 0.6 to 4.2 m, which yield acceleration of the vertical slip rates from greater than 0.1 to 2.4 mm/yr through time. The variable slip rates, yet with increasing outline remark that this region is now experiencing its most seismically active period during the Holocene. Though, the occurrence of more frequent seismic event in near future is not far beyond expectation.

Key words: Cosmogenic dating, active fault, historical earthquakes, western Anatolia

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TÜBİTAK

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Turkish J Earth Sci
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Meeting Abstract

The northern Thessaly strong earthquakes of March 3rd and 4th and their neotectonic setting. Preliminary results

Spyros Pavlides[1,*], Alexandros Chatzipetros[1], Sotiris Sboras[2], Galanakis Dimitris[1], Christos Pikridas[3], Stylianos Bitharis[3], Ilias Lazos[1], Evaggelos Kremastas[1], Ioannis Papaioannou

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Abstract

A sequence of earthquakes Mw=6.3 and Mw=6.1 occurred on March 3rd and 4th in Northern Thessaly, northern Greece, followed by Mw=5.1 and Mw=5.2 aftershocks. They are associated normal, unknown, hidden, faults within the crystalline paleozoic basement. Surficial ground deformation, that is liquefaction phenomena along the rivers plains mainly, as well as soil fissures and rock falls, have been mapped. Evidence of characteristic geological indications of the unmapped seismic fault is concerned, after fieldwork, within the schist and gneisses. Geologically the main fault length of the surface could be considered a 15-20 km NW-SE trending and average dip to NE 50o. The seismic fault (seismic source) of the main shock was modeled, and the Coulomb static stress changes are calculated for receiver faults. The determination of the active tectonic regime of the region by geodetic data, and the known studied faults of NE Thessaly plain are presented, as well as the revised historical seismicity. This earthquake raises new concerns and challenges, revising some established views, such as the status of active stress trends, the direction of active tectonic structures, the existence of a seismogenic fault in a mountainous volume of crystalline rocks without typical geomorphological expression, and the role of Blind Faults to Seismic Hazard Assessment.

Key words: Thessaly, blind fault, active fault, seismic source, Aegean region.

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POSTER PRESENTATIONS

TÜBİTAK

Turkish Journal of Earth Sciences
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Turkish J Earth Sci
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Meeting Abstract

Submarine Stratigraphic And Structural Features Offshore of Küçük Menderes Graben (North of Samos Island) and Surroundings By High Resolution Seismic Reflection Method

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Abstract

Submarine stratigraphic and structural features of offshore Küçük Menderes Graben (North of Samos Island) and surroundings were investigated under this survey. High Resolution multi-channel seismic reflection data were collected by K. Piri Reis, research vessel of Dokuz Eylül University, in the study area in August-2005 and in March-2008 for this purpose. Thirteen distinct unconformities were traced below the study area that separate thirteen progradational stacked paleo-delta sequences (Lob1-Lob13) on seismic profiles. As a result of comparison with the oxygen isotopic stages (δ^{18}), these sequences (Lob1-L13) were interpreted that they have been deposited during the sea-level lowstands within Pleistocene glacial stages. In the study area the basement surface which observed as the lowest unconformity surface of the seismic sections was called 'Acoustic Basement'. This basement which traced approximately all of the seismic sections has generally quite wavy surface and underlains the upper seismic units. It was observed that these seismic units which terminated their formation in Pleistocene (Lob1-Lob13) and Holocene period were cut and uplifted by acoustic basement. Tectonic and structural interpretation was carried out to constitute the submarine active tectonic map of the study area by correlated active faults identified on seismic sections. Submarine active tectonic map with basement topography and sediment thickness map were correlated together to present the relationship between tectonic deformation and stratigraphy. It was observed that the Küçük Menderes Graben continues WSW-ENE direction under the sea and the normal faults limiting the south of this graben structure extend towards the Samos fault.

