Εκκλησία Μεσοχωρίου

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ΕΔΑΦΟΜΗΧΑΝΙΚΗΣ
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# Τα Νέα της Ε Ε Ε Ε Γ Μ

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Σεισμοί Θεσσαλίας – Φαινόμενα ρευστοποίησης
(Φωτ. Γ. Παπαθανασίου)

(αφιέρωμα στην σελίδα 3)

## Π Ε Ρ Ι Ε Χ Ο Μ Ε Ν Α

# ΟΙ ΣΕΙΣΜΟΙ ΤΗΣ 3ης & 4ης ΜΑΡΤΙΟΥ 2021 ΣΤΗΝ ΘΕΣΣΑΛΙΑ

## The northern Thessaly strong earthquakes of March 3 and 4 and their neotectonic setting

**Pavlides S., Chatzipetros A., Sboras S., Kremastas E. and Chatziioannou A.**

***Ηρόδοτος ο Αλικαρνασσεύς (****485-425 π.Χ.)*

*«...Ποσειδέωνα ποιήσαι τον αυλώνα (Τέμπη) δι' ου ρέει ο Πηνειός... εστι γάρ σεισμού έργον, ως εμοί εφαίνετο είναι, η διάστασις των ορέων (Ολύμπου και Όσσας)»*

***Herodotus of Alikarnassos*** (*Asia Minor today Bodrum*), *Historian* (485-425 BC),

*" . . .Poseidon created the gorge (of Tempi), from where the Pinios river flows . . . and it seems to me that this is the creation of earthquake (s), that is, the separation of the Olympus from Ossa mountains"*

The strong earthquakes (Mw 6.3 and mb5.8, CSEM-EMSC) of March 3 and 4 affected a large area, due to the surprisingly low dip angle of the causative fault plane. Surficial effects of the earthquake sequence consist of a variety of phenomena that were observed all over the area. Dozens of soil liquefaction occurrences , such as sand "craters" and flows (Fig. 1) were mapped in areas adjacent to Pinios and Titarisios rivers.

*Fig. 1. Examples of sand flow and craters in the liquefied area SE of Pineiada village.*

The first area is located between the villages of Koutsochero to Pineiada and Zarko, while the latter is less extended and is observed mainly in the area of Vlachogianni and Varko villages. The liquefaction phenomena were mapped in great detail with UAVs (Figure 2). Comparison with current and historical satellite images, show that in the area of Pinios river the liquefaction is clearly associated with older abandoned meanders of the river, indicating a differentiated composition, more susceptible to liquefaction (Fig. 3).


*Figure 2. Orthorectified image of the liquefied areas (gray spots). Images from a series of high flying UAV campaigns have been combined with orthophotos from the Cadastral project of Greece.*


*Fig. 3. A detailed UAV composite orthophoto (yellow border) overprinted onto a satellite image, clearly shows that the distribution of individual liquefaction features (gray spots) coincides with an abandoned and filled bend of Pinios river. The current riverbed is visible at the right part of the map.*

Field work and the analysis of interferometric information (Fig. 4 a,b, Foumelis pers. com.) show that the well-known and studied Tyrnavos fault (TF, Fig.4), as well as the Titarisios valley fault, which is the NW extension of the known Larissa fault (LF, Fig. 4), did not generate the mainshock, although they appear to have been triggered and partially activated by the main seismogenic fault as sympathetic structures.

Tyrnavos fault (TF, Fig. 4) is a typical geological structure similar to many others in the broader area (Caputo and Pavlides, 1993; Caputo, 1995; Caputo et al., 2004). It strikes West-Northwest and has a surficial length of 10-12 km. This fault is one of the best studied active structures in Greece for more than 30 years by the research team of "Geology of Earthquakes" of AUTh in collaboration with R. Caputo, Professor at University Ferrara and is included in the Greek Database of Seismogenic Sources (GreDaSS http://gredass.unife.it, Sboras, 2011; Caputo et al., 2014,

2012; Caputo and Pavlides, 2013; Sboras et al., 2014), in which it is described in detail. According to geological data, geophysical surveys and palaeoseismological excavations studying the geological history of the fault, a slow activity is documented, which is characterized by vertical surface co-seismic displacements of 20-40 cm and a possible recurrence period of about 1-2.5 ka, as well as a low slip rate of 0.05-0.25 mm/year. Its earthquake potential is estimated to M 6.1 to 6.3 (Caputo et al., 2004), based on the empirical relationships Ms *versus* SL of Pavlides & Caputo 2004 and Wells, and Coppersmith, 1994. The active deformation of the area is also well documented by recent primary geodetic data analysis (Chatzipetros et al., 2018; Lazos et al., 2020).

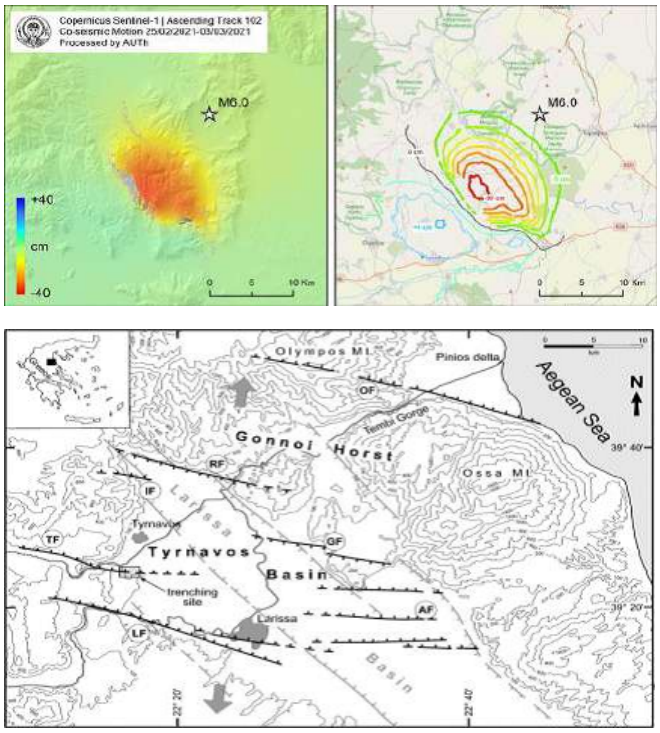


*Fig. 4. InSar maps* (a, b, Fumelis, AUTh) and *simplified map of the North Thessaly fault system* (a, b, Fumelis, AUTh, c, Caputo et al., 2004).

As far as the insofar unknown and unmapped seismic fault is concerned, fieldwork showed that there are characteristic geological indications in the Pelagonian bedrock, consisting of Paleozoic mica schist and gneiss (e.g. Kilias and Mountrakis, 1987; Kilias et al., 1991), indicating that a low angle normal fault has acted as a hidden or blind fault during the earthquake. It is associated with the bedrock schistosity, as well as with small high angle reverse faults of the Pelagonian anticline. The presumed seismic fault extends in the broader area between the villages of Zarko and Megalo Eleftherochori, as an inherited shear zone (Fig. 5). Geologic indications include outcrops of the post Alpine shear zone (Fig. 5a), located along the boundary between interferometrically-indicated uplift and subsidence terrains (fig. 4, that is 0 line of displacement), the existence of cataclasite and fault gouge in the shear zone (Fig. 5b), which indicates reactivation of the fault in brittle conditions during the neotectonic period (inverse tectonics) and slickenlines compatible with the active stress field. Fault surfaces strike at N160oE and dip at 50o on average which is in good agreement to the published focal mechanisms by Greek and other international Institutes. Co-seismic indicators include small, ruptured fault surfaces with detached rock slabs and pieces, as well as small-scale soil fractures following the trace of the mapped fault (Fig. 5c,d), with negligible vertical displacement and small heave (up to 2 cm).

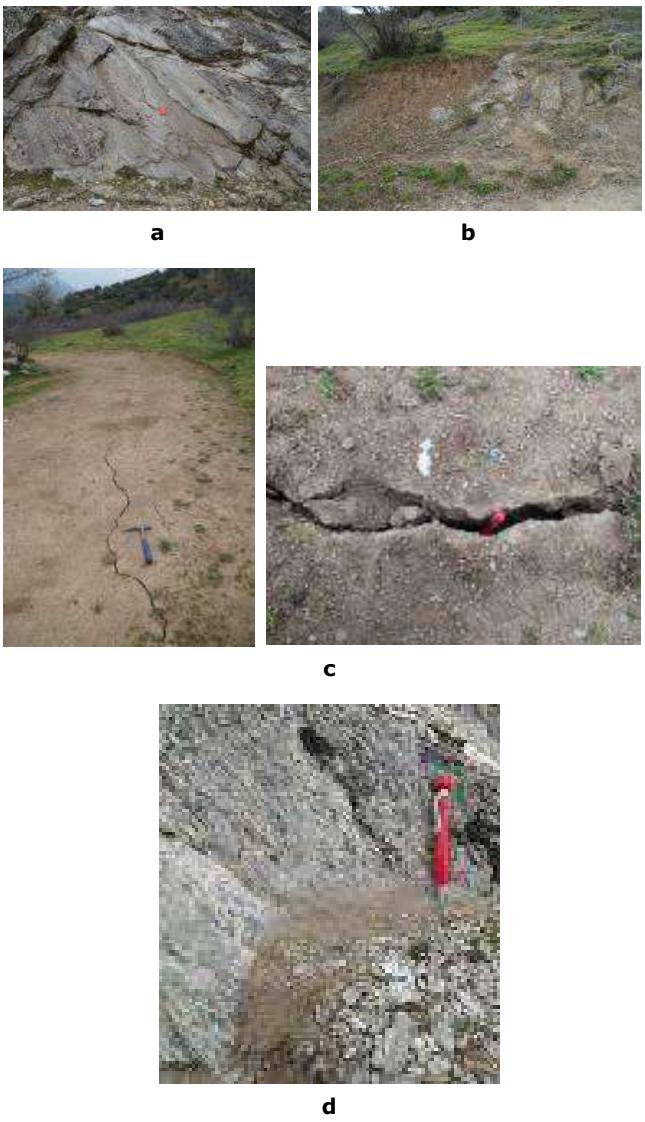


*Fig. 5. a. fault surface of the low-angle normal fault in the bedrock, believed to be a strand of the causative fault zone. b. a zone of intense brittle shearing, accompanied by fault gouge and cataclasite within the low-angle normal fault zone. c. coseismic surface cracks in the soil cover, following the inferred strike and location of the causative fault zone in the bedrock.*

The seismic fault model (seismic source) of the mainshock is based on the GFZ's moment tensor solution (strike, dip and rake), the scalar relationships of Wells & Coppersmith (1994; length and width), and the interferograms along with the site observations (position). The Coulomb static stress changes are calculated for receiver faults similar to the seismic source at a depth of 8 km. A vertical cross-section normal to the source's strike is also calculated. Results show stress-load beyond the tips of the fault, suggesting a triggering scenario for faults of similar geometry and kinematics located in this red area (Fig. 6). The northwestern edge of the fault (red-yellow) activated during the second event of 4th of March. The seismic source is also used to model the vertical displacement on the ground after using the Okada formulae (Fig. 7). The maximum calculated vertical displacement is 2.93 cm. Both Coulomb and Okada calculations were performed with the Coulomb v3.3 application (Toda et al., 2005; Lin & Stein, 2004).

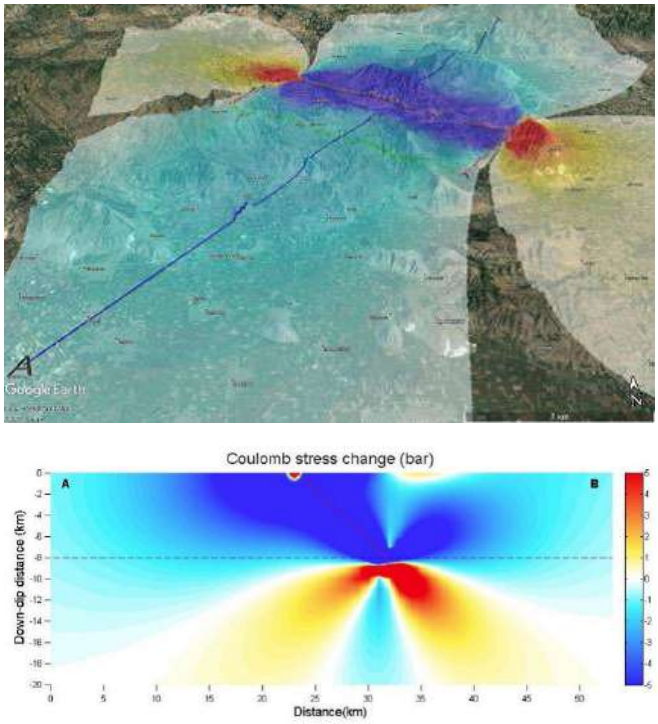


*Fig. 6. (a). The seismic fault model (seismic source) of the mainshock is based on the GFZ's moment tensor solution. The Coulomb static stress changes (seismic source at a depth of 8 km). (b) Vertical cross-section normal to the source's strike (A-B). Results show stress-load beyond the tips of the fault, suggesting a triggering scenario for faults of similar geometry and kinematics located in this red area.*

*Fig. 7. A preliminary model of the seismic source is showing vertical displacement on the ground*

Concerning the historical seismicity of the region, important details and revisions are included in Papaioannou (2017a, 2017b, 2018, 2019). During the 20th century a similar earthquake of magnitude 6.3 occurred in Larissa on March 1, 1941, exactly 80 years ago, with very serious damage to the city and the surrounding villages, mainly in the eastern Thessalian plain, which is associated to the "Asmaki" fault (Caputo Papaioannou, 2018), while another earthquake M5.6 occurred in the same area in November 1901, focusing on the village of Verdikousa, probably along the extension of the same fault. Another large earthquake in the broader area occurred on 1892 (Papazachos & Papazachou 2003; Ambraseys 2009; Papaioannou, 2017a, 2019), while there is information about an earthquake of 1781 of the same magnitude. A report of an earthquake of a similar magnitude in 1766 is disputed and revised in Papaioannou (2017b). Other active geological structures of the area within the Larissa plain include Gyrtoni, Rodia, Elassona, Gonoi, Tempi and Omolio faults (GreDaSS http://gredass.unife.it) which are currently being studied using advanced methods (satellite imagery, high resolution UAV models, geodetic, geological and paleoseimological ones; e.g. Tsodoulos et al., 2016, Kremastas et al., 2018). It is worth mentioning that the first to mention earthquakes as a possible cause of formation of Tempi valley, with the contribution of God Poseidon, is the historian Herodotus (485-425 BC).

Concluding this earthquake raises new questions and concerns, while revising some established views, such as:

(a) The status of active stress trends, (b) The direction of active tectonic structures, (c) The existence of a seismogenic fault in a mountainous volume of crystalline rocks without typical geomorphological expression. (d) The role of Blind Faults to Seismic Hazard Assessment

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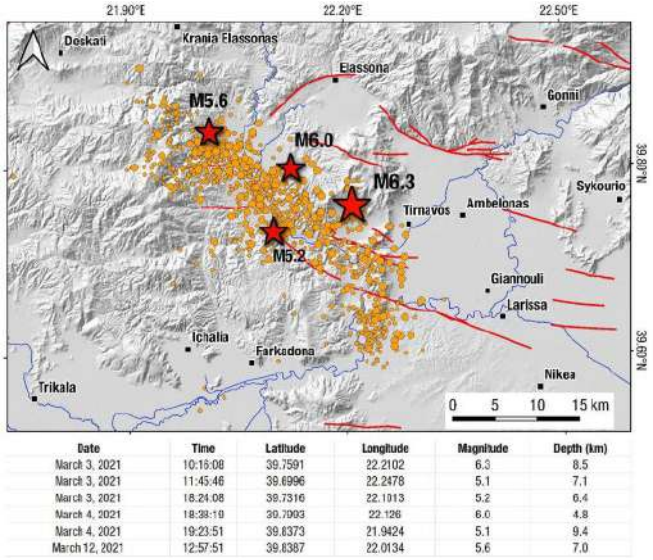
## Preliminary report of liquefaction phenomena triggered by the March 2021 earthquakes in Central Thessaly, Greece

**Sotiris Valkaniotis; George Papathanassiou; Athanassios Ganas; Evagellos Kremastas; Riccardo Caputo**

On the 3rd and 4th of March 2021, two strong earthquakes of M6.3 and M6.0, respectively occurred at Thessaly, Central Greece. During extensive field survey and mapping, accompanied by UAV aerial surveys, following the strong earthquakes, numerous (more than 400 cases) liquefaction-related features were identified, including sand blows and craters, fissures and lateral spreading cracks/ruptures along the Pinios and Titarisios river banks. A rapid documentation of these features was important, as most of these features were going to be erased or smoothed by the ploughing sea-son that is ongoing in the area.

On the 3rd and 4th of March 2021, two strong earthquakes of M6.3 and M6.0, respectively occurred at Thessaly, Central Greece. Distribution of aftershocks and events of M>5 for the sequence are shown in Figure 1. This sequence is considered as the most hazardous one regarding the triggering of liquefaction phenomena in Greece the last 40 years. Liquefaction is the transformation of saturated, unconsolidated granular material from a solid state to a liquid state as a consequence of increased pore pressures that reduce the effective strength of the material (Youd, 1973). The loss of shear strength can cause permanent ground deformations and damage to man-made structures.

During extensive field survey and mapping, accompanied by UAV aerial surveys, following the strong earthquakes, numerous (more than 400 cases) liquefaction-related features were identified, including sand blows and craters, fissures and lateral spreading cracks/ruptures along the Pinios and Titarisios river banks. A rapid documentation of these features was important, as most of these features were going to be erased or smoothed by the ploughing season that is ongoing in the area.




| Date | Time | Latitude | Longitude | Magnitude | Depth (km) |
|---|---|---|---|---|---|
| March 3, 2021 | 10:16:08 | 39.7591 | 22.2102 | 6.3 | 8.5 |
| March 3, 2021 | 11:45:46 | 39.6996 | 22.2478 | 5.1 | 7.1 |
| March 3, 2021 | 18:24:08 | 39.7316 | 22.1013 | 5.2 | 6.4 |
| March 4, 2021 | 18:38:19 | 39.7093 | 22.126 | 6.0 | 4.8 |
| March 4, 2021 | 19:23:51 | 39.8373 | 21.9424 | 5.1 | 9.4 |
| March 12, 2021 | 12:57:51 | 39.8387 | 22.0134 | 5.6 | 7.0 |

**Figure 1.** Location map with epicenters (orange) of the March 2021 Thessaly, Greece earthquake. Epicenter data from the revised NOA catalogue. Events with magnitude larger than 5 are shown as red stars. Active faults, from the NOAFaults database and modified from Caputo (1995), with red lines.

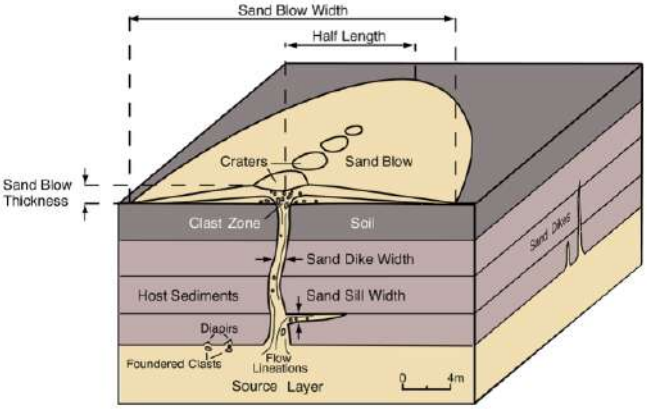



**Figure 2.** Schematic diagram showing liquefied layers and overlying liquefaction features, including intrusive sand dikes and sills and an extrusive sand blow. From Tuttle (2019).

Interferograms created using Copernicus Sentinel-1 radar imagery reveal the extent of areas with liquefaction and lateral spreading phenomena. In Figure 3, coherence from the coseismic interferogram and a pre-event interferogram are compared, highlighting two large areas of low coherence along Titarisios river to the north (Figure 4) and Pinios river to the south. Low coherence in interferograms corresponds to either spots with low correlation (due to presence of water, change of land use etc) or areas with ground displacement characterized by high frequency lateral heterogeneities and/or surface disturbance.

As those two low coherence areas do not appear in interferograms before and after the earthquake, we consider those as areas of widespread liquefaction and lateral spreading. This was also validated by the field survey.

The maximum length of the ground fissures generated by liquefaction, from where a mixture of sandy and silty material was ejected, was 60m while the maximum diameter and depth of sand craters was 2.5m and 1.5m, respectively. The

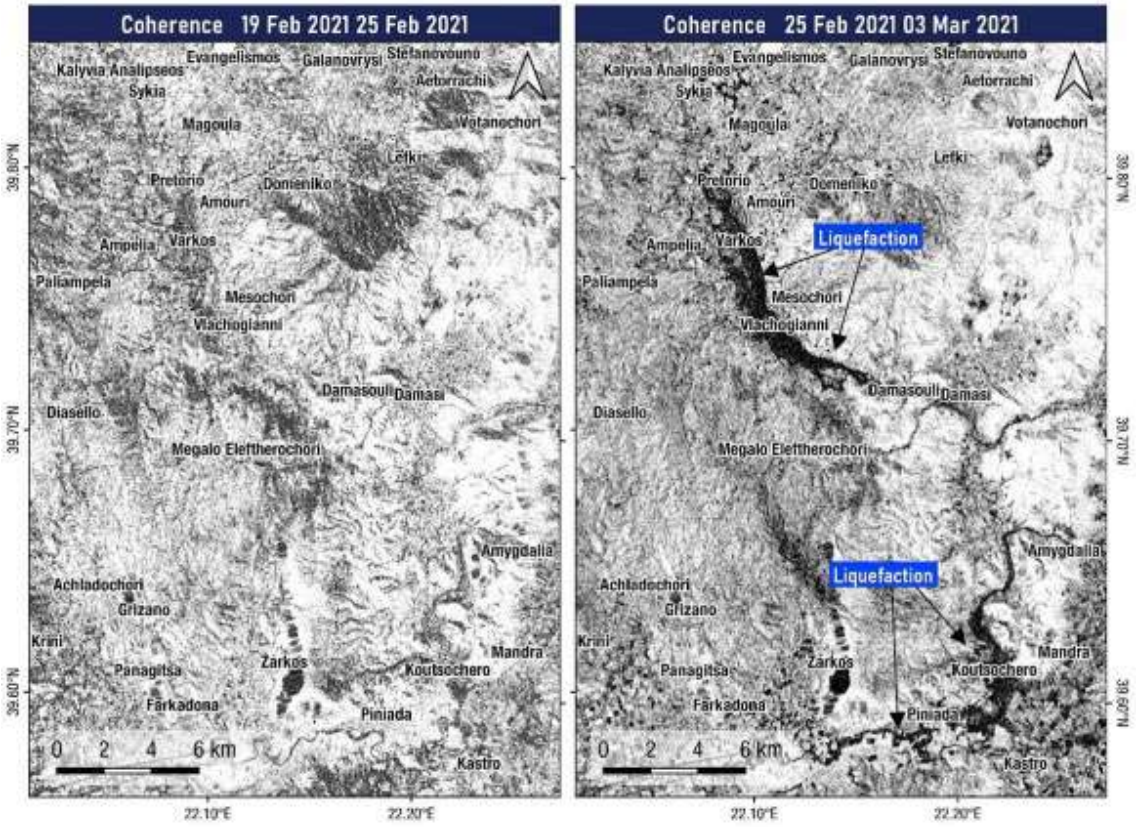



**Figure 3.** Difference of coherence in interferograms pre-event(left) and coseismic (right). Dark areas of low coherence correspond to areas of widespread liquefaction and lateral spreading.

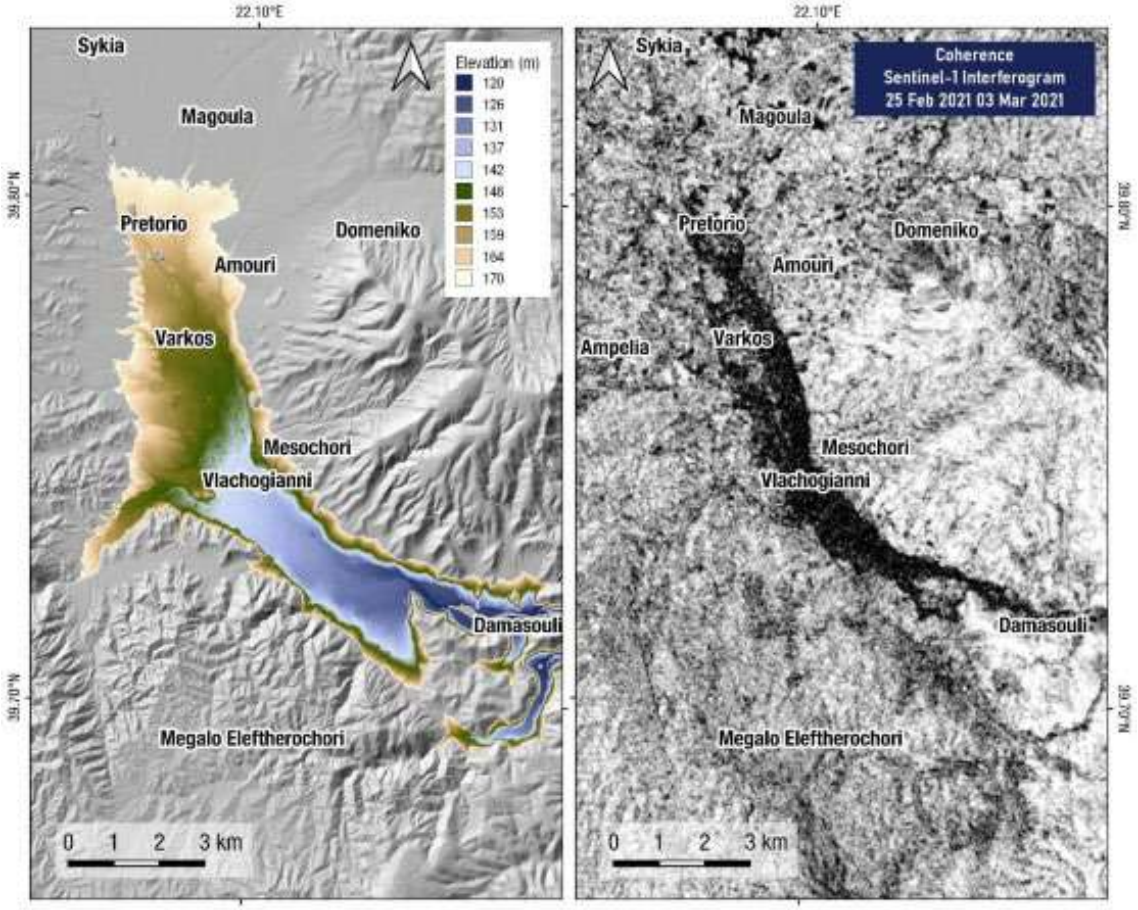



**Figure 4.** Left: elevation map of Titarisios river valley between Pretorio and Damasouli (only elevations between 120 and 170 m.a.s.l. are shown). Right: Low coherence in the coseismic Sentinel-1 interferogram correspond to liquefaction along Titarisios river bed and floodplain.

majority of the liquefaction surface manifestations were reported on a zone of approximately 10km length and 1km width around Pinios river and between the settlements of Farkadona, Zarko and Koutsochero, along the so called Piniada valley (Caputo et al 2021). A large number (but less concentrated) of liquefaction features were additionally documented between the villages Varko and Damasi along Titarisios river floodplain, situated at the epicentral area of both earthquakes.

The former area is geomorphologically characterized as a flood plain that periodically covered by the flooding material of Pinios river (Figures 5 & 6, Mantovani et al. 2018, Caputo et al. 2021) and it had been classified as highly susceptible to liquefaction by Papathanassiou et al. (2010). In addition, within this liquefiable zone, the Pinios river formed many meanders that are classified as one of the most prone to liquefaction areas; particularly the areas of point bar deposits that developed in the inside bank of Pinios river meanders.

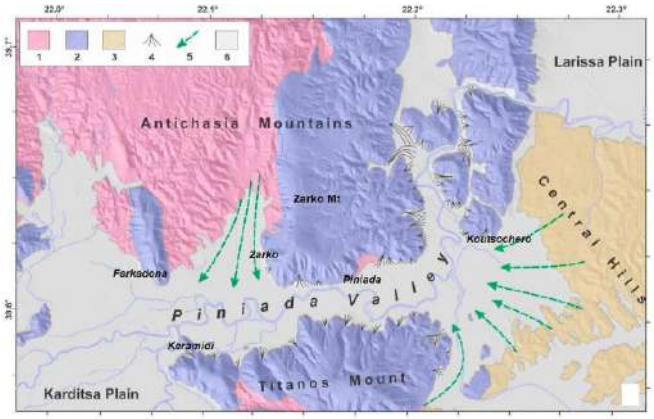



**Figure 5.** Simplified geologic map of Pinios river study area (from Caputo et al. 2021). 1: Palaeozoic gneiss and schists; 2: Triassic-Lower Jurassic recrystallized limestones; 3: Pliocene-Early Pleistocene fluvio-lacustrine deposits; 4: Late Pleistocene alluvial cones (from carbonate rocks); 5: Late Pleistocene alluvial cones (from Palaeozoic and Neogene-Quaternary rocks): 6: Late Quaternary alluvial deposits.

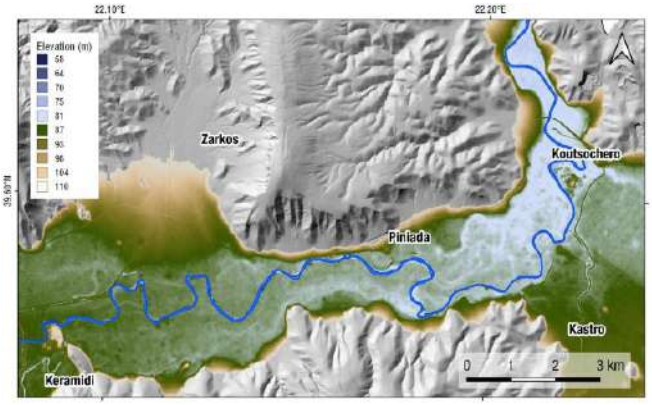



**Figure 6.** Elevation map of the Pinios river valley strand between Zarko and Koutsochero (only elevations between 58 and 120 m.a.s.l. are shown). A 1-2 km wide valley can be seen to form along the meandering river bed of Pinios river.

As it is shown in the compiled relevant map (Figure 7), the spatial distribution of the liquefied sites is strongly related not only to the present locations of meanders but mainly to oxbow lake areas that formed as the remains of the bend in the river. In order to spatially correlate the locations of the -liquefied sites with the oxbow lakes, we took into account historical aerial imagery (Hellenic Army Geographical Service) and multi-temporal optical satellite imagery. As a preliminary result of our research, we concluded that the highest density values of liquefaction phenomena are concentrated within the point bar areas of these abandoned meanders. In Figure 8, it is shown an example of the spatial distribution of the liquefaction-induced phenomena in the inside bank of an oxbow lake, as it can be clearly delineated based on the aerial imagery of 1945.

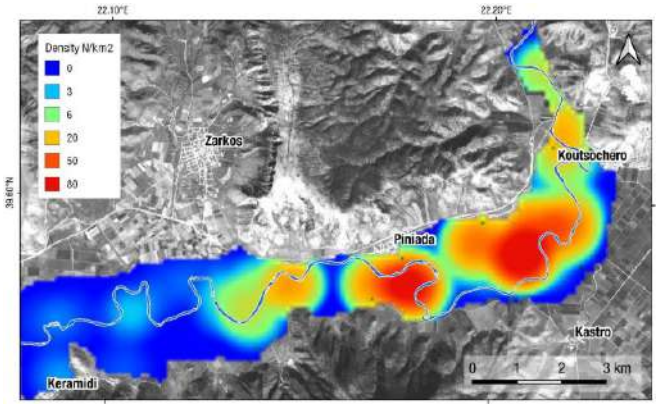



**Figure 7.** Density (number per square kilometer) of mapped liquefaction features along Pinios river.

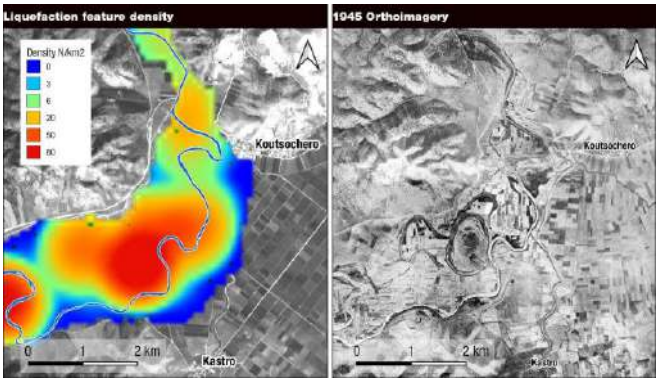



**Figure 8.** Left: density map of liquefaction features (number per square kilometer). Right: 1945 orthoimagery (from Hellenic Army Geographical Service).

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**Figure 9.** Liquefaction fissure with ejected sand (Photo taken by G. Papathanassiou 07/03/2021).

**Figure 10.** Sand crater (Photo taken by G. Papathanassiou 05/03/2021).

**Figure 11.** Aerial view of multiple linear liquefaction fissures (Photo taken by G. Papathanassiou 05/03/2021).

**Figure 12.** Lateral spreading along Pinios river (Photos taken by S. Valkaniotis 05/03/2021).

**Figure 13.** Liquefaction fissure with ejected sand (Photo taken by A. Ganas 06/03/2021).

**Figure 14.** Liquefaction fissure with ejected sand (Photo taken by S. Valkaniotis 05/03/2021).

**Figure 15.** Close-up of liquefaction fissure with small craters (Photo taken by S. Valkaniotis 05/03/2021).

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The report is available in the Zenodo repository: https://doi.org/10.5281/zenodo.4608365

(zenodo, March 16, 2021, https://zenodo.org/record/4608365#.YFI3JdyxU2w)

**Liquefaction mapping continues, Thessaly #earthquake. 8" tablet for scale.**

(Sotiris Valkaniotis, @SotisValkan, Mar. 29, 2021, https://twitter.com/SotisValkan/status/1376511254118989826?cn=ZmxleGlibGVfcmVjcw%3D%3D&refsrc=email)


**Newsletter #22 - The early March 2021 Thessaly [Greece] Earthquake Sequence**

**Αγαπητοί Συνάδελφοι και Φίλοι**

Το 22ο τεύχος του "Newsletter of Environmental, Disaster, and Crises Management Strategies", που εκδίδεται υπό την αιγίδα του Προγράμματος Μεταπτυχιακών Σπουδών "Στρατηγικές Διαχείρισης Περιβάλλοντος, Καταστροφών και Κρίσεων" του Εθνικού και Καποδιστριακού Πανεπιστημίου Αθηνών είναι αποτέλεσμα μιας επιοικοδομητικής συνεργασίας και ανταλλαγής γνώσεων μεταξύ γεωλόγων, σεισμολόγων, φυσικών, γεωγράφων, και πολιτικών μηχανικών της χώρας. Με γνώμονα την επιστημονική αρτιότητα και την άριστη ποιότητα, παρακολούθησαν με διάφορες μεθόδους και προσεγγίσεις τη σεισμική ακολουθία στις αρχές Μαρτίου στο βορειοανατολικό τμήμα της Θεσσαλικής πεδιάδας και τις συνοδές της επιπτώσεις, με αποτέλεσμα να χαρτογραφήσουν και να ερμηνεύσουν τα φαινόμενα. Η σεισμική ακολουθία περιλαμβάνει τον κύριο σεισμό στις 3 Μαρτίου με μέγεθος Mw=6.3 και τον σεισμό μεγέθους Mw=6.1 στις 4 Μαρτίου, που έπληξε την ίδια περιοχή.

Στο πλαίσιο του 22ου τεύχους, γίνεται αρχικά ανασκόπηση της γεωλογίας, της νεοτεκτονικής και της ενεργού τεκτονικής της πληγείσας περιοχής. Ακολουθεί ανασκόπηση της ιστορικής και πρόσφατης σεισμικότητας με όλους τους γνωστούς ιστορικούς και ενόργανους σεισμούς, που έχουν πλήξει την περιοχή αλλά και τη Θεσσαλία γενικότερα. Παρουσιάζονται τα μέχρι τώρα επιστημονικά δεδομένα για τη γένεση του σεισμού και των μετασεισμών του και για την εξέλιξη της μετασεισμικής του ακολουθίας. Αναφέρονται τα πρώτα αποτελέσματα από την επιτόπια αποτύπωση αμέσως μετά την εκδήλωση του κύριου σεισμού των πρωτογενών και δευτερογενών επιπτώσεών του στο φυσικό και στο δομημένο περιβάλλον της περιοχής. Ιδιαίτερη έμφαση έχει δοθεί στον εντοπισμό και τη χαρτογράφηση του ρήγματος, που θεωρείται υπεύθυνο για τον κύριο σεισμό, καθώς και στα εκτεταμένα φαινόμενα ρευστοποίησης που εκδηλώθηκαν σε παραποτάμιες περιοχές και εντός των κοιλάδων των ποταμών Τιταρίσσιου και Πηνειού, που διατρέχουν την πληγείσα περιοχή. Συμπεριλαμβάνονται στην έκδοση αυτή τα πρώτα αποτελέσματα της ανάλυσης σεισμολογικών δεδομένων και δορυφορικών δεδομένων καθώς και εφαρμογής μεθόδων συμβολομετρίας για την παρακολούθηση της επιφανειακής παραμόρφωσης, που προκλήθηκε από το σεισμό, αλλά και την διαδικασία της ολίσθησης κατά τον πρώτο και το δεύτερο σεισμό.

Όλα τα παραπάνω στοιχεία προέρχονται από επιστημονικές ομάδες πανεπιστημίων, οργανισμών, ινστιτούτων, κέντρων και εθνικών αρχών, συμπεριλαμβανομένων του Εθνικού και Καποδιστριακού Πανεπιστημίου Αθηνών (Ε.Κ.Π.Α.), του Αριστοτελείου Πανεπιστημίου Θεσσαλονίκης (Α.Π.Θ.), του Πανεπιστημίου Πατρών (Π.Π.), του Δημοκρίτειου Πανεπιστημίου Θράκης (Δ.Π.Θ.), του Χαροκοπείου Πανεπιστημίου (Χ.Π.), του Γεωδυναμικού Ινστιτούτου του Εθνικού Αστεροσκοπείου Αθηνών (ΓΙ-ΕΑΑ), της Ελληνικής Αρχής Γεωλογικών και Μεταλλευτικών Ερευνών (ΕΑΓΜΕ) και του Οργανισμού Αντισεισμικού Σχεδιασμού και Προστασίας (ΟΑΣΠ).

Το τεύχος είναι προσβάσιμο **εδώ**.

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**BGSG Call for Papers: Special Issue on the 2021 Northern Thessaly, Greece, Earthquake Sequence**

The **Bulletin of the Geological Society of Greece** (BGSG) is inviting papers for a **Special Issue** on the 2021 Northern Thessaly, Greece, Earthquake Sequence.

The 2021 Northern Thessaly, Greece, Earthquake Sequence included a M6.3 mainshock on March 3, followed 32 hours later by a M6.0 event and a M5.6 event on March 12, and with thousands of smaller aftershocks. This was the most significant earthquake sequence in northern Thessaly in 80 years, and the first large events in this area of Greece since the major upgrades of the seismological, strong motion and geodetic networks. The sequence raises numerous questions related to fault interactions, blind faulting, near- and far-field ground motions, damage distribution, earthquake triggering, liquefaction phenomena and seismic hazard and seismotectonics of the Northern Thessaly.

BGSG welcomes contributions to the Special Issue that focus on these and other scientific aspects of this sequence.

The volume will be in English, but we can aid translation of Greek-language contributions accepted for the volume.

Guest editors for the BGSG Special Issue on the Thessaly Earthquakes are:

- Alexandros Chatzipetros (Aristotle University of Thessaloniki) ac@geo.auth.gr
- Christophe Gruetzner (University of Jena) christoph.gruetzner@uni-jena.de
- Haris Kranis (National and Kapodistrian University of Athens) hkranis@geol.uoa.gr

**Deadline for submission** of manuscripts: **23 April 2021** Papers submitted earlier will be reviewed as they are received. Papers will be published online upon acceptance and will be collected into an issue of BGSG planned for June 2021.

Submit your manuscript in BGSG's online submission system: **https://ejournals.epublishing.ekt.gr/index.php/geosociety/about/submissions#onlineSubmissions**.

Authors should follow BGSG's author guidelines.

Address questions about scientific issues to the Guest editors or BGSG Editor-in-Chief Athanassios Ganas at aganas@noa.gr.

# ΑΡΘΡΑ

## Disaster in the Himalayas

### How a landslide sent a deluge of water, rocks and debris surging down

**Anand Katakam and Marco Hernandez**

High in the Indian Himalayas, a large mass can be seen clinging to the steep face of Raunthi peak, one day before disaster struck. The image was taken by Planet Labs and merged with a 3D model of the area built by Reuters.

Detailed satellite imagery taken the following day by Planet Labs shows the missing chunk of rock or ice and reveals some of the initial aftermath.

This event is what is believed to have sent a destructive torrent of rocks, dust and ice that travelled 1,500 metres from near the peak down the valley, causing deadly flash floods.

The landslide happened on Feb. 7 some 20 kilometres west of Nanda Devi, India's second-highest peak, and resulted in a flash flood that authorities say killed more than 200 people, destroyed villages, and swept away two hydro-electric projects.

Avalanches and flash flooding in the Himalayas are common during summer and monsoon months, as melting snow and heavy rains combine. But incidents like this are rare so early in the year, alarming scientists studying climate change that is rapidly heating the world's highest mountains.

Experts are still studying the details of exactly what happened, but detailed satellite imagery helps to build a comprehensive picture of the events that unfolded. Scientists said heavy snowfall followed by bright sunshine led to snow-melt in the area. That could have triggered a chain reaction that led to the avalanche and heavy flow of ice, water, rocks and debris surging down the Dhauliganga river valley. While at least 70 bodies were recovered, the state government has formally declared that another 136 people missing are presumed dead.

"The area witnessed a heavy snowfall and then solar rays [sunshine] resulted in the melting of ice," said Ravi Chopra, director of the non-profit People's Science Institute in Uttarakhand state, where the incident took place.

Dave Petley, Professor of Geography at The University of Sheffield, told Reuters there was a reduction in the amount of snow, which could have helped trigger the landslide, but not enough to cause downstream flooding.

"There was clearly a thaw event happening at the time of the landslide. But this looks to be superficial snow only, not large volumes.", said Petley, who studies landslide events.

**A deluge of debris and water**

Satellites captured images of the torrent of water, rocks and debris barrelling down the valley. The images below from Planet Labs show the entire valley on the day of the disaster and provide more evidence of what unfolded. The dust plumes show how extensive the landslide was.

Much of the damage downstream was caused by a torrent of water making its way through the valley. Initial news reports suggested this was due to a Glacial Lake Outburst Flood (GLOF) - a sudden release of water from a glacier resulting in a rapid downstream flow. But Prof. Petley disagreed. "This event was definitely not a GLOF - there is no evidence of a breached glacial lake," he said. "We know for certain that a large block, consisting mostly of rock but with some ice, detached from the mountainside."

Feb. 6, 2021


Feb. 7, 2021


"It remains possible that there was considerable buried ice in the valley floor that was picked up and melted, but only fieldwork would tell us the answer," he said. It remains unclear where the large volume of water which caused the flooding originated. Fieldwork by the Indian government is ongoing.

**Destruction**

The Dhauliganga River valley bore the brunt of the flooding. As the debris raced through the valley it reached as far as Joshimath, an important military outpost for the Indian army and a religious site for Hindus.

A local witness recorded the moment the Dhauliganga River overflowed, carrying debris near Raini village on Feb. 7.

The flood caused major damage to two hydro power projects on the Rishiganga and Dhauliganga River valleys. The Rishiganga Hydroelectric Project, owned by Indian conglom-erate Kundan Group, and the state-owned National Thermal Power Corporation's (NTPC) Tapovan Vishnugad project were constructed within 5 kilometres of each other.


Satellite images: PLEIADES © CNES 2021, Distribution Airbus DS / produced by Earthrise

**The village**

Sept. 30, 2017


Feb. 09, 2021


The torrent skirted the village of Raini and washed away a bridge and the 13.2 megawatt Rishiganga project on the banks of its namesake river, a tributary of the Dhauliganga.

The bridge was a supply lifeline for residents of the neighboring village of Raini Chak Lata on the other side of the river. Perched high on a hill, the majority of the villagers survived, but the flooding washed away worker accomodation for the hydro project on the valley floor and left the surrounding area almost barren.

**The dam**

Dec. 12, 2019


Feb. 09, 2021

About 5 kilometres downstream, the 520 megawatt Tapovan dam - still under construction as part of the larger Tapovan Vishnugad hydro power project - bore the brunt of the flood. The water descended from Raini to the dam, ramming through the 22 metre-high barrage and overcoming its 12 metre-high water gates. The barrages survived and remained standing amidst a vast expanse of slush.

**Trapped in the tunnel**

As the area flooded, water trapped multiple construction workers in a tunnel which was designed to divert the flow of the Dhauliganga. As it surged down past the dam, the flood resulted in a major blockage of the tunnel entrance, located 234 metres upstream from the Tapovan barrage. Dozens were inside working at the time.

Members of a rescue team work inside a tunnel after a part of a glacier broke away in Tapovan, in the northern state of Uttarakhand, India, on Feb. 11. REUTERS | Anushree Fadnavis.

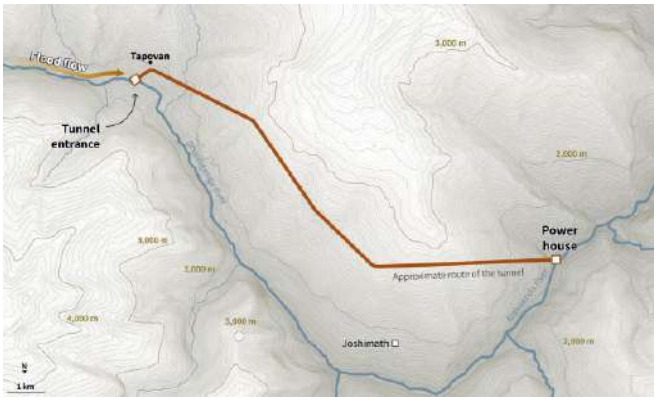
It is unclear how deep the workers were in the tunnel. Rescuers were using a combination of bulldozers and excavators to unblock the tunnel, but with limited success.

Since then, rescue efforts have waned with those missing in the floods now presumed dead.

An aerial view shows a damaged barrage after a flash flood swept a mountain valley destroying dams and bridges, in Tapovan in the northern state of Uttarakhand, India, Feb. 12

The tunnel is a 11.77 kilometre-long channel on the barrage's bank that diverts water towards the underground power generation house downstream merging with the Alaknanda River, according to an Environmental Impact Assessment (EIA) prepared by the NTPC for the Asian Development Bank in 2007.

But as the project was still under construction, it remains unclear how deep the tunnel was, and why workers were unable to get to the other end to escape.




Incidents like the one on the Dhauliganga are rare in February, the month with the lowest amount of water flowing through the Dhauliganga, according to a 2007 environmental assessment carried out by the company constructing the dam. As such, the disaster has prompted calls by environmental groups for a review of power projects in the ecologically sensitive mountain area. Though the precise cause of the flooding remains unknown, some point towards climate change, rapidly heating the world's highest mountains. Experts say rampant construction is adding to the burden weighing on rural communities across the Himalayas, especially in areas close to glaciers.

**A landslide-prone zone**

The map below shows landslides noted in NASA's Global Landslide Catalog from January 2007 to September 2020.


A spokeswoman for India's power ministry said the country has strict measures in place regarding the planning of hydropower projects and the rights of local people are always considered. The use of explosives in construction in the region was criticised after devastating floods in the state in June 2013, dubbed a "Himalayan tsunami" that claimed more than 5,000 lives.

(reuters.com, Feb. 26, 2021, https://graphics.reuters.com/INDIA-DISASTER/LANDSLIDE/yqdvzeaxypw/index.html)

## Geothermal energy could save the planet. But watch for earthquakes

### An underground lab in Switzerland is trying to unlock the potential of deep geothermal energy

The Rotondo granite of the Bedretto tunnel

Burrowed 1.5 km beneath a valley in Ticino, a region of southern Switzerland close to the Italian border, the Bedretto Underground Laboratory for Geoenergies is part mechanics garage, part construction and excavation site. Inside the six-by-three metre cavern – which was once part of a railway tunnel – a team of researchers specialising in geology and seismology conduct their work wearing hard hats. This is one of the world's leading research facilities in deep geothermal, a renewable energy source that has the potential to upend our reliance on fossil fuels.

"I'm sorry it's a bit of a mess today," says lab manager Marian Hertrich, referring to the motors, laptops, giant spools of fibre optic cables and drill rig that compete for space in the tight quarters. For a man who spends half his life underground, the German geophysicist is suspiciously tanned.

The lab is situated in an abandoned ventilation arm of the Furka base tunnel, operated by Swiss railway company Matterhorn Gotthard Bahn. One end disappears into inky blackness, the other to dimly-lit railway tracks, where a team dressed in high-viz overalls are ferried in and out to the southeastern exit of the five-kilometre-long tunnel on a custom-made trike that affixes to the steel rails. Half the adventure is getting here. The 40-minute walk in is unnerving, with pools of water underfoot and 16,000 volts running in cables overhead. On one part of the tunnel wall you can see where a mass of molten magma forced its way through a long rupture millions of years ago – a feature marked by a vertical join between two different rock types. One is Rotondo granite – an immense physical barrier which engineers tunnelled under 50 years ago.

"One of the reasons I chose Bedretto as a tunnel is because it has two exits. I don't want to have a landslide or an avalanche," says Domenico Giardini, professor of seismology and geodynamics at Swiss university ETH Zürich. "If you want to operate a lab under a mountain for 20 years, it needs to be very safe."

A leading authority on deep geothermal energy, Giardini is the brains behind the pioneering underground rock lab, a collaboration between ETH Zürich and the Werner Siemens Foundation, which provides funding for research projects and is the lab's main financial backer. Inaugurated in May 2019, the lab's mission is to explore the potential of geothermal energy – a renewable energy source buried deep underground.

By inducing tiny artificial tremors known as micro-quakes and seeing how the underground rock behaves, the team hopes to finally crack how to make this overlooked, underutilised renewable safe and economically viable over the long-term, and to tap into a new supply of clean energy that could help Switzerland – and other countries – relinquish reliance on fossil fuels.

