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Θέμα: WTC2023 - ΥΠΟΒΟΛΗ ΠΕΡΙΛΗΨΕΩΝ

Αγαπητοί συνάδελφοι,

Η περίοδος υποβολής επιστημονικών περιλήψεων για το WTC2023 (www.wtc2023.gr) που θα φιλοξενηθεί του χρόνου στην Αθήνα και διοργανώνεται από την ΕΕΣΥΕ έχει ξεκινήσει και θα διαρκέσει έως 31-5-2022. Σας προσκαλούμε να υποβάλλετε τις περιλήψεις σας (ABSTRACTS) και εν συνεχεία τα επιστημονικά σας άρθρα για να δημοσιοποιήσουμε, σε διεθνές περιβάλλον, το υψηλό επιστημονικό επίπεδο που διαθέτουμε στην Ελλάδα, την τεχνογνωσίας μας και τις καινοτόμες τεχνολογίες που μελετούμε ή και ήδη εφαρμόζουμε στα υπόγεια έργα στη χώρα μας.

Αναμένουμε τις εργασίες σας.

Με εκτίμηση,

Νικόλαος Ρούσσος
Πρόεδρος ΕΕΣΥΕ

Ιωάννης Φίκιρης
Πρόεδρος Οργανωτικής Επιτροπής WTC2023

ΑΡΘΡΑ

The Evolution of Geotechnical Information Management

Why Cloud-Based Management is Growing Fast

All earth scientists know the geological time scale. From the Archean era of the Earth's formation billions of years ago, through the Paleozoic and Mesozoic eras of shifting land formations and bizarre primitive creatures, to the relatively recent Holocene epoch we live in now, the geological time scale helps to describe the timing and relationships between geological events throughout our planet's history.

A similar time scale can help us understand the rapid evolution of geotechnical information management (GIM). While studying the Earth and its geology has always generated large amounts of critical and interesting data, it was only in the past four decades that GIM was anything more than gathering piles of papers into filing cabinets and hoping nothing would become misplaced.

Since then, GIM has evolved rapidly, allowing geoscientists to do their jobs better and faster, as well as enabling them to find innovative new uses for the same data. Now more than ever, geotechnical work relies on advanced information management that allows data to be collected easily, analyzed quickly, and stored securely. What's more, it must be reliable and accessible to allow users to connect from anywhere (including directly in the field), streamline workflows, and ensure business continuity.

For these reasons, it's unsurprising that a shift to cloud-based GIM is in motion. But how much do you know about what GIM used to look like? Understanding the challenges throughout GIM's evolution makes it clear why cloud-based management is growing fast.

The Pre-Computer Era

From the very beginning of geoscience through to the relatively ancient times of the early 1980s, geoscientists did not have easy access to computers. The few pieces of computing equipment available were the size of entire rooms, incredibly expensive, lacked reliable storage, and resided far from the field.

Salvatore Caronna, founder of gINT, said nearly every geotechnical activity had to be done manually. Effectively taking measurements sometimes required making personal sacrifices.

"Today, a lot of data reading is automated," he said. "Back then, the tests could last several days. I had to record at specific intervals the whole time. I had a cot at the site, I would wake up, I would take a reading, and I would go back to sleep."

In this era, everything was recorded by hand, such as borehole logs, lab testing, and section diagrams. Back at the office, a typist had to transcribe the information onto reports, which introduced errors. Caronna said field workers and typists had to continually proofread and revise – which sometimes meant having to retype the entire report. Additionally, typists had to carefully align the paper to type information into specific fields on forms, which was time-consuming and costly.

Information management barely existed in this era. For the most part, it was simply organizing overflowing folders in filing cabinets. Comparing data from previous projects or nearby sites meant diving into reams of paper. Making matters worse, these papers had a habit of multiplying, as the same information would have to be copied and recopied by different people anytime they needed a different type of report that displayed information in a different way. As a result, errors frequently cropped up during the copying process.

"QA and QC was a nightmare," Caronna said. "There wasn't a single source of truth. The same data was represented in different ways by different people."

The DOS and Floppy Disk Era

In August 1981, the IBM Personal Computer was born. No longer did computers have to be the size of an elephant and cost more than a lavish sports car. Suddenly, computing became convenient, affordable, and readily available.

Many geotechnical departments quickly embraced the PC and took advantage of its ability to store up to 360 kilobytes of data on a 5.25-inch floppy disk. Entire groups of data and reports could be easily gathered into one place for easy access. Caronna said the floppy disk also made accessing older data much easier.

"When we started a new project, we had to write a proposal," he said. "We would grab as much data as we could from projects nearby. I spent many an hour going through paper reports to try to find information that was relevant to the proposal. With information on floppy disks, I could more easily pull data."

Though the technology was groundbreaking, change didn't happen overnight. Caronna said many organizations resisted PCs, as they believed condensing data into disks would make it easier to steal (realistically, large projects could require hundreds of disks – hardly easy to pocket).

And while PCs made data entry easier and improved collaboration, they didn't immediately solve the problem of having to manually input the same data into every form that used it. In some cases, convenient access to PCs made data entry errors worse.

"All of a sudden, executives, engineers, and management were typing their own stuff," he said. "And that lead to a lot of complaints."

Many geotechnical organizations tried to come up with in-house solutions for geotechnical information management, but most were quickly dropped. In their place arose numerous companies that specialized in geotechnical software. Caronna said he was inspired to transition from geotechnical work and form gINT by the desire to solve the tedium and inaccuracy of repeated data entry. By 1986, gINT eliminated the data entry issue by allowing data to be reused wherever it is needed.

"You could put one point in the database, and it's sent to log, graph, section, and exports," he said. "That replaced the work of five or six people."

The Windows and Network Drive Era

Through the 1980s and early 1990s, geotechnical software continued to advance. Data collection became automated and capable of recording data at faster intervals, eliminating the need for geoscientists to manually record data at the expense of sleep.

PCs advanced as well. Not only did floppy disks evolve into a 3.5-inch size with a capacity of 1.44 megabytes, but comput-

ers also started to store data locally on hard drives. Eventually, organizations gained the ability to store data on a centralized network of numerous connected PCs. These networks allowed data to be easily recorded and accessed by anyone without having to dig through a filing cabinet for the right folder or floppy disk.

"Having a network allowed you to take a single project and access it remotely at a decent speed," Caronna said. "You were able to share and collaborate among offices and personnel."

Network drives changed the way geoscientists worked. Previously, data had to be processed relatively close to project sites, and geoscientists were forced to move to where the projects were. But by accessing data remotely, increasing numbers of geoscientists could process data in the comfort of their home base. Clients could also access data in real time using the rapidly developing internet without getting their shoes dirty.

At the same time, Microsoft Windows made computers increasingly accessible. Windows NT and Windows 95 eventually eliminated the need for working within DOS entirely and enabled software to become more intuitive. The new interface helped GIM applications advance and extend their capabilities.

"The database in the DOS version of gINT could be extended, but it was crude and limited," Caronna said. "In the Windows version, everything could be customized yourself. Smart reports allowed you to write the rule to make the report be anything you want."

For example, if moisture content tests were not run on a borehole, a smart report could automatically suppress the column for moisture data and adjust the rest of the columns appropriately, eliminating the need to generate a new report. Geologists discovered numerous new ways to mine value out of data.

However, the divide between the site and the office remained. The rough, dirty conditions would overwhelm most electronics, and the early field devices were awkward to use, Caronna said. Despite the great leap in data management and analysis, field workers were still stuck with pen and paper.

The On-Premises Application Server Age

By the mid-1990s, many segments of geoscience developed the ability to share data among teams and clients across the world. But the process often wasn't easy at first. Roger Chandler, Co-Founder of Keynetix and Business Development Director at Bentley Systems, said his team had a particularly rough experience working onsite in the Philippines, supported by an engineering term in the United Kingdom, and providing materials to a client in the Netherlands. "Getting information off the vessel via satellite was a nightmare," he said.

Specialized yet primitive on-site devices evolved into ruggedized versions of the same devices found back in the office. Though some could run versions of the same applications as off-site researchers, many of them were still too bulky and unwieldy to bring into project areas, and they didn't easily connect with devices back at the office.

Worldwide data sharing via online servers improved as technology advanced, though more data to share meant more demand for that data. Contractors began requesting the raw data behind the charts and reports. As they received increasing amounts of data from different organizations, they wanted to come up with their own spreadsheet standards for everyone to fill in, rather than having to interpret different spreadsheet standards used by different teams. Data organization became standardized across geotechnical projects.

At first, online servers were just depositories of data – virtual filing cabinets. Even as applications began being hosted on drives to unify standards, users treated them as just another place to store information, Chandler said. Users could access a project if they wanted to, but at first there was no way to allow full collaboration on a project with the knowledge of how the data was entered or changed.

"Up through 2010, GIM was still thought of as an efficient way to create pieces of paper," Chandler said. "Paper sent through the email was thought of as efficient."

Gradually, geotechnical desktop solutions started to enable limited collaboration. For example, HoleBASE began to allow more than one person to work on a project in the same office. Soon, all project data could be stored, accessed, and changed in the same place and in the same way. The ability to do even more with the same data caused specialist data management roles to arise. Close to three decades after the PC became widely available, nearly everything outside of the project sites themselves became digitized.

"We were able to take things much further than paper," Chandler said.

The Cloud Era

Eventually, both data and digital processes moved online, forming what we know as the cloud. Geotechnical processes became digital from the start, transforming the way work was carried out. Storage cabinets finally vanished from offices. But that transformation wasn't painless, as version control was still an issue at first.

"Every week, clients would take information from the application and export it as the latest version of the data, then every company imported it," Chandler said. "This drove everyone nuts. No one knew what the latest info was, or what the differences between the data sets were."

Thankfully, applications evolved to eliminate these headaches, and cloud-based computing became the final piece of the digital transformation puzzle. Applications such as OpenGround were no longer bound to local computers and specific locations. Instead of having to retrieve data stored online for use within local applications, geoscientists could access data and carry out their work in the same online location, complete with version tracking that clearly showed which person changed what information. With no need to work on data offline, version control problems reduced significantly.

The process of transferring data also improved. Before applications migrated to the cloud, sharing data meant sharing files back and forth. Now, team members can find and access the data within each application without having to decipher code. "You've taken the data transfer and you've put it behind the scenes of the applications where it belongs. In the same way HTML makes your web browser work without having to email HTML files and import them to your browser," Chandler said.

The rise of smartphones and tablets provided the breakthrough on-site geoscientists were waiting for. Just add a ruggedized case, and they can bring convenient and familiar technology with them. Not only can they work with mobile versions of geotechnical applications used throughout the team, they can collaborate with far-flung team members via the cloud. The last vestiges of pen and paper use are starting to fade away. "These devices work in the rain, unlike pen and paper," Chandler said.

Making the Move: Migration Paths for Desktop GIM Users

While the benefits of cloud-based GIM (and the limitations of legacy software) are clear, planning the move from a trusted and time-tested desktop application can be daunting. "Most organizations are worried about the downtime and risk associated with a migration, making them hesitant to rock the boat," Chandler explained. "The irony is that, once the migration is complete, a cloud-based solution ultimately reduces downtime and risk."

As with any major technological shift, there eventually comes a time when legacy product can no longer keep up with the needs of its consumers, who are often left without a path forward. It was for this reason that OpenGround was designed to provide a smooth migration plan for users of desktop GIM products. "Generally, migration from HoleBASE to OpenGround takes only a weekend," said Chandler.

Looking Ahead to the Future of GIM

Though the jump to the cloud was a huge evolutionary step, GIM continues (and will continue) to change and improve. For example, geotechnical companies are making great use of sensors and data collection devices, making it easier than ever to monitor sites and gather information in near real-time throughout the project. Digital twins can produce a detailed yet intuitive model of any project, improving both visibility and decision-making. And GIM will continue to evolve in new directions, some of which are in development and others we might not be able to imagine today. The new eras certain to emerge could make today's advancements look ancient.

(Bentley Expert, Mar 24, 2022, https://blog.virtuosity.com/the-evolution-of-geotechnical-information-management)

Geothermal developments in Greece – Country update 2015-2020

Maria Papachristou, Paschalis Dalampakis, Apostolos Arvanitis, Dimitrios Mendrinos and Nikos Andritsos

ABSTRACT

The intense tectonic and volcanic activity in the Hellenic area has caused the accumulation of thermal energy in relatively shallow and, thus, economically accessible depths. This is manifested as numerous low, medium and high enthalpy hydrothermal systems across the country. The geothermal exploration has, thus far, identified more than forty (40) areas of geothermal interest, thirty-two (32) of which are officially characterized as "geothermal fields". However, only a small fraction of the proven geothermal resources is exploited. Reaching an estimate of around 260 MWth, the installed geothermal capacity pertains to heating/cooling and recreation/healing uses. The local geothermal market is dominated by the Ground Source Heat Pumps (63% of the total installed capacity), whereas direct uses are limited to balneotherapy and greenhouse heating, followed by small-scale applications, such as soil heating, dehydration and aquaculture. All new and important exploitation projects are realized in low temperature fields of Northern Greece, where the social acceptance and the support from local authorities have created a favorable investment environment. On the other hand, the share of geothermal energy in the electricity production sector remains zero. In July 2018, an international tender announced by "PPC-Renewables" was concluded successfully, with the selection of a strategic partner for the construction of small power plants (5-8 MWe) in four geothermal areas (Lesvos, Methana, Nisyros and Milos-Kimolos complex). Regarding exploration, the on-going projects concern further research in known low enthalpy areas (Strymon Basin, Akropotamos, Evros Delta, etc.), as well as reconnaissance studies in other promising areas, such as eastern Thessaly, Lesvos and Lemnos islands.

1. INTRODUCTION

The development of Renewable Energy Sources (RES) has been one of the major energy policy lines of Greece for more than a decade. In 2010, Greece endorsed the National Renewable Energy Action Plan (NREAP, 2010), which had set specific targets for the RES shares in gross final consumption for 2020 (40% electricity, 20% heating and cooling, 10% transport). So far, only the target for heating and cooling has been met.

Regarding geothermal energy, the 2020 target for electricity, heating and Ground Source Heat Pumps (GSHPs) was 120 MW, 51 ktoe and 50 ktoe, respectively. In reality, the power generation from geothermal energy is absent. The contribution in heating remains at low levels, with a greater share in the tertiary and the agricultural sector (mainly for balneotherapy and greenhouse heating). The target for the GSHPs will most probably be accomplished, given the steadily increased use of shallow geothermal systems in Greece.

In the islands of Milos and Nisyros (the two confirmed high enthalpy fields of Greece), the public confidence towards geothermal electricity generation has not been restored yet; however, the social environment is much more positive in other prospective geothermal regions, e.g. in Lesvos island or in Macedonia and Thrace, where exploitable medium enthalpy resources most probably exist.

The use of low enthalpy geothermal energy for direct applications is better perceived, as it is evident by the new and important investments in northern Greece and the first geothermal district heating project that is under development in Thrace. In addition, several exploration/exploitation projects have been carried out or are still in progress in eastern and central Macedonia, Thrace, central Greece, Lemnos Island, etc.

In 2019, a new National Energy and Climate Plan (NECP, 2019) entered into force, foreseeing a very small share of geothermal energy in the electricity generation system, i.e. 100 MWe from geothermal energy in 2030 and 300 MWe in 2040. The contribution of geothermal energy (including GSHPs and ambient heat) in the final energy consumption (residential and tertiary sectors) is expected to be 734 ktoe in 2030 and 896 ktoe in 2040. In order to meet these targets, the Greek State has committed to implement a series of measures, regulatory initiatives and financial support programs. One of them is the, long anticipated, new geothermal Law that came into effect in March 2019, as an effort to modernize the institutional framework for the research and exploitation of geothermal energy. Moreover, since January 2016, Greece has a new RES support scheme. The feed-in tariff (FiT) has been eplaced by a technology-specific sliding scale Feed-in Premium (FiP). FiT remains applicable only for small RES plants (≤0.5MW).

2. GEOTHERMAL RESOURCES

2.1 Geology Background

Due to the country's geotectonic regime, the geologic conditions are favorable, or even ideal, for the formation of important geothermal systems, in both continental Greece and the Aegean islands (Figure 1). In these areas, the intense tectonic and, in some cases, magmatic/volcanic activity, have created extended thermal anomalies and very high geothermal gradients.

Figure 1: Main geothermal areas of Greece

The Aegean area constitutes one of the most rapidly deforming segments of the Alpine-Himalayan belt, displaying the highest deformation rates in the whole Africa-Europe collision zone (Francalanci et al., 2005; McKenzie, 1972; Papazachos and Comninakis, 1971). The deformation is associated with the subduction of the eastern Mediterranean lithosphere under the Aegean plate along the Hellenic Arc and the westward motion of Anatolia along the North Anatolia Fault. This geodynamic and tectonic regime, and especially the formation of the South Aegean Active Volcanic Arc (*SAAVA*), have contributed to the increase of the heat flow and the development of

important high temperature geothermal reservoirs at relatively shallow depths. The active volcanic zone extends from the Saronikos Gulf as far as Nisyros and the SW edge of Kos Island, including the active centers of Methana, Milos, Santorini and Nisyros (Figure 1).

The Cenozoic volcanism in the Aegean area took place in successive phases from the Upper Eocene/Lower Oligocene until the present (Fytikas et al., 1984). It started in the northernmost part of the Aegean area and progressively shifted southwards. The volcanism in northeastern Greece and the islands of Samothrace, Lesvos and Lemnos (north Aegean region) is extinct, whereas Milos, Nisyros and Santorini islands belong to the high heat flow zone of the Aegean. This is attributed to the presence of large solidified magma chambers at relatively shallow depths, as well as to the intrusions of molten magma close to the surface (3-5 km below surface) due to strong extensional tectonic activity (Fytikas, 1989; Fytikas & Andritsos, 2004).

The existence of **high temperature (>320°C) reservoirs** in Milos and Nisyros Islands has been confirmed since mid-1970s. On the other hand, *north* and *northeastern Greece*, a typical back-arc region, is characterized by significant **low to medium temperature reservoirs (up to 150°C)**, without excluding even higher temperatures at depth, as indicated by application of chemical geothemometers (Mendrinos et al., 2010).

In eastern Macedonia and Thrace important geothermal systems have been developed inside the sedimentary Tertiary basins (such as Evros Delta basin, Xanthi Basin, Nestos Delta basin, Strymon Basin, etc.) that were created during the tectonic phases that followed the Alpine orogenic event (Figure 2). The existence of these geothermal fields is associated to the active extensional tectonics, crustal thinning, magmatic intrusions, large open faults (that affect both the metamorphic basement and the sedimentary sequence and favor the quick rise of thermal fluids), and the presence of very permeable geologic formations (Kolios et. al., 2007).

In central Macedonia, the low temperature geothermal fields of Langadas and Nea Apollonia (Mygdonia Basin) owe their existence to very large and deep NW-SE active faults.

In *central Greece*, the E-W tectonic graben of Sperchios and the north part of Euboea island belong to the back-arc region and host some of the most well-known thermal springs of Greece (Thermopylae, Edipsos, etc), associated to the volcanic center of Lichades island complex. These areas are characterized by very high heat flow, attributed to the effect of the North Anatolian Fault, which is extended to the NE Aegean Sea and ends up in central Greece. The main geothermal reservoirs are most probably developed inside the Cretaceous limestones of the basement, but have not been thoroughly explored yet.

The increased heat flow and the low to medium temperature reservoirs of the *east and northeast Aegean islands* (Samothrace, Lesvos, Chios, and Ikaria) are mainly related to Miocene volcanism and recent extensional tectonic activity.

Western Greece is less favored, with only a few areas of geothermal interest (low temperature fields) and significantly lower heat flow rates. The geothermal gradients measured in the *Ionian Islands, Peloponnese, Crete and the south Dodecanese islands* are very low, mostly due their geotectonic position, i.e. along the Hellenic Trough and the sedimentary arc (low heat flow zone).

2.1 Geothermal Exploration

Geothermal exploration in Greece started in the 1970s, targeting the high enthalpy resources in the volcanic islands of Milos and Nisyros. It then progressively moved to other promising areas across the country, focusing in Northern Greece, for the investigation of low temperature (up to 90-99°C) resources.

So far, thirty-two (32) areas are officially determined as "geothermal fields" and several more have been identified as areas of geothermal interest. Since 2015, the exploration activities mostly focused on additional investigation and further drilling exploration in known low temperature areas of Northern Greece, as well as on reconnaissance studies in Lemnos, Lesvos, Euboea and Santorini Islands and in Eastern Thessaly.

The plans for exploring the medium enthalpy resources in Chios and Samothrace islands, Evros River Delta and Nestos River Delta, as well as for Sperchios basin, Akropotamos (Kavala), Soussaki, and Ikaria island (see Andritsos et al., 2015), were never implemented because the awarded contractors withdrew from the projects.

During the period 2015-2020, the following exploration activities were carried out:

• *Lesvos Island:* A new preliminary study was conducted at the eastern part of the island, which included a geophysical survey, as well as temperature measurements and sampling at springs and shallow wells. This study revealed a new geothermal area near Mytilene, where waters of 30-33°C are produced from depths up to 150m (Xenakis et al., 2016).

• *Lemnos Island*: The reconnaissance study resulted in the identification of an interesting area at the south-eastern part of the island (Moudros area). The measured wellhead temperatures at existing very shallow (70-105 m) wells ranged between 24 and 29.6°C (Arvanitis et al., 2016a).

• *Euboea Island (Edipsos)*: The exploration work pertained to the mapping and geochemical study of the numerous onshore and submarine hot springs of the area, in an attempt to provide further information and a more complete understanding of the local hydrothermal system. The recorded temperatures ranged from 30 to 82°C (Vakalopoulos et al., 2016a). It was concluded that the northwestern Euboea island (along with the neighboring Sperchios basin geothermal system) is characterized as the first so-far documented active terrestrial mineralizing geothermal system associated with ore-bearing travertines in Greece (Kanellopoulos et al., 2017).

• *Eastern Thessaly (central Greece)*: Reconnaissance studies were conducted in five (5) areas (Faros-Paliourio, Chalki-Kileler, Mikrothives-Almyros, Krini-Agios Georgios and Ampelia-Farsala). At the area of Ampelia, the wellhead temperatures at existing wells (depths between 235 and 410m) reach 41.3°C (Vakalopoulos et al., 2016b). After the evaluation of the regional geology and the geophysical/thermometric/geochemical data, the drilling of four (4) new large diameter exploration wells was proposed at the area of Ampelia-Farsala, where the higher temperatures (35.1-41.3°C) had been measured (Vakalopoulos et al., 2016b).

• *Santorini Island*: The exploration project included temperature and electrical conductivity measurements in 141 existing shallow wells across the island, selective sampling and chemical analyses. The scope of this study was to evaluate the geothermal resources of Santorini, with a particular emphasis on the shallow aquifers, and to suggest further research/development activities. The thermometric investigation revealed a very interesting zone of geothermal anomaly in the central part of the island, with temperatures exceeding 26-27°C, at very shallow (40-190 m) depths (Papachristou et al., 2016).

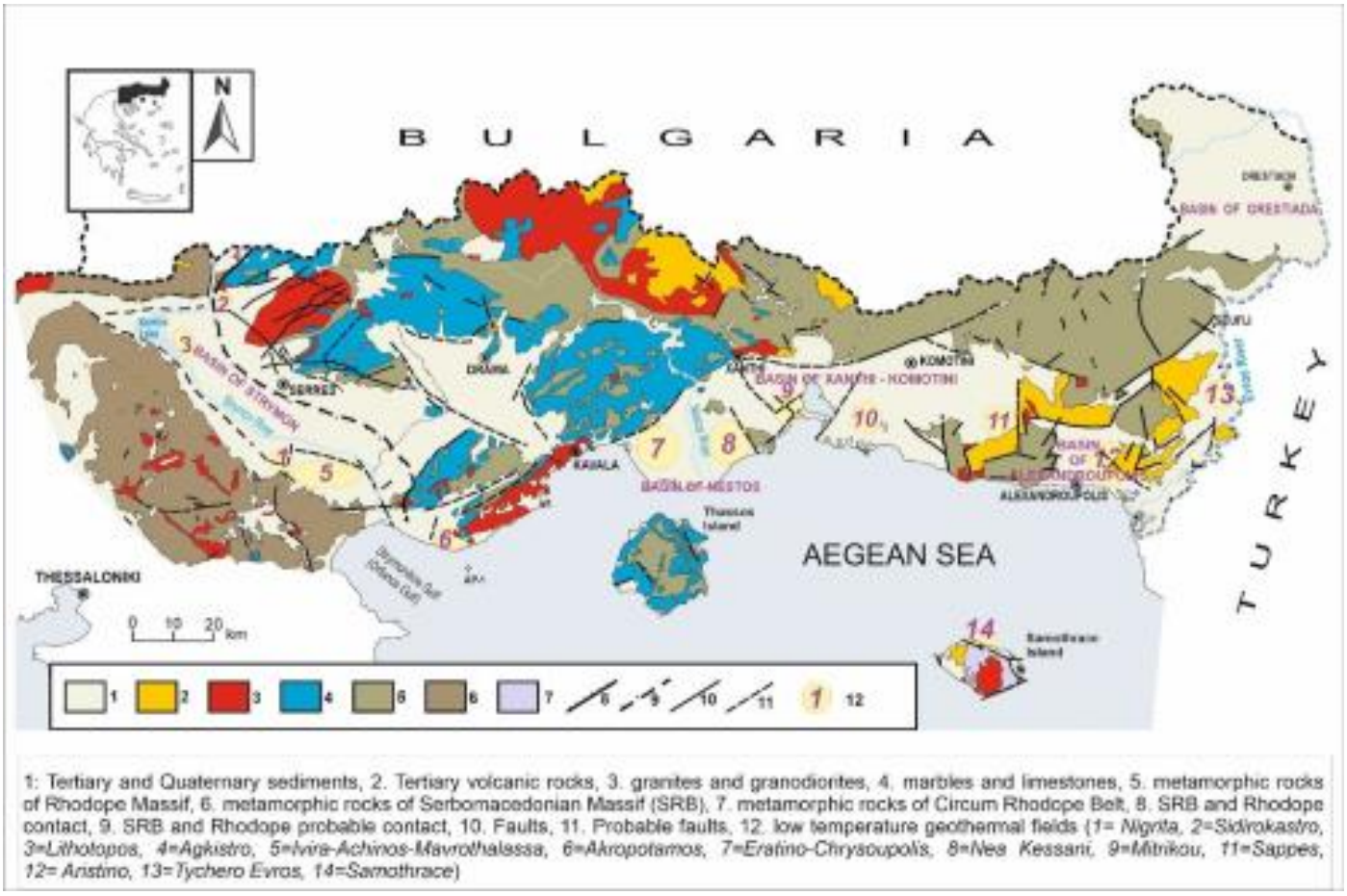

Figure 2: Simplified geologic map of northeastern Greece with the main geothermal fