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Faculty of Geology & Geo environment

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INTRODUCTION

The reputation of Santorini, in recent years, maintained because of the large tourism development and its geological formation. Scientific studies have been published, largely focused in the field of History, Prehistoric Archaeology, Marine Santorini but of Geological changes. This island has to bring, interesting points in different disciplines (Archaeology, History, Folklore, Architecture, Church History, etc.). Thanks to geological history, Santorini became center of attraction and the subject of archaeological research.

The group of islands that make up Santorini, belongs to a wider group of islands, that of the Cyclades. The geographical structure, consists of the islands of Thira, Thirasia, Aspronisi, Palea and Nea Kameni occupying an area of 79194 sq. km and a length of 67 km. Thera crescent-shaped with a length of 15 km and a maximum width of about 6 km to the center. The island population of about 14218 inhabitants (2011) and distributed in fifteen villages: Fira, Firostefani, Imerovigli, Oia, Emporio, Megaloxorio, Pyrgos, Mesa Gonia-Kamari, Exo Gonia, Vourvoulos, Firostefani, Kontoxori, Bothwnas, Karterados, Mesaria, Akrotiri. The highest formation of the island is the rocky mass of the Prophet Elias –there the namesake monastery.

West of Thera and towards the northern end lies the second largest island of Thirasia. Its length is 6 square kilometers and a width of 2 km.

The most famous volcanic eruption of Santorini was in the 17th century BC. Named as "Minoan" from the leader of the excavations of Akrotiri, Spyros Marinatos since initially associated with the distruction of the Minoan civilization. This theory was reversed in recent years due to modern findings.

After the terrible eruption of the 17th century BC, the island of Santorini inhabited in the late 13 century BC–early 12th. In the course of time, the culture of the island, as will appear in the SYMPOSIUM "KALDERA 2014", formed and interacts because of many particularities.

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Opening Remarks

"Brief historical review and literature impact of Santorini island on the works of Elytis, Seferis and Venezis"

THE CHAIR OF THE ORGANIZING COMMITTEE
DR. ELISAVET GRAPSA
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1st International Geo-Cultural Symposium

"Kaldera 2014"

ABSTRACTS VOLUME

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Geodynamic section of the Aegean Volcanic Arc and palinspastic configurations

Papanikolaou D.

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The composition of the Cycladic continental crust beneath Santorini volcanic Caldera and Kolumbo submarine volcano largely determines the type of volcanism on the surface. As magma is created at about 180-200 km depth above the actual Hellenic subduction zone and rises through the Aegean lithosphere, it crosses the pre-Alpine continental crust of the Cyclades, approximately 10-15 km thick. This upper crustal element includes a core of Carboniferous granites (ortho-gneisses) and a mantle of garnet-mica schists corresponding to the Palaeozoic Metamorphic Basement cropping out on Ios Island. At higher levels it crosscuts various Alpine units comprising Mesozoic metamorphic rocks with HP/LT Tertiary metamorphism (Athinios/Ios blueschists), non metamorphic Mesozoic carbonates and Tertiary flysch (Proph. Ilias/Anafi autochthon) and Late Cretaceous allochthon metamorphic units (Anafi greenschists, metaophiolitic rocks and granites intruded into marbles). The above Alpine tectonic units are separated by early Tertiary primary thrusts and secondary Miocene extensional detachments. During middle-late Miocene the opening of the Cretan Basin took place immediately south of the Cyclades and has been maintained up to present. During Late Pliocene – Early Pleistocene extensional and/or transtensional neotectonic structures have resulted in the formation of graben structures in the central-southern Aegean, like the Anhydros graben between Ios-Amorgos in the north and Anafi in the south. The Pliocene transgression of the sea on the former land of the Southern Cyclades generated a several hundred meters thick sequence of marine sediments. Kolumbo Volcano is located within the Anhydros graben/basin with a Pleistocene-Holocene history as indicated by seismic reflectors observed on air-gun profiles most likely corresponding to different volcanic eruptions. The Alpine basement of the Anhydros basin very likely comprises the entire nappe pile which should be preserved below the sea bottom, escaping erosion before the subsidence of the neotectonic graben in Pliocene as this observed in Anafi. The geochemical characteristics of the Kolumbo volcano and hydrothermal system may be related to the composition of the various elements of the Cycladic upper crust.

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Geological tourism in Greece and its opportunities for local development

Schorr T.

VolcanoDiscovery Tours & Methana Promotion

Greece is one of the most interesting geological destinations in the world. Four active volcanoes, many interesting geological structures (caves, valleys, mountains) and famous mining areas like for example Laurion provide many opportunities to offer individual or organized excursions. To get Greece attractive for this kind of tourism, infrastructure, information and laws have to be improved. Already existing geological museums & regions have to be connected in a network. Geological tourism has to be advertised.

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A recent approach towards culturar rootes and geotourism: Geo-culturar rootes in Lesvos Island, the new trend (North-Eastern Aegean Sea, Greece)

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The aim of this study was to investigate two definitions of the touristic industry, Geotourism and Cultural routes, which the last years are key tools for sustainable tourism development. During this process it was considered necessary to explain in more depth the combination of these two definitions with Geoparks, Cultural heritage and Cultural tourism. In this research our effort was to assess whether those definitions can be combined, in order to create a "product" , which can help an area, in our case Lesvos Island, to develop sustainable tourism through the combination of culture with the geological formations.
For this reason, the first idea was to create Cultural routes for Lesvos Island, in North Eastern Aegean Sea, after the UNESCO's Certification in October 2012 for the whole island, as a Geopark, combining Geotourism with Cultural routes.
The following research objectives were undertaken:

-consider the significance of the nomination the island succeeded as a Geopark from a tourist and a stakeholder's perspective

-examine the prospects of geotourists in an island with rich geological and cultural heritage

-identify the sites that were included in the geo-cultural routes we have created

-underline the significance of the geological formations played in the everyday life of the locals that is clearly stated to all the buildings (from fortifications to mansions towards the airport)

-identify the Strengths, Weaknesses, Opportunities and Threats of the Lesvos Island as a tourist destination conclude to the profile of Lesvos island tourists, cultural tourists, geotourists and of local community's demographic profile

-investigate whether they are any prospects towards the creation of cultural geotourism routes in Lesvos Island.

In conclusion, the creation of geo-cultural routes was proposed, as a way to enforce actions that their main purpose will be the sustainable development of Lesvos Geopark with respect to the unique elements of the island of natural, geological and cultural interest.

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Baseline ecological assessment of two candidate marine protected areas in Santorini Island, Greece

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Santorini Island, with its exceptional natural scenery and geomorphologic versatility, has been proposed as an ideal place to create the first marine reserve in the Cyclades Archipelago, Aegean Sea. Initially, the area between Perissa and Kamari beach (Perissa Rock) was suggested as suitable to this end, based on fish biomass data, the presence of a NATURA 2000 site, and first contacts with the local community. Following the suggestions of local small-scale fishers' representatives the Akrotiri Peninsula was later added as another area of relevant interest.
To assess the current ecological state of these areas, a rapid yet thorough baseline study was conducted in October 2012. Our sampling methods provided rigid "ecological snapshots" that enable sound designation, management, and future monitoring. The ecological parameters under study were selected based on the existing literature and common practices applied elsewhere in Greece and the rest of the Mediterranean. Methodological tools of the "Habitats" (92/43/EC) and the "Water Framework" (WFD, 2000/60/EE) Directives were also taken into account.
Our most important findings were (i) the low total fish biomass and the absence of adult top predators, indicating a depleted ecosystem due to overfishing (ii) the overabundance and overgrazing effects of the (allochthonous) herbivore spinefoot fishes (*Siganus* spp.), as reflected by the abnormal structure and composition of the infralittoral algal communities, (iv) the absence of signs of pollution or other direct anthropogenic effects, as indicated by the good environmental status of the *Posidonia oceanica* meadows and the upper infralittoral vegetation (*Cystoseira* canopies), and (v) the presence of a rich diversity of species and habitats which accounted for highly appealing seascapes, especially along the Akrotiri and wider Caldera coasts. These findings are discussed together with their implications for protection and management

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Major accidents in the offshore hydrocarbon exploitation and the new European Safety Regulation for offshore oil and gas activities

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In the aftermath of the "Deepwater Horizon" accident in the US Gulf of Mexico in May 2010 the European Commission reviewed the existing Member States' safety frameworks for offshore operations and proposed new legislation to ensure that the world's highest safety, health and environmental standards apply everywhere in the EU marine waters. After its approvals from the European Parliament and the Council, the new European Directive 2013/30/EU on safety of offshore oil and gas operations was adopted. The Member States have a two years period to amend their National Legislation to coop with the new Directive provisions.
The presentation will give an historical overview on major accidents occurred in the offshore oil & gas operations, the lessons learnt and how they shaped the offshore safety legislation over the years. Finally, the main points of the new European Directive and the Greek actions taken so far for its transposition into Greek legislation will be given.

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Nisyros caldera: Towards a detailed geoelectromagnetic study

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Nisyros Island is an active volcano located in the Southern Aegean belonging to the Hellenic Volcanic Arc (HVA) that consists of the prominent volcanoes of Aegina, Methana, Milos, Santorini, Kolumbo, and Kos. That arcuate feature, extending from Methana, northwest, to the Island of Nisyros southeast, is a chain of volcanic islands resulting from the subduction of the African tectonic plate beneath the Eurasian plate. The truncated cone-shape of Nisyros has a diameter of 8 km long and at the centre dominates its caldera (4 km diameter). In the frame of the ongoing research project MT-GEAR, which aims to contribute to the investigation of the geoelectric structure of Southern Aegean, and particularly to attempt to image the Hellenic Subduction Zone, onshore MagnetoTelluric (MT) and Transient Electromagnetic (TEM) measurements were recently carried out on the central and eastern part of HVA, including Nisyros. MT data were collected at two sites inside the caldera of Nisyros (spacing about 2.5 km), using two MT systems running simultaneously plus a remote reference station installed in Omalos plateau (Western Crete). TEM technique was also applied in a twofold objective: to constrain the apparent resistivity of the uppermost hundreds of meters of each one of the MT sites and equally important to conduct a 2.5 km long TEM pilot profile (comprised of measurements every 200m) connecting the MT sites. Combined MT and TEM data analysis resulted to 1D model of the conductivity structure of Nisyros, while the geoelectrical TEM pilot profile provides additional information about the surficial geology and tectonics of the caldera.
The research is co-funded by the European Social Fund (ESF) and National Resources under the Operational Programme ’Education and Lifelong Learning (EdLL) within the context of the Action ’Supporting Postdoctoral Researchers’ in the framework of the project title “MagnetoTellurics in studying Geodynamics of the hEllenic Arc (MT-GEAR)”.

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Santorini Volcano and its magma plumbing system

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This presentation will summarise published and ongoing research on the volcanological history of Santorini, its eruptive behaviour and the origin of its magmas. Santorini caldera lies in a NE-SW trending fault zone, and regional faults have played a major role in the development of the caldera. Volcanism began about 650,000 years ago, and the last eruption occurred in 1950. Santorini has had a highly explosive history, with repeated large Plinian eruptions alternating with interplinian periods characterized by effusive activity, edifice construction and weak explosive activity. At least four caldera collapses have occurred. Detailed studies of eruptive products allow us to reconstruct vent evolution during explosive eruptions and caldera formation. Santorini magmas range from mafic to silicic in composition. Detailed phase equilibria studies show that basalt ascending from the mantle stalls at about 15 km, at the contact between the lower and upper crust, where it differentiates to andesite. The large volumes of silicic magma ejected during plinian eruptions are stored, however, at about 8 km depth. Volatile contents (H2O + CO2 + Cl) of crystal-hosted glass inclusions measured by secondary ion mass spectrometry are consistent with magma storage within this range of depths. Ongoing work is focussing on the timescales of assembly of the large silicic magma chambers that feed Plinian eruptions at Santorini. Diffusion modelling of trace element gradients in crystals in the products from two such eruptions (Minoan 3,600 y and Cape Riva 22,000 y) shows that the crystals had resided at high temperature for only several decades to a couple of hundred years prior to the respective eruptions. A concept emerging at Santorini, and at other volcanoes elsewhere, is that large shallow magma chambers are assembled on timescales that are very short compared to the total preceding repose time of the system.

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Reconstructing pre-eruption Minoan Thera

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In perhaps one of the most significantly damaging volcanic events in history, a thriving Minoan culture was near-fatally damaged by the Late Bronze Age (LBA) eruption of Thera. Archaeological criteria suggests this island was a major LBA trade and cultural center, abruptly destroyed by a major Plinian eruption. Geological and archaeological criteria are used to suggest a reconstruction of the pre-eruption landscape of Thera during Minoan occupation: (a) mapping of the preserved LBA landscape and sediments exposed in outcrop today; (b) imaging the buried LBA landscape beneath the Minoan tephra layer by geophysical techniques; (c) inferring a pre-eruption geomorphology from accessory components within the LBA tephra layers; (d) assuming repeated caldera collapse and edifice rebuilding of this volcanic field through the past 500 ka from excellent geological mapping of the Thera archipelago and geophysical surveys of the caldera and surrounding seafloor; (e) applying current volcanic-edifice construction rates from the Kameni Islands following the Minoan event, to the ca. 22 ka period between the Cape Riva and Minoan eruptions, to approximate the size of a central island within the Cape Riva caldera during Minoan times; and (f) interpreting depictions of the LBA landscape in wall paintings from the archaeological excavation at Akrotiri. The resulting pre-eruption palaeogeography of Thera is not unlike others already published except for a larger central LBA island within the caldera and other changes in topographic features – significant here is the application of wall painting/fresco depictions found within the Akrotiri excavation as documentation supporting these geological and geophysical criteria.

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Was there a devastating tsunami from the late Bronze Age eruption of Santorini?

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During the Late Bronze Age (LBA) one of the largest eruptions of the Holocene era took place on Santorini. Archaeological evidence published in 1939 suggested that the LBA tsunami was a major event that contributed to the demise of the Minoan civilisation. Finding support for this conclusion, however, has proved elusive. The eruption is undoubtedly similar in style to Krakatau, 1883 when a devastating tsunami killed 60,000 people. The LBA eruption is at least three times the volume of Krakatau, thus it seems inevitable that a major tsunami was generated. Prehistoric tsunamis are recognised from their associated sediments, but few are identified from the LBA event and, for many, their origin is disputed. Preservation potential of tsunami sediments depends on local conditions that, in the Aegean area, may not be favourable, thus explaining their absence. The LBA pyroclastic deposits on Santorini are considered to be almost entirely primary, except for an enigmatic deposit at Pori interpreted as tephra reworked by a tsunami generated by the Phase 2 eruption. On Crete exhaustive research during the 1990's failed to find any evidence of a tsunami whatsoever. Here we present new evidence from Crete that challenges previous conclusions that tsunami sediments are not preserved here. Coring at three coastal locations reveals the presence of marine sands at depth beneath the marshy areas found here. At Malia, three marine sands have been sampled. The deepest at 4 m is dated at ~4,200 BCE, the sand at 3 m correlates with the 3500 BCE LBA eruption and, at 2 m, the shallowest sand may represent the 365 CE earthquake tsunami. The sediments at Malia record coseismic subsidence of 7 m over the past 6,000 years, with at least 3 m since 3500 BCE. At Delphinos in west Crete dating of sediment overlying a marine sand at 2 m depth suggest a Late Bronze Age origin. Further research is required, but the new work on Crete provides compelling evidence that the LBA eruption on Santorini generated a tsunami that was of regional extent and possibly of major societal importance.

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Tectonic structure of Santorini volcanic field based on terrestrial gravity measurements (1976-2012)

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Santorini is the most active volcano of the Hellenic Volcanic Arc (South Aegean Sea) and is best known for the Minoan eruption of the late Bronze Age. Dionysos Satellite Observatory of the National Technical University of Athens carried out gravity measurements during 1976. The latest campaign was carried out in December 2012 at selected locations on Thera, Nea Kameni, Thirasia and Aspronisi islands, which were sites of measurements during 1976. Absolute gravity values were calculated for each station during the processing of the two sets of raw gravity data and consequently Bouguer gravity disturbance maps were produced after the appropriate corrections and reductions. Separation of regional and residual gravity anomalies aimed at anomalies improving the accuracy of the final results. A second order surface was produced through the adjustment of the complete Bouguer gravity disturbance of the year of 1976 for every set of measurements from both 1976 and 2012. The residual complete Bouguer disturbances of 1976 indicated four regional maximums (Athinios, Tripiti, Fira and Kolumbo) and one regional minimum (in the area of Akrotiri), while these of 2012 indicated one regional maximum (Aspronisi) and two regional minima (between Fira and Athinios and the area of Akrotiri). Subtraction of the surfaces of the residual complete Bouguer disturbances between 1976 and 2012, can indicate if a potential fault is active (like in the area between Fira and Athinios) or inactive (like in the area of Akrotiri). Gravitational profiles from the subtraction of the residual complete Bouguer disturbances of 1976 and 2012 demonstrate six potential faults on the main island (Thera). The combination of our results with the geology of Santorini volcanic field and the future gravity measurements offshore will strengthen our knowledge on the significance and the activity of these fault zones.

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Monitoring Santorini volcano from space in the framework of BEYOND Center of Excellence

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The recently established Centre of Excellence for Earth Observation based monitoring of Natural Disasters in south-eastern Europe, BEYOND - http://beyond-eocenter.eu/, aims primarily to set up innovative integrated observational solutions to operate space borne and ground-based monitoring networks in a complementary, unified and coordinated manner. The research portfolio covers a broad spectrum of phenomena, addressed under the three research domains of BEYOND: Meteorological and human induced hazards, geophysical hazards, and atmospheric pollution and air quality.

Within BEYOND, special attention has been given to the intense geophysical activity that took place at Santorini volcano in early 2011. Using satellite radar interferometry we detected and estimated a clear and large inflation signal, up to 150 mm/yr in the line-of-sight direction, with a radial pattern outward from the center of the caldera. Since February 2012 our latest InSAR and GPS data suggest that the intense geophysical activity has diminished, signaling a new phase of relative geophysical stability in the area.

The seamless monitoring of the volcano is of paramount importance, however. To this end, BEYOND has been granted access to TerraSAR-X, COSMO-SkyMed and Radarsat-2 SAR data and has been employing Persistent Scatterer Interferometry techniques to effectively exploit the diversity of the available observational space-based geodetic networks in terms of the temporal, spectral and spatial resolution, coupled with the extensive measurements from in-situ cGPS and gravity data.

In the same direction, a complimentary modeling application for the simulation of volcanic ash dispersion has been customized for Santorini. This system is based on a detailed daily weather forecast model accompanied by a Lagrangian dispersion model and it has been designed to provide an early warning system for volcanic ash. This information is of particular interest for aviation safety.

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Urban Geology as a link between Geology and History

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Urban geology is the study of geological elements that shape a city and its course through history. It deals with issues such as its geological basement, its geomorphological features, its vulnerability to natural hazards, its building stones and decorative elements, etc. We present some cases from Thessaloniki city, some of which have been highlighted by senior students of the Department of Geology at the Aristotle University of Thessaloniki since 2011, in the frame of the optional "Teaching of Geology" course. These cases include landmarks of the city, such as the Rotunda, the White Tower, the Arch of Galerius, the city walls etc. They also include several secondary features, which are nevertheless important for the historical evolution of the city, such as the Evangelistria quarries, the now covered city centre torrents, the Axios Gate swamps, etc. The importance of local and regional geology and geomorphology is examined in terms of their effect on the evolution of the city throughout its 2,300 year-long history. Some examples include strong earthquakes that caused fatalities, extensive destruction and socioeconomic changes, such as the 1759 and 1981 ones, the provenance of various decorative and building stones in the city's monuments, the shaping of the coastal zone and the associated fortifications due to various geomorphic factors, the effect of faulting on the present state of Byzantine monuments, etc. Finally, we present some thoughts on how urban geology principles may be applied to Santorini, as it is a globally unique example of a civilization that is indivisibly associated with its local geological structure.

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Historical earthquakes in the volcano of Thera

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The volcanic eruptions in the island complex of Thera (Santorini), including the volcanic center of Columbo, have a long historical record after the pre-historic giant Plinian eruption of 17th century BC. The first historical eruption was reported around 197 BC while the last one occurred on AD 1950. Several of the known historical eruptions were preceded, associated or followed by earthquake activity. In addition, earthquakes were also reported in volcanically calm time intervals. We searched through the available historical documents and compiled a list of historical earthquakes that were felt in Santorini. Then we discriminated between local and distant earthquakes, which is useful to understand better the local earthquake phenomena genetically associated with the volcanic center. For the local earthquakes an effort has been made to re-assess seismic intensities in 12-point scale (MM) and earthquake magnitudes from empirical intensity/magnitude relationships developed by Papadopoulos (2011) for instrumental Greek earthquakes. A good example is the long series of shocks that associated the AD 1650 Columbo eruption with the occurrence of at least one large earthquake during the paroxysmal phase. We concluded with the compilation of a parametric historical earthquake catalogue in Santorini.

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Source characteristics of earthquakes in volcanic regions

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Earthquakes near volcanoes are known as volcano-tectonic. They reflect the interaction of two processes: the magma migration towards the earth's surface with the crustal tectonic activity of the broader region. A measure of which of these two processes prevails in a volcanic region, is given by the percentage of the isotropic component of the complete seismic moment tensor, compared to its deviatoric component. To resolve the isotropic component of the moment tensor and its uncertainty is crucial for volcanic environments. In linearized inversion problems, where the earthquake or explosive source location and origin time are fixed (e.g. assumed to be known), the uncertainty of the moment tensor is evaluated from the eigenvalues and eigenvectors of the design matrix, which allows the representation of the theoretical misfit by a 6-dimensional error ellipsoid. Since the design matrix depends only on the structural model and the receiver source geometry, the analysis can be performed either with real seismic waveforms or without. In non-linear inversion problems, where the free parameters are eight (e.g. the 6 elements of the moment tensor, depth and origin time), we propose a waveform inversion scheme in which the trace of the moment tensor varies systematically, and the remaining seven free parameters are optimized for each specific value of the trace. In this way, a 1-dimensional experimental probability density function of the moment tensor trace is constructed. The robustness of the method is shown using two shallow depth earthquakes (Mw 4.9 and 4.7) with epicenters close to the Columbo volcano. We use 15 near-regional ($\Delta \sim 100$ km) records at frequencies below 0.1 Hz and two velocity models. We conclude that the main uncertainties are attributed to the velocity model and to the trade-off between the isotropic component and the source depth.

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Contribution of the geomorphological analysis of the seafloor topography surrounding the Aegean Volcanic Arc to the understanding of tectonic and geomorphic processes

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Volcanism in the Aegean Arc generally first occurred about 3-4 million years ago. Results from multibeam acoustic imagery along the modern Aegean volcanic arc, has permitted the presentation of the submarine volcanic outcrops on a synthetic map combining the onshore/offshore observations. This may constitute the base map for future multidisciplinary studies such as their volcano-tectonic evolution. This study reveals that most of the submarine volcanic centers are usually located within neotectonic grabens formed by normal faulting, sometimes overprinted by subvertical strike-slip structures. They either represent independent features or the offshore continuation of the volcanic islands in the Aegean Sea (Methana, Milos-Antimilos, Santorini, Nisyros). The volcanic relief reaches up to 1200m creating steep cones or domes and craters with a base level at depths around 400-600m. The most active one is Kolumbo volcano, NE of Santorini which hosts an active hydrothermal vent field at the depth of 500m approximately.

These areas are Natural Laboratories offering the required challenging marine environment for validating a number of survey platform parameters, sensor capabilities in terms of observing fauna, habitats, minerals and morphology. Hazards relating to submarine volcanoes differ significantly from their subaerial counterparts, and therefore should be addressed separately in dedicated research efforts. Risk analysis for future catastrophic eruptions in submarine volcanoes is challenging and requires the most innovative, cutting-edge, next-generation technologies to be developed and employed.

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Polygenetic evolution of Kolumbo submarine volcano, Aegean Sea

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Underwater volcanoes represent a window to the earth interior and are therefore of multi-folded scientific interest. Yet, conclusions regarding the volcano's interior had to be drawn from seafloor images or geological, chemical and biological samples, thus from the volcano's surface or from within the caldera. Here we show for the first time the 3D-architecture of an explosive submarine volcano.

The seismic data allow concluding on the polygenetic evolution of the Kolumbo submarine volcano in the central Aegean Sea. The first and yet only reported explosive eruption occurred in 1650 AD following one year of strong earthquake activity. The resulting tsunamis significantly destroyed the infrastructure on the east coast of Santorini and adjacent islands. The about 500 m deep crater has a diameter of 1700 m, the shallowest part of its rim lies in 18 m water depth. Motivated by the observation that earthquakes clustered around Kolumbo in the 1st decade of this century we imaged the internal structure of Kolumbo and adjacent volcanic cones by means of more than 1600 km of reflection seismics in 2006.

The data elucidate the vertical stacking pattern of five cone-shaped volcaniclastic sequences that build Kolumbo underwater volcano in the central Aegean Sea. The entire volume of volcaniclastic sediments is estimated to 14-22 km^3. The seismic reflection patterns of near-by volcanic cones, which are not all monogenetic, imply that most of the cones also evolved during explosive eruptions leaving pyroclastic sequences behind. The central Aegean Sea experienced ≥24 explosive eruptions, which justifying further risk assessment. Kolumbo and the adjacent volcanic cones emerged along an extensional intrabasinal normal growth fault within the Anydros Basin. This basin opened during several north-west to south-east directed tectonic pulses. Onset of underwater volcanism post-dated the major rift phase.

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Unique nexus between geodynamic and biogeochemical processes at shallow hydrothermal vents, Kolumbo submarine arc-volcano, Santorini

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Active submarine volcanoes and linked hydrothermal vent fields are among the most poorly understood major features on Earth. Here, we report on integrated geodynamic, mineralogical, geochemical and biological investigations of the hydrothermal field located on the floor of the density-stratified acidic (pH: 5) crater of the Kolumbo shallow-submarine arc-volcano, near Santorini. Kolumbo features rare geodynamic setting at convergent boundaries, where arc-volcanism and seafloor hydrothermal activity are occurring in thinned continental crust. Enrichments of polymetallic sulphide-sulphate spires in Sb (avg.: 8,330 ppm; max: 2.2 wt%) and Tl (avg.:510 ppm; max: 1,000 ppm) are among the highest reported from modern seafloor hydrothermal systems. Epithermal suite geochemical association and enrichment (Au, As, Sb, Hg, Ag, Tl, Ag) indicate a new hybrid seafloor "Aegean-arc type" analogue of epithermal-to-volcanic-hosted-massive-sulphide deposits. Depth profiles (100–500 m) above the active vents indicate injection of hydrothermal NH_4^+ and Fe from the seafloor to the water column and biologically mediated NH_4^+ oxidation below the euphotic zone.

XAFS data have indicated a possible dominance of the relatively more toxic trivalent species (Sb^{3+}) rather than pentavalent species (Sb^{5+}) forms in biomorphous pyrite dominating the spires, and reduced forms of As (As^{1-} or As^{3+}) in the form of "orpiment (As_2S_3)-type'' phases in As-rich overlying material.

16S rRNA gene analysis confirmed the presence of highly diverse microbial communities that are spatially associated to Fe-rich microbial mats which cover the hydrothermal spires and the surrounding crater floor. Iron microbial-mat XAFS data reveal dominating ferrihydrite-type phases, and high-proportion of microbial sequences akin to "Nitrosopumilus maritimus", a mesophilic Thaumarchaeota strain capable of chemoautotrophic growth on hydrothermal ammonia and CO_2. Our findings highlight that acidic shallow-submarine hydrothermal vents nourish marine ecosystems in which nitrifying Archaea are important and suggest ferrihydrite-type Fe^{3+}(hydrated)-oxyhydroxides in associated low-temperature Fe mats are formed by anaerobic Fe^{2+}-oxidation, dependent on microbially produced nitrate.

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Historical bathymetric charts and the evolution of Santorini submarine volcano, Greece

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Historical bathymetric charts are a potential resource for better understanding the dynamics of the seafloor and the role of active processes such as those associated with submarine faulting, landsliding, and magmatism. The British Admiralty, for example, have been involved in lead line measurements of seafloor depth since the early 1790s in a wide range of settings, including oceanic islands. Here, we report on an analysis of historical bathymetric charts in the region of Santorini volcano, Greece. Repeat lead line surveys in 1848, 1866 and 1928 and multibeam swath bathymetric surveys in 2001 and 2006 have been used to document changes in the depth of the seafloor in Santorini caldera. The data reveal that the flanks of the Kameni islands, a volcanic dome and dacitic lava complex in the caldera centre, have shallowed by up to 215 m and deepened by up to 60 m since 1848. The largest shallowing occurred between the 1866 and 1928 surveys and was accompanied by a significant increase in the surface area of Nea Kameni, especially its southeast flank. Field observations by the French Geologist, F. A. Fouqué, during 1866-1870 suggest the shallowing is associated with the formation of the Giorgos and Aphroessa domes and their associated lava flows. Other shallowing probably occurred during 1925-1928 when lava flows filled the narrow straits between Nea Kameni and Mikra Kameni. The largest deepening occurred between the 1928 and 2001 and 2006 surveys, on the shelf and slope of Nea Kameni and so could reflect large-scale slope failures on the flanks of the newly formed lava flows. However, deepening is also observed between the 1866 and 1928 surveys and so it seems unlikely that this mechanism could explain both events. Another possibility is that the deepenings are the result of a load-induced stress relaxation that followed the emplacement of the 1866-1870 submarine lavas. We tested this possibility by constructing a model in which the lavas loaded an elastic plate overlying a Maxwell viscoelastic substrate. By comparing the observed and calculated subsidence at different times since loading we have derived a best-fit plate thickness and substrate viscosity of 100 m and 10^{18} Pa s respectively. A similar mechanical model was derived by Parks et al. (EGU abstract, 2013) from a joint inversion of a short-term GPS and InSAR data set. They showed that the southwest flank of Nea Kameni has undergone a short-term subsidence of ~6.5 mm/yr, approximately half of which could be attributed to viscoelastic stress relaxation. We caution, however, that our estimates of the long-term subsidence based on repeat bathymetric surveys have not been corrected for thermal contraction due to cooling. Neither have they been corrected for magma chamber deflation or subaerial lava loading. These factors may act to increase the subsidence and so either a thicker elastic lid or more viscous Maxwell substrate could probably still explain the observed bathymetric

differences. Irrespective, historical lead line and modern sonar bathymetric data suggest that the volume of submarine lavas associated with the 1866-1870 volcanic activity are ~0.45 km^3 and that the magma addition rate is ~0.11 km^3/yr. This rate is a factor of 5 higher than has been estimated from the analysis of the subaerial eruptions.

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Building materials in rupestrian habitation at Thirasia, an example of adjustment to the local environment

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Thirasia, the second largest island of the Santorini volcanic complex, is characterized by a unique traditional architecture which is based on the use of local materials. Although the lack of preservation is obvious these structures remain almost untouched. The absence of human intervention in conjunction with the effects of desolation of the older settlements has given us a great opportunity to study in depth the traditional structural systems and materials, but also their deterioration mechanisms.

One of the questions arise is how the particular geological environment has affected the structural choices of the inhabitants, who seem to have had an excellent knowledge of its characteristics.

After having accomplished an extended survey of the traditional structural systems, a series of analyses both in building materials (stones and mortars) and in the soil from Thirasia had been made. In particular, chemical, physical, microstructure and mechanical properties of the building materials were recorded using XRF, SEM and optical microscopes. The reactivity and the composition of the soil were tested as well as its gradation. The survey and analysis of these traditional structures showed that the inhabitants have taken full advantage of the available local materials (pumice, stones etc) and developed their own architecture in harmonization with their environment. Stones were used mainly unshaped while the soil was enriched with lime in order to increase plasticity and applied as strong compacted mortar with good adhesive properties.

Considering also the fact that these constructions were built during periods of great poverty, we conclude that the traditional rupestrian structures of Thirasia are an example of low cost and sustainable style of building completely adjustable to local environment.

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Synergy for the sustainable development and safety of the Hellenic Tourist Beaches: Project's scope and presentation

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Greece is ranked amongst the 20 top touristic destinations with most of the growth associated with beach destinations. At the same time, most of the Greek (and world's) beaches are under erosion, posing a serious threat to tourist industry. Thus, there is an urgent need to (a) acquire information that will improve our understanding of beach dynamics and provide the basis for effective management plans; and (b) present the framework that will allow prospective tourists/users to make informed choices of beach destinations. Within this framework, the main objectives of the BEACHTOUR project are to (i) construct a GIS-based, dynamic and user-friendly platform for storing/visualizing information on the environmental characteristics of the Greek beaches, as well as information pertinent to beach management (e.g. presence of coastal infrastructure) using web-based remote sensing information; (ii) assess the accuracy/sensitivity of high resolution satellite imagery to define beach spatial characteristics and nearshore bathymetry; (iii) develop/test an automated Beach Monitoring System-BMS which can record, process and communicate (in quasi-real time) high frequency information on beach morphodynamic and nearshore hydrodynamic characteristics, meteorological conditions and safety issues; (iv) advance a state-of-the-art morphodynamic model of comparable spatio-temporal resolution; and (v) identify 'best practices' in science-driven beach monitoring, management and decision-making, aiming to relate beach vulnerability to economic losses and suggest effective adaptation measures. The BEACHTOUR project "Cooperation 2011-2015" (11SYN_8_1466) acknowledges the Operational Program "Competitiveness and Entrepreneurship", co-funded by the European Regional Development Fund (ERDF) and the General Secretariat for Research and Technology (Hellenic Ministry of Education).

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Assessing coastal vulnerability using environmental and socio-economic indicators in coastal areas with high cultural value

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Climate change has significant repercussions on the natural environment, triggering obvious changes in the natural processes that have a severe socio-economic impact on the coastal zone; where a great number of human activities are concentrated. So far, the estimation of coastal vulnerability was based primarily on the natural processes and less on socio-economic variables, which would assist in the identification of vulnerable areas. The present investigation proposes a methodology to examine the vulnerability of a highly touristic area in the Island of Crete to an expected sea level rise of up to 40 cm by the year 2100, according to the A1B scenario of IPCC 2007. The methodology includes the combination of socio-economic indicators into a GIS-based coastal vulnerability index for wave-induced erosion. This approach includes three sub-indices that contribute equally to the overall index. The sub-indices refer to coastal forcing, socio-economic and coastal Characteristics. All variables are ranked on a 1-5 scale with 5 indicating higher vulnerability. The socio-economic sub-index includes, as indicators, the population of the study area, cultural heritage sites, transport networks, land use and protection measures. The coastal forcing sub-index includes the frequency of extreme events, while the Coastal Vulnerability Index includes the geological variables (coastal geomorphology, historical coastline changes, and regional coastal slope) and the variables representing the marine processes (relative sea level rise, mean significant wave height, and tidal range). The main difficulty for the estimation of the index lies in assessing and ranking the socio-economic indicators. The whole approach was tested and validated through field and desktop studies, using as a case study the Elouda bay, Crete Isl., an area of high cultural and economic value, which combines monuments from ancient and medieval times, with a very high touristic development. The area was found to de ranked as high vulnerable.

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Submarine areas with potential Marine Aggregate deposits in Greece

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Marine aggregates (MA) are sands and gravels dredged from the sea bed and are used in: concrete and mortar manufacture, asphalt and coated products, block making, drainage and fill materials, leisure and sport facilities and beach replenishment (CEDA, 1993; BMAPA, 2004).
The aim of this study that is conducted within the framework of the project MARE is to identify subaqueous locations that may host MA deposits in Greek coastal areas, utilizing any available data and information collected. Emphasis is given on possible MA deposits in the form either of relict and/or modern (upper Holocene) formations. On the basis of coastal lithology and available subbottom shallow stratigraphic information 16 locations have been identified from which 4 belong to Cyclades plateau, 2 to Dodecanese, 4 to the North Aegean, 2 to Evoia, 2 to south Aegean Sea and 2 to the Ionian Sea. In addition, deltaic coasts (eg. Evros, Pinios/ Thessalia, Acheloos and Alfios) are also promising areas for the existence of marine aggregates. Of course, the ultimate decision for the most suitable areas will follow bathymetry and seismic sub-bottom profiling data, ground truthing and environmental issues (e.g. benthic community, beach stability).
The project MARE (MIS: 375655) is supported by the co-finance of the European Union (European Social Fund - ESF) and Greek National funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) - Research Funding Program: THALES (Investing in knowledge society through the European Social Fund).

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Impact of land use intensity on water quality: a case study in five districts of KPK,Pakistan

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This paper encompasses the impact of land use intensity on water quality in selected districts of KPK-Pakistan. Water quality is an advancing concern worldwide. Urbanization and land use intensity is enhancing the quality degrading aspect of water. The Industrial, commercial and urban centers pose high land use intensity. A spatial tool, Landscape Intensity Index (LDI), from raster land use map was applied to estimate land use intensity. A total of 1742 water samples from the districts of Bonair, Swat, Dir Lower, Dir Upper and Mardan were collected as of public tube wells, domestic tube wells, public works taps, hand pumps, open wells, springs and surface water resources. Water quality was studied regarding the bacterial content, color, odor, pH, electrical conductivity (EC), taste, turbidity, total dissolved solids (TDS), hardness and the concentrations of arsenic, bicarbonate, carbonate, chlorine, fluoride, iron, magnesium, nitrate, potassium, sodium and sulphate in collected water samples. Estimated safe sample and land use percentages are 30 and 91 for Bonnair, 15 and and 54 for Swat, 04 and 98 for Dir Lower, 10 and 97.5 for Dir Upper and for Mardan 21 and 96.5 respectively. The investigations revealed that a reverse relation exists between land use intensity and water quality of the project area. High cropping intensity, such as, 193% in Swat District demonstrates a deviation from the investigated relationship.

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Investigating the active hydrothermal field of Kolumbo volcano using CTD profiling

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The Kolumbo submarine volcano NE of Santorini Island and the unique active hydrothermal vent field on its crater field (depth ~500 m) have been recently explored in multiple cruises aboard E/V Nautilus. ROV explorations showed the existence of extensive vent activity and almost completely absence of vent-specific macrofauna. Gas discharges have been found to be 99%-rich in CO2, which is sequestered at the bottom of the crater due to a special combination of physicochemical and geomorphological factors.

The dynamic conditions existing along the water column in the crater have been studied in detail by means of temperature, salinity and conductivity depth profiles for the first time. CTD sensors aboard the ROV Hercules were employed to record anomalies in those parameters in an attempt to investigate several active and inactive vent locations. Large anomaly (~5%) is observed in the salinity values over the active chimneys. Temporal CTD monitoring inside and outside of the crater was carried out over a period of two years. Direct comparison between the vent field and locations outside the main cone, where no hydrothermal activity is known to exist, showed completely different characteristics. The hydrothermal vent field was mapped extensively, while the data exhibited a strong connection to the cone's morphology. CTD profiles suggest the existence of four distinct zones of physicochemical properties in the water column that seem to agree very well with the existing geomorphological data. The layer directly above the chimneys exhibit gas discharges highly enriched in CO2. Continuous gas motoring is essential to identify the onset of geological hazards in the region.

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Tectonic structure of Santorini volcanic field derived from terrestrial angle measurements of the National Geodetic network (1955-2011)

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The intense seismicity that occurs in the region of the Aegean Sea, reflects the tectonic structure and processes of movements and upheaval that are constantly in this area as a result of major deformations of tectonic plates.
This study is focused on the implementation of a specific methodology for the determination of tectonic deformations observed over the time in the region of Thira (Santorini). The original angle measurements of National Geodetic Network, made by the army, during the periods 1955 to 1956 and 1982 to 1987 were used for the calculation of the shear strain of the specific area with the method of observations. GPS measurements were done in 2011 in common triangulation sites and the angles which calculated from these coordinates compared with those of period 1982 -1987.
The position and direction of the calculated shear strains defined by the fact that the proximal faults are still active. In the surrounding area the size and the direction of the trend could be affected by faults and the recent tectonic and seismic events that have occurred in the region.

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Resolving the paleogeography of the pre-Minoan caldera of Santorini on the basis of cosmic ray exposure chronology

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The prehistoric eruption of the insular stratovolcano occurred in around the 17th Century BC and not only reshaped the entire physiography of Santorini, but also shuddered the Late Bronze Age (LBA) thalassocratic Minoan empire. Central to the sequence of events that ensued from the Minoan eruption was edifice collapse that led to the post-Bronze Age multifarious physiography of the island. Yet, the actual palaeotopography of pre-catastrophe Santorini remains a point of contention. Irrespective of the conclusions reached by those claims, they all stress the existence of a flooded pre-Minoan caldera associated with the penultimate eruption of Santorini. As long as more than two episodes of caldera development unfold within the modern day caldera cliffs, it would be possible to discriminate Minoan from pre-Minoan cliffs and reconstruct the accurate paleogeography through cosmic ray exposure dating, by looking for 3.7 ka and older cliffs respectively.

Cosmic Ray Exposure (CRE) dating allows deciphering the exposure history of surface rocks. Specifically, terrestrial cosmogenic nuclides (TCN) are produced in surface rocks by interaction with the cosmic-rays and they accumulate proportionally to the exposure duration. Thus, their concentration comprises a chronometer of the exposure age of surface rocks. In that respect, CRE is potentially able to chronologically discriminate events temporarily well separated in the caldera of Santorini. Cosmogenic ^{36}Cl, and secondarily ^{10}Be have been suitable in dating lavas. There are three pathways of ^{36}Cl production in surface rocks: spallation of Ca and K by high-energy neutrons, capture of low-energy neutrons by ^{36}Cl and capture of slow negative muons by Ca and K. ^{10}Be is primarily produced by spallation reactions of O. Consequently, the concentration of cosmogenic nuclides in rocks is directly related to the sum of production rates from all three pathways and, hence, to the exposure duration of the exhumed caldera cliffs.

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Marketing for cultural routes and the geo-cultural routes in Lesvos Island, Greece

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This study was aiming to offer tourists a unique experience through the creation of cultural routes in Lesvos Island, Greece. Particularly, in the heritage marketing, consumers are interested in a symbolic relationship with cultural heritage , for individuals and groups aspects of heritage which must be relevant and meaningful, searching for what to be represented/ embodied in their personal identity, or something tangible. Lesvos Island's tourists (which are mainly cultural tourists and geotourists) as being identified both from the qualitative literature review, as well as, by the quantitative analysis of the questionnaires, interviews and observation, wish to have the same symbolic relationship with heritage as the consumers in heritage marketing.
In order for these routes to be formed it was necessary to set the following research objectives:
-taking under consideration the UNESCO's Certification for the whole island, as a Geopark, emphasizing the unique elements of the island of natural, geological and cultural interest and how these were combined presenting the continuous relationship between earth and human beings
-conduct qualitative research for the heritage marketing and more specifically for the marketing for cultural routes
-cite the theory of the marketing mix process (segmentation, targeting and positioning)
-give the theoretical background of the Marketing Mix 7P's (Product, Price, Promotion, Place, People, Physical Evidence)
-identify the Strengths, Weaknesses, Opportunities and Threats of the Lesvos Island as a tourist destination
-conduct a Stakeholder's analysis
-state the CERTESS Project of the European Institute for Cultural Routes as the most suitable for constructing our routes
-present our Marketing Mix 7P's, our unique product (as well as the other 6 P's), the two Geo-cultural routes and the three Thematic routes (bridges, thermal baths and Mytilini's sightseeing)in Lesvos Island that will be soon presented via www.geo-culturalroutes.gr website Geo-cultural routes as an action wish to help the sustainable development of Lesvos Geopark, the tourism growth by showing respect to its unique elements and fill in the lack of routes that were combining nature and geological formations with culture.

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The 20th century eruption of Santorini Volcano: First implications on petrological and geochemical evolution of their magmatic products

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Santorini volcano experienced three separate eruptive periods during the first half of the 20thcentury, but since 1950 remains dormant. All three eruptions produced dacite lava flows and/or domes and pyroclastics onto the Nea Kameni Islet, located in Santorini's caldera centre. Especially, during 1925-1928 the Dafni lavas, during 1939-1941 the WW2 lavas, and finally in January of 1950 the Liatsikas lavas were formed. Fouque, Smith, Niki, Ktenas and Reck are distinct lava flows and/or domes of the composite WW2 lavas. This study uses LM, SEM-EDS, XRD, ICP-MS and RAMAN analyses in order to assess and interpret any change in the petrological and geochemical character of the erupted magmatic products.

Field studies, literature and old aerial and satellite images reveal that all the explosive periods created classic surface morphologies normally associated with viscous felsic lavas e.g.typical blocky lavas. Particular characteristics include cohesive and highly viscous parts but also rafted blocks of bedded scoria in Fouque's lavas, lava stalactites in Smith's lavas, flow folds and layering in Liatsikas lavas, coulee and levée in Niki's lavas and signs of gas escape and oxidation in all above lavas. Xenolithic enclaves, which are present in all lava flows, show abnormal shapes, sizes up to 0.5m, less porosity than the host lava and mineral phenocrysts such as olivine and plagioclase. Petrography by polarizing and electron microscopy show that porphyritic and especially trachytic textures prevail mostly in Dafni flows and glomeroporphyric in Liatsikas 1950 lava, whereas in WW2 lavas we found all of them equally. Qualitative and quantitative measurements on mineral assemblages display sieve texture, synneusis and resorbed crystals in Plag phenocrysts (An41-An53), whereas oscillatory and reverse zoning found mostly in Niki's, Dafni's and Liatsikas lavas. Both Opx(En43.9-68.6,Wo3.0-5.4, Fs28.7-36.3) and Cpx(En38.0-46.2, Wo20.8-45.2, Fs18.5-36.9) were found in all lava flows. They usually are zoned with Mg-rich core (especially in Niki's lavas), whereas some Dafni's lavas comprise unusually P-rich Cpx and pigeonite crystals within the groundmass. Olivine (Fo50.4-79.2- Fa20.7-48.1) is present, except in enclaves, as xenocryst in lavas of all eruptive periods. The amount of Fe-Ti oxides is decreasing with time. XRD and RAMAN analyses on whole-rock and minerals disclose minor differences in Plag and Cpx compositions and quantities. RAMAN results indicate tiny inclusions of Cpx and Opx within Plag as well as magnetite and apatite within Cpx and Plag. So, the common mineral crystallization sequence comprises Fe-Ti-oxides± Apatite□Pyroxenes□Plagioclase. In addition, the data obtained by ICP-MS major, trace and rare earth element analyses show remarkable stability, though some exceptions exist. Specifically, major and trace elements such SiO2=65,12±1.8%wt.,TiO2=0,80±0.02%wt., MgO=1,46±0.05 %wt. and Zr=192,45±0,05ppm remain practically constant between lavas of all three eruptive phases. The most obvious exception is in the gradually increased Pb content in various lavas

(max. in Niki's lavas), displaying as a positive anomaly in rock/primordial mantle patterns. This anomaly, which as increases may indicate more and more shallow crustal contamination, accounts for a slightly heterogeneous magma chamber. Significant negative anomalies in Ba, Nb-Ta and Sr, as well as LIL and LREE enrichment in the lavas of all eruptions are characteristic of the subduction setting and its fluids. In opposite, uniform distribution of the negative Eu anomaly is due to similar quantities of plagioclase fractionation.

The overall evaluation of the data obtained suggests notable constancy or slight changes in chemistry and mineralogy of lavas of the 20th century, the latter being mostly attributed to minor variations in the magmatic differentiation and magma chamber physicochemical conditions. On the other hand, the significant decrease with time in volume of all products (solid: Dafni=857x103m3, WW2=690x103m3,Liatsikas=8x103m3and gases (SO2): Dafni=108m3, Liatsikas=7x104m3), duration(Dafni=949days, WW2=711days, Liatsikas=24days)and explosivity index (VEI: Dafni<4, Liatsikas<1), can be ascribed to a declining dynamic of the upper magma chamber and perhaps gradually limited feeding from the lower one. Based on the time which the volcano has remained dormant since 1950 and on all the above data we consider with due caution that the restricted arrest and magma chamber movements noticed in Santorini during 2012 is rather a continuation of the decreasing volcanic activity during the 20th century than a start of a new cycle of explosions.

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The emergence and growth of a submarine volcano: the Kameni islands, Santorini (Greece)

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The morphology of a volcanic edifice reflects the integrated eruptive and evolutionary history of that system, and can be used to reconstruct the time-series of prior eruptions. We present a new high-resolution merged LiDAR-bathymetry grid, which has enabled detailed mapping of both onshore and offshore historic lava flows of the Kameni islands, emplaced in the centre of the Santorini caldera since at least AD 46. We identify three new submarine lava flows: two flows, of unknown age, lie to the east of Nea Kameni and a third submarine flow, located north of Nea Kameni appears to predate the 1925-1928 lava flows but was emplaced subsequent to the 1707-1711 lava flows. Yield strength estimates derived from the morphology of the 1570/1573 lobe suggest that submarine lava strengths are approximately two times greater than those derived from the onshore flows. To our knowledge this is the first documented yield strength estimate for submarine flows. This increase in strength is likely related to cooling and thickening of the dacite lava flows as they displace sea water. Improved lava volume estimates derived from the merged LiDAR-Bathymetry grid suggest typical lava extrusion rates of ~ 2 - 3 m^3s^{-1} during four of the historic eruptions on Nea Kameni (1707-1711, 1866-1870, 1925-1928 and 1939-1941). They also reveal a linear relationship between the pre-eruption interval and the volume of extruded lava. These observations may be used to estimate the size of future dome-building eruptions at Santorini volcano, based on the time interval since the last significant eruption.

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A quarry mark from ancient Thera

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A quarry mark of the type of Window or Gate appears in the archaic quarry of Peleketo in Mt. Profetes Elias on Thera, as well as in the Minoan quarry of Ta Skaria in Palaikastro, Crete. Both are incised on rocks and not on cut blocks, the latter being almost double in size than the former. The absence of Minoan strata in the area of ancient Thera is further attested in the case of Peleketo quarry by the presence of two archaic names inscribed under the quarry mark. If these quarry marks from Thera and Crete are considered to be contemporary, then the Minoan character of all the quarries at Ta Skaria could be disputed. The quarry mark from Crete was engraved close to Quarry E, which seems to have been one of the last areas of extraction, since many half-finished blocks lie in situ. A possible sea route that connected 7th century Thera with the eastern coast of Crete is echoed by Herodotus (IV 151-152), in the story about the Theran messengers who arrived at Itanos and were led to Libya by the *porphyra* fisherman Korobios. These quarry marks could then be interpreted as indications of a company of builders that moved from place to place after having undertaken a project of quarrying and building stones in different city-states. Such is the case of "κομπανίες" or "μπουλούκια" in Epirus and the Peloponnese, whose activities date from the 18th century until 1960.

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Suddenly that summer-paleoecological results from the Akrotiri excavations

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The Plinian volcanic eruption, which destroyed the settlement of Akrotiri on the island of Thera, has led to unique preservation primarily by charring of organic remains from the Bronze Age settlement. The palaeoecological information concentrates primarily around materials from inside the site as opposed to reconstructing the natural environment and provides refined details about faunal and floral assemblages related to site occupation. Information, however, has also been obtained from the insect record relating to local extinctions, such as, for example, the recovery of the blind weevil, Amaurorhinus bewickianus. Multidisciplinary investigations have pointed to information about variable preservation from Akrotiri which ranges from charring to calcification. Archaeobotanical and palaeoentomological results with an emphasis on autecology, biogeography, cultivation patterns and storage methods have produced new data concerning the exact dating of the volcanic eruption which destroyed the settlement. The taphonomy and preservation of remains of the bean weevil, Bruchus rufipes, pests of pulses, from the storage jars of the West House at Akrotiri indicates that the time of death of this assemblage as a result of the eruption could have been in the summer, after the harvest, shortly after this material was transported into the West House storeroom. From this insect material, the use of a new pre-treatment methodology for dating chitin has produced a date of 1744 - 1538 BC for the eruption. This date is within the range and narrows the dates obtained from pulses, from the same context. It, therefore, confirms the utility of chitin as a dating material. Future investigations from both pristine contexts in the settlement, and natural contexts with adequate preservation could provide more information about the Bronze Age eruption and the longer term history of the island.

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Aspects of the History of Santorini – 20th century

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The fame of Santorini, in recent years, is maintained and is developed from cause of her big tourist growth but also of her geological formation. Scientific published studies that have been focused essentially on the field of geology, history, prehistoric archaeology and shipping. The island has been to highlight particularly interesting points in the field of education and in various other sectors that have not been investigated to date as it should be (folklore, architecture, church history, etc.). One of these points is the emergence of history of the 20th century on the island.
In the historical context of the 20th century: The events taking place in Santorini are still based on Greek history (war, refugees, etc.), but also the three volcanic eruptions (1925, 1939-40, 1950) for which there are many detailed descriptions, since scientists had more convenience and mobility to research them. The gleaning of data that will be shown briefly are on the field of archeology (Hiller von Gaertringen), General History (Second World War - Refugees from Asia Minor), Local History (1956 Earthquake – tourism development) Education - welfare system (Eye Clinic – Antitracho School). This presentation will contribute to the objectives of the conference and the wider promotion of the history of Santorini.

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The fossil flora of Santorini Island

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Santorini is part of the Cycladean Volcanic Arc. During the last ca. 200000 years, twelve major and numerous minor eruptions produced the Thera Pyroclastic Fm. (Druitt et al., 1989). The caldera walls of Thera consist of lavas and pyroclastics with very characteristic pumice layers. A plant layer above the so-called Middle Pumice Series contains well-preserved plant fossils. The age of this layer has initially been estimated at 37 to 35 ka based on a radiocarbon age of carbonized wood (Pichler and Friedrich, 1976) but has later been revised to ca. 60 ka (Friedrich and Velitzelos, 1986).
Fossil plants from Santorini have first been described by Lacroix (1896), who recognized Chamaerops, Phoenix, Pistacia and Olea. A few more taxa have later been recognized (Friedrich, 1980). Of these, all are also found in the Mediterranean region today and Phoenix, Olea and Pistacia spp. are currently native to Crete. Chamaerops is a monotypic genus of palms confined to southwestern Europe (eastwards to Italy) and Northwest Africa. It grows in arid environments in southwestern Spain and as part of meso-Mediterranean vegetation along the North African coast, partly in connection with deciduous oaks, *Quercus canariensis* Willdenow (T. Denk, personal observation). The occurrence in Santorini is interesting as it demonstrates the circum-Mediterranean distribution of this plant until the latest Pleistocene. This is in accordance with the Cenozoic record of Chamaerops (Kolakovsky, 1964). Two new records for the Pleistocene of Santorini are presented: *Rhamnus alaternus* and *Coriaria myrtifolia*.

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