An Innovative Platform for Virtual Underwater Experiences Targeting the Cultural and Tourism Industries

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VIRTUAL DIVER: An Innovative Platform for Virtual Underwater Experiences Targeting the Cultural and Tourism Industries

in a nutshell

The underwater environment beyond its natural unique beauties has a great scientific interest as it pertains all fields of marine research; despite this, it has not been adequately exploited for cultural and tourism purposes. Virtual and augmented reality technologies have advanced considerably in re-producing and re-presenting unreachable large-scale environments. To this end, this work presents an integrated interactive framework for exploring the underwater world such as submerged cities, shipwrecks, sunken harbors, diving and marine parks, either in situ via augmented reality, or remotely via virtual reality. The developed framework, named VIRTUALDIVER, will enable domain experts to design immersive xReality experiences and users to experience environments that are typically accessed only by underwater vehicles in cost-intensive, scientific missions. This will promote the underwater cultural heritage, and natural environment through the development of innovative research, teaching, tourism and creative products.

current
projects
and events.

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Scope of VIRTUAL DIVER

The development of an innovative product for the provision of specialized services in tourism, with emphasis on marine, diving and cruise tourism.

The combination of research results of underwater surveys along with terrestrial data and their exploitation in the creative – cultural industry.

The creation of a complex Digital Platform for the realization of Virtual Experiences and the narration of various narrative scenarios.

The development of a Mapping Methodology and 3D Visualization of the underwater area, emphasizing on the interpretation of the geological / geomorphological structures of the Greek seabed and its spatial connection to the coastal surface for the needs of Virtual and Augmented Experience.

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The Santorini volcanic complex was chosen for the application of the interactive platform, as it is one of the most visited destinations in Europe.

Volcanism in Santorini started about 2 million years ago with the extrusion of dacitic lavas from vents in the area of Akrotiri. The most characteristic type of activity over the last 200.000 years has been the cyclic construction of shield volcanoes interrupted by large explosive and destructive events. **The present-day caldera is a multiple structure formed by at least four collapses over 180 ky, the last of which was associated with the LBA eruption.**
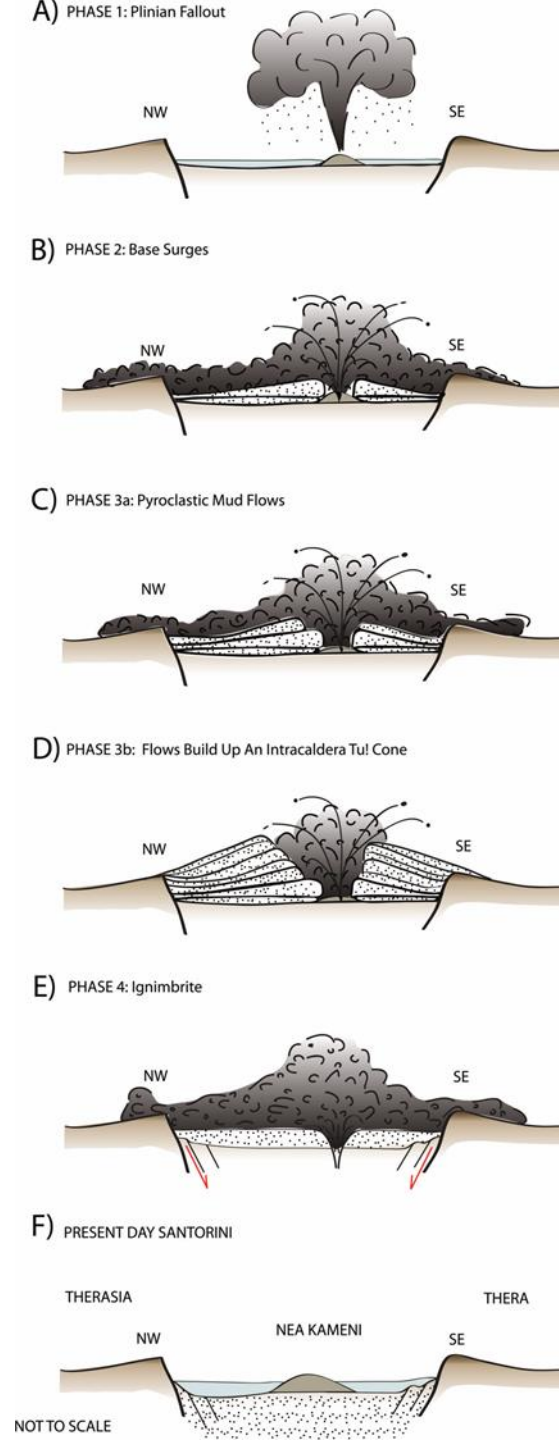
(Druitt et al. 1999)

Simplified geological map of Santorini

Second explosive cycle
- Kameni volcano
- Minoan Tuff
- Therasia dome complex
- Skaros shield
- Cinder cones of Megalo & Kokkino Vouno Cape Columbos tuff ring
- Pyroclastic deposits
- Products of First explosive cycle (mainly pyroclastic)
- Cinder cones of Akrotiri Peninsula
- Peristeria volcano
- Early centres of Akrotiri Peninsula
- Basement massif

Akrotiri

Akrotiri

Skaros

Thirassia
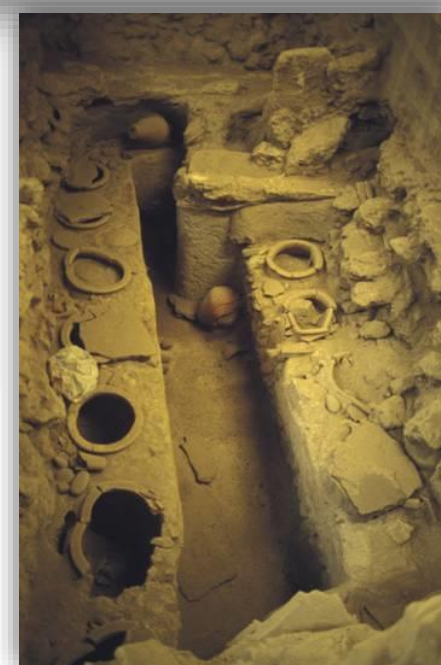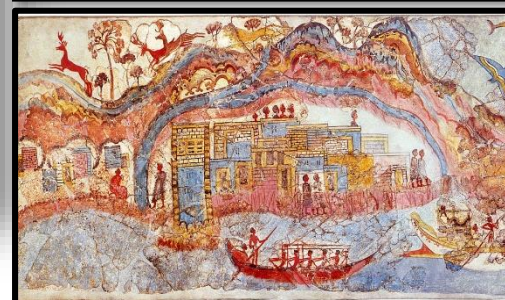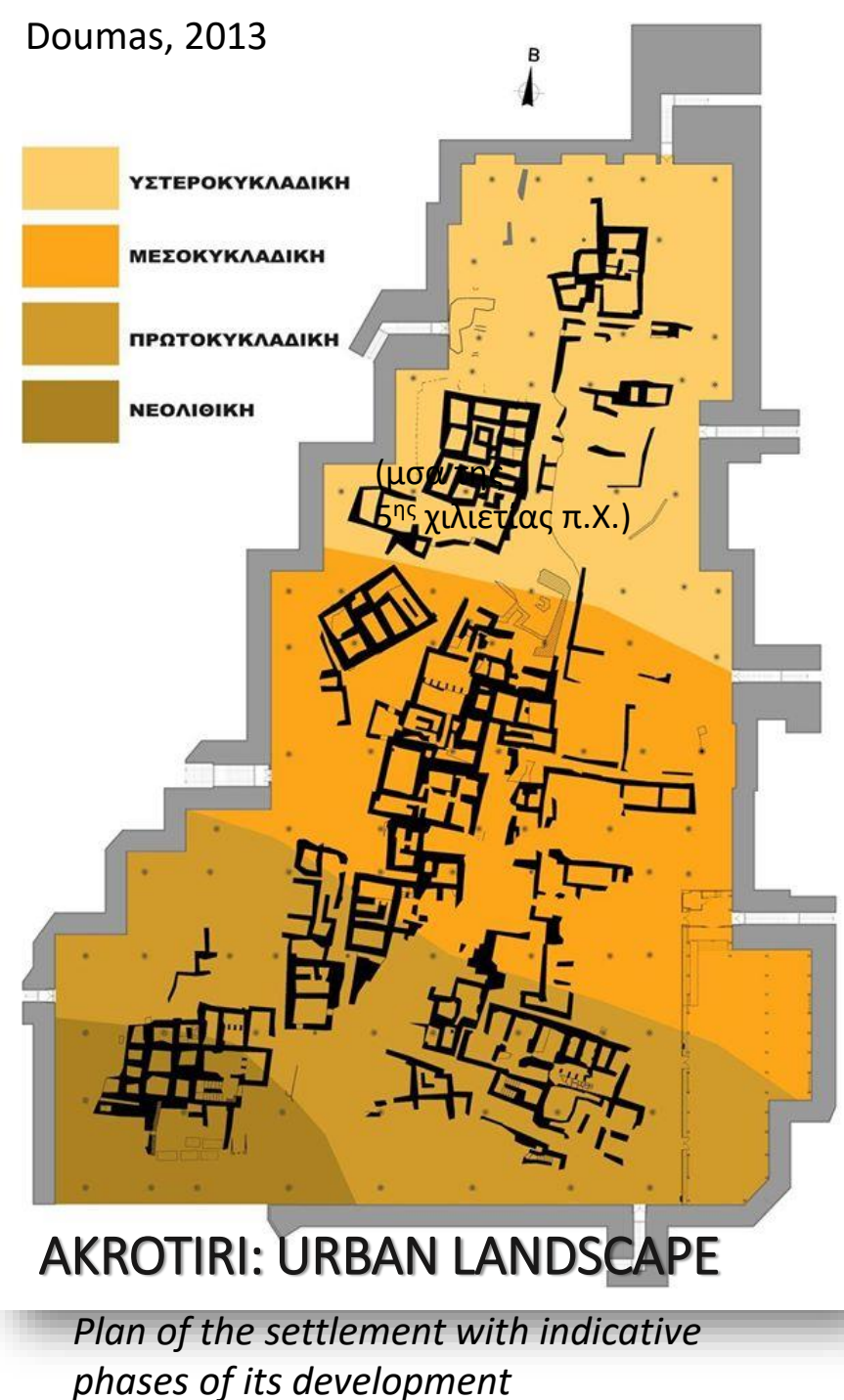
The Late Bronze Age (LBA or 'Minoan') eruption

The ***Minoan eruption*** happened around **1610 BC** in the Late Bronze Age. It was one of the largest **Plinian** eruptions in younger time resulted in rainstorms of lapilli, bombs and fiery cloud flows merging into the sea. The height of the plinian eruption column is estimated **36-39 km** (Pyle, 1990), with an estimated **VEI of 6**. The eruption was followed by collapse of the magma chamber that enlarged an existing caldera. Recent marine seismic survey reveals a sediment sequence on the ocean floor around Santorini that is generally massive or chaotic as is typical of submarine pyroclastic flow deposits. This sequence has a thickness up to about 80 meters in areas close to the coast of Santorini corresponding caldera collapse volume to be about **55 km³** (Sigurdsson et al, 2006). Recent studies reveal Minoan eruption deposits to **78–86 km³**, making it **the largest known Holocene eruption** (Johnston et al., 2014).

- Preceded by 18,000 y of repose
- Late 17th century BCE
- Five phases, P0 to P4
  - P0 - precursory explosions
  - P1 – plinian fallout
  - P2 & P3 – phreatomagmatic
  - P4 – pyroclastic flows

- 30-80 km³ dense-rock equivalent
- Environmental effects
1. Destruction of a Bronze-Age town
2. Tsunamis to northern Crete
3. Ash fallout over Middle East
4. Tropospheric cooling of <1 °C
5. Stratospheric ozone depletion

Druitt (2014), Johnston et al., (2015)

A) PHASE 1: Plinian Fallout
NW SE

B) PHASE 2: Base Surges
NW SE

C) PHASE 3a: Pyroclastic Mud Flows
NW SE

D) PHASE 3b: Flows Build Up An Intracaldera Tuf Cone
NW SE

E) PHASE 4: Ignimbrite
NW SE

F) PRESENT DAY SANTORINI
THERASIA   THERA
NW   NEA KAMENI   SE
NOT TO SCALE

Phases 1-3 (c)
Pre-Minoan P1 P2a P2b P3

Phase 4 (d)
P4 P3

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ΥΣΤΕΡΟΚΥΚΛΑΔΙΚΗ

ΜΕΣΟΚΥΚΛΑΔΙΚΗ

ΠΡΩΤΟΚΥΚΛΑΔΙΚΗ

ΝΕΟΛΙΘΙΚΗ

(μέσα της 5ης χιλιετίας π.Χ.)

AKROTIRI: URBAN LANDSCAPE

Plan of the settlement with indicative phases of its development

The wide excavation which occurred at Akrotiri in Santorini has uncovered one of the most important prehistoric settlements of the Aegean Sea. The great development and prosperity of the settlement are proven by its large extent (ca. 20 hectares), the **elaborate drainage system** and the sophisticated **multistoried buildings** with the magnificent **wall-paintings**, **furniture** and **vessels**. The various imported objects found in the buildings indicate the wide network of its external relations. Akrotiri was in contact with Crete but also communicated with the Greek mainland, the Dodecanese, Cyprus, Syria and Egypt.

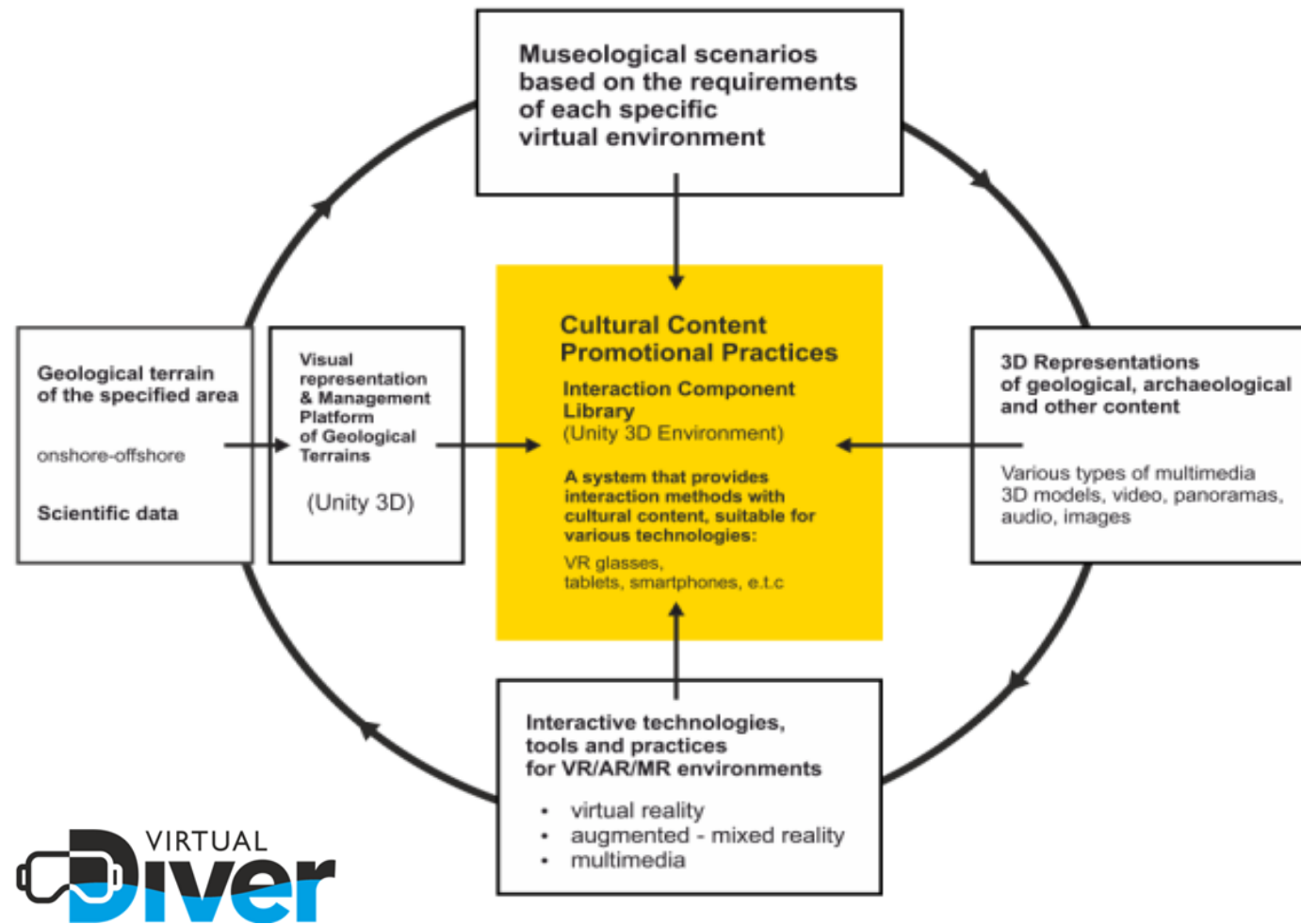*The unique landscape of Santorini volcano*

Diving within the most active caldera of the world

Photo credits to Vlasopoulos O.

VIRTUALDIVER platform is a unified design solution for developing interactive experiences for the cultural and tourism sector. The platform integrates cutting edge VR and AR technologies combined with a designer-friendly multimedia management workflow methodology as a toolkit for building and visualising interactive narratives.

Overall structure of the developed VIRTUALDIVER framework

Museological scenarios based on the requirements of each specific virtual environment

Geological terrain of the specified area

onshore-offshore

Scientific data

Visual representation & Management Platform of Geological Terrains

(Unity 3D)

Cultural Content Promotional Practices

Interaction Component Library
(Unity 3D Environment)

A system that provides interaction methods with cultural content, suitable for various technologies:

VR glasses, tablets, smartphones, e.t.c

3D Representations of geological, archaeological and other content

Various types of multimedia 3D models, video, panoramas, audio, images

Interactive technologies, tools and practices for VR/AR/MR environments

- virtual reality
- augmented - mixed reality
- multimedia

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(Nomikou et al, 2020)

VIRTUALDIVER platform will be available as a provided service from the project's consortium. The project's goal is to shape a new unique tourism product internationally, promoting the enormous onshore and offshore cultural reserve of Greece. In addition, it will raise the value of the platform's clients (municipalities, ministries, cultural institutions, etc.) and bring increased revenue to the region of application.

Multimodal mapping for VR

Capturing of real-world scenes in 3D models for the visualization in VR is based on a multimodal Mapping Methodology:

**i)** a methodology and the system of acquiring heterogeneous-bathymetric, visual and multi-spectral data

ii) an innovative Structure-from-Motion approaches that compensate the refraction in underwater image creation for 3D reconstruction of small details and adopting incremental approaches to deal with a large number of images

iii) a combination of image processing techniques to restore the warm colors of underwater scenes that suffer from light absorption in water

iv) co-registration algorithms to combine heterogeneous data for the creation of novel texture for the reconstructed 3D models and photomosaics

v) classification of multispectral data using deep learning algorithms for recognizing geological materials and create new synthetic texture for seabed models

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Onshore Data
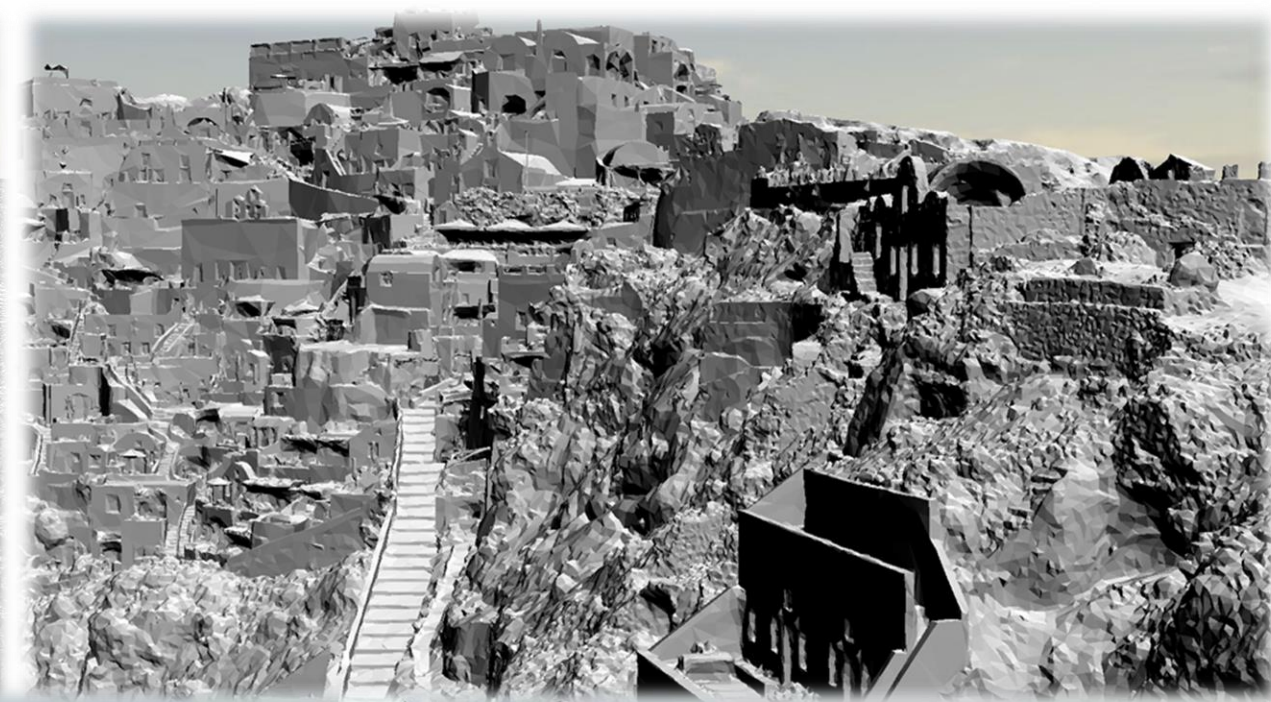
Data acquisition is based onUnmanned Aerial Vehicles (UAV) for the acquisition of the more detailed visual and multispectral data. These latter can accurately capture the volcanic geomorphology and the steep internal slopes of Santorini's caldera, as well cultural heritage details. The 3D Virtual Representations (single elevation model, 3D detailed photo-textured models and geological maps) are of high-resolution, but simplified geometric structure in order to constitute the detailed background of the Interactive Platform for the implementation of Virtual Experiences.

Santorini is a **Natural Laboratory** 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.

R/V AEGEAO: 2001, 2006, 2012, 2013, 2014
R/V ENDEAVOR: 2015
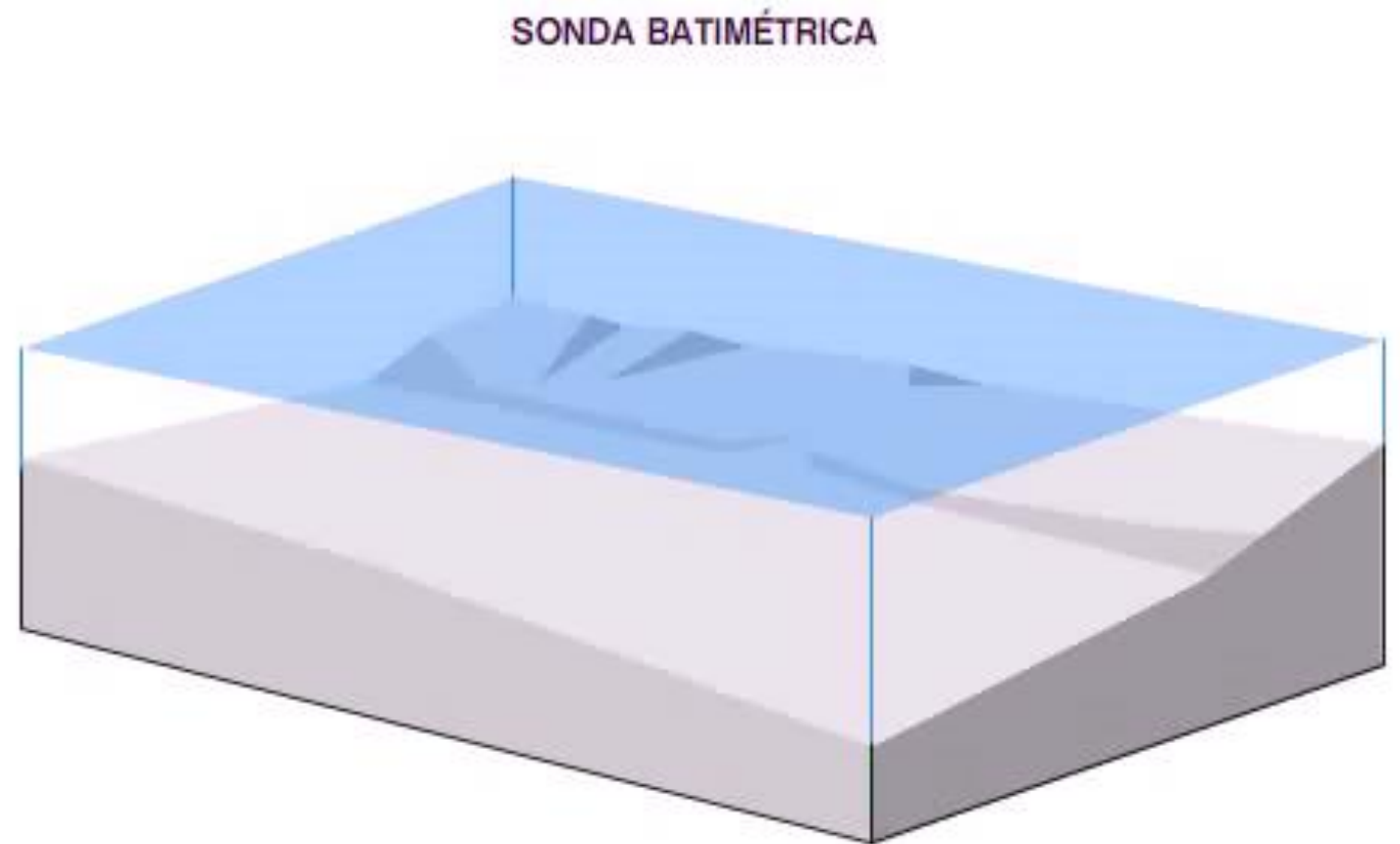E/V NAUTILUS: 2010, 2011
R/V MARCUS LANGSETH: 2015
R/V POSEIDON: 2006, 2017, 2019
YPAPANTI shuttle boat: 2015
OCEAN LINK: 2019

VIRTUAL Diver

(Nomikou et al, 2014)
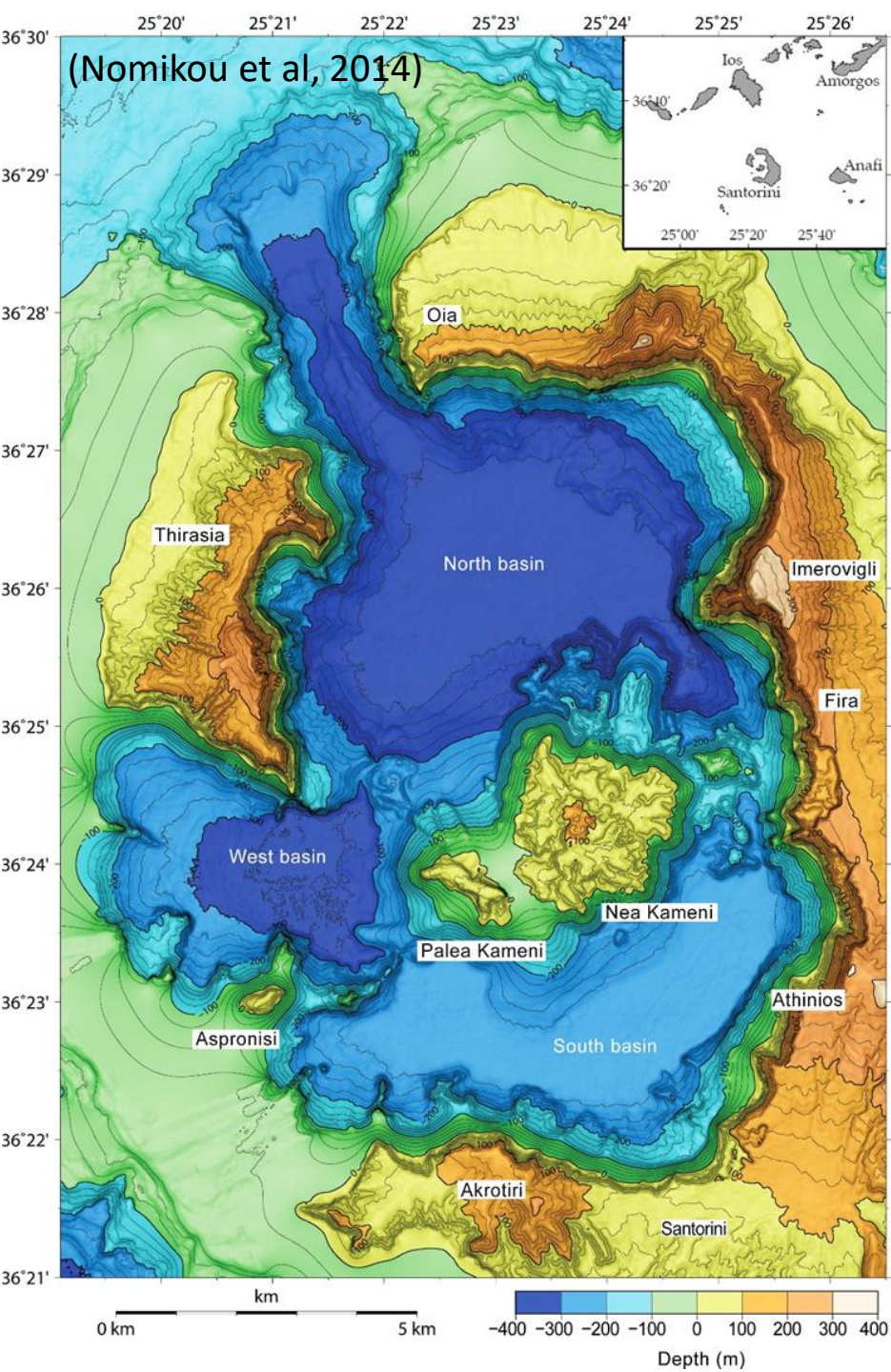
Onshore Data

SONDA BATIMÉTRICA

La sonda batimétrica permite realizar mapas batimétricos de detalle.
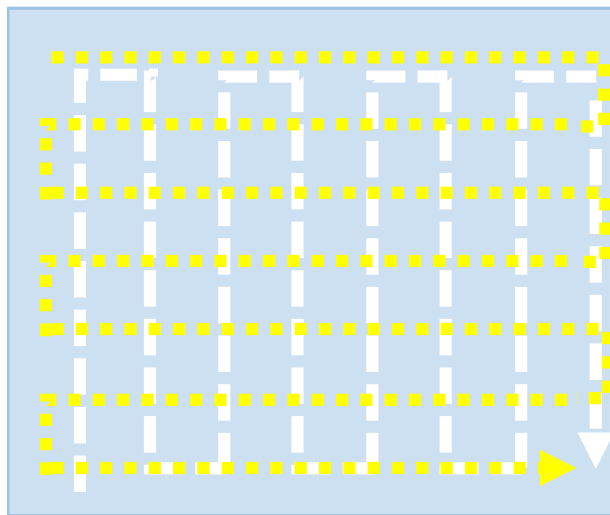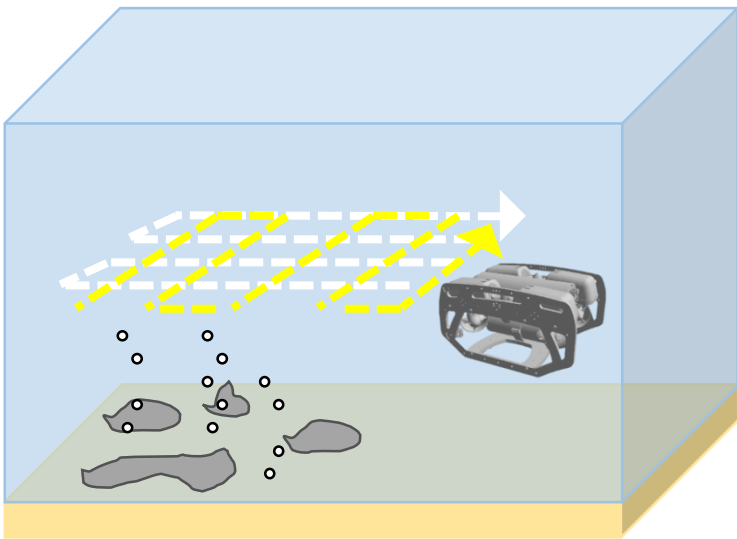Aprieta el botón para ver como funciona.

The data acquisition is based on high-resolution bathymetric systems (multibeam systems) for the larger part of the Santorini's caldera seafloor.
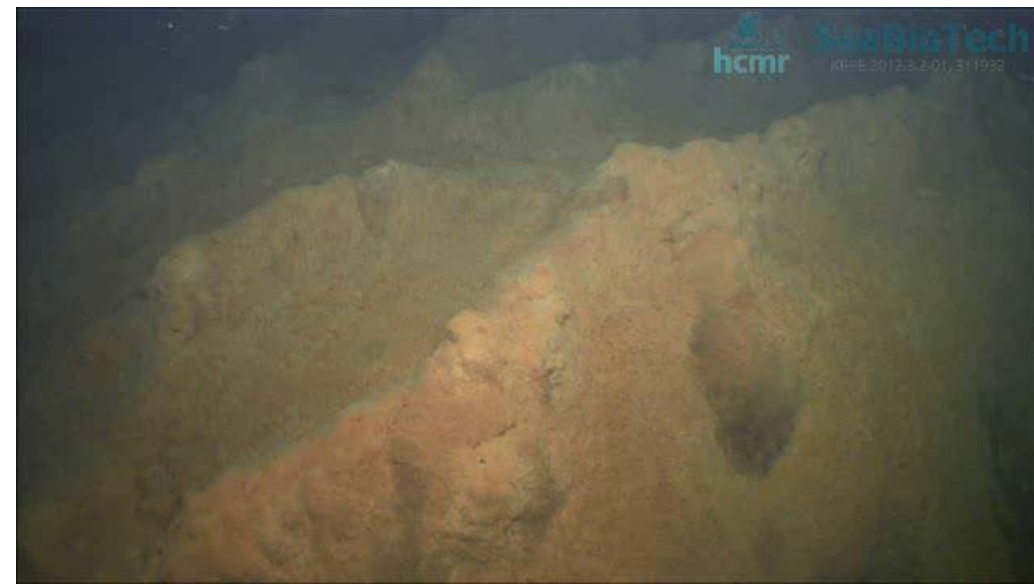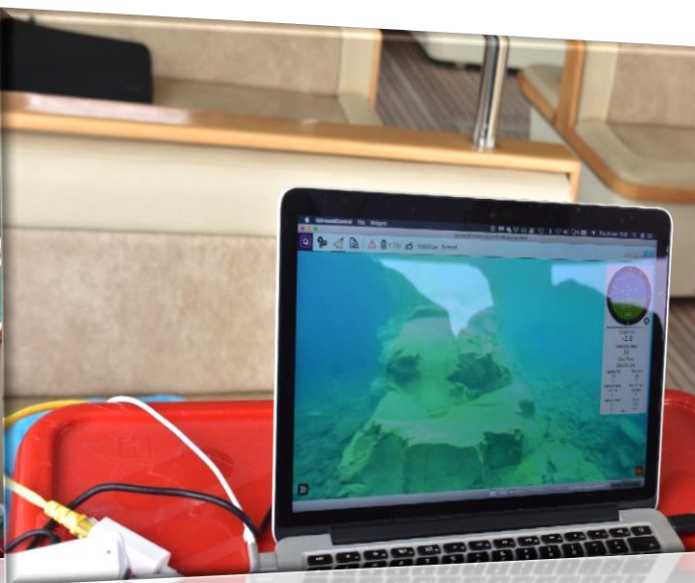
ROV missions within Santorini caldera
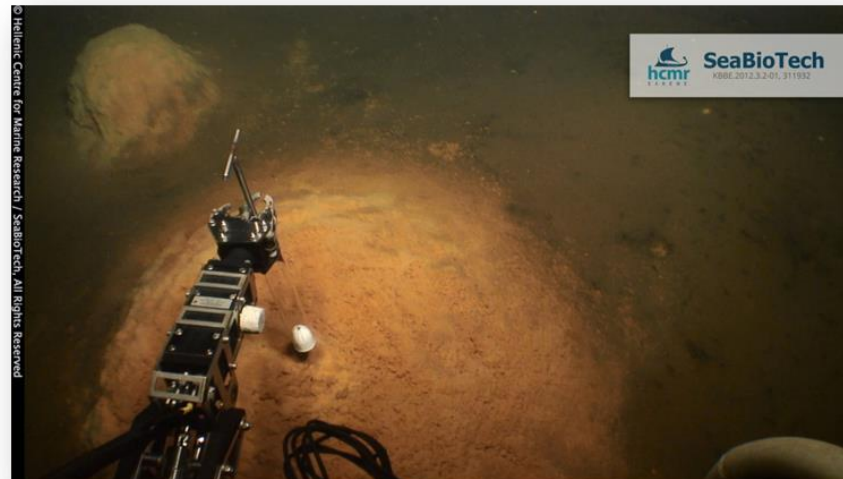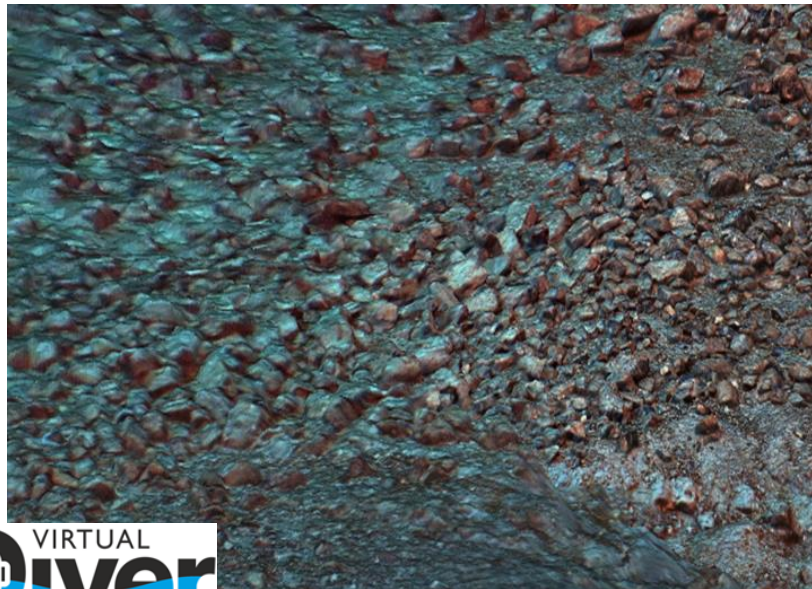
Exploring offshore geomorphological features using low-cost ROV and photogrammetric techniques

The use of low-cost, Remotely Operated Vehicle (ROV) and underwater photogrammetry techniques, Structure from motion (SfM) for 3D reconstruction of caldera's sea floor.

In **VIRTUAL DIVER**, images captured by drone and ROVs using open-source 3D reconstruction software (Colmap, Meshroom) were processed, combined with custom algorithms.
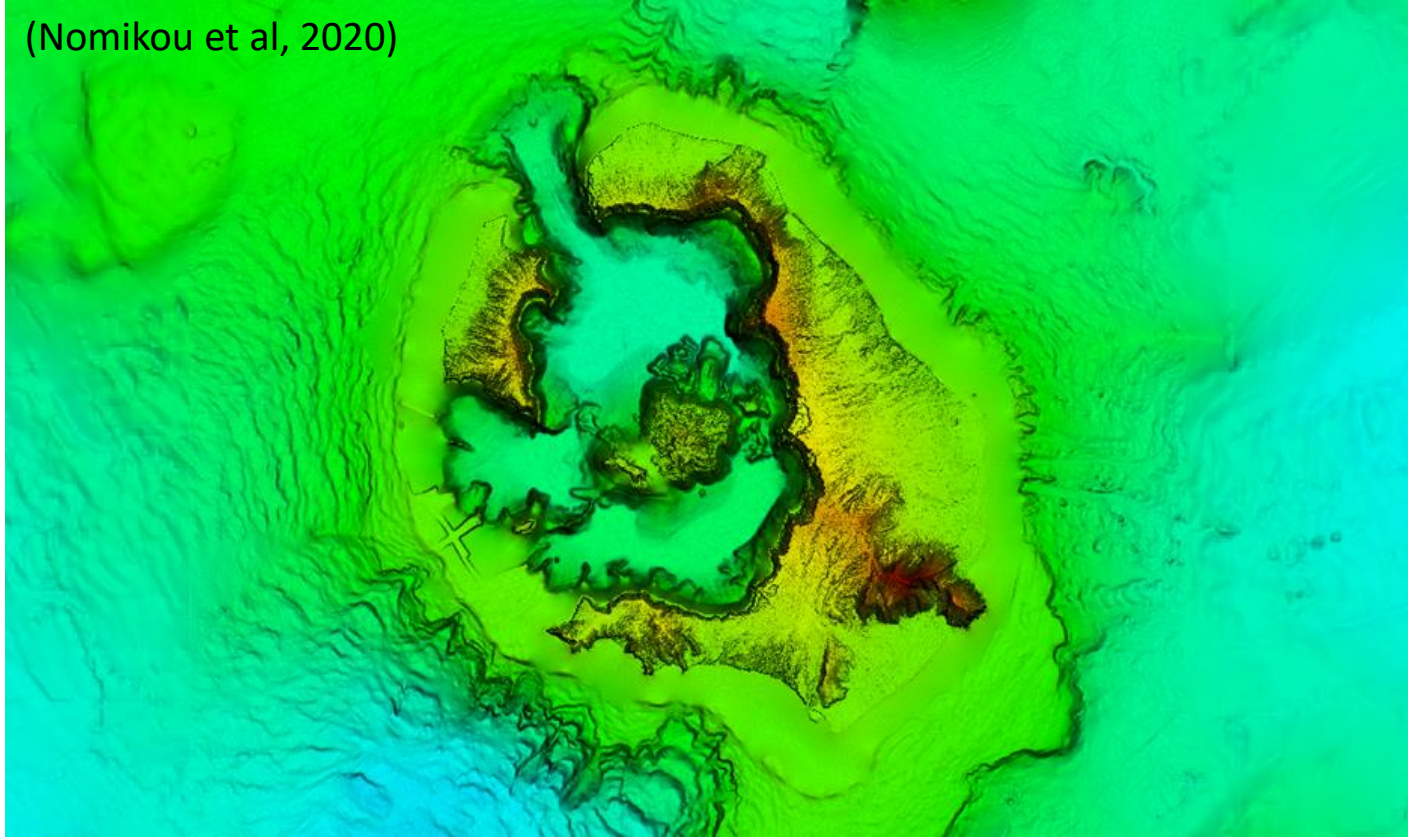

Drone Images

ROVs images

(Nomikou et al, 2020)

Bathymetric data

LIDAR data

STRM data

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VIRTUALDIVER METHODOLOGY

The methodology developed by our team consists of three main steps.
➤ Initially, bathymetric and SRTM data were scaled down to meet the smallest resolution of our dataset (LIDAR).
➤ Afterwards, the elevation data were combined based on the slope of the relief which also considers a buffer area aiming to a smoother terrain. Although this minimizes the spikes and the steep effects on the terrain, it can lead to ambiguities, so particular attention is required.
➤ Finally, the surface data and the WorldView4 imagery are combined applying the well-known nearest neighbour matching technique leading to the final terrain background.

In **VIRTUALDIVER**, the platform is being developed on the Unity 3D technology, one of the most widespread platforms for designing, development, and implementation of interactive 3D environments, and will consist of two interconnected systems:
  (i) management of 3D terrains and their relevant metadata
  (ii) implementation of narrative scenarios

WorldView4 imagery of Santorini volcano combined with surface data

The **goal** is the management unit of the 3D terrains to be able to import and manage single seabed and terrestrial topography, while subsequently the interactive platform will be able to provide a series of specially developed tools aiming for a designer's friendly workflow of VR interactive experiences production.
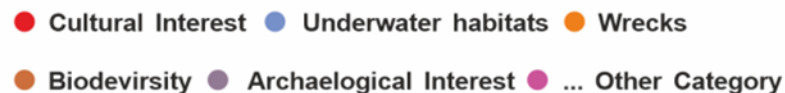
Interactive platform development

VIRTUALDIVER Interaction platform is developed using the Unity Real-Time Development Platform and acts as an add-on for the platform dedicated for developing interactive experiences.

Creation of geo-ecotourism scenarios, educational material and productions and their interconnection through the interactive platform

(Nomikou et al, 2020)

Narrative scenarios, multimedia educational material for selected points of interest, and a series of audiovisual products are being created to be used to produce interactive experiences. Each scenario in the VIRTUALDIVER platform consists of a number of points of interest, categorized according to their characteristics such as: tourist interest, geological interest, marine ecosystem, archaeological site, etc. To illustrate each point of interest, the design team use a range of interaction components for the exploitation of multimedia content, each of which will correspond to a different type of data (e.g. image, audio, video, panoramic images and videos, 3D objects, use of 360 video footage, panoramic and drone photos, 3D animation, interactive maps, interactive timelines, explanatory interactive diagrams, specially designed soundscapes, etc.)

User Interface Design

The interactive components were complimented with a set of UI designs that promote simplicity and ease of use. The goal was to give the design team a familiar User Interface to work with in order to create seamless interactive narratives. The same design principles were applied to all the interactive components (visual and functional consistency) providing thus a unified experience for the design team.

(Nomikou et al, 2020)

Concerning the end users' needs and requirements, a set of UI designs was implemented, based on best practices for VR User Interface design combined with academic research from the HCI field specialized in VR application development. Based on research literature concerning head movement and hand usage in VR, a set of ergonomic interaction rules was defined, thus making the overall VR experience more comfortable. Based on those design rules, an interactive tool bar was designed and developed that makes it easier and more intuitive for the user to explore interactive multimedia content and navigate between narratives.
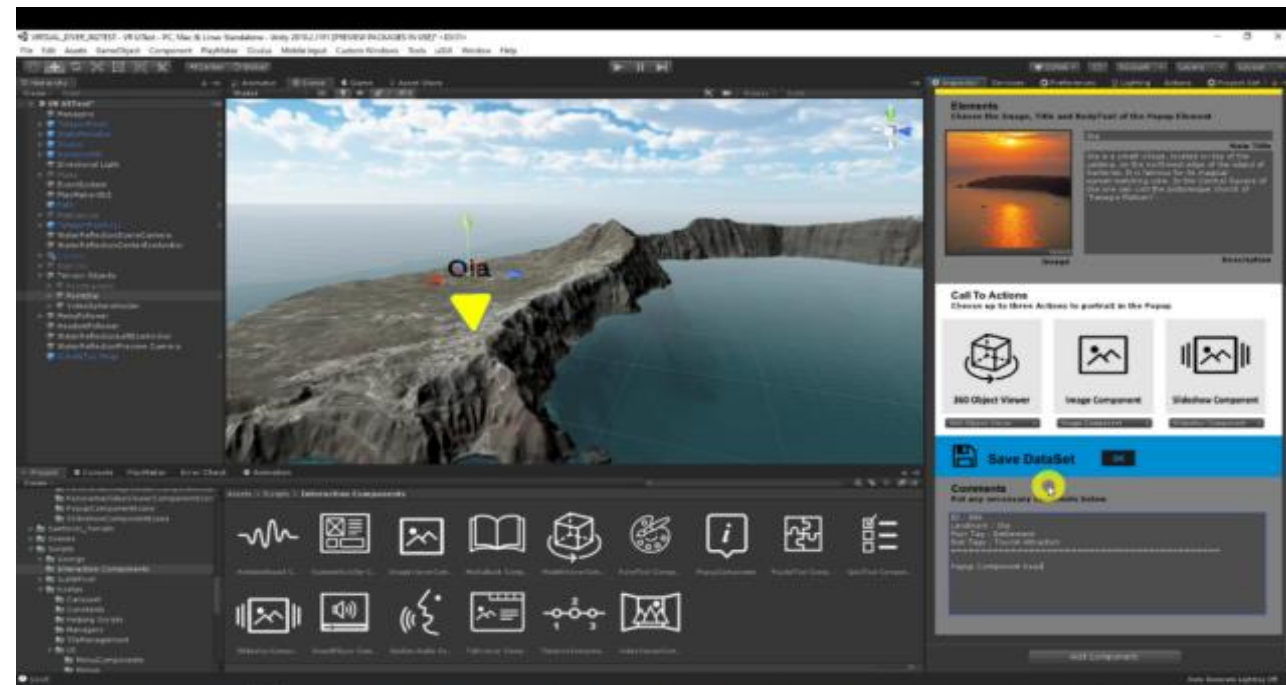
Tablets Smartphones	VR Headset	VR Headset + Specialized peripherals
in-situ interaction	hotels, cruise boats, from home	hotels, cruise boats, specially designed space
experience	**experience**	**experience**
• geolocation • augmented reality • 3D content • multimedia	• narrative immersion • surround sound • 3D content • multimedia	• narrative immersion • surround sound • emphasis on kinaesthetics (fly,dive) • 3D content • multimedia

• for mainstream use	• special use	• very special use
needs typical tablet/smartphone ideal solution for mass tourism	**needs VR glasses** would be mainstream in 3 years	**needs VR Glasses + Specialized peripherals** already commercialized as setup

The platform will be able to assimilate real (or virtual) environments with the help of different media such as tablets or virtual reality glasses, as well as more specialized peripherals. This product will be a tool for supporting businesses and professionals operating in the field of Culture and Tourism, enhancing special aspects of tourism such as cruises, diving, scientific and other.

Conclusions

- VD will promote technical and financial constraints on the creation of Virtual Experiences in the exciting submarine world, in order to be an attractive entertainment and cultural product that will be deployed by tourism and cultural institutions in Greece

- VD Interaction Platform will simplify the process of implementing the Integrated Virtual Experience - narrative scenarios, audio-visual productions and educational material – on the one hand for non-experts and, on the other hand, the creation of geospatial backgrounds and 3D visual information

- VD will address private (or non) operators with an innovative B2B service in order to boost their commercial value through the creation of a unique tourist product - experience of impressive virtual environments

- VD will establish a new approach to promoting the cultural and environmental supplies through enhancing special forms of tourism. Regarding the underwater environment, which is hardly accessible to the average visitor in Greece, VD will serve as a mediator for the perception of this particular aspect of the world that surrounds us.

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(Nomikou et al, 2020)

www.virtualdiver.gr

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Stay tuned...