Key words: Multi channel seismic reflection, Submarine active faults, Küçük Menderes Graben, Stacked paleo-delta sequences

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TÜBİTAK

Turkish Journal of Earth Sciences
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Turkish J Earth Sci
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Meeting Abstract

Precursor analysis of 30 October 2020 Samos Earthquake using swarm A, B and C magnetic data

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Abstract

Tectonic movements of plates produce stress on the lithosphere. Furthermore, releasing energy of the accumulated stress results in substantial ruptures, earthquakes. Preparation phase of earthquakes requires long time for producing an earthquake. The magnetic data that used in this study was obtained from Swarm satellite mission. Swarm is a European Space Agency mission that contains three identical satellites. Pre-earthquake and post-earthquake magnetic variations can be monitored by Swarm satellites. In this study, 184 days of the Swarm satellite magnetic field data is processed to reveal precursor anomalies for M7.0 Samos Earthquake. The earthquake happened on 30.10.2020-11.51 UTC. The focal depth of the earthquake is 21 km. The magnetic data that used in this study was obtained from Swarm satellite mission. In this study, the Magnetic Swarm Anomaly Detection by Spline analysis (MASS) is applied to the low resolution VFM Level 1B 1Hz data. Reliability of results are depend on how successfully external sources are removed using geomagnetic indices. The interpolated hourly D_{st} and K_p and 3 hourly a_p are mapped respect to time and relative day to 30.10.2020. It can be said that there is a relationship between lithospheric variations due to the great earthquakes and time variant magnetic data. Pre-earthquake and post-earthquake variations are interpreted on the distribution of the anomalous data. As a result, pre-earthquake data are specified by linear characteristics. Then exponential rise is observed on the post-earthquake data.

Key words: Swarm satellite constellation, precursor analysis, Samos earthquake, satellite magnetic data

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TÜBİTAK

Turkish Journal of Earth Sciences
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Turkish J Earth Sci
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Meeting Abstract

Non-linear soil behavior analysis of collapsed building after the Samos Earthquake (30.10.2020 Mw=6.9)

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Abstract

Samos Earthquake (30.10.2020, Mw = 6.9) had catastrophic effects on the Bayraklı district (within Bornova Plain) of Izmir. 17 buildings completely collapsed, almost thousand building were heavily damaged due to the earthquake. Bornova Plain is an east-west trending tectonic depression developed within the horst-graben system of Western Anatolia. The Bornova Plain was filled with the alluvium brought by the short, seasonal streams that reach the plain from the surrounding high masses. Seasonal changes in the flow regimes of these streams have created an inhomogeneous accumulation in horizontal and vertical directions. This thick accumulation of low S-wave velocity and intensity will amplify the earthquake waves. However, it should be noted that the basin topography of the plain will also have unwanted effects on earthquake waves. 3513 strong ground motion station located in the Bayraklı district and on the coast of Izmir Bay measured the peak acceleration value (PGA) of the earthquake as 0.108 g. Although the building stock of İzmir does not differ from place to place, various analyzes have been made in the areas where the buildings collapsed after the earthquake was located to investigate the reasons for the collecting of demolitions in a single area. In this context, an earthquake simulation was carried out for the soil under a collapsed building. In designing this earthquake simulation; Earthquake data of 3513 strong-motion station, soil-bedrock model of 3513 strong-motion station, soil-bedrock model of a collapsed building were used. For this analysis, the soil-bedrock model under the collapsed building was created by the inverse solution of single-point microtremor measurement. In summary, the study was carried out by deconvolved the 3513 strong-motion station earthquake data to the bedrock interface located under the station and transferring this transported data from the bedrock interface under the collapsed building to the soil layers and the ground surface. According to the findings obtained from this process, the soil under the collapsed building amplified the earthquake waves more than 2 times. Also, dynamic soil behavior during the earthquake moved away from linear behavior and showed non-linear behavior from an average depth of 55-60 m.

Key words: Non-Linear soil behavior, microtremor, Samos Earthquake, İzmir

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TÜBİTAK

Turkish Journal of Earth Sciences
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Turkish J Earth Sci
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Meeting Abstract

The Sisam (Samos) Earthquake of October 30, 2020, and its aftershocks

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Abstract
The epicenter of the Sisam (Samos) Earthquake of October 30, 2020 (11:51:25UTC, M_L=6.6, koeri; M_w=7.0, usgs) was in the Aegean Sea, ~10 km north of Sisam Island and ≥40 km from the Aegean region of Turkey. This major earthquake had a focal depth of 12 km. The aftermath from the earthquake's mainshock was 117 dead, up to 1500 injured. In the subsequent 6 months, there were 5913 aftershocks ($1.0 \leq M_L \leq 5.3$) according to the electronic earthquake catalog data of Boğaziçi University Kandilli Observatory and Earthquake Research Institute (KOERI) within the earthquake's deformation zone. The 50 of these are aftershocks with magnitude 4.0 and greater. The cause of the mainshock was an E-W oriented normal faulting, and showed seismotectonic behavior compatible with the active tectonics of western Anatolia. According to the epicenter map of the aftershocks, the October 30, 2020, Sisam earthquake process resulted in crust deformation of 75 x 41 km. Even though the seismicity of the mainshock surroundings was compatible with that of western Anatolia, it showed low activity and high risk compared to local seismicity. A stable decay of aftershock activity was observed from the spatial and temporal analyses of the aftershocks that occurred within 6 months of the mainshock event, and in this study, the aftershock regime of the earthquake has been discussed by evidences obtained. Moreover, from calculation performed for the probable duration of aftershocks, it was seen that the aftershock duration is in the order of year.

Key words: Sisam, Samos, aftershock, aftershock duration, earthquake source, fault plane

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TÜBİTAK

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Turkish J Earth Sci
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Meeting Abstract

Palaeoseismic history of the Manisa Fault Zone, Western Anatolia

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Abstract

The 45-km-long, E-W to NW–SE-striking Manisa Fault (MF), which constitutes the western section of the Gediz graben system, is made up of two main fault segments. Previous studies are mostly concentrated on the western segment of MF to decipher Quaternary-Holocene characteristics. According to previous studies, the western segment is responsible for three paleo-earthquakes which correspond to 926 AD, 1595 or 1664 AD, with the most recent event in 1845 AD. To shed light on (i) Holocene palaeoseismic activity of MF, (ii) the earthquake recurrence interval and elapse time since the last activity of fault, five trenches were excavated on the eastern segments. Evaluation of field observations suggests that the MF has been the source of multiple Late Pleistocene and Holocene surface-rupturing earthquakes.

Detailed studies of trench walls and dating studies signify that the eastern segment of MF is responsible for at least five surface faulting earthquakes during the Holocene. According to Oxcal distribution using the Bayesian methods, the events are: E1: 30,7±8,8ka; E2: 15,0±5,0ka; E3: 6,3±1,6ka; E4: 2,6±0,9ka; E5: 0,6±0,4ka and E6: 0,1±0,1 ka. When the events are compared with the historical earthquakes, the E3, E4, and E5 events may correlate with the earthquakes of 17 AD, 926 AD, 1845 AD, respectively. According to these findings, it is understood that both fault segments were broken during the 926 AD and 1845 AD earthquakes, and that ruptured in a way that triggers each other.

On the other hand, in the light of the proposed interevent time, the estimation of the recurrence interval for the MF is varied between 0.16 and 3.5 ka for the Holocene. The elapsed time since the most recent surface ruptured earthquake on the MF is 160 years. Accordingly, MF poses a significant hazard, and therefore, it is necessary to assess the potential seismic hazard for the densely populated area of Manisa, Western Anatolia.

Key words: Palaeoseismology, active fault, Manisa Fault, Gediz Graben, western Anatolia

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