Marian Hertrich, the lab manager of the Bedretto Underground Laboratory for Geoenergies

Described as the sun beneath our feet, geothermal (a portmanteau of 'earth' and 'heat' in Greek) is the residual heat from molten rocks formed within the Earth's interior billions of years ago. Geothermal energy converts this natural heat percolating deep underground into electricity.

Humans have been tapping into geothermal for thousands of years. Ancient Romans harnessed its powers to heat rooms, bathe and even treat skin diseases in Pompeii. Today, the world's oldest geothermal field, Larderello in Tuscany, still generates 10 per cent of the total global geothermal energy supply. The World Energy Council estimates that geothermal has the potential to deliver more than 8 per cent of the world's electricity needs. But it still has the status of an outsider, accounting for only 0.3 per cent of globally installed renewable energy capacity, mainly due to seismic risk, the drawn-out experimental phase and high start-up costs.

On paper, geothermal sounds too good to be true. Our planet will most likely supply heat for millions of years to come, and, unlike solar and wind, geothermal doesn't rely on the fickle climate above ground. "If you go one metre down, the rock doesn't know if it's night or day," Giardini says. "If you go three metres down, the rock doesn't know if it's winter or summer. It doesn't know anything at all because the rock is so efficient at retaining heat."

Geothermal pulled clean energy innovator Iceland out of economic ruin in the 70s, by enabling the country to transition from expensive fossil fuel imports to generating 80 per cent of its own electricity and heating. Today, nine out of ten Icelanders live in geothermally-heated homes. But Switzerland isn't a volcanic island where scalding hot water can be drawn out just a few hundred metres under your feet. In this landlocked, mountainous country, you need to go deep – around 3,000 metres into hard crystalline rock – to hit temperatures of 100 degrees Celsius.

An enhanced geothermal systems (EGS), also known as "hot rocks", is a type of deep geothermal system designed for less tectonically active regions such as Switzerland. EGS works by injecting water at high pressure into the Earth's bedrock, where it absorbs the heat from these "hot rocks", before being recovered via a shaft bored into the ground. Unlike conventional geothermal systems that harvest heat from porous rocks where hot water naturally flows, EGS has to artificially

engineer permeability. The technology was first trialled in New Mexico half a century ago, but has only seen incremental gains in this time. EGS could, in theory, unlock untold stores of heat from almost anywhere in the world. The International Energy Agency (IEA) estimates that the heat flowing into the top few kilometres of the Earth's crust amounts to more than two million times the world's annual total energy consumption.

The entrance to the Bedretto ventilation tunnel

In 2050, every one of Switzerland's 26 cantons is poised to run on partial geothermal power, with a view to phase out nuclear energy, which currently supplies 40 percent of Switzerland's energy needs, and replace fossil fuels. According to the Swiss Federal Office of Energy, which invested £47 million into geothermal projects in 2020, Switzerland already has the highest concentration of heat pumps per square kilometre in the world, supporting almost 15 per cent of Swiss heating systems in homes and offices. But heat pumps fall under the umbrella of "shallow" geothermal, which harnesses warmth emanating from the Earth's crust between 1.5 and 400 metres below ground. "Deep" geothermal projects like EGS, on the other hand, require drilling down to depths of 5,000 metres.

In this respect, Switzerland may have an unexpected ace up its sleeve – a vast network of underground tunnels. Built by the armed forces as part of the country's now retired "Swiss Reduit" defence system, these alpine fortresses are how Switzerland came to bunker itself into the Alps during World War II. In the last few decades, some of the tunnels have been repurposed for high security storage - outfitted with bulletproof vaults to stow away gold. But the former military bunkers of the Saint-Gotthard Massif mountain range could also serve as portals to a green energy source ripe for harvesting.

"Underground labs are usually expensive affairs, because you need to reach them first," Giardini says. "That's where having a ready-made tunnel comes in handy."

Cables snake out of boreholes lined with sensors

There's one major issue with enhanced geothermal systems: earthquakes. The reputation of geothermal power in Switzerland nosedived in 2006, when the city of Basel was rocked by a 3.4-magnitude earthquake triggered by a pilot project. The uncontrolled tremors were a result of Geopower Basel pumping pressurised water up to 4.8km underground prospecting for geothermal. While there were no serious injuries, the quake shattered roof tiles and rendered cracks in buildings in the city of medieval cathedrals, which sits atop a 125-metre-long active fault (a natural earthquake along the fault in the 14th century flattened the city). Months after the plug was pulled on the operation, sensors recorded thousands of tiny quakes, which were attributed to the deep geothermal project.

The ground trembled again in 2013, this time 200 km east in the city of St. Gallen, during the drilling for a £135 million-funded EGS project that was shelved shortly after.

The Bedretto lab is running research and exploring techniques to try to make the most of deep geothermal without running the risk of another incident. In November 2020, Bedretto began its first full-scale stimulations, which are known to cause tiny levels of shaking (imperceptible without scientific measuring equipment), or "micro-earthquakes." A stimulation involves creating a network of cracks in the granite by injecting a few tens of cubic metres of cold water through it. "When you run an experiment, there are maybe 10,000 small quakes, and you need to locate them in real time," Giardini says.

The location of these experiments is a small pool excavated at the tunnel's base, which could easily be mistaken for an underground spring. But rather than cave-dwelling fish, cables sprout out from two 22cm boreholes drilled 300 metres deep at 45-degree angles into the granite to access reservoirs – not the spectacular alpine kind that Ticino is known for, but heated underground ones, created artificially by pumping water at high pressure to prise open cracks (known as fractures) into less permeable areas of rock. These cracks act as a radiator, transferring heat in the rock to the water, which, in the case of geothermal plants, is then piped back up to the surface of the Earth, where it evaporates into steam. The steam rotates the blades of a turbine, in turn activating a generator which creates electricity that can be directly transported via conventional power lines. A renewable in the most literal sense, the condensed steam can even be pumped back underground, restarting the cycle.

Lining the boreholes are different types of sensor, including acoustic and pore-pressure (which measure the force of the water as it runs through the cracks), as well as fibre optic cables and geophones (which detect ground velocity produced by seismic waves). Together, these monitor and record vibrations in the granite as the water is injected into sections

of the borehole. This data helps to map out the rock's permeability by revealing the fracture's size, characteristics, quantity, direction and stress capabilities under different water pressures. Knowing to what extent the granite can be made 'artificially permeable' will inform whether a reservoir that stands up to geothermal extraction can actually be made.


Scientists work at a borehole that has been drilled at a 45° angle

For now, the lab is pumping in liquid at 17°C, with hot water experiments scheduled later in 2021, in conjunction with Bedretto tunnel's second lab opening. Eventually, sufficient fractures will have been made in the rock to connect the two boreholes, creating a reservoir of heated underground fluid, where the full EGS process can be tested and studied.

By using long boreholes to create underground reservoirs at the 100 metre scale, Bedretto is conducting experiments under conditions that more closely mimic those of a geothermal power plant. And by dividing the boreholes into different sections, the team is able to conduct multi-stage stimulations, which should, in theory, limit the seismic risk by giving the researchers more control.

"I think the biggest event so far was -3.2 or something," says Ben Dyer, a seismologist for Geo-Energie Suisse, one of Bedretto Lab's partners. To put these numbers in context, magnitudes need to reach around 2.5 before they're perceptible above ground. "I think to be honest, when you get beyond zero through the rock, we'd hear the cracks [in the lab]," Dyer says. Anything less than that is considered a micro-quake. These are scrutinised nonetheless, displayed in real-time as a series of squiggly lines or "seismic waves" on an ECG-like monitor.

Erring on the side of caution, Bedretto has installed five seismographs (devices which measure the movement of the Earth) in the tunnel's interior: one at the entrance, one at the end, and three directly in the lab, as well as three new seismographs at the Furka, Nufenen and Gotthard Alpine passes. ETH's own seismic risk study concluded there would be a 1 in 10 million chance of a magnitude 2-2.5 earthquake being triggered. But, as Giardini plainly says, "Small risk doesn't mean zero risk. It's really very difficult to introduce any new technology unless you really prove there is no risk."

The line between inducing artificial tremors to yield sufficient data, and triggering an earthquake that could derail the entire project, is a fine one. Research at Bedretto has potential to drive down the costs and risks associated with the discovery of geothermal heat. But by the same token, any negative incidents could give pause to investors in geothermal projects. "The best thing that could happen to geothermal in Switzerland would be to have one project that finally works, with no snags," says Elmar Grosse Ruse, a climate expert from World Wildlife Fund (WWF) Switzerland.

Hazel Gibson, former postdoctoral researcher at Plymouth University's Sustainable Earth Institute, has dedicated the past two years to finding out how to manage public trust in geothermal technology. "In the case of deep geothermal, not only is this space invisible, it's also completely alien to most people, who don't think about what is going on under their feet until they need to," she says. "It's unfamiliar technology, and unfamiliar risks are often subjectively judged to be more risky than familiar ones." She adds that the language associated with geothermal - words like "fracture", "fault", "earthquake" and "seismic" - can be daunting.

But for the residents of Bedretto Valley, avalanches are a far more tangible threat than a minor quake. Bookended to the west by Nufenen, Switzerland's highest paved alpine pass, and to the east by the town of Airolo in the southern foothills of the Gotthard Pass, the valley is streaked with steep gullies and meandering rivers, where a quartet of villages are bunkered into the hillside.

Scarcely 500 metres from Bedretto Tunnel's south east entrance is the chocolate-box hamlet of Ronco (home to just four permanent residents) and 3 km down the road, 13th century hamlet Villa – which went as far as to remodel its church bell tower to serve as an avalanche breaker. The days of being evacuated on mule-drawn sleighs may be long gone, but Agnese Leonardi – who lives here with her two teenage sons and husband Marco – recalls how snowdrifts came right up to the second floor of their larch timbered home one winter, rendering them snowed in, in the most literal sense. They run the nearby Cioss Prato ski lift and a grotto at its base, which is ornamented with 15-million-year-old crystals, dredged from the depths of the Gotthard by Agnese's crystal hunter father-in-law, Gilberto Leonardi. The family know more than most about the unusual properties of the ground beneath their feet, and yet look blank at the mention of Bedretto Lab, despite it being on their doorstep.

The lab says it's been fully transparent about its activities. At its unveiling in May 2019, more than 300 people from the public (including Bedretto Valley's residents) were invited to

visit and chat one-to-one with the team's researchers. But with Covid-19 hitting pause on these tours for the best part of 2020, some residents remain in the dark.

"The idea that if scientists provide more information then people will automatically feel more comfortable with a scientific idea is not really true," Gibson, who is not directly involved in the Bedretto project, says. "What is more important to help people connect to new scientific ideas is the way we communicate." Social solutions, she says, are just as important as technical ones.

Getting a community of 106 like Bedretto onside is one thing, but convincing a city with a population of 200,000, like Geneva, is another. People have an inherent fear of earthquakes. "All of our system is based on the fact that everything below us is stable, otherwise we feel sick immediately," Giardini says. "It's not so different from the fear of sharks. You are on the beach, and say there is a dolphin, everyone comes to take a picture. You say there is a shark and people fly out of the water, even if the two are equally dangerous."

But despite incidents like that at Basel, "geothermal still has an image of a clean, silent source of energy in Switzerland," Grosse Ruse says.

The environmental community is also generally onside with geothermal, despite controversy over some projects imperilling freshwater resources, like New Mexico's Lightning Dock plant. "Although engineered geothermal does involve some processes that are similar to fracking, they don't require the addition of possibly hazardous chemicals below ground," explains energy expert and author Chris Goodall.

Currently, geothermal is a bit-player in Switzerland's energy production, alongside wind and solar, which account for 8.5 per cent of total energy consumption, and hydropower, which generates 60 per cent of the country's domestic electricity production.

Often referred to as the water tower of Europe, Switzerland is primed for hydropower, thanks to its mountainous terrain and high levels of annual rainfall. But Grosse Ruse says there is a need for something new. "There's not much potential left for 'more' hydropower in Switzerland. Those projects have such a high detriment on the rivers and biodiversity," he says. "And with hydropower, we know that even if receding glaciers continue at the pace they are at the moment, the capacity would still be very limited in the next two decades."

Different countries may have different reasons to opt for geothermal over other renewables. "It is possible that geo-thermal may never become cost competitive with solar and wind in somewhere like the UK," Goodall says. "Whereas, say, in Kenya, it is a real competitor because temperatures close to the surface are so much higher." Giraffes and geo-thermal happily co-exist in Hell's Gate National Park in the Great Rift Valley, where steam generates close to half of the East African country's electricity. When it comes to surface footprint, geothermal plants also take up considerably less space than solar or wind farms, and their underground res-ervoirs serve a dual purpose – hoarding both energy and car-bon dioxide.

But despite the list of pros, many geothermal projects never make it past the exploratory phase, which only pays off if sufficiently hot and abundant water reservoirs are uncovered. Australia's flagship geothermal developer, Geodynamics Limited, learned this lesson the hard (and expensive) way, investing £110m drilling five-kilometre-deep wells into South Australia's Cooper Basin that are now plugged with concrete.

Even at Bedretto's modest 1,500-metre depths, the early engineering challenges – before stress levels in the rock were even measured – were hairy, lab manager Hertrich recalls. "We drilled and drilled (into the rock) and metre by metre it was completely dry," he says of their preliminary excavations. "We left it open for two weeks and not a single drop of water came out. I was really concerned. Then all of a sudden we drilled through a fracture zone, and then the fun began."

One knowledge gap that still needs to be filled is where the best sites are for developing large-scale EGS. Production-scale deep drilling remains the ultimate test of a geothermal prospect. "The problem was getting a drill to fit in here," Hertrich says. In the end, the team commissioned a Swedish company to manufacture a drill rig from scratch tailor-made to the tunnel's exact specifications. Whilst he won't disclose the cost, the geophysicist says that hiring a geothermal drilling rig can set companies back £100,000 a day. The vast majority of EGS projects are stalled by the capital costs; generating backing for the lab was swift by industry standards. Bedretto's main sponsor, the Werner Siemens Foundation, invested £3.3 million in the lab infrastructure alone, while a raft of other investors, including the Federal Office of Energy and European Research Council, contributed a further £6.5 million. A significant cost saving has been rent-free-premises, thanks to the Matterhorn-Gotthard-Bahn, which granted ETH Zurich unlimited use of Bedretto tunnel for the next decade.

Another of the Bedretto lab's main challenges (shared by other deep geothermal energy projects) is a technological one; namely data acquisition and realtime analytics. "Currently, the independent software for analysing hundreds of data streams of seismic data, sampled with as high frequencies as 1 MHz, in real time, doesn't exist," Bedretto's Head of IT, Philipp Kästli, says. To deal with this, the Bedretto team has written its own.

"This isn't the kind of data you can put on a stick," Giardini says, referring to the 12TB of uncompressed data generated by the lab on an average day. "We are metres away from the borehole, so what we see is extremely high frequency. This frequency would usually be taken away by the friction inside the earth so you wouldn't see it." This seismic data is read and transported back to ETH's headquarters in Zurich in real-time – the only way to send it, since the cumulative amount would simply overwhelm the system. "We need to transfer

continuously in order to bring this data back from this remote mountain area to Zurich, without re-cabling the landscape," Kästli says.

These ten-centimetre-diameter cores of granite were excavated in 2019

The most important thing if deep geothermal is to become more mainstream is understanding the geology. Hertrich and his team have committed to learning the behaviour of Rotondo Granite inside out, under every possible rock stress scenario. "Usually you drill in the dark. You drill, you install (boreholes) and then you stimulate," he says. Not at Bedretto. Propped up against the tunnel's exposed walls are dynamite-like crates containing 10cm diameter cores of granite excavated from experimental boreholes in May 2019. These salt-and-pepper samples have been scrutinised for every vein, pore, joint and fracture for nine months, by some of the industry's keenest eyes. The drilled cores are being used to learn where and how to create fractures for Bedretto's heat reservoirs, so the team can manipulate the rock's behaviour in the way they want to. Such a level of geological, geophysical and geochemical surveillance is nudging geothermal into new territory.

In reality, it's still a long and expensive process to get from lab to plant. The Bedretto lab has no intention of building a commercial geothermal plant on site, although next summer it hopes to extricate hot water from the experimental research reservoir for heating and electricity generation (depending on the temperature), in conjunction with a regional electricity provider.

Whether or not a world in the throes of a climate and energy crisis can afford to wait for geothermal to commercially mature remains to be seen. Whilst shallow geothermal covers 1.3 per cent of Switzerland's heating needs at the moment, that's not nearly enough to fill the 40 per cent energy shortfall that nuclear will leave behind in 2050. The Bedretto lab is slated to run until 2024, so electricity isn't going to be generated overnight, and presently, there are no operational deep geothermal plants in Switzerland. The planning and construction of a typical heat-and-power geothermal plant can take up to six years and their outlay can be in the region of £50m.

But the patience and investment could pay off, especially if companies can identify areas where drilling is more likely to hit geothermal pay dirt. This is something Bedretto's research will directly inform in other regions of Switzerland, as well as Scandinavia, which shares a similar rock geology.

If the hard data retrieved from in-situ stimulations like Bedretto can bolster public and investor confidence, it has the capacity to spark an energy revolution, starting with fast-tracking the deployment of geothermal power in its home country.

Giardini is well aware that success or failure here could well determine the fate of deep geothermal energy in Switzerland, and possibly beyond. "Usually failures are the ones that end up in the newspaper," he says. "If you have a 2.5 magnitude earthquake, everyone will know."

(Sarah Freeman / WIRED, Wednesday 24 March 2021, https://www.wired.co.uk/article/swiss-rock-lab?utm_medium=email&utm_content=Px96uegOdI-vLpzKE65pjfXbfsxJ_uxBNOGaD-11swKL-iGGvqjiqrLNrE-zoNvWPZ)

# ΝΕΑ ΑΠΟ ΤΙΣ ΕΛΛΗΝΙΚΕΣ ΚΑΙ ΔΙΕΘΝΕΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΝΩΣΕΙΣ

Σχολή Πολιτικών Μηχανικών
Εθνικό Μετσόβιο Πολυτεχνείο

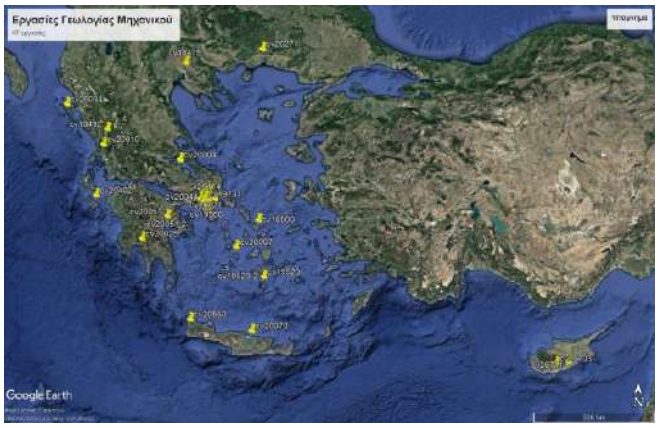
## Εργασία Χριστουγέννων Γεωλογίας Μηχανικού

### 1ο Έτος Σχολής Πολιτικών Μηχανικών (2020-2021)

*Ποια πετρώματα διάλεξαν οι πρωτοετείς στις χριστουγεννιάτικες βόλτες τους;*

Στο πλαίσιο του μαθήματος της Γεωλογίας Μηχανικού, δόθηκε μια προαιρετική εργασία για την περίοδο των γιορτών των Χριστουγέννων που είχε ως θέμα τον **εντοπισμό και χαρακτηρισμό μιας γεωλογικής εμφάνισης πετρώματος και την αποτύπωση αυτής σε χάρτη**. Ζητήθηκε από τους πρωτοετείς φοιτητές της Σχολής να εντοπίσουν στην ευρύτερη περιοχή της κατοικίας τους μία θέση εμφάνισης πετρώματος και έπειτα να προσδιορίσουν την κατηγορία του πετρώματος, να το φωτογραφίσουν και να αποτυπώσουν τις γεωγραφικές συντεταγμένες της θέσης χρησιμοποιώντας εφαρμογή σε κινητό τηλέφωνο και χάρτη Google Earth.

Η ανταπόκριση των φοιτητών ήταν μεγάλη και οι εργασίες ήταν στην πλειοψηφία τους πολύ καλές έως εξαιρετικές. Συνολικά παραδόθηκαν 47 εργασίες από ποικιλία περιοχών στην Ελλάδα και στην Κύπρο (Σχήμα 1). Το μεγαλύτερο ποσοστό των εργασιών (65%) προερχόταν από περιοχές της Αττικής (Σχήμα 2). Οι φοιτητές αναγνώρισαν και χαρακτήρισαν πολύ καλά τα πετρώματα που διάλεξαν, ενώ πολλοί επέλεξαν περιοχές που είχαν αναφερθεί στο μάθημα.

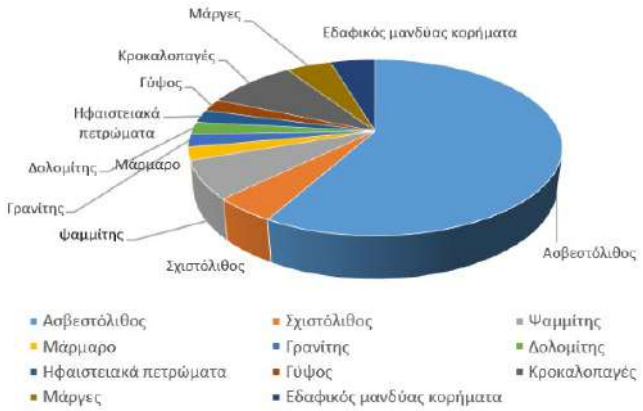



**Σχήμα 1. Θέσεις αποτύπωσης και χαρακτηρισμού των πετρωμάτων-εδαφών στην Ελλάδα και την Κύπρο.**

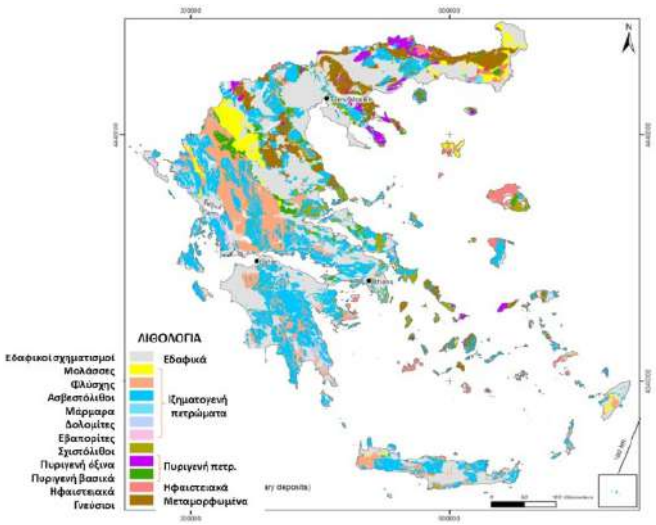
### Κατηγορίες γεωλογικών σχηματισμών

Οι φοιτητές επέλεξαν πετρώματα που συναντάμε συχνά στην Ελλάδα, όπως τον ασβεστόλιθο αλλά και πετρώματα που συναντάμε σπανιότερα, όπως: γρανίτη, ηφαιστειακά πετρώματα, γύψο κ.α. Η συχνότητα εμφάνισης των διαφορετικών γεωλογικών σχηματισμών που δίνεται στο Σχήμα 3 βασίζεται στις περιγραφές των φοιτητών και σε κάποιο βαθμό αντικατοπτρίζει τη συχνότητα εμφάνισης των πετρωμάτων στην Ελλάδα (Σχήμα 4).


**Σχήμα 2. Θέσεις αποτύπωσης και χαρακτηρισμού των πετρωμάτων-εδαφών στην περιοχή της Αττικής.**

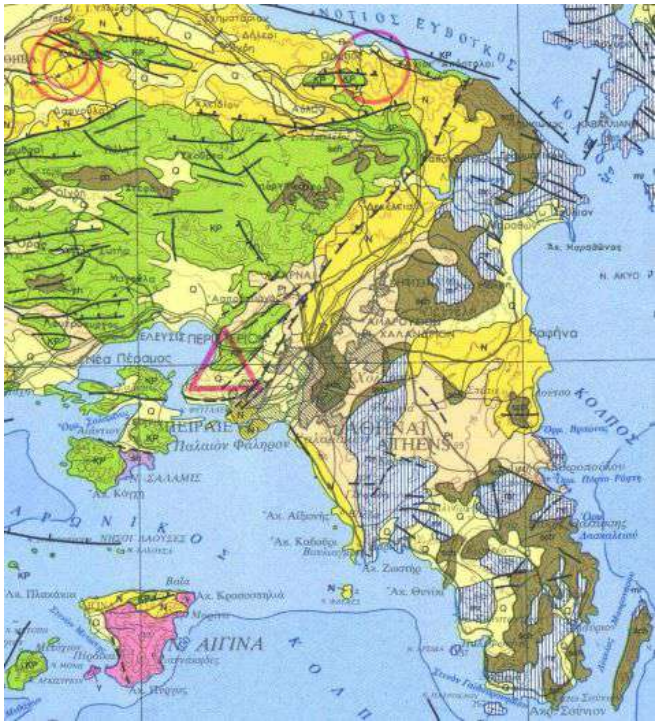



**Σχήμα 3. Συχνότητα εμφάνισης συγκεκριμένου γεωλογικού σχηματισμού σύμφωνα με τις περιγραφές των φοιτητών.**




**Σχήμα 4. Χάρτης εμφάνισης πετρωμάτων και εδαφών στον Ελλαδικό χώρο (από Saroglou, (2019), *Geosciences*, 9, 4, 163, p. 1-21).**

Στο Σχήμα 5 παρουσιάζεται ο γεωλογικός χάρτης της Αττικής (απόσπασμα σεισμοτεκτονικού χάρτη Ελλάδας σε κλίμακα 1:500.000, ΙΓΜΕ 1989) και δίδεται εδώ ενδεικτικά μόνο για να τονιστεί η ποικιλία των γεωλογικών σχηματισμών στη περιοχή της Αττικής (διαφορετικές χρωματικές αποχρώσεις).




**Σχήμα 5. Γεωλογικός χάρτης Αττικής (απόσπασμα σεισμοτεκτονικού Χάρτη Ελλάδας κλίμακα 1:500.000, ΙΓΜΕ 1989).**

**Ενδεικτικές θέσεις γεωλογικών εμφανίσεων και αποτύπωσης**

Πολλοί φοιτητές διάλεξαν εμφανίσεις ασβεστολίθων από πρανή σε παλαιά λατομεία (όπως Τουρκοβούνια, Νίκαια, Θέατρο Βράχων) αλλά και χαρακτηριστικών λόφων της Αθήνας (Λυκαβηττός, Άρειος Πάγος, Τουρκοβούνια). Επιλεγμένα παραδείγματα θέσεων χαρακτηρισμού και αποτύπωσης γεωλογικών σχηματισμών από τους φοιτητές παρουσιάζονται στο Σχήμα 6.

Ασβεστόλιθος, Τουρκοβούνια (Χ. Λάζαρη)

**Σχήμα 6. Παραδείγματα θέσεων χαρακτηρισμού και αποτύπωσης γεωλογικών σχηματισμών από τους φοιτητές. Σε παρένθεση το όνομα του φοιτητή-φοιτήτριας.**

Ασβεστόλιθος, Βάρη (Μ. Νικολίτση)

Μάργες & ψαμμίτες, Ραφήνα (Λ. Στελλάκης)

Ιγκνιμβρίτης, Σαντορίνη (Β. Λουκίσα)

**Αποτύπωση σε χάρτη της γεωλογικής εμφάνισης**

Οι περισσότεροι χρησιμοποίησαν πολύ καλά εφαρμογές εύρεσης της γεωγραφικής τους θέσης στο κινητό και στο Google Earth, ενώ βρήκαν και άλλες εφαρμογές σχετικές με την εργασία, όπως μια εφαρμογή κινητού για τον εντοπισμό ορυκτών ενός πετρώματος. Κάποιοι φοιτητές αναγνώρισαν και γεωλογικά φαινόμενα στην περιοχή που επέλεξαν, όπως: καρστικό ανάγλυφο, εμφάνιση ρήγματος, αποσάθρωση των πετρωμάτων (όπως του γρανίτη), διάταξη των ηφαιστειακών πετρωμάτων κ.α. (Σχήμα 7).

Καρστικό βύθισμα - Δολίνη, Βόνιτσα (Α. Κομποτιάτη)

Κατοπτρική επιφάνεια ρήγματος Αρκίτσας, Λαμία (Γ. Μαζιώτη)

**Σχήμα 7. Ορισμένοι φοιτητές σχολίασαν, εκτός από τον χαρακτηρισμό, και γεωλογικές δομές (ρήγματα, καρστικά βυθίσματα κ.α.) και διεργασίες (αποσάθρωση, διάβρωση).**

Όπως φαίνεται και από τα παραπάνω οι φοιτητές κάλυψαν αρκετά σημεία της χώρας αλλά και ένα πλήθος γεωλογικών σχηματισμών, καθώς η χώρα μας παρουσιάζει μια εξαιρετική ποικιλία πετρωμάτων και γεωλογικών καταστάσεων. Η ποικιλία γεωυλικών και καταστάσεων μεταφράζεται σε προκλήσεις για τον Πολιτικό Μηχανικό και αναδεικνύει τη σημασία της Γεωλογίας Μηχανικού για την κατασκευή των τεχνικών έργων.

Ευχαριστούμε και συγχαίρουμε τους φοιτητές μας. Η συμμετοχή τους ήταν πολύ σημαντική για την ευρύτερη εκπαιδευτική διαδικασία, έστω και αν αυτή έγινε πέρα από το αυστηρό πλαίσιο της ύλης ενός μαθήματος του προγράμματος σπουδών της Σχολής.

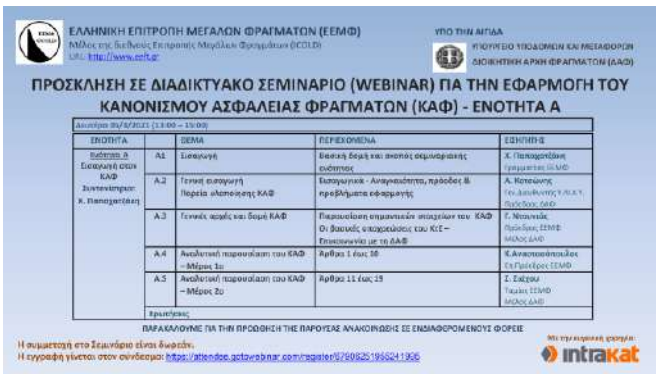
Χ. Σαρόγλου, Δρ. Ε.ΔΙ.Π.
Β. Μαρίνος, Επ. Καθηγητής

ΕΕΜΦ
GCOLD

## ΕΛΛΗΝΙΚΗ ΕΠΙΤΡΟΠΗ ΜΕΓΑΛΩΝ ΦΡΑΓΜΑΤΩΝ

### Σεμινάρια Εφαρμογής Κανονισμού Ασφαλείας Φραγμάτων

Η **Ελληνική Επιτροπή Μεγάλων Φραγμάτων (ΕΕΜΦ), υπό την αιγίδα της Διοικητικής Αρχής Φραγμάτων**, διοργανώνει σειρά εκπαιδευτικών διαδικτυακών σεμιναρίων με θέμα την εφαρμογή του Κανονισμού Ασφάλειας Φραγμάτων.


Τα Σεμινάρια απευθύνονται σε Μηχανικούς και Επιστήμονες Δημόσιων και Ιδιωτικών Φορέων που ασχολούνται με το σχεδιασμό, την κατασκευή και τη λειτουργία Φραγμάτων & Ταμιευτήρων, και στοχεύουν να τους ενημερώσουν σχετικά με τις

διαδικασίες και τις υποχρεώσεις που απορρέουν από την εφαρμογή του Κανονισμού Ασφαλείας Φραγμάτων.

Η συμμετοχή στο Σεμινάριο είναι δωρεάν.

Το πρώτο Σεμινάριο θα διεξαχθεί στις **05/04/2021 ώρα 13:00-15:00**.

Για την εγγραφή σας παρακαλούμε πατήστε στον παρακάτω σύνδεσμο:

https://attendee.gotowebinar.com/register/6790625195524 1995

Ο.Α.Σ.Π.
Οργανισμός Αντισεισμικού Σχεδιασμού & Προστασίας

**ΟΡΓΑΝΙΣΜΟΣ ΑΝΤΙΣΕΙΣΜΙΚΟΥ ΣΧΕΔΙΑΣΜΟΥ ΚΑΙ ΠΡΟΣΤΑΣΙΑΣ**

ΥΠΟΥΡΓΕΙΟ ΥΠΟΔΟΜΩΝ ΚΑΙ ΜΕΤΑΦΟΡΩΝ

## Ο.Α.Σ.Π. 2020
## Δραστηριότητες


Δημοσιεύτηκε το ετήσιο Τεύχος Δραστηριοτήτων του Οργανισμού Αντισεισμικού Σχεδιασμού και Προστασίας.

Στο τεύχος αποτυπώνεται το σύνολο των δραστηριοτήτων του Οργανισμού στο 2020, ενός έτους που χαρακτηρίστηκε από 2 σημαντικά σεισμικά γεγονότα, που εκδηλώθηκαν σε συνθήκες πανδημίας. Ο ΟΑΣΠ το 2020 συνέχισε με δράσεις που έχουν κοινωνική διάσταση, δίνουν προτεραιότητα στην εφαρμοσμένη έρευνα, στην εκπαίδευση του γενικού πληθυσμού και ειδικών ομάδων, στη διεθνή συνεργασία, και στην αποτελεσματική διαχείριση του σεισμικού κινδύνου.

Το τεύχος είναι διαθέσιμο **εδώ**

ETAM
ΕΛΛΗΝΙΚΟ ΤΜΗΜΑ ΑΝΤΙΣΕΙΣΜΙΚΗΣ ΜΗΧΑΝΙΚΗΣ
HELLENIC ASSOCIATION FOR EARTHQUAKE ENGINEERING

## Υποψηφιότητες Βραβείων Νέων Μηχανικών και Ερευνητών

Είμαστε στην ευχάριστη θέση να σας ενημερώσουμε ότι σύμφωνα με την ομόφωνη απόφαση της Εκτελεστικής Επιτροπής του Ελληνικού Τμήματος Αντισεισμικής Μηχανικής (Ε.Τ.Α.Μ.), κατά τη Συνεδρίαση της 9ης Φεβρουαρίου 2021 ενεργοποιείται η διαδικασία απονομής δύο βραβείων για νέους Μηχανικούς και Ερευνητές της χώρας μας στο αντικείμενο της Αντισεισμικής Μηχανικής. Τα βραβεία αυτά αφορούν:

(α) Μια δημοσίευση σε επιστημονικό περιοδικό κατόπιν κρίσης

(β) Μια Διδακτορική Διατριβή

Οι όροι και οι προϋποθέσεις συμμετοχής περιγράφονται αναλυτικά στον παρακάτω σύνδεσμο:

(Προθεσμία έως και την **1η Απριλίου 2021**)

Υποβολή Συμμετοχής

Ελληνικό Τμήμα Αντισεισμικής Μηχανικής
Νίκης 4, Αθήνα
www.eltam.org
etamannouncements@gmail.com

**ΕΛΛΗΝΙΚΗ ΕΠΙΤΡΟΠΗ ΣΗΡΑΓΓΩΝ και ΥΠΟΓΕΙΩΝ ΕΡΓΩΝ (Ε.Ε.Σ.Υ.Ε.)**
**Ιπποκράτους 196, ΤΚ.11472Αθήνα, Ελλάδα.**
**e-mail: eesye.gr@gmail.com / www.eesye.gr**

Αθήνα, 9 Μαρτίου 2021

**Θέμα: Γυναίκες & Σήραγγες**

Αγαπητοί / ές Συνάδελφοι

Η Ελληνική Επιτροπή Σηράγγων και Υπογείων Έργων, στα πλαίσια συνεργασίας με τη Διεθνή Επιτροπή Σηράγγων & Υπογείων Έργων ITA-AITES και την Επιτροπή Σηράγγων της Βραζιλίας, συλλέγει στοιχεία για τον αριθμό γυναικών στην Ελλάδα που είναι ενεργές μηχανικοί και εργάζονται ή εργάσθηκαν σε / για υπόγεια έργα.

Στο πλαίσιο αυτό γίνεται σχετική προσπάθεια καταγραφής και για το λόγο αυτό καλούνται οι γυναίκες μέλη της ΕΕΣΥΕ και και όχι μόνον να δηλώσουν, εφόσον το επιθυμούν, το όνομα και την εμπειρία τους σε υπόγεια έργα είτε εργάζονται τώρα σε αυτά ή έχουν εργαστεί τα τελευταία 30 έτη. Η καταγραφή γίνεται μέσω της ακόλουθης φόρμας.

Φόρμα Καταγραφής

Το συντονισμό της δράσης εκ μέρους της ΕΕΣΥΕ έχει αναλάβει η Δρ. Π. Γιούτα-Μήτρα, τέως Αντιπρόεδρος της ΕΕΣΥΕ. Για περισσότερες πληροφορίες μπορείτε να επικοινωνείτε απ' ευθείας μαζί της στην ηλεκτρονική διεύθυνση antipaxos@metal.ntua.gr.

Παρακαλείσθε όπως κοινοποιήσατε τα ανωτέρω και σε μη μέλη μας, ώστε να δοθεί μία πληρέστερη εικόνα για την Ελλάδα.

Για το Δ.Σ. της ΕΕΣΥΕ

SIMSG ISSMGE

**International Society for Soil Mechanics and Geotechnical Engineering**

**ISSMGE News & Information Circular March 2021**
www.issmge.org/news/news-and-information-circular-march-2021

**1. 20ICSMGE / 7iYGEC – NEW DATES – MAY 2022**

New dates have been confirmed for the conferences in Sydney as follows; 7iYGEC - Friday 29 April-Sunday 1 May 2022 20ICSMGE – Sunday 1 May – Thursday 5 May 2022.

For more information, please visit the conference website (https://icsmge2021.org/) which is in the process of being updated.

**2. CORPORATE ASSOCIATES' PRESIDENTIAL GROUP**

The March 2021 CAPG update (https://www.issmge.org/corporate-associates/corporate-associates-presidential-group) has important information on the soon upcoming CAPG speciality session at the International Foundations Conference and Equipment Expo (IFCEE), in Dallas, USA, May 10 -14, 2021, the CAPG sessions at the 20th ICSMGE in Sydney (May 2022), the successful completion of the world wide online sessions for the ISSMGE Overdesign Survey, planning of CAPG contributions to the ISSMGE virtual Time Capsule project and other important areas.

**3. ISSMGE TC217 LAND RECLAMATION SEMINAR SERIES**

The committee of TC217 is hosting a trilogy of online seminars on topics relating to land reclamation from consultant, specialist contractor and academic perspectives. Please register your interest to attend these seminars here: https://forms.gle/QLPkWYzFguxbqJPz7

Seminar Programme:

1. Construction and Reclamation of the SARB Islands offshore the coast in Abu Dhabi by Dr. Ir. Patrick Mengé - 11 March 2021, 7pm (GMT+8)
2. Innovative Approaches to Land Reclamation in Singapore by Er. James Lam Pei Wei - 15 April 2021, 7pm (GMT+8)
3. Land Reclamation using Soft Clay by Prof. Chu Jian - 20 May 2021, 7pm (GMT+8)
4. Application of Machine Learning in Cement Stabilisation in Land Reclamation by Assoc. Prof. Darren Siau Chen Chian - 20 May 2021, 7:30pm (GMT+8)

**4. BULLETIN**

The latest edition of the ISSMGE Bulletin (Volume 15, Issue 1, February 2021) is available from the website https://www.issmge.org/publications/issmge-bulletin/vol-15-issue-1-february-2021

**5. ISSMGE FOUNDATION**

The next deadline for receipt of applications for awards from the ISSMGE Foundation is the 31st May 2021. Click **here** for further information on the ISSMGE Foundation.

**6. CONFERENCES**

For a listing of all ISSMGE and ISSMGE supported conferences, and full information on all events, including deadlines, please go to the Events page at https://www.issmge.org/events. However, for updated information concerning possible changes due to the coronavirus outbreak (ie. postponements, cancellations, change of deadlines, etc), please refer to that specific event's website.

As might be expected, many events have been rescheduled and we update the Events page whenever we are advised of changes.

The following are events that have been added since the previous Circular:

**ISSMGE Events**

**16TH INTERNATIONAL CONFERENCE ON GEOTECHNICAL ENGINEERING, 23-02-2022 - 24-02-2022** University of Engineering & Technology (UET) Lahore, Pakistan; Language: English; Contact information: Dr. Jahanzaib Israr; Department of Civil Engineering, University of Engineering & Technology Lahore; Phone: +923344132808; Email: 16icge@uet.edu.pk; Website: https://16icge.uet.edu.pk/

**GEOTECHNICAL ENGINEERING FOR THE PRESERVATION OF MONUMENTS AND HISTORIC SITES, 22-06-2022 - 24-06-2022** Naples, Italy; Organizer: TC 301, AGI (Italian Geotechnical Society), Contact person: Filomena de Silva, Email: secretary@tc301-napoli.org, Website: http://www.tc301-napoli.org

**XVIII EUROPEAN CONFERENCE ON SOIL MECHANICS AND GEOTECHNICAL ENGINEERING - 25-08-2024 - 30-08-2024** Lisbon, Portugal; Organisers: SPG; E-mail: spg@lnec.pt


The Innovation and Development Committee of ISSMGE is pleased to announce that through the initiative of Dr. Miguel Angel Cabrera, Dr. Luis Felipe Prada-Sarmiento, and the Colombian Geotechnical Society (SCG), the 125 papers from the proceedings of the 13th International Symposium on Landslides (XIII ISL) are available in the online library here:

https://www.issmge.org/publications/online-library

The abstracts and papers of the proceedings were reviewed through ISSMGE's Conference Review Platform which is part of its cyber-infrastructure aiming to support open access.

The XIII ISL was originally scheduled to be held in Cartagena, Colombia in June 2020, but due to the SARS-CoV-2 pandemic it was postponed and rescheduled in an online platform and held from the 22nd to the 26th of February, 2021.

Detailed acknowledgements for the XIII ISL can be found at the ISSMGE online library acknowledgements section.

VII International Conference on Earthquake Geotechnical Engineering
Roma (Italy), 17-20 June 2019

VII ICEGE ROMA 2019

The Innovation and Development Committee of ISSMGE is pleased to announce that through the initiative of TC203 Chair, Prof. Misko Cubrinovski and the conference Chairs Prof. Francesco Silvestri (University of Napoli Federico II, Conference Chairman) and Nicola Moraci (University of Reggio Calabria, President of AGI, the Italian Geotechnical Society), the 674 papers of the 7th International Conference on Earthquake Geotechnical Engineering (7ICEGE) that was held on June 17-20, 2019, in Rome, Italy are available in the online library here:

https://www.issmge.org/publications/online-library

The conference and proceedings were made possible by the contributions of numerous people and organizations. Detailed acknowledgements for the 7ICEGE can be found at the ISSMGE online library acknowledgements section.

ISRM

International Society for Rock Mechanics and Rock Engineering

**ISRM News Journal**

Dear ISRM Member

The 2020 issue, volume 23, of the ISRM News Journal is now online on the ISRM website. Since 2012 the ISRM distributes the News Journal to all members in electronic version, and prints copies which are available at our sponsored symposia.


The News Journal includes news from the society life, including board and regional reports, commission work, conference and symposia reports and papers from awarded members, among other content. Click here to read it directly on our website or to download it.

Best regards

Luís Lamas
ISRM Secretary General

**News**
**www.isrm.net/noticias/?tipo=1&todas=1&show=info**

33rd ISRM Online Lecture is Online
2021-03-25

The 33rd Online Lecture with the title "The role of rock mechanics in the safe and economic development of oil fields" by Professor Sergio Fontoura is now online.

ARMS11 both online and offline and with extended date for abstract submission
2021-03-24

ARMA Student Design Competition
2021-03-19

The ARMA Student Design Competition, jointly organized by ARMA student chapters at the University of Kentucky and Virginia Tech, offers undergraduate and graduate students an opportunity to test their knowledge, creativity, team-work, and problem-solving skills by exposing them to a real-life rock engineering-related case-study problem.

2020 News Journal is online
2021-03-18

Last years' issue of the ISRM News Journal with the Anual Review, conference reports, technical papers and more is now online.

ARMS11 - abstract submission deadline extended to 1 April 2021
2021-03-12

33rd ISRM Online Lecture on March 25
2021-03-09

The 33rd Online Lecture with the title "The role of rock mechanics in the safe and economic development of oil fields" by Professor Sergio Fontoura will broadcast on the 25th March at 10 A.M. GMT.

Course on Empirical Methods in Rock Mechanics and Rock Engineering by Dr. Nick Barton
2021-03-07

The new ISRM course on "Empirical Methods in Rock Mechanics and Rock Engineering " by Dr. Nick Barton, is available on the ISRM website, in open access.

International Webinar on Rock Mechanics organized by young members of ISRM National Groups
2021-03-06

Some Young Members of different ISRM National Groups (Chile, France, Italy, Paraguay, and Spain) started working in the organization of a series of international webinars on rock mechanics, with the aim of involving young researchers in different educational activities.

## 33rd ISRM online lecture by Prof. Sergio Fontoura

Dear ISRM Members and Rock Mechanics Colleagues,

For the 33rd ISRM Online Lecture the ISRM invited Prof. Sergio Fontoura. The title of the lecture is "**The role of rock mechanics in the safe and economic development of oil fields**". The lecture will broadcast on the 25th March at 10 A.M. GMT.

Sérgio Fontoura graduated in Civil Engineering in 1972 at the Pontifical Catholic University of Rio de Janeiro and immediately enrolled as a MSc student at the same School. During his MSc studies, after deciding to join the Academic life, he started to teach Soil Mechanics as an Assistant Teacher. After finishing his degree, he spent a short period of work as field engineer in charge of soft soil sampling campaign and designing equipment for sampling and testing soft clays. He left Brazil in 1975 to become a PhD student at the University of Alberta, Canada, and graduated in 1980 under the supervision of Professor Nobert Morgenstern. He returned to Brazil and joined the academic staff at the PUC-Rio.

In 1983, he spent a short period at the Disaster Prevention Research Institute from the University of Kyoto, Japan, where he developed studies on underground excavations in Japan as Visiting Scholar, hosted by Professor Toru Shibata. In the academic year of 1988 – 1989, he stayed as a Visiting Professor at the University of Toronto in close collaboration with Professor Evert Hoek.

Over the years, Professor Fontoura has taught many courses on Soil Mechanics, Solid Mechanics, Underground Excavations and Rock Mechanics. In 1990, he introduced the course on Petroleum Geomechanics at the Catholic University in Rio and, after that, he became fully involved in the field of rock mechanics to the petroleum industry. At the same year, he started the Group of Technology and Petroleum Engineering at PUC-Rio with the mission of carrying out research and development project for the Brazilian Industry. This research group is still very active and has developed many studies for several oil companies operating in Brazil, notably in the fields of wellbore construction and reservoir engineering.

Professor Fontoura has supervised over 100 students in their research work and some of these students are today very active as professionals in the oil industry. He has published over 120 articles in many areas of geotechnical engineering notably in the application of rock mechanics to petroleum engineering. He has worked as consultant for rock mechanics engineering projects and has served as expert in judicial case involving failure of engineering structure.

Professor Fontoura has dedicated part of his time serving the Professional Associations. He helped forming the Brazilian Tunneling Committee where he served as first president for four years and representative of Brazil at the International Tunneling Association. He served as President of the Brazilian Rock Mechanics Committee for 8 years and he was the representative and voting delegate of Brazil in the ISRM Council from 2003 to 2015. During this period, he attended all Council meetings and participated actively as member of the Rock Testing Commission and served as Chair of the Petroleum Geomechanics Commission and Co-Chair of the ISRM Young Member Committee. In 2015 he was elected to serve ISRM as Vice-President for South America and his term ended in 2019. He was the Chair of the Organizing Committee of the 14th ISRM Congress held in Foz do Iguaçú, Brazil.

The lecture will remain online so that those unable to attend at this time will be able to do it later. As usual, the attendees will be able to ask questions to the lecturer by e-mail during the subsequent five days. All online lectures are available from **this page**.

ASSOCIATION INTERNATIONALE DES TUNNELS ET DE L'ESPACE SOUTERRAIN
AITES | ITA
INTERNATIONAL TUNNELLING AND UNDERGROUND SPACE ASSOCIATION

**Scooped by ITA-AITES #38, 2 March 2021**

Construction of test disposal tunnel under way at Onkalo : Waste & Recycling | Finland

Tunnel between Italy and Austria to provide geothermal heat | Austria

Helsinki-Tallinn tunnel firm to set up research centre in metals mine | Finland - Estonia

WestConnex construction blast plans from Haberfield to St Peters dumped | Australia

First tunneling machine reaches future Wilshire/La Cienega subway station | United States of America

Norwegian tunnel developments with electric vehicles

Veravali-Powai-Ghatkopar water supply tunnel: BMC to bring new TBM to complete project | India

'It is epic down there': First look at Brisbane's new underground station | Australia

Boris Johnson 'wants a giant roundabout under Isle of Man' to connect Britain with Northern Ireland | UK

Explained: The key features of Mumbai's undersea tunnel, the first in India

HS2 construction site prepares to launch tunnel boring machine | UK

Tunneling Industry Outlook 2021 | United States of America

**Scooped by ITA-AITES #39, 16 March 2021**

Norway's $325 million ship tunnel gets go-ahead

Australia's Metro Tunnel eastern entrance work completed ahead of schedule

Webuild unveils Mireillle the TBM for Grand Paris Express Line 16 | France

Strabag and West End Connectors anticipated to build Toronto subway tunnel projects | Canada

Malacañang exec: Kaliwa Dam project pushing through, tunneling machine arriving in May | Philippines

NPC deputy proposes abolishing superstition-fueled discrimination against women in China's construction industry

S$356m contract awarded for tunnel between future Aviation Park and Loyang MRT stations on Cross Island Line | Singapore

The Eisenhower Tunnel transformed transportation in Colorado, but now it needs serious upgrades | United States of America

Mexico City to invest 41 billion pesos to upgrade Metro subway system

TRA underground project in Taoyuan to break ground in 2022 | Chinese Taipei

BMRCL deploys fifth tunnel boring machine | India

Green lights for Sydney Metro West | Australia

Email: communication@ita-aites.org

**Scooped by ITA-AITES #40, 30 March 2021**

Trio of companies win prep work on $3bn new road tunnel under Swiss Alps

Barhale opts for simultaneous pipejacks | UK

Do the Shetland Islands need a tunnel vision? | UK

Inside HS2 factory creating walls for the Chiltern tunnels | UK

Work on Mohmand Dam in top gear despite pandemic hiccups | Pakistan

A look inside a crumbling Hudson River rail tunnel | United States of America

Fugro completes geotechnical investigation for Fehmarnbelt Tunnel | Denmark - Germany

China's longest underwater highway tunnel to be completed

This inverted building saves energy because it's 300 feet underground | United States of America

New tunnelling machine for the Snowy Hydro 2.0 named Lady Eileen | Australia

Geothermal energy could save the planet but watch for earthquakes | Switzerland

Province, Metrolinx move ahead with Yonge North Subway extension project | Canada

**http://www.britishtunnelling.org.uk**

**BTS March 2021 Meeting:**
**Werrington Grade Separation Curved Box Jack**

Speaker

**Matt Hadden, Senior Project Manager, Morgan Sindall Infrastructure**

A diver-under structure was required to take two railway lines beneath the East Coast Main Line, removing a key bottleneck on the network. A 150m long, 8m high, 11.5m wide, 750m radius curved reinforced concrete box weighing 11,000T was constructed offline and then jacked 165m into position during a 9-day partial closure of the main line.

In this lecture, Matt Hadden will discuss the engineering challenges faced in the construction of the scheme.

Thursday 18th March 2021 at 18:00 hrs [GMT], Online at: https://youtu.be/l6UKpfRpv5o

**BTSYM Workshop:**
**Point clouds in Geoengineering**
**Thursday, 15 April at 15:00 to 17:00 hrs [UTC+1]**

**Workshop Leaders:**

Ioannis Farmakis - PhD Candidate, Queen's University, Canada Stratis Karantanellis - PhD Candidate, AUTH, Greece

Delivered by Ioannis Farmakis and Stratis Karantanellis, Engineering Geologists from the Aristotle University of Thessaloniki, Greece, and doctorate researchers focusing on investigating landslide and rockfall phenomena by applying high-resolution Close-range Sensing, Computer Vision, and Geoinformatics, the themes of the workshop will include:

- The integration of point clouds into geoengineering workflows which is actively driving a big cluster of slope engineering practice in both industry and academia.
- Applications ranging from precise topography extraction, CAD modelling, change detection to the generation of inputs to numerical analyses.
- An introduction to the point cloud data type, its specificities, and capturing techniques.
- State-of-the-art applications and practices including preliminary site investigation, rock slope modelling and monitoring, as well as future considerations in geoengineering are discussed.
- An interactive session tackling essential aspects of point cloud processing will be presented, including the live demonstration of workflows and methodologies ranging from basic to advanced open-source solutions.
- Q&A Session.

**Book your place at: http://bit.ly/3I2uUH2**

Priority will be given to BTSYM/BTS individual members

For more information contact George.Doulkas@strabag.com or Yannis.Vazaios@arup.com

## Not a Boring Competition - UK entrants

Two British teams have made the final 12 of circa 400 entries into the 'Not a Boring Competition' hosted by The Boring Company. https://www.boringcompany.com/competition

The competition challenges teams from around the world to bore a 30m long and 500mm diameter tunnel as quickly and accurately as possible. With the final event scheduled for summer 2021, near Los Angeles, USA, plenty of work lies ahead for the two teams.

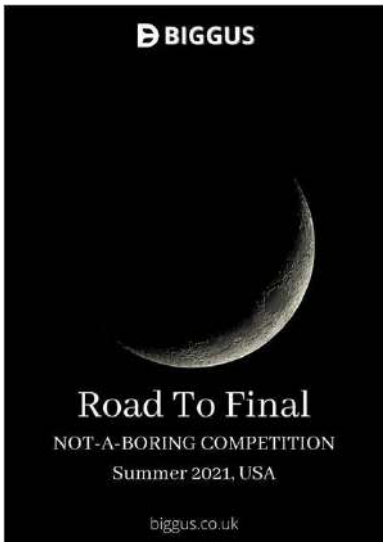
**The Warwick Boring Team**


A group of thirty students, known as the Warwick Boring team at University of Warwick have been working on the innovative tunnelling technology – The Boring Machine to make our transport greener, cheaper and faster in the future.

For further details see: -

- LinkedIn: https://www.linkedin.com/company/warwick-boring
- Twitter: https://twitter.com/warwickboring
- Facebook: https://www.facebook.com/warwickboring
- Website: www.warwickboring.com

**Biggus Diggus**




Biggus started as small team of graduate tunnel engineers who wanted to kill some time during the Covid lockdown. They are presenting their novel idea of a boring machine which they hope will help speed up the process of tunnelling.

Further details see: -

- Website: https://biggus.co.uk/

Both the teams feature current and past students from University of Warwick; including alumni of MSc Tunnelling & Underground Space.

BTSYM wishes both teams Best of Luck in their preparations for the competition later this year and tracking their progress from here to the finish line!

**International Association for Engineering Geology and the Environment**

**IAEG YouTube Channel**

Recently the IAEG has implemented its own communication system by creating its own YouTube channel where we have published all the webinars already present on the specific page of our site and those in progress. (IAEG YouTube channel). This is next to the YEG streaming webinar channel, which is also posted on the IAEG website. In these pandemic times, many lectures or conferences take place online. Unfortunately, the different time zones do not allow many in the world to be able to follow and learn about the interesting online lessons. In the era of globalization, it is important that more and more people, and especially young people coming from remote regions, can draw on important sources of culture.

I think you have surely given some online lecture or conference that you have recorded, so I ask you to spread your knowledge all over the world, helping many people to grow, through the IAEG platform (https://www.iaeg.info/ webinar and IAEG channel on YouTube).

Sure of your sensitivity towards these issues, send your webinars that you may have registered at the following address: giorgio.lollino@irpi.cnr.it.

**International Research Association on Large Landslides**
**http://irall.sklgp.cdut.edu.cn/index.htm**

**Free Lectures on Large Landslides**

The International Research Association on Large Landslides, hereinafter named "iRALL" is an international non-governmental, non-political, non-profit-making and unaffiliated institution for the promotion of knowledge about large landslides.

**Free lectures on large landslides from iRALL**

Look back the lectures here.

You can also watch the lectures by scanning the QR code.

Click here to view the lecturers and topics.

For more information, please visit:
SKLGP Website http://en.sklgp.cdut.edu.cn/
iRALL Website http://irall.sklgp.cdut.edu.cn/

# ΠΡΟΣΦΟΡΕΣ - ΠΡΟΚΗΡΥΞΕΙΣ ΘΕΣΕΩΝ ΓΙΑ ΓΕΩΤΕΧΝΙΚΟΥΣ ΜΗΧΑΝΙΚΟΥΣ

**Institute for Sustainability and Innovation in Structural Engineering**

**Position available on Earthquake Engineering and Seismology (PhD Student)**

The Historical and Masonry Structures (HMS) group of the Institute for Sustainability and Innovation in Structural Engineering (ISISE), University of Minho, Portugal, plans to open soon a position PhD student (duration of the contract planned for 3 years) to join the STAND4HERITAGE project, which is funded by a European Research Council Advanced Grant.

The position will focus on the stochastic analysis of the seismic signal with the aim to generate a representative variation of ground motion records (both source and structure-sensitive), and to examine the influence of the signal on the dynamic (seismic) behavior of masonry structures.

Necessary qualifications: MSc degree in Civil Engineering or Earthquake Engineering with some background in seismic engineering, stochastic analysis or geophysics. Additional experience in regional ground motion simulation (e.g. physic-based including deterministic, stochastic, hybrid or site-based approaches) or similar qualifications would be considered an asset. Students completing their MSc degree this summer are invited to demonstrate their interest in the position.

If interested, please send your résumé with a copy of the BSc and MSc certificate to Dr Shaghayegh Karimzadeh Naghshineh (shaghkn@gmail.com) until Sunday, April 11th (23:59 GMT). If your MSc certificate is not yet issued, please provide your current courses certificate and GPA.

Paulo B. Lourenço

**MSc in Tunnelling and Underground Space Bursary 2021**

The British Tunnelling Society (BTS) is intending to award a bursary with a value of up to £20,000.

This may be divided between two or more candidates if the situation arises where there is not a single clear winner.

This bursary will be available for the 2021/22MSc Tunnelling and Underground Space course and it is intended that it will cover course fees with the balance contributing towards living expenses.

Please refer to the terms within the attached invitation. The application form is also attached.

Applications close at **1700hrs on Monday 17 May 2021.**

Below is a video that provides an overview pf the MSc Tunnelling & Underground Space at University of Warwick

# ΠΡΟΣΕΧΕΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΚΔΗΛΩΣΕΙΣ

Για τις παλαιότερες καταχωρήσεις περισσότερες πληροφορίες μπορούν να αναζητηθούν στα προηγούμενα τεύχη του «περιοδικού» και στις παρατιθέμενες ιστοσελίδες.

Λόγω της πανδημίας του κορωνοϊού, υπάρχουν αλλαγές είτε στον τρόπο διεξαγωγής των συνεδρίων (με φυσική παρουσία ή virtual), είτε των ημερομηνιών διεξαγωγής κάποιων συνεδρίων. Συνιστάται να ελέγχετε την ημερομηνία διεξαγωγής απ' ευθείας στον ιστότοπο του συνεδρίου.

Second International Conference on Geotechnical Engineering - Iraq 2021, 5-6 April 2021, Akre (Aqrah), Duhok, Iraq, http://ocs.uobaghdad.edu.iq/index.php/icgeotecheng/icgte

Virtual Rocscience International Conference on Numerical Modelling "The Evolution of Geotech: 25 Years of Innovation", April 20th - 21st, 2021, www.rocscience.com/learning/rocscience-conference

2nd Vietnam Symposium on Advances in Offshore Engineering – Sustsainable Energy & Marine Planning, 22-24 April 2021, Ho Chi Minh City, Vietnam, https://vsoe2021.sciences-conf.org

16th International Conference of the International Association for Computer Methods and Advances in Geomechanics – IACMAG - CHALLENGES and INNOVATIONS in GEOMECHANICS, 03-05-2021, Torino, Italy, www.symposium.it/en/events/2020/16th-international-conference-of-iacmag?navbar=1

9th International Symposium on Geomechanics ISRM Specialized Conference "Applied Geomechanics in Proactive Designs: Opportunities, Challenges and Security", Virtual, 3 - 6 May, 2021, Medellin, Colombia, https://minas.medellin.unal.edu.co/gruposdeinvestigacion/giga/en/symposium-9/about-symposium.html

ATS 2020 AUSTRALASIA TUNNELLING CONFERENCE, 10th – 13th May 2021, Melbourne, Australia, www.ats2020.com.au

TISOLS Tenth International Symposium on Land Subsidence, Living with Subsidence, 17-21 May 2021, Delft - Gouda, the Netherlands, www.tisols2020.org/tisols2020

Virtual 2020 CHICAGO ICTG International Conference on Transportation Geotechnics, May 23 - 26, 2021, Chicago, Illinois, USA, http://conferences.illinois.edu/ICTG2020

Fifth International Conference on New Developments in Soil Mechanics and Geotechnical Engineering, 27 – 29 May 2021, Nicosia, Northern Cyprus https://zm2020.neu.edu.tr/

2021 ICOLD MARSEILLE - ICOLD 27th Congress - 89th Annual Meeting Sharing Water: Multipurpose of Reservoirs and Innovations, 4 - 11 June 2021, Marseille, France, https://cigb-icold2021.fr/en/

International Airfield and Highway Pavements Conference, June 6-9, 2021, Austin, Texas, USA, www.pavementsconference.org

MSL 2021 The 1st Mediterranean Symposium on Landslides SLOPE STABILITY PROBLEMS IN STIFF CLAYS AND FLYSCH FORMATIONS, 7-9 June 2021, Naples, Italy, https://medsymplandslides.wixsite.com/msl2021

Felsmechanik- und Tunnelbautag

**6th Rock Mechanics& Tunneling Day**
**Rock mechanical aspects of the Railway Project Stuttgart –Ulm and other national and international projects**
**10.06.2021, Rosengarten, Mannheim, Germany**
**www.felsmechanik.eu**

We hereby invite you to the 6th Rock Mechanics and Tunneling Day in June 2021. We look forward to welcoming you on site in Mannheim or virtually in June 2021.

**Program**

- Invited lecture "Mobility, Environment, CO2-Reduction – The Role of the German Railway"
- Overview lecture Stuttgart-Ulm "Status of Design and Construction of the Project Stuttgart –Ulm"
- "From Civil Construction to Slab Tracks & Signalling for the Railway Node Stuttgart"
- "Tunnels to Obertürkheim-Undercrossing the bridge "Bruckwiesenweg" and the Railway line to Ulm"
- "Full face excavation of large cross sections in leached gypsum keuper underneath buildings and comparison with sidewall headings"
- "2. Main line for Rapid Transit Train, Munich. Overview of project with a focus on tunnel construction at Europe's largest nodal station"
- "2. Main line for Rapid Transit Train, Munich, lot 41 Marienhof. A project with challenges in the heart of Munich"
- "2. Main line for Rapid Transit Train, Munich. Lot 50 -construction measures tunnel and station east"
- "Challenges of the new underground long-distance train station in Frankfurt"
- "GPE –Grand Paris Express, Overview of Project –Challenges for Tunneling"

Registration should be made until May 10, 2021, via E-Mail: wbi@wbionline.de, or via: www.felsmechanik.eu.

5th Symposium of the Macedonian Association for Geotechnics "The problems associated with soft rocks in rock engineering", an ISRM Specialized Conference, 10-12.06.2021, Ohrid, North Macedonia, https://mag.net.mk/v-mag-symposium-28-30-5-2020

9th International Conference on Computational Methods for Coupled Problems in Science and Engineering (COUPLED PROBLEMS 2021), 13-16 June 2021, Sardinia, Italy, coupledproblems_sec@cimne.upc.edu

Rapid Excavation and Tunneling Conference RETC2021, June 13-16, 2021, Las Vegas, Nevada, USA, www.retc.org

Cities on Volcanoes 11 - Volcanoes and Society: environment, health and hazards, 14-18 June 2021, Heraklion, Crete, https://pcoconvin.eventsair.com/volcanoes11

Joint meeting of ISSMGE TC201 and TC210, ICOLD TC E and TC LE "Dams and Levees: Particle Movements – Case Studies, Experiments, Theory", June 16-19, 2021, Budapest, Hungary, www.isc6-budapest.com

6th International Conference on Geotechnical and Geophysical Site Characterization "Toward synergy at site characterisation", June 16-19, 2021, Budapest, Hungary, www.isc6-budapest.com

EGRWSE 2020 - 3rd International Conference on Environmental Geotechnology, Recycled Waste Materials and Sustainable Engineering, 17-19 June 2021, Izmir, Turkey, www.egrwse2020.com

2nd ICPE 2021 The Second International Conference on Pressin Engineering, 19-21 June 2021, Kochi, Japan, https://icpe-ipa.org/

DFNE 2021 3rd International Conference on Discrete Fracture Network Engineering (in conjunction with ARMA 2021), June 23-25, Houston, Texas, USA, www.dfne2021.org

1st International Conference on Sustainability in Geotechnical Engineering, ICSGE, 27-30 June 2021, Lisboa, Portugal, http://icsge.lnec.pt/#

DFI Deep Mixing, 5-8 July 2020, TBD, Gdansk, Poland, www.dfi.org/DM2020

II International Seminar "Tailings and Waste Rock Disposal", July 12 – 14, 2021, Lima, Peru, www.geoingenieria.org.pe

7th ICRAGEE International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, 12-17 July 2021, Bengaluru, India, http://7icragee.org

AFRICA 2021 Water Storage and Hydropower Development for Africa, 13-15 July 2021, Lake Victoria, Uganda, www.hydropower-dams.com/africa-2021

GEOCHINA 2021 - 6th GeoChina International Conference Civil & Transportation Infrastructures: From Engineering to Smart & Green Life Cycle Solution, July 19 to 21, 2021, Nan-Chang, China, http://geochina2021.geoconf.org

PanAm Unsat 2021 3rd Pan-American Conference on Unsaturated Soils, 25-28 July 2021, Rio de Janeiro, Brazil, https://panamunsat2021.com

7th International Conference on Industrial and Hazardous Waste Management 27-30 July 2021, Chania, Crete, Greece, http://hwm-conferences.tuc.gr (online participation available)

ACE 2020 14th International Congress on Advances in Civil Engineering, 6-8 September 2021, Istanbul, Turkey, www.ace2020.org/en

XVIth International Congress AFTES 2021 Underground, a space for innovation, 6 to 8 September 2021, www.aftes2020.com

COMPLAS 2021 XVI International Conference on Computational Plasticity, Fundamentals and Applications, 7-10 September 2021, Barcelona, Spain, https://congress.cimne.com/complas2021/frontal/default.asp

RMEGV 2021 - 5th International Workshop on Rock Mechanics and Engineering Geology in Volcanic Fields, 9÷11 September 2021, Fukuoka, Japan, https://ec-convention.com/rmegv2021

International Conference on Textile Composites and Inflatable Structures (MEMBRANES 2021), 13-15 September 2021, Munich, Germany, https://congress.cimne.com/membranes2021/frontal/default.asp

EUROGEO WARSAW 2020 7th European Geosynthetics Congress, 19-22 September 2021, Warsaw, Poland, www.eurogeo7.org

37th General Assembly of the European Seismological Commission, 19-24 September 2021, Corfu, Greece, www.escgreece2020.eu

EUROCK TORINO 2021 - ISRM European Rock Mechanics Symposium Rock Mechanics and Rock Engineering from theory to practice, 20-25 September 2021, Torino, Italy, http://eurock2021.com

This British Tunnelling Society "BTS 2020" Conference and Exhibition, Sept 30th - Oct 1st, 2021, London, United Kingdom, www.btsconference.com

Virtual EUROENGEO 3RD EUROPEAN REGIONAL CONFERENCE OF IAEG, 7 - 10 October 2021, Athens, Greece, www.euroengeo2020.org

10th International Conference on Scour and Erosion (ICSE-10), October 17-20, 2021, Arlington, Virginia, USA, www.engr.psu.edu/xiao/ICSE-10 Call for abstract.pdf

3rd International Symposium on Coupled Phenomena in Environmental Geotechnics, 20-22 October 2021, Kyoto, Japan, https://cpeg2020.org

ARMS11 11th Asian Rock Mechanics Symposium, Challenges and Opportunities in Rock Mechanics, 21-25 October 2021, Beijing, China, www.arms11.com

HYDRO 2021 Roles of hydro in the global recovery, 25-27 October 2021, Strasbourg, France, www.hydropower-dams.com/hydro-2021

EURO:TUN 2021 Computational Methods and Information Models in Tunneling, October 27th - 29th, 2021, Bochum, Germany, http://eurotun2021.rub.de

GFAC 2021 International Conference "Geotechnics fundamentals and applications in construction: investigations, design, technologies", October 27–29, 2021, Saint Petersburg, Russia https://gfac.spbgasu.ru

Emerging Technologies and Applications for Green Infrastructure, 28-29 October 2021, Ha Long, Vietnam, https://cigos2021.sciencesconf.org

5TH World Landslide Forum Implementation and Monitoring the USDR-ICL Sendai Partnerships 2015-2015, 2-6 November 2021, Kyoto, Japan, http://wlf5.iplhq.org

ISFOG 2020 4th International Symposium on Frontiers in Offshore Geotechnics, 8 – 11 November 2021, Austin, United States, www.isfog2020.org

2021 GEOASIA7 - 7th Asian Regional Conference on International Geosynthetics Society, November 22-26, 2021, Taipei, Taiwan, www.geoasia7.org

ICGE – Colombo – 2020 3rd International Conference in Geotechnical Engineering, 6-7 December 2021, Colombo, Sri Lanka, http://icgecolombo.org/2020/index.php

2nd International Conference TMM-CH Transdisciplinary Multispectral Modelling and Cooperation for the Preservation of Cultural Heritage - Rebranding The World In Crisis Through Culture, 12-15 December, 2021 Athens, Greece https://tmm-ch.com/

GeoAfrica 2021 - 4th African Regional Conference on Geosynthetics Geosynthetics in Sustainable Infrastructures and Mega Projects, 21-24 February 2022, Cairo, Egypt, https://geoafrica2021.org

ICEGT-2020 2nd International Conference on Energy Geotechnics, 10-13 April 2022, La Jolla, California, USA, https://icegt-2020.eng.ucsd.edu/home

WTC 2022 World Tunnel Congress 2022 - Underground solutions for a world in change, 22-28 April 2022, Copenhagen, Denmark, www.wtc2021.dk

SYDNEY 7iYGEC 2021 7th International Young Geotechnical Engineers Conference A Geotechnical Discovery Down Under, 29 April - 1 May 2022, Sydney, Australia, http://icsmge2021.org/7iygec

SYDNEY ICSMGE 2021 20th International Conference on Soil Mechanics and Geotechnical Engineering, 1–5 May 2022, Sydney, Australia, www.icsgme2021.org

LARMS 2021 – IX Latin American Rock Mechanics Symposium Challenges in rock mechanics: towards a sustainable development of infrastructure, 15 – 18 May 2022, Asuncion, Paraguay, https://larms2021.com

## 5th International Symposium on Cone Penetration Testing

**8-10 June 2022, Bologna, Italy**
**http://cpt22.org**

The Italian Geotechnical Society (AGI) and the University of Bologna are pleased to announce the 5th International Symposium on Cone Penetration Testing, CPT'22, to be held in Bologna, Italy, on June 8-10, 2022. CPT'22, organized under the auspices of the ISSMGE Technical Committee TC102, follows the successful symposia held in Delft, The Netherlands (2018), Las Vegas, Nevada USA (2014), Huntington Beach, California USA (2010) and Linköping, Sweden (1995).

As tradition of the CPT events, which foster a lively debate on recent advancements on cone penetration testing, the Symposium aims at providing Researchers, Practitioners and Contractors with a unique opportunity of sharing up-to-date knowledge in equipment, testing procedures, data interpretation and related applications, as well as discussing emerging solutions and new ideas with the largest gathering of world's experts, academics and non-academics, working in the broad and dynamic area of CPTs.

As tradition of the CPT symposia, the event aims at providing Researchers, Consultants, Practitioners and Contractors with a specialist forum on cone penetration testing in order to share recent findings and research advancements and to discuss the variety of their practical application in the typical lively and friendly environment.

Accordingly, the conference themes are purposely broad and inclusive. They encompass well-established topic categories typically addressed in CPT events (**Equipment and Testing Procedures**; **Data Interpretation**; **Applications**), but also a focus on innovative research areas and emerging fields of CPT application. Emphasis is expected to be placed, among others, on the use and interpretation of cone penetration tests in "unusual soils" (e.g. intermediate, residual volcanic, earth fills, tailings and any other geomaterial with limited experience), innovative analytical and numerical strategies for CPT data interpretation, comparative/combined studies between CPT and DMT and/or other in-situ tests, applications of CPT to offshore engineering and to environmental engineering, soil liquefaction studies, experience from geotest sites.

**Organizer**

Italian Geotechnical Society (AGI) and University of Bologna (endorsed by TC102)

**Associazione Geotecnica Italiana**
Tel. +39 06 4465569
Fax +39 06 44361035
E-mail info@cpt22.org
Address: Viale dell'Università 11, 00185 Roma

3rd European Conference on Earthquake Engineering and Seismology (3ECEES), 19-24 June 2022, Bucharest, Romania, https://3ecees.ro

## 9th International Congress on Environmental Geotechnics

**Highlighting the role of Environmental Geotechnics in Addressing**

## Global Grand Challenges
**26-29 June 2022, Chania, Crete island, Greece**
**www.iceg2022.org**

The 9th International Congress on Environmental Geotechnics is part of the well established series of ICEG. This conference will be held on an outstanding resort in the town of Chania of the island of Crete in Greece. The theme of the conference is "Highlighting the role of Environmental Geotechnics in Addressing Global Grand Challenges" and will highlight the leadership role of Geoenvironmental Engineers play on tackling our society's grand challenges.

Contact Information

- Contact person: Dr. Rallis Kourkoulis
- Email: rallisko@grid-engineers.com

IS-Cambridge 2020 10th International Symposium on Geotechnical Aspects of Underground Construction in Soft Ground, 27 - 29 June 2022, Cambridge, United Kingdom, www.is-cambridge2020.eng.cam.ac.uk


## UNSAT2022
**8th International Conference on Unsaturated Soils**
**June or September 2022, Milos island, Greece**

ICONHIC2022: THE STEP FORWARD - 3rd International Conference on Natural Hazards & Infrastructure, 5 – 7 July 2022, Athens, GREECE, https://iconhic.com/2021

# Eurock 2022
**Rock and Fracture Mechanics in Rock Engineering and Mining**
**12÷15 September 2022, Helsinki, Finland**
**www.ril.fi/en/events/eurock-2022.html**

**Themes**

- Rock mass Characterization
- Geophysics in rock mechanics
- Mechanics of rock joints
- Jointed rock mass behaviour
- Rock support, probability based design
- Rock stress measurements
- Constitutive modelling of rock
- Rock drilling
- Blast induced fractures
- Rock engineering and mining education
- Geological disposal of spent nuclear fuel
- Recent advances in rock mechanics research
- Field and laboratory investigations
- Case studies

**Contact Person:** Lauri Uotinen
**E-mail:** lauri.uotinen@aalto.fi

## 6th Australasian Ground Control in Mining Conference – AusRock 2022
**17 – 19 September 2022, Melbourne, Australia**

**Organizer:** UNSW Sydney, AusIMM
**Contact Person:** Ismet Cambulat
**E-mail:** icambulat@unsw.edu.au

XII ICG - 12th International Conference on Geosynthetics, September 18 – 22, 2022, Rome, Italy, www.12icg-roma.org

28th European Young Geotechnical Engineers Conference and Geogames, 17 – 19 September 2022, Moscow, Russia, https://www.eygec28.com/?

11th International Conference on Stress Wave Theory and Design and Testing Methods for Deep Foundations, 20 - 23 September 2022, De Doelen, Rotterdam, The Netherlands, https://www.kivi.nl/afdelingen/geotechniek/stress-wave-conference-2022

# LARMS 2022
**IX Latin American Congress on Rock Mechanics, Rock Testing and Site Characterization**
**an ISRM International Symposium**
**16-19 October 2022, Asuncion, Paraguay**

**Symposium Themes**

- Site characterization,
- Rock mass properties,
- Rock mass classification,
- Foundations,
- Slopes,
- Tunnels,
- Soft Rock,
- Shotcrete

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# AusRock 2022

**6th Australasian Ground Control in Mining Conference –an ISRM Regional Symposium**
**07 -09 November 2022, Melbourne, Australia**

Organizer: UNSW Sydney, AusIMM
Contact Person: Ismet Cambulat
E-mail: icambulat@unsw.edu.au

88th ICOLD Annual Meeting & Symposium on Sustainable Development of Dams and River Basins, April 2023, New Delhi, India, https://www.icold2020.org

# 15th ISRM

**International Congress in Rock Mechanics**
**9÷14 October 2023, Salzburg, Austria**

Organizer: Austrian Society for Geomechanics
Contact Person: Prof. Wulf Schubert
E-mail: salzburg@oegg.at

# ΕΝΔΙΑΦΕΡΟΝΤΑ ΓΕΩΤΕΧΝΙΚΑ ΝΕΑ

## Solving the mystery of ancient rockslides in the Alps

A rockslide in the European Alps. Credits: Activefrenchriviera.com More

The triggering factors of massive, pre-historic rockslides that occurred in the Alps have finally been revealed.

Signs of ancient rockslides are evident in the European Alps as rock debris has accumulated in valleys. Since there are no historic records of those landslides, there has been a long-lasting debate over their causes.

The landslides are dispersed in relatively small areas and appear to have occurred during the same periods. Moreover, data show that the ground movements were massive and carried large quantities of rocks downwards. Hence, if similar incidents struck in a populated region in the Alps, they would have a devastating impact.

Some researchers believe that the rockslides were caused by intense erosion or precipitation that destabilized the slopes while others suggest that the triggering factors were seismic shocks. However, until now, no unique explanation had been found since the rocky slopes vanished through time.

A new study conducted by scientists from the University of Innsbruck and the Central Institute for Meteorology and Geodynamics in Austria concluded that those rockslides were indeed triggered by earthquakes. The findings were published in Nature Communications.

The researchers could not find answers in the mountainous terrain; hence they focused their investigation on ocean and lake sedimentation, a process that is also impacted by seismic activity. In particular, scientists assessed two major rockslides in the Alps and retrieved boreholes from sedimentary rocks from two lakes.

The team's aim was to find traces of seismic activity within the sediments by applying sophisticated techniques such as computer tomography scans on the retrieved cores and hydroacoustics at the surface of the lake. Their findings suggest that 10 strong and shallow earthquakes occurred in the region during the past 10,000 years.

What was more interesting is that two of those temblors occurred at the same time with the studied rockslides. Therefore, the study deduced that the cause of the ground failures was the seismic shaking solving the chronic debate. Scientists also found patterns of another impact that earthquakes impose on slopes. A seismic shock may not trigger a landslide but also decrease the stability of slopes (seismic fatigue) due to the formation or cracks or due to the reduction of the material's shear strength. The team discovered that at least 5 earthquakes occurred in the studied region before the rockslides and the slopes' integrity was compromised.

It is also worth mentioning that since then, no major earthquakes have struck the region so similar rockslides have not been historically recorded. The developed technique can provide evidence on future landslide phenomena. The team's goal is to assess the findings and derive landslide hazards in populated areas in the Alps.

(Geoengineer.org, Feb, 16, 2021, https://www.geoengineer.org/news/solving-the-mystery-of-ancient-rockslides-in-the-alps)

## Seismic control of large prehistoric rockslides in the Eastern Alps

**Patrick Oswald, Michael Strasser, Christa Hammerl & Jasper Moernaut**

**Abstract**

Large prehistoric rockslides tend to occur within spatio-temporal clusters suggesting a common trigger such as earthquake shaking or enhanced wet periods. Yet, trigger assessment remains equivocal due to the lack of conclusive observational evidence. Here, we use high-resolution lacustrine paleoseismology to evaluate the relation between past seismicity and a spatio-temporal cluster of large prehistoric rockslides in the Eastern Alps. Temporal and spatial coincidence of paleoseismic evidence with multiple rockslides at ~4.1 and ~3.0 ka BP reveals that severe earthquakes (local magnitude $M_L$ 5.5–6.5; epicentral intensity $I_0$ VIII¼–X¾) have triggered these rockslides. A series of preceding severe earthquakes is likely to have progressively weakened these rock slopes towards critical state. These findings elucidate the role of seismicity in preparing and triggering large prehistoric rockslides in the European Alps, where rockslides and earthquakes typically occur in clusters. Such integration of multiple datasets in other formerly glaciated regions with low to moderate seismicity will improve our understanding of catastrophic rockslide drivers.

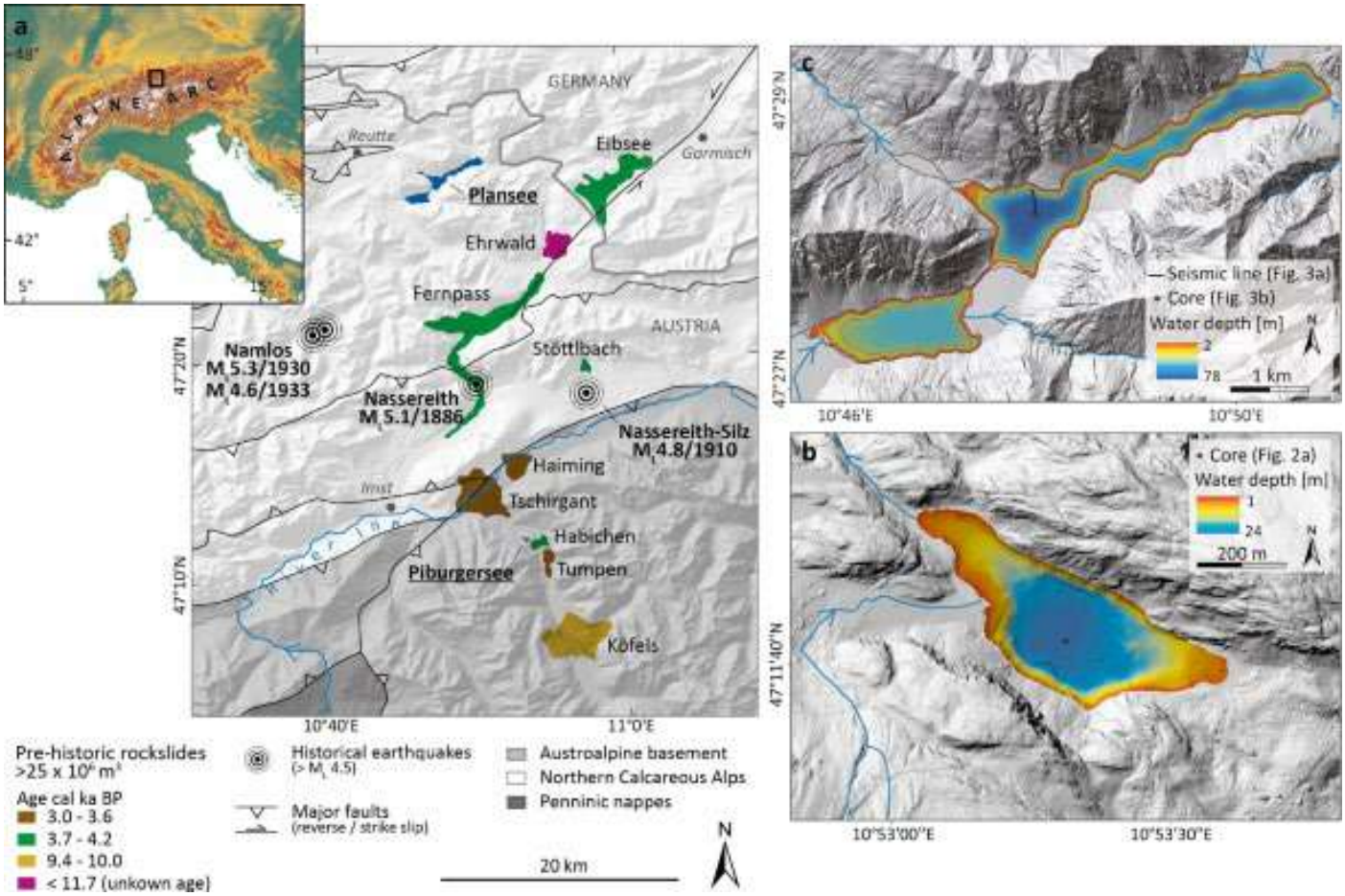
**Introduction**

Large rockslides are major landscape modifiers in mountainous regions and often induce secondary and cascading hazards, such as rockslide-induced impulse waves or valley damming with subsequent outburst floods. Documented rockslides are mostly triggered by heavy precipitation or severe earthquakes. Some prehistoric rockslides were of extraordinary size, and if similar events were to occur today they would have devastating impacts. Our understanding of the causes of prehistoric rockslides is hampered by the lack of adequate observational data to test trigger hypotheses, and by the uncertainties related to rockslide modelling and to linking mechanic processes to mappable rockslide features. As prehistoric rockslides show a tendency to occur in spatio-temporal clusters, a common trigger is often proposed, such as hydro-climatic change or seismic activity. Yet, instability of a large rock slope does not occur by a single strong disturbance, but rather forms the final stage of progressive rock slope weakening towards critical slope stability by a complex interplay of predisposition and preparation factors. Besides lithological and structural control, predisposition in formerly glaciated mountainous regions is typically achieved by oversteepened topography and glacial debutressing. Progressive

weakening of rock slopes acts on different time scales including long-term stress-release fracture propagation driven by deglacial unloading (static fatigue), repeated earthquake-induced loading (seismic fatigue) and seasonal pore pressure increase (hydromechanical fatigue). In contrast to laboratory tests and in-situ rock slope monitoring of static and hydro-mechanical fatigue mechanisms, direct investigations of seismic fatigue are scarce and difficult due to long reoccurrence time and the unpredictability of severe earthquakes, and therefore the role of seismicity in controlling large rockslides remains unclear.

*Nature Communications* **volume 12**, Article number: 1059 (2021)

(16 February 2021, https://www.nature.com/articles/s41467-021-21327-9)




**a** Study area comprises large rockslides (>25 × 106 m³) clustering in space and time affecting different geological units (Austroalpine basement, Northern Calcareous Alps), historical earthquakes $M_L$ 4.6–5.3 and location of the investigated lakes Piburgersee and Plansee. Major reverse and strike-slip faults subdivide tectonic units or unit-internal nappes. Dashed line shows location of the Piburgersee-Plansee transect of Fig. 4. **b** Lake Piburgersee bathymetry and coring site of Fig. 2. Blue lines indicate the in- and outflow. **c** Lake Plansee bathymetry including seismic profile and coring location of Fig. 3 in the central basin. Contour distance is 20 m. Blue lines with arrows indicate main in- and outflows. Onshore digital elevation models are derived from Copernicus Land Monitoring Services and Land Tirol—data.tirol.gv.at.

## Camogli, Italy: the unfortunate impact of a landslide in a cemetery

On 22 February 2021 a large coastal landslide occurred in the town of Camogli, near to Genoa in northwest Italy. In common with so much of Italy, Camogli is a historic town; thus, an urban landslide almost inevitably damages the historic fabric. In this case the landslide affected a large urban cemetery, which led to over 200 coffins falling into the sea. Fortunately no-one was injured.

An Italian fire brigade helicopter captured some images of the site. The image below shows the aftermath of the landslide:-

The landslide at Camogli in Italy. Image collected from an Italian fire brigade helicopter.

This appears to be a large rockfall on a near-vertical coastal slope, and it seems likely that there is undercutting by the sea. The image below is the Google Earth view of the site:-


Google Earth image of the site of the landslide at Camogli

The Italian Fire Brigade helicopter also captured the aftermath, with the remains of over 200 coffins floating in the sea, many having been damaged:-

The aftermath of the landslide at Camogli in Italy. Image collected from an Italian fire brigade helicopter.

Clearly this is a deeply unfortunate incident that will have been very distressing for all involved. News reports suggest that the slope at Camogli had started to suffer from instability problems after a major storm in 2018. Works to mitigate the instability on parts of the cliff were ongoing, with scaling and vegetation removal, prior to the installation of a reinforcing mesh. Works were being undertaken at the time, such that workers at the site had to escape. However, the reports suggest that the actual section of cliff that collapsed may not have been subject to these works.

Efforts are now underway to retrieve the coffins and the remains.

(Dave Petley / THE LANDSLIDE BLOG, 23 February 2021, https://blogs.agu.org/landslideblog/2021/02/23/camogli-1)

## The Char Dham Project: landslides associated with road widening in northern India

The dreadful landslide disaster last month in northern India has served to highlight, very clearly, the threat posed by poor awareness of slope issues in the Hindu Kush Himalayas. Regular readers will be bored of my repeatedly making the point that we are failing to adequately consider, or manage, these threats across a range of human activities as development continues apace.

In Uttarakhand there is another very major infrastructure project, alongside the hydroelectric schemes that we so badly damaged on 7 February, that is also leading to substantial levels of loss. This is the Char Dham project, a road widening scheme of sufficient magnitude that it has its own Wikipedia entry:

*Char Dham National Highway (Hindi: चार धाम महामार्ग), is an under construction two-lane (in each direction) express National Highway with a minimum width of 10 metres in the Indian state of Uttarakhand. The under construction highway will complement the under-construction Char Dham Railway by connecting the four holy places in Uttarakhand states namely Badrinath, Kedarnath, Gangotri and Yamunotri. The project includes 900 km national highways which will connect whole of Uttarakhand state.*

I am not against the development of infrastructure in high mountain areas, indeed quite the opposite, but these zones are fragile. These roads have the potential to be a vital lifeline, but they also have the potential to create untold havoc. Unfortunately, there are growing concerns about the latter, caused by poor alignment selection, engineering design and construction practise. In particular, there is clear evidence that the road widening is causing slope instability on a grand scale. Reports suggest that data from the Ministry of Road Transport and Highways has indicated that there are at least 161 major slope failures along the alignment, with more expected due to poor construction practises and the removal of trees. Bizarrely, a committee of the Supreme Court in India that has been investigating the project appears to be split, releasing two reports, one of which favours continuing with a 10 m wide road bench, the other indicating that it should be narrowed to 7 m.

There is an interesting article on the environmental costs of the Char Dham project on the First Post website, which includes this horrifying picture:

Landslides on the Char Dham highway. Image taken on NH94 by Mallika Bhanot

SANDRP also has a good article about this project.

Whilst the Char Dham project is undoubtedly important both strategically and in development terms, it is undeniable that

the practises shown above are deeply problematic. Their legacy is likely to last for a long time.

(Dave Petley / THE LANDSLIDE BLOG, 4 March 2021, https://blogs.agu.org/landslideblog/2021/03/04/chardham-1)

## The Tavernola landslide: a potential tsunami-inducing failure causing concern in Italy

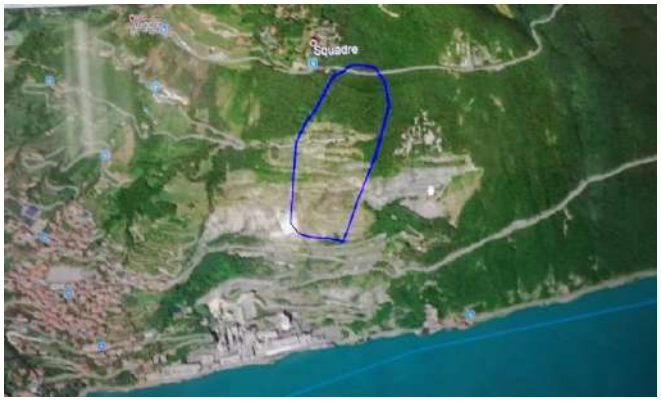
This morning, loyal reader Stéphane Baize (@Stef_EQ_Geology) tweeted an Italian newspaper article about the Tavernola landslide on the banks of Lago d'Iseo in northern Italy. In recent days a large section of mountain has started to move at a significant rate, driving fears of a major slope collapse. The estimated volume of the resultant landslide ranges from 440,000 to 2.1 million m³. The slope is steep, suggesting that the mass could accelerate rapidly. Modelling indicates that in the worst case scenario the resultant tsunami could be large – wave heights of 9 metres above the current lake level are possible. The banks of the lake are densely populated, the list of settlements at risk includes Tavernola, Montisola, Marone, Sulzano, Iseo, Sale Marasino, Castro and Paratico.

The wave would hit Montisola within 30 seconds of the landslide entering the water. Tavernola would be struck a minute later.

The newspaper L'Eco di Bergamo has an image of the site of the unstable slope:-

A panoramic view of the site of the Tavernola landslide in Italy

Meanwhile, Tutto Notizie has an image indicating the approximate location of the unstable mass:-




The approximate boundaries of the Tavernola landslide.

The outcome of this event will depend on a range of complex parameters, most of which are difficult to predict. Failure of the Tavernola landslide is not inevitable, and indeed there are signs that the landslide has slowed in recent hours. Those who followed the trials and tribulations of the Mannen landslide in Norway will understand how difficult it is to predict failure.

Second, the volume of rock that could fail is hard to estimate. This will be determined by the dynamics of the slide, the structure of the rock mass and the ability of the landslide to entrain material downslope.

Third, the failure sequence will be key. Will the Tavernola Landslide fail as a single block, or will there be multiple events? The resultant tsunami is very dependent on this component, but again it is difficult to predict.

In the meantime, the authorities have little choice but to manage the risk and to monitor the slope, hoping that the movement will stop. This will then provide time for a solution to be found.

Of course I am bound to note that this landslide is occurring on a slope that has been extensively quarried, and thus is likely to be a manmade event, at least in part.

**Comment**

A ground-based radar is currently used to monitor the landslide. In the past it was used to monitor periodically the slope (e.g. 2–3 campaigns per year), but since a few weeks ago it has been permanently installed to provide near real time displacement measurements.

(Dave Petley / THE LANDSLIDE BLOG,11 March 2021, https://blogs.agu.org/landslideblog/2021/03/11/tavernola-landslide-1)

## The stability of mine waste tailings facilities


The aftermath of the Brumadinho tailings failure in Brazil.

In recent years there has been a sequence of major failures in mine waste tailings facilities, involving loss of life, severe economic damage and environmental catastrophe. As global mining continues to expand there are major concerns about the likelihood of further major failure events, although the industry would maintain that there are serious efforts ongoing to improve tailings management.

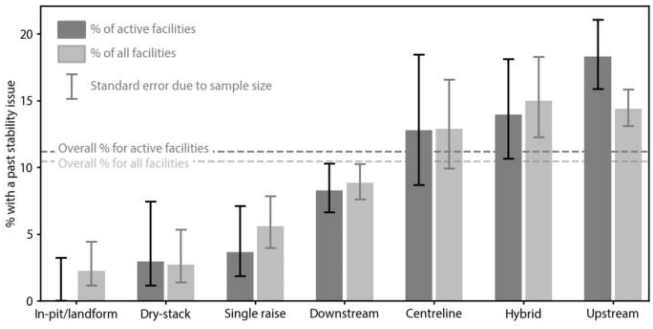
A really interesting paper has just been published in the journal *Scientific Reports* (Franks *et al.* 2021), which is available open access, which reports upon a database of tailings facilities worldwide. This database has been compiled through requests for disclosures from mining companies. They requested information on tailings facilities from 726 publicly-listed extraction companies. In total, 107 companies responded. The authors recognise that this has limitations, but the results are still eye-opening.

Franks *et al.* (2021) included in their request for information the following:

*Companies were requested to disclose any situation where a facility, "at any point in its history, failed to be confirmed or certified as stable, or experienced notable stability concerns, as identified by an independent engineer (even if later certified as stable by the same or a different firm)."*

In total, 10% of all tailings facilities were reported to have suffered a stability issue, but as the image below shows, this was much higher for the (much more risky) upstream type of tailings dam:-

The hazards associated with the upstream method are clear to see. Given the potential impacts of the failure of a tailings dam, the figures in this graph are alarming.




Stability of tailings facilities. Proportion of facilities with a stability issue by raise type. Error bar lengths are binomial confidence intervals for the subsample represented by each bar, showing ± 1 standard error (approximately 68%). Figure from Franks *et al.* (2021).

It is also notable that the authors found that:

*A significant number of facilities (501; 29%) have not formally considered the downstream effects of a hypothetical catastrophic failure*

This is a remarkable finding.

The authors note that their database accounts for only about 30% of global commodity production. I think one can hypothesise that the companies that have made a disclosure are more likely to be managing their facilities properly. If so, the global picture is probably even worse than the figure above suggests.

I cannot sum up the implications of this piece of work better than Franks *et al.* (2021) themselves:

*The sheer scale of global tailings production and the high impact of tailings facility failures highlights the need to improve all aspects of tailings disposal and management. Furthermore, the data highlight the need to continue developing management options and technologies to both minimize tailings production and to repurpose tailings to reduce storage requirements and their associated risks. In the short term, the data suggest that ever larger tailings storage facilities will continue to be built in locations with ever higher consequences of failure. Greater transparency brought about by these and future disclosures could play an important role in the reduction, and ideally elimination, of catastrophic tailings facility failures.*

This paper is a good start, and a very valuable contribution, but the industry has a long way to go.

**Reference**

Franks, D.M., Stringer, M., Torres-Cruz, L.A. *et al.* 2021 Tailings facility disclosures reveal stability risks. *Scientific Reports* **11,** 5353 (2021). https://doi.org/10.1038/s41598-021-84897-0.

(Dave Petley / THE LANDSLIDE BLOG, 12 March 2021, https://blogs.agu.org/landslideblog/2021/03/12/the-stability-of-mine-waste-tailings-facilities)

## Researchers test sand-silt mixtures to predict liquefaction resistance

Ground failure during strong earthquakes has emphasized the need for a greater understanding of the response of silty soils to undrained cyclic loading. A paper in the March 2021 issue of *Journal of Geotechnical and Geoenvironmental Engineering* offers help.

"Application of Critical State Approach to Liquefaction Resistance of Sand–Silt Mixtures under Cyclic Simple Shear Loading" focuses on granular soils containing nonplastic fines (silt), investigating the combined effect of the void ratio, effective vertical stress, and fines content on the liquefaction resistance of sands. Researchers Daniela Dominica Porcino, Theodoros Triantafyllidis, Torsten Wichtmann, and Giuseppe Tomasello restricted testing to certain types of coarse (Ticino sand) and fine (nonplastic local silt) materials, and a specific specimen reconstitution method (moist tamping). Read more in the following abstract and see their full findings in the ASCE Library.

**Abstract**

An extensive experimental program of constant-volume (undrained) cyclic simple shear tests was undertaken on Ticino, Italy, sand with different contents of nonplastic fines, ranging from 0% to 40%. The samples were reconstituted by moist tamping and tested with different initial states, including void ratios and effective vertical stresses. Test results confirmed that the concept of equivalent granular void ratio $e_*$ is appropriate for the interpretation of the undrained cyclic behavior of sand with different amounts of fines up to the limiting fines content. Because a single trend for critical state (CS) data points was observed in the $e_*$-log($p'$) plane (*EG-CSL*) for different amounts of fines, the cyclic simple shear test results were analyzed within a unified critical state soil mechanics (CSSM) framework in terms of an alternative state parameter, $\Psi_*$. A unique correlation between undrained cyclic strength (CRR) and $\Psi_*$ was found, irrespective of the fines

content and initial state. Although a correlation between the cyclic resistance ratio and the conventional state parameter Ψ works as well, the procedure based on $\Psi_*$ has the advantage that the cyclic behavior of a certain sand with different contents of non plastic fines is described by a single reference curve (*EG-CSL*). In contrast to previous investigations in the literature, which mainly used triaxial tests, the CRR-$\Psi_*$ correlation proposed in the present study is based on cyclic simple shear tests, which better represent the real ground conditions under seismic loading.

Read the full paper in the ASCE Library:
https://doi.org/10.1061/(ASCE)GT.1943-5606.0002470

(ASCE CIVIL ENGINEERING Source, March 15, 2021,
https://source.asce.org/researchers-test-sand-silt-mixtures-to-predict-liquefaction-resistance)

**Knappensee: a large landslide at an old open cast mining site in eastern Germany**

On Thursday 11 March 2021 a large landslide occurred on the banks of an abandoned and flooded open case coal mine site at Knappensee in eastern Germany. The images after the event are impressive:-

The aftermath of the landslide at Knappensee on 11 March 2021

The event was captured on a remarkable video that has been posted to Youtube. This video starts with an orientation problem that is soon resolved:-


https://www.youtube.com/watch?v=xhLew-dqPGA

Judging by news reports, the banks of the Knappensee have been undergoing remediation to allow the site to become a recreation attraction. This bank had been undergoing work recently – I note the various vessels in the video – and was a site with known geotechnical problems. The unslipped areas in the image above have little or no vegetation, suggesting engineering works since the last growing season.

MDR.de reports that:

*The landslide at Knappensee was probably triggered by renovation work in the bank area. Experts from the Saxon Mining Authority have come to this conclusion. In the past few weeks, the first careful security measures have been carried out in this area. Among other things, dump material has been removed and work has been prepared in the bank area, said the Mining Authority. This was also the case on the day of the landslide, which is why this work is suspected to be the trigger.*

The landslide appears to have been retrogressive, starting with a small failure at the toe. That in turn may have been triggered by a slip under the water, but that is speculation at this point. The final scar is reported to be 500 m by 200 m.

The landslide generated a displacement wave – reported to be about 1.5 metres high. Whilst this would be small in a marine environment, in a non-tidal lake this is significant event. This tsunami damaged properties on the other side of the lake:-

Damage caused by the displacement wave at Knappensee in Germany

The level of the lake has been raised by 32 cm as a result of the landslide. This is now being lowered, but slowly because of the fear that rapid drawdown will trigger further instability.

Large failures in open cast coal mines, or in coal mine waste piles, are not rare, Recent examples include:-

- The 2014 Mina Pecket landslide in Chile
- The 2013 Hatfield Colliery landslide in the UK
- The 2017 Kakanj landslide in Bosnia

(Dave Petley / THE LANDSLIDE BLOG, 15 March 2021,
https://blogs.agu.org/landslideblog/2021/03/15/knappensee-1)

**Tbilisi: a 500,000 cubic metre landslide, probably triggered by road construction**

In Tblisi in Georgia, a 500,000 cubic metre landslide has developed on the edge of the metropolitan area, probably trig-

gered by construction of a road. The landslide which is described in articles in both Vestnikkavkaza.net and JAM News, is impressive in scale:-

The landslide in Tblisi

The image above shows a very large fissure that defines the mobile block. This appears to be sliding towards the left of the image, where the slope has been cut for road construction. The image below provides a sense of the motion:

The sense of movement of the landslide in Tblisi

The under-excavation road is being protected from minor rockfalls by a barrier of what appears to be concrete blocks. This suggests that the movement has been developing for a few days at least.

The landslide has developed on the margins of a new road linking two residential areas of Tbilisi – Vashlijvri and Nutsubidze. I believe that the Google Earth image below shows the site. This image was taken in July 2020:-

The JAM.net article provides some insights from local experts:

*"The earth may descend tomorrow, the day after tomorrow, or in a year, but it will definitely come down. Where and how – the issue of modeling, it needs to be assessed," said Geologist Tea Godoladze, director of the National Center for Seismological Monitoring.*


Google Earth image of the site of the landslide in Tblisi

*According to her, geologists and surveyors who have already made the initial assessment have come to the conclusion that cracks in the slope are the result of improper intervention in the environment. And, most likely, a landslide cannot be avoided.*

*The danger exists both in the immediate vicinity of the landslide and in other areas, since the support system is also broken there, said geomorphologist Lasha Sukhishvili.*

*"The speed of the landslide is still unclear. This can take years. But, for example, due to heavy rain or some vibrations, the process may speed up a little," said Sukhishvili.*

Managing a landslide of this scale will be challenging. I am reminded of the Rattlesnake Ridge landslide, where the pragmatic solution has been simply to allow it to move whilst monitoring it carefully.

(Dave Petley / THE LANDSLIDE BLOG, 19 March 2021, https://blogs.agu.org/landslideblog/2021/03/19/tblisi-m1)

# ΕΝΔΙΑΦΕΡΟΝΤΑ - ΣΕΙΣΜΟΙ

## Assessment of Information Security Vulnerabilities in Common Seismological Equipment

**Michael Samios, Christos P. Evangelidis, Emmanouil Serrelis**

**Abstract**

Modern seismic and Global Navigation Satellite Systems stations are nowadays equipped with Internet of Things de-vices that acquire, process, and transmit various geophysical parameters in near-real time.

This technological advance has introduced a new threat paradigm for common seismological devices. Such threats can be assessed with standard information security methods and practices.

This article aims to identify security weaknesses, describe weak security points and potential attacks on such environments, and anticipate the countermeasures needed.

Real tests and attacks have been applied to demonstrate the lack of data encryption and user authentication processes, the risks posed by unencrypted communication protocols, unsafe practices regarding settings and passwords, and poor design implementations.

All these factors may impact and possibly disrupt the daily operation of seismic observatories because they can lead to falsifying data, altering configurations, or producing malicious false alarms. These in turn may cause unnecessary public concern or distrust, financial losses, or even national security issues. For all these reasons, several countermeasures and solutions are also proposed and evaluated to address each of the identified vulnerabilities.

(Seismological Research Letters (2021) 92 (2A): 933–940, https://doi.org/10.1785/0220200151**,** February 10, 2021, https://pubs.geoscienceworld.org/ssa/srl/article-abstract/92/2A/933/594594/Assessment-of-Information-Security-Vulnerabilities?redirectedFrom=fulltext)

# ΕΝΔΙΑΦΕΡΟΝΤΑ - ΓΕΩΛΟΓΙΑ

### Scientists detect signs of a hidden structure inside Earth's core

While most of us take the ground beneath our feet for granted, written within its complex layers, like pages of a book, is Earth's history. Our history.

Now researchers have found more evidence for a whole new chapter deep within Earth's past – Earth's inner core appears to have another even more inner core within it.

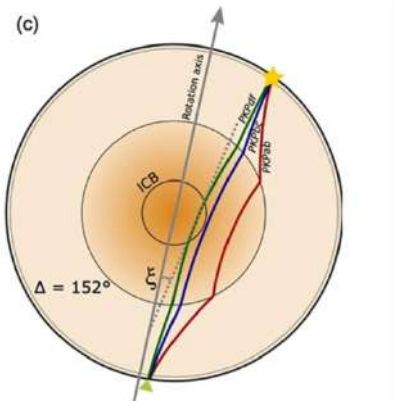
"Traditionally we've been taught the Earth has four main layers: the crust, the mantle, the outer core and the inner core," explained Australian National University geophysicist Joanne Stephenson.

Our knowledge of what lies beneath Earth's crust has been inferred mostly from what volcanoes have divulged and seismic waves have whispered. From these indirect observations scientists have calculated that the scorchingly hot inner core, with temperatures surpassing 5,000 degrees Celsius (9,000 Fahrenheit), makes up only one percent of Earth's total volume.

Now Stephenson and colleagues have found more evidence Earth's inner core may have two distinct layers.

"It's very exciting – and might mean we have to re-write the textbooks!" she added.

The team used a search algorithm to trawl through and match thousands of models of the inner core with observed data across many decades about how long seismic waves take to travel through Earth, gathered by the International Seismological Centre.




Differences in seismic wave paths through layers of Earth. (Stephenson *et al., Journal of Geophysical Research: Solid Earth,* 2021)

So what's down there? The team looked at some models of the inner core's anisotropy – how differences in the make-up of its material alters the properties of seismic waves – and found some were more likely than others.

While some models think the material of the inner core channels seismic waves faster parallel to the equator, others argue the mix of materials allows for faster waves more parallel to Earth's rotational axis. Even then, there's arguments about the exact degree of difference at certain angles.

This study failed to show much variation with depth in the inner core, but did find there was a change in the slow direction to a 54 degree angle, with the faster direction of waves running parallel to the axis.

"We found evidence that may indicate a change in the structure of iron, which suggests perhaps two separate cooling events in Earth's history," Stephenson said.

"The details of this big event are still a bit of a mystery, but we've added another piece of the puzzle when it comes to our knowledge of the Earths' inner core."

These new findings may explain why some experimental evidence has been inconsistent with our current models of Earth's structure.

The presence of an innermost layer has been suspected for some time now, with hints that iron crystals which compose the inner core have different structural alignments.

"We are limited by the distribution of global earthquakes and receivers, especially at polar antipodes," the team wrote in their paper, explaining the missing data decreases the certainty of their conclusions. But their conclusions align with other recent studies on the anisotropy of the innermost inner core.

A new method currently under development may soon fill in some of these data gaps and allow scientists to corroborate or contradict their findings and hopefully translate more stories written within this early layer of Earth's history.

This research was published in the **Journal of Geophysical Research**.

(Geology Science, March 4, 2021, https://geology-science.info/scientists-detect-signs-of-a-hidden-structure-inside-earths-core)

### Evidence for the Innermost Inner Core: Robust Parameter Search for Radially Varying Anisotropy Using the Neighborhood Algorithm

**J. Stephenson, H Tkalčić, M. Sambridge**

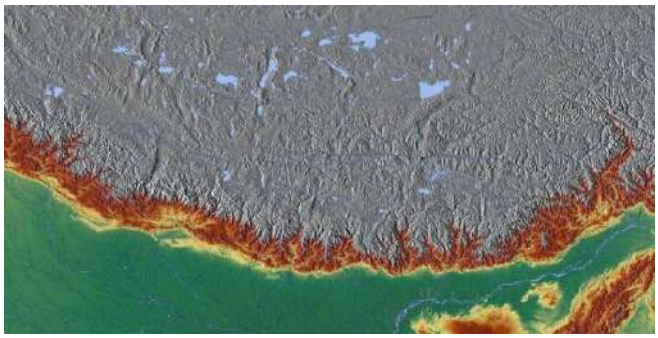
**Abstract**

The model of cylindrical anisotropy in the inner core (IC) states that seismic rays traveling parallel to the Earth's rotational axis travel faster than those parallel to the equator. There have been continuing discrepancies in estimates of the strength and orientation of anisotropy, with some evidence suggesting that such a model may not be supported by available data. Here, we scrutinize the radial dependence of anisotropy within the IC, where the nature of anisotropy has been shown to change anywhere between a 300 and 800 km radius. We use recent travel time data from the International Seismological Centre in conjunction with the neighborhood algorithm to provide a robust means of testing this idea, through examination of an ensemble of models that satisfac-

torily fit the data. This can be done with no explicit regularization and without the need for subjective choices associated with binning of phase data. In addition, uncertainty bounds are calculated for anisotropic parameters using a likelihood ratio approach. We find evidence to suggest that commonly employed spatial averaging (binning) methods may be detrimental to obtaining reliable results. We conclude that there is no significant change in the strength of anisotropy with depth in the IC. Instead, we find a change in the slow direction of anisotropy to 54° within the innermost IC at an ~650 km radius with fast direction parallel to the Earth's rotational axis.

(First published: 07 December 2020, https://doi.org/10.1029/2020JB020545, https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2020JB020545)

## The 'breathing' Himalaya: Great mountains grow in a cycle of rising and falling



How and when do mountains grow? It is tempting to think of mountain formation as something that takes place only extremely gradually, on timescales of tens of millions of years. One tectonic plate slowly pushes up against and slightly under another, until eventually up rises a mountain range. Of course, that picture is far too simplistic. We know, for example, that processes like erosion and earthquakes affect the way mountains grow.

Synthesizing data from more than 200 studies of the Himalaya, a team led by Caltech postdoctoral fellow Luca Dal Zilio has pieced together a far more complete picture of the mountain-building process. In a review study published in the journal Nature Reviews Earth & Environment on May 2, Dal Zilio and his colleagues bridged timescales ranging from the seconds of shaking during an earthquake to the millions of years it takes for long-term tectonic processes to play out.

"When we think about the concept of mountains, we really need to think about something that is dynamically changing, and those changes happen at different time scales," says Dal Zilio, an Earth scientist in Caltech's Seismology Laboratory.

The researchers found that the Himalaya cycle through events that cause the range to rise and subside, rise and subside. "It's almost as though the range is breathing," says Dal Zilio. "However, the rising events over millions of years are larger than the rapid subsidence events during earthquakes. In the long run, this process leads to the growth of the Himalayan range."

The researchers focused on the wealth of geological, geophysical, and geodetic data that came out of the devastating 2015 Gorkha earthquake in Nepal and its aftershocks. For example, using radar images from satellites, scientists previously found that Mount Everest dropped by about a meter during the magnitude 7.8 temblor. But in the months following that event, scientists showed that the mountain regained roughly 60 percent of that lost elevation.

Dal Zilio and his colleagues drew on observations from the last several decades from the Himalaya, such as the thickness of the crust at different locations and what is known about the geometry of the Main Himalayan Fault, the roughly 2,000-kilometer-long fault at the base of the mountains. They were then able to simulate multiple earthquake cycles, including the so-called interseismic period between earthquakes when elastic stress slowly builds until some or all of it is released in the form of an earthquake. That allowed the researchers to see how much the various processes contributed to the growth of the mountains.

Dal Zilio has also used the model to study the earthquake cycle in the Himalaya. The 2015 Gorkha earthquake was what is called a partial rupture. It only released about half of the fault's accumulated stress. "Really we were expecting an even larger earthquake," explains Dal Zilio. "Our model is helping us understand why the partial rupture happened and what the possible scenarios are for the future."

Developing an understanding of how the Himalaya grow and change with time and how its earthquake cycle is affected is particularly important given the activity of the Main Himalayan Fault and its history of producing major earthquakes (some as large as magnitude-8.8) that affect one of the most populated regions on Earth.

The new Nature Reviews Earth & Environment paper is titled "Building the Himalaya from tectonic to earthquake scales."

**More information:** Luca Dal Zilio et al. Building the Himalaya from tectonic to earthquake scales, *Nature Reviews Earth & Environment* (2021). DOI: 10.1038/s43017-021-00143-1

Provided by **California Institute of Technology**.

(Geology Science, March 4, 2021, https://geology-science.info/the-breathing-himalaya-great-mountains-grow-in-a-cycle-of-rising-and-falling)

## Building the Himalaya from tectonic to earthquake scales

**Luca Dal Zilio, György Hetényi, Judith Hubbard & Laurent Bollinger**

**Abstract**

Convergence of the Indian Plate towards Eurasia has led to the building of the Himalaya, the highest mountain range on Earth. Active mountain building involves a complex interplay between permanent tectonic processes and transient seismic events, which remain poorly understood. In this Review, we examine the feedbacks between long-term tectonic deformation (over millions of years) and the seismic cycle (years to centuries) in the Himalaya. We discuss how surface morphology of the Himalaya indicates that the convergence is largely accommodated by slip on the Main Himalayan Thrust plate boundary fault, which developed in the roots of the mountain range over millions of years. At shorter (decadal) timescales, tectonic geodesy reveals that elastic strain is periodically released via earthquakes. We use examples from earthquake cycle models to suggest that partial ruptures could primarily occur in the downdip region of the Main Himalayan Thrust. Great (Mw 8+) Himalayan earthquakes are

more commonly associated with complete megathrust ruptures, which release accumulated residual strain. By synthesizing numerous observations that co-vary along strike, we highlight that tectonic structures that developed over millions of years can influence stress accumulation, structural segmentation, earthquake rupture extent and location, and, consequently, the growth of the mountain range.

Key points

- The Himalayan mountain belt is a unique subaerial orogenic wedge characterized by tectonically rapid, ongoing crustal shortening and thickening, intense surface denudation and recurrent great (Mw 8+) earthquakes.
- The history of the orogen has been investigated from long (million-year) to short (seconds to days) timescales using a variety of geological and geophysical techniques.
- The magnitude 7.8 Gorkha earthquake and aftershocks were monitored by extensive local geophysical networks, providing a unique set of observations of a major Himalayan earthquake and the Himalayan seismic cycle.
- Observations across the Himalaya reveal along-strike segmentation patterns at various temporal scales, controlled by inherited tectonic complexities developed over millions of years.
- Developing a complete understanding of deformation across timescales from seconds to millions of years requires an integrated, interdisciplinary effort.

(*Nature Reviews Earth & Environment* (2021) Published: 02 March 2021, https://www.nature.com/articles/s43017-021-00143-1)

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## Rainbow Mountain of Peru

Llama walking over a Rainbow Mountain of Peru. Each of the colors on the mountain comes from a different mineral which is due to different environmental conditions and mineralogy when the sediment was originally deposited, subsequently diagenetically altered.

(Geology Science, Feb 24, https://twitter.com/GeologyScience/status/1364577252864888838)

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## Το Γεωπάρκο Γρεβενών - Κοζάνης στο Παγκόσμιο Δίκτυο Γεωπάρκων της UNESCO

Το **Γεωπάρκο Γρεβενών - Κοζάνης**, κατά τη διάρκεια της 5ης τακτικής συνεδρίασης του Συμβουλίου του Παγκόσμιου Δικτύου Γεωπάρκων της UNESCO, που πραγματοποιήθηκε διαδικτυακά στις 8 και 9 Δεκεμβρίου 2020, αξιολογήθηκε θετικά ανταποκρινόμενο στις συστάσεις της αρμόδιας επιτροπής που ακολούθησαν την αξιολόγηση στο πεδίο τον Αύγουστο του 2018.

Ως αποτέλεσμα, η υποψηφιότητα για ένταξη στο δίκτυο, **θα προωθηθεί μαζί με άλλες 7 περιοχές από Δανία, Ιταλία, Φινλανδία, Γερμανία, Πολωνία και Ινδονησία** για απόφαση οριστικής ένταξης στο Παγκόσμιο Δίκτυο Γεωπάρκων από την Εκτελεστική Επιτροπή της UNESCO, στην προγραμματιζόμενη εαρινή συνάντησή της, η οποία προσδιορίζεται για το χρονικό διάστημα 7 - 21 Απριλίου 2021.

Η συγκεκριμένη εξέλιξη αποτελεί δικαίωση της **πολύχρονης και επίπονης προσπάθειας κατά κύριο λόγο της Δρ. Αννας Ράσσιου και των συνεργατών τ**ης, που αφιλοκερδώς εδώ και περισσότερο από μια δεκαετία προωθούν την έννοια του ΓΕΩΠΑΡΚΟΥ Γρεβενών - Κοζάνης, σε τοπικό και διεθνές επίπεδο, μέσω της εκπόνησης μελετών, της διενέργειας ερευνών και της πραγματοποίησης διεθνών συναντήσεων – εκδηλώσεων με απώτερο σκοπό να καταστεί ευρύτερα γνωστό.

Η προσπάθεια αυτή **υποστηρίχθηκε από τους φορείς της περιοχής** με προεξάρχοντες την Περιφέρεια Δυτικής Μακεδονίας και τους Δήμους Γρεβενών, Κοζάνης, Βοΐου, Δεσκάτης και Σερβίων, καθώς και τον Φορέα Διαχείρισης του Εθνικού Πάρκου Βόρειας Πίνδου, οι οποίοι παρείχαν κάθε δυνατή στηριξη συνυπογράφοντας το 2017 σχετικό Σύμφωνο Συνεργασίας με Συντονιστή Φορέα την Αναπτυξιακή Δυτικής Μακεδονίας Α.Ε. - ΑΝΚΟ στο πλαίσιο της επανυποβολής της σχετικής πρότασης.


**Η ΑΝΚΟ, επίσης αφιλοκερδώς**, συντόνισε την όλη διαδικασία επανυποβολής του αιτήματος και την αντιμετώπιση ζητημάτων διοικητικής και διαχειριστικής φύσης.

Κατά την πορεία της προσπάθειας ένταξης του Γεωπάρκου ως μέλους του Παγκοσμίου Δικτύου Γεωπάρκων της UNESCO, από την αρχική ακόμη υποβολή πρότασης το 2014, διαπιστώθηκε η πολυπλοκότητα του εγχειρήματος από την άποψη τόσο της επιστημονικής προσέγγισης, όσο και των διοικητικών - διαχειριστικών διαδικασιών.

Στο ενδιάμεσο χρονικό διάστημα το Γεωπάρκο Γρεβενών-Κοζάνης ανέπτυξε πλούσιο έργο με τη διοργάνωση διεθνών συνεδρίων και εκπαιδευτικών εκδηλώσεων και την παραγωγή ενημερωτικών εντύπων και επιστημονικών εκδόσεων, με όσα μέσα είχε στη διάθεσή του, προσπαθώντας να γίνει ευρύτερα γνωστό μεγιστοποιώντας, το όφελος για την περιοχή.

Βασικοί στόχοι του ΓΕΩΠΑΡΚΟΥ Γρεβενών-Κοζάνης, όπως αποτυπώνονται και στο Επιχειρησιακό του Σχέδιο το οποίο υποβλήθηκε και αξιολογήθηκε απολύτως θετικά από τους αρμόδιους ελεγκτές της UNESCO, είναι:

- Η προστασία της γεωκληρονομιάς της περιοχής
- Η συμμετοχή στην επιστημονική έρευνα της γης, μέσα από εθνικές και διεθνείς συνεργασίες
- Η εκπαίδευση σε όλες τις ηλικίες μέσα από την εξερεύνηση της γης
- Η διατήρηση και ανάδειξη της τοπικής ιστορίας, του πολιτισμού και της γεωμορφολογικής ιστορίας της περιοχής
- Η ανάδειξη και υποστήριξη οικιστικών κέντρων που θα διασυνδέονται και θα εξυπηρετούν την ευρύτερη περιοχή ενδιαφέροντος και τη στρατηγική του Γεωπάρκου
- Η ολοκληρωμένη ανάπτυξη του αγροτικού χώρου και
- Η βιώσιμη τοπική ανάπτυξη

Το Γεωπάρκο Γρεβενών - Κοζάνης, με τη συμβολή όλων των φορέων της περιοχής, μπορεί να μετατρέψει τη Δυτική Μακεδονία σε έναν εθνικό και διεθνή τουριστικό προορισμό, δεδομένου ότι στη γεωγραφική του ζώνη συναντώνται ιδιαίτερα γεωλογικά σημεία ενδιαφέροντος, τα οποία είναι μοναδικά παγκοσμίως και αξιολογήθηκαν αναλόγως από την UNESCO, αυξάνοντας παράλληλα την επισκεψιμότητα της Περιφέρειας και συμβάλλοντας στην οικονομική ανάπτυξη και στην αύξηση της απασχόλησης.

Η επίσημη αναγνώριση του Γεωπάρκου, έρχεται να τονώσει τον γεωγραφικό χαρακτήρα του τόπου, την κληρονομιά του, το περιβάλλον του, την αισθητική και τον πολιτισμό του, δημιουργώντας αξιόλογη βάση για μια κατ' εξοχήν μορφή βιώσιμου τουρισμού, τον Γεωτουρισμό και εισάγοντας στην Περιφέρεια Δυτικής Μακεδονίας έναν νέον οικονομικό πόρο για την τοπική κοινωνία.

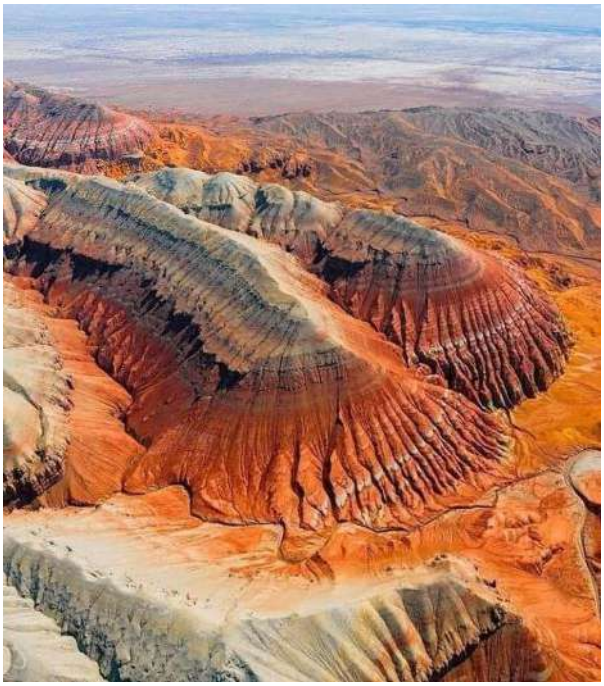
(3 Μαρτίου 2021, https://www.ankoeunet.gr/articles/el/News/atpage/1/readabout/to-geoparko-grevenon---kozanis-sto-pagkosmio-diktuo-geoparkon-tis-unesco)

## Τα χρώματα της γης

### Aktau Mountains (Altyn Emel National Park, Kazakhstan)

They are made up of cenozoic continental sediments: with deposits from the middle Eocene at the base (Akbulak formation), from the Oligocene in the middle (Aktau formation) and from the Oligocene to the late Miocene at the top (Chul'adyr Oligocene Formation)

These deposits include everything from sandstons and red clays to light quartz sandstones, with interspersed anhydrite & Gypsum deposits with fossil remains of mammals being relatively abundant at some levels. These sediments are relatively poorly consolidated and therefore are susceptible to being easily eroded in the dominant arid climate, forming a landscape of Badlands.

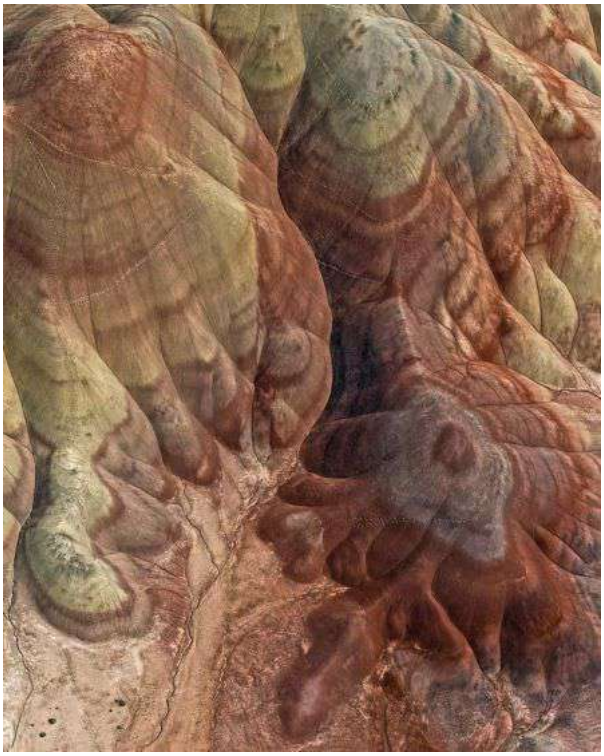


Dr-Ahmed Abd El Kader, 6 Μαρτίου 2021, https://www.facebook.com/photo?fbid=2904631026532318&set=a.1693373474324752

### John Day National Monument, Oregon (USA)

The hills in the John Day region consist of the discharge of old volcanoes that disappeared long ago.

Wind and water have transported the volcanic material here over the course of hundreds of thousands of years, and deposited it layer by layer. Traces of different iron minerals give the rock its brownish and red colours.

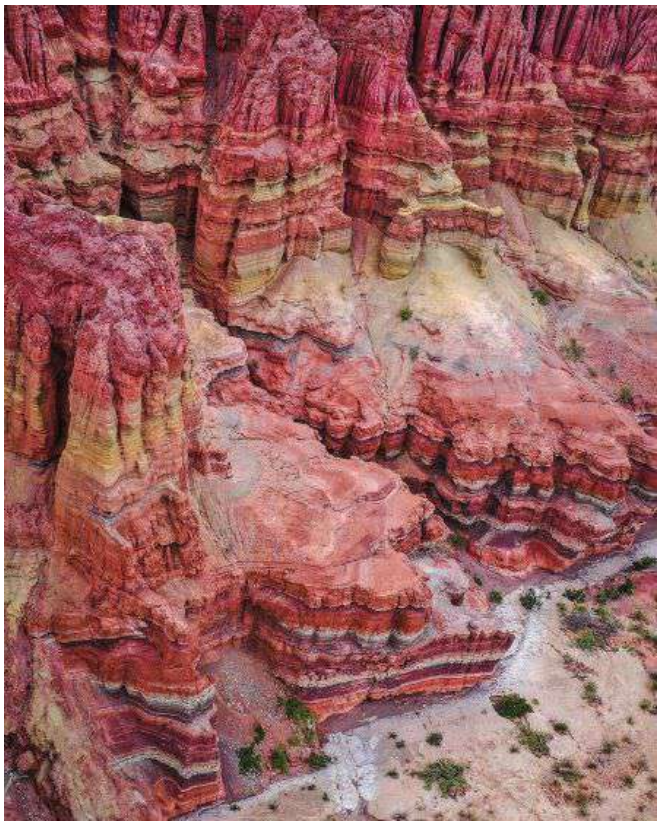


https://www.face-book.com/photo?fbid=2904364476558973&set=a.1693373474324752

**Dolerite in Koster Islands, Sweden**

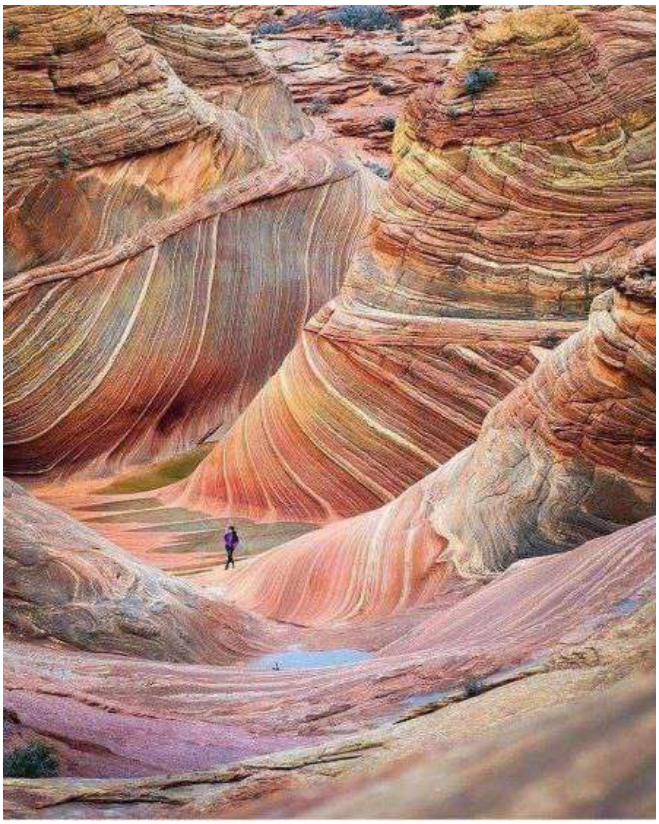
**The La Yesera Formation (Salta Province, Argentina)**

A formation or geological formation is consists of a certain amount of rock strata that have a comparable lithology, facies or other similar properties. The Yesera Formation consists of a succession of colored layers deposited during the

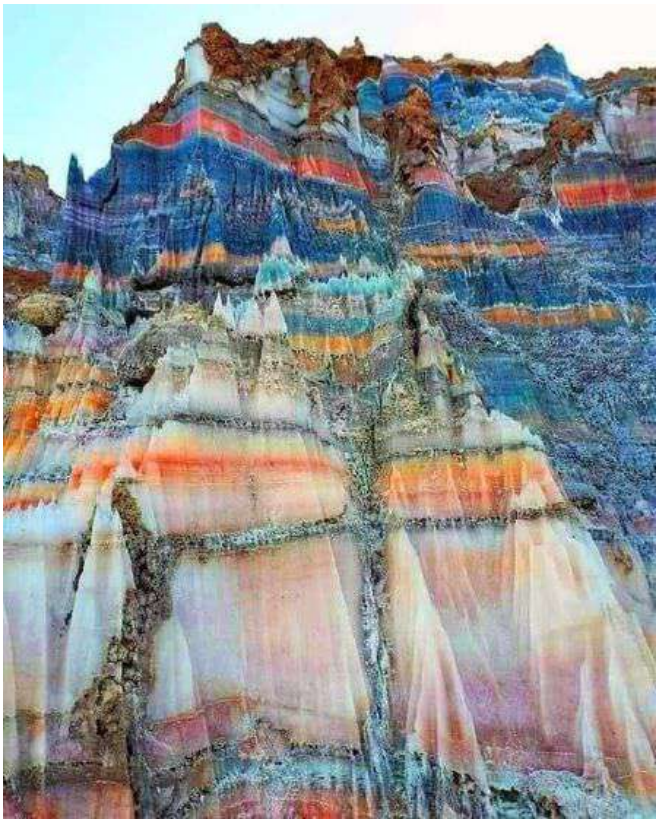


https://www.linkedin.com/feed/update/urn:li:activity:6775715603886968832/

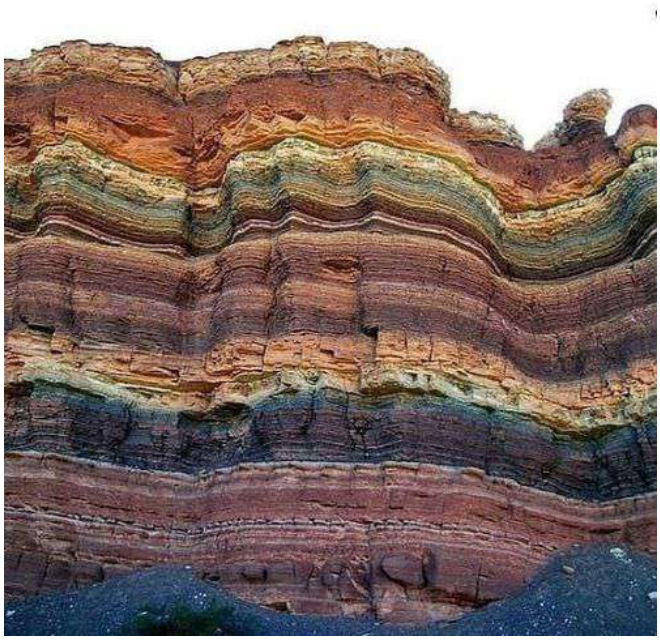
**Coyote Buttes in the Paria Canyon-Vermilion Cliffs Wilderness of the Colorado Plateau**



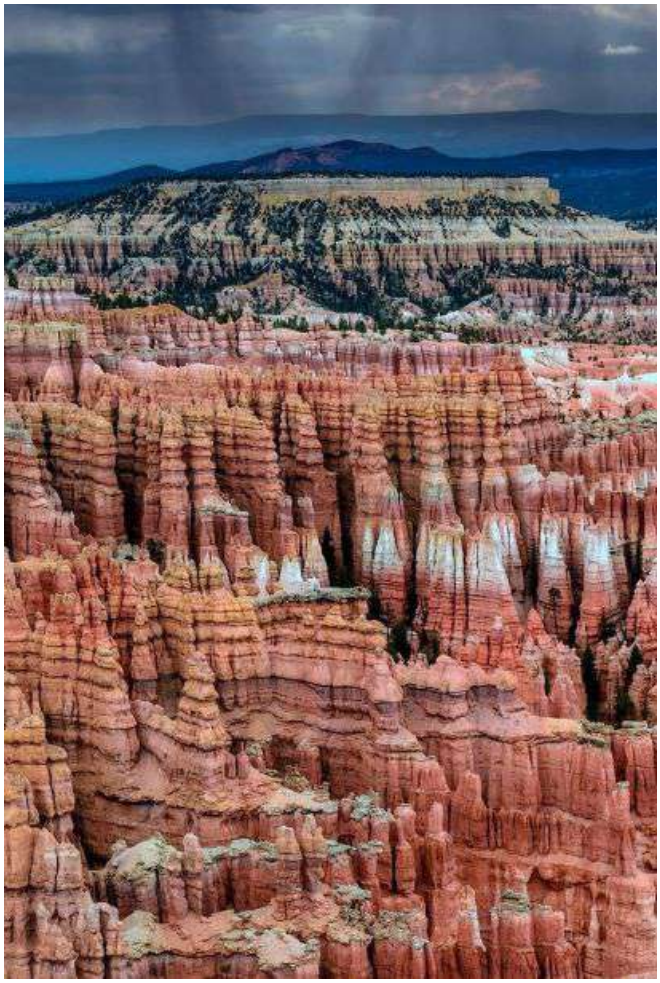
**Mountains of salt, Darbest, Iran**



**This is not a piece of cake this is quebrada de humahuaca, Argentina**

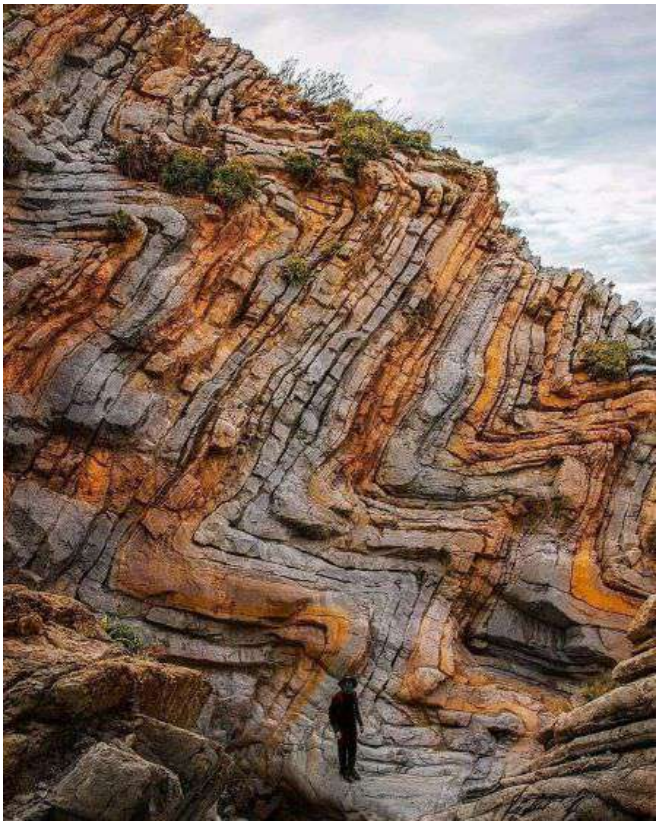


**The Hoodoos of Bryce Canyon National Park**

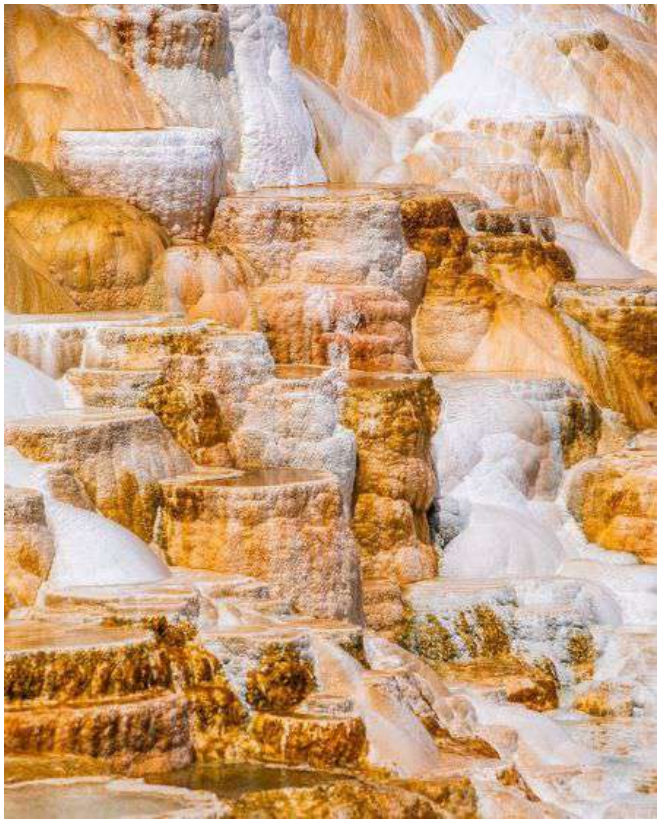


**Coal seams, Denali Alaska, Usibelli mine**

**Chevron Folds at Millook Haven, England**



**Mammoth Hot Springs in Yellowstone National Park**



# ΕΝΔΙΑΦΕΡΟΝΤΑ - ΠΕΡΙΒΑΛΛΟΝ

**Timelaps of a river**


https://twitter.com/GeologyyScience/status/1364223654490374150

# ΕΝΔΙΑΦΕΡΟΝΤΑ - ΛΟΙΠΑ

## UCL team solve Antikythera Mechanism mystery

**Researchers at UCL have recreated a mechanical Cosmos for the Antikythera Mechanism, known to many as the world's first analogue computer.**

Exploded model of the Cosmos gearing of the Antikythera Mechanism.

The ancient Greek Antikythera Mechanism was used to predict the positions of the Sun, Moon and the plants as well as lunar and solar eclipses. Discovered in a Roman-era shipwreck in 1901 by divers near the Mediterranean island of Antikythera, the astronomical calculator has fascinated researchers ever since.

The hand-powered device consists of a complex combination of 30 surviving bronze gears used to predict astronomical events. Studies in 2005 using 3D X-rays and surface imaging enabled researchers to show how the mechanism predicted eclipses and calculated the variable motion of the moon, but a full understanding of the gearing system at the front of the device had so far eluded scientists' efforts.

Published in *Scientific Reports*, the team's findings are said to represent a significant advancement toward understanding the full capabilities of the Antikythera Mechanism. The paper reveals a new display of the ancient Greek order of the Universe (Cosmos).

"Ours is the first model that conforms to all the physical evidence and matches the descriptions in the scientific inscriptions engraved on the mechanism itself," said lead author Tony Freeth, professor of mechanical engineering at UCL. "The Sun, Moon and Planets are displayed in an impressive tour de force of ancient Greek brilliance."

Only around a third of the mechanism has survived and is split into 82 fragments. The biggest surviving fragment, known as Fragment A, displays features of bearings, pillars and a block. Another, known as Fragment D, features an unexplained disk, 63-tooth gear and plate.

The 2005 data revealed thousands of text characters hidden inside the fragments, unread for nearly 2000 years. Inscriptions on the back cover include a description of the cosmos display, with the planets moving on rings and indicated by marker beads. The team worked to reconstruct this display.

Two critical numbers in the X-rays of the front cover, of 462 years and 442 years, accurately represent cycles of Venus and Saturn respectively. When observed from Earth, the plants' cycles sometimes reverse their motions against the stars. Experts must track these cycles over long time-periods to predict their positions.

PhD candidate and team member Aris Dacanalis explained that the classic astronomy of the first millennium BC originated in Babylon, but that nothing in the astronomy suggested how the ancient Greeks found the highly accurate cycles for Saturn and Venus.

Using an ancient Greek mathematical method described by the philosopher Parmenides, the team has reportedly discovered how the cycles were derived, as well as recovering the cycles of all other planets where evidence was missing.

"After considerable struggle, we managed to match the evidence in Fragments A and D to a mechanism for Venus, which exactly models its 462-year planetary period relation, with the 63-tooth gear playing a crucial role," said PhD candidate and team member David Higgon.

Professor Freeth explained that the team then created mechanisms for all of the planets that would calculate the new advanced astronomical cycles and minimise the number of gears in the whole system, so that they would fit into the tight spaces available.

"This is a key theoretical advance on how the Cosmos was constructed in the Mechanism," added co-author, Dr Adam Wojcik (UCL Mechanical Engineering). "Now we must prove its feasibility by making it with ancient techniques. A particular challenge will be the system of nested tubes that carried the astronomical outputs."

A video with further information can be found here.

(THE ENGINEER, 15th March 2021, https://www.theengineer.co.uk/ucl-team-solves-antikythera-mechanism-mystery)

## A Model of the Cosmos in the ancient Greek Antikythera Mechanism

**Tony Freeth, David Higgon, Aris Dacanalis, Lindsay MacDonald, Myrto Georgakopoulou & Adam Wojcik**

**Abstract**

The *Antikythera Mechanism*, an ancient Greek astronomical calculator, has challenged researchers since its discovery in 1901. Now split into 82 fragments, only a third of the original survives, including 30 corroded bronze gearwheels. Microfocus X-ray Computed Tomography (X-ray CT) in 2005 decoded the structure of the rear of the machine but the front remained largely unresolved. X-ray CT also revealed inscriptions describing the motions of the Sun, Moon and all five planets known in antiquity and how they were displayed at the front as an ancient Greek Cosmos. Inscriptions specifying complex planetary periods forced new thinking on the mechanization of this Cosmos, but no previous reconstruction has come close to matching the data. Our discoveries lead to a new model, satisfying and explaining the evidence. Solving this complex 3D puzzle reveals a creation of genius—combining cycles from Babylonian astronomy, mathematics from Plato's Academy and ancient Greek astronomical theories.

Nature, *Scientific Reports* **volume 11**, Article number: 5821 (2021)

(Published: 12 March 2021, https://www.nature.com/articles/s41598-021-84310-w)

HERE ARE NINE AMAZING BRIDGES THAT CAN DO SO!



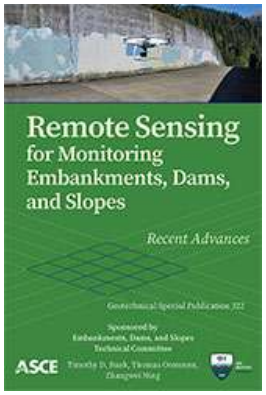






https://www.youtube.com/watch?v=hH2sjv1xoW8

# ΝΕΕΣ ΕΚΔΟΣΕΙΣ ΣΤΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΠΙΣΤΗΜΕΣ




**Remote Sensing for Monitoring Embankments, Dams, and Slopes: Recent Advances**

**Embankments, Dams, and Slopes Technical Committee**

**Geotechnical Special Publication 322**

**Timothy D. Stark, Thomas Oommen and Zhangwei Ning**

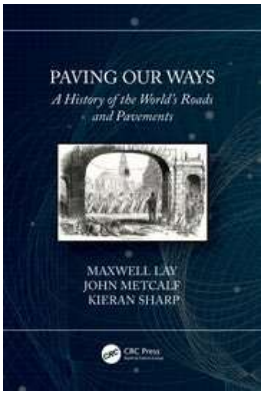
*Remote Sensing for Monitoring Embankments, Dams, and Slopes: Recent Advances*, GSP 322, provides information on selecting and deploying a monitoring network to assess the behavior, geometry, total and differential EDS movement, and potential risks of the EDS movement on people and infrastructure.

Topics include general technologies used for EDS monitoring, selection and installation of networked sensors for predictive analytics and image recognition, application of monitoring techniques in the design of early warning systems, case studies, and support for decision-makers in implementing early warning systems.

Information on a broad range of technologies, such as radio detection and ranging (radar), synthetic aperture radar (SAR), interferometric synthetic aperture radar (InSAR), light detection and ranging (LiDAR), digital photogrammetry and image processing, microelectromechanical systems (MEMS), automatic motorized total stations (AMTS), and unmanned aircraft systems (UAS) to deploy the remote sensing technologies is also included.

This Geotechnical Special Publication will be useful to both practitioners and researchers to understand and utilize currently available remote sensing technology and to advance and refine the monitoring of embankments, dams, and slopes.

(ASCE Publishing, 2021)




**Paving Our Ways**
**A History of the World's Roads and Pavements**

**Maxwell Lay, John Metcalf, Kieran Sharp**

*Paving Our Ways* covers the international history of road paving in an interesting, readable and technically accurate way. It provides an overview of the associated technologies in a historical context.

It examines the earliest pavements in Egypt and Mesopotamia and then moves to North Africa, Crete, Greece and Italy, before a review of pavements used by the Romans in their magnificent road system. After its empire collapsed, Roman pavements fell into ruin. The slow recovery of pavements in Europe began in France and then in England.

The work of Trésaguet, Telford and McAdam is examined. Asphalt and concrete slowly improved as paving materials in the second part of the 19th century. Major advances occurred in the 20th century with the availability of powerful machinery, pneumatic tyres and bitumen. The advances needed to bring pavements to their current development are explored, as are the tools for financing, constructing, managing and maintaining pavements.

The book should appeal to those interested in road paving, and in the history of engineering and transport. It can also serve as a text for courses in engineering history.

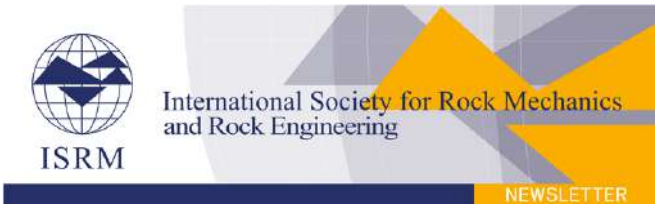
(CRC Press, 23 November 2020)

Join us for a webinar on Thursday, 13 May 2021 from 1:00–2:00pm AEDT, presented by Dr Maxwell Lay, Dr John Metcalf and Kieran Sharp, for an overview of the book.

No charge but registration is essential.

Register now

# ΗΛΕΚΤΡΟΝΙΚΑ ΠΕΡΙΟΔΙΚΑ




**www.isrm.net/adm/newsletter/ver_html.php?id_newsletter=204**

Κυκλοφόρησε το Τεύχος #53 (Μαρτίου 2021) του News-letter της ISRM με τα παρακάτω περιεχόμενα:

- ISRM International Symposium Eurock 2021 will be online
- 33rd ISRM online lecture by Prof. Sérgio Fontoura
- Volume 23 - 2020 of the ISRM News Journal
- Online course on "Empirical Methods in Rock Mechanics and Rock Engineering" by Dr. Nick Barton
- Online course on "Prevention methods for Landslides in Rock Masses" by Prof. Zhong-qi Quentin YUE
- A Tribute to Milton Kanji (1937-2021)
- IX LARMS, Asuncion, Paraguay, 16-19 October 2022
- ARMS11, Beijing, China, 21-25 October 2021, the 2021 ISRM Asian Regional Symposium
- 9th International Symposium on Geomechanics, 5-6 May 2021, Colombia, an ISRM Specialized Conference
- ISRM Rocha Medal 2023 nominations
- The 1st International Young Scientists Forum for DDA
- International Webinar on Rock Mechanics organized by young members of ISRM National Groups
- ISRM Sponsored Conferences


Κυκλοφόρησε το IGS Newsletter της International Geosynthetics Society με τα παρακάτω περιεχόμενα:

**IGS NEWSLETTER – March 2021**

*Helping the world understand the appropriate value and use of geosynthetics*

**httpwww.geosyntheticssociety.org/newsletters**

- New IGS Digital Library READ MORE
- IGS Job Shadowing Initiative READ MORE
- Countdown To GeoAfrica 2022 READ MORE
- 4th International Conference on Transportation Geotechnics (ICTG) READ MORE
- Tailings and Mine Waste 2021 Call for Abstracts Closing READ MORE
- IGS Attracts 3,000 Followers On LinkedIn READ MORE
- Raising The Bar On Geotextile Specification READ MORE
- Upcoming Webinars
  Hong Kong Landfills Webinar REGISTRATION INFORMATION
  Get Online For Soft Soil Webinar REGISTRATION INFORMATION
  Ballast Stabilization Webinar REGISTRATION INFORMATION

# ΕΚΤΕΛΕΣΤΙΚΗ ΕΠΙΤΡΟΠΗ ΕΕΕΕΓΜ (2019 – 2022)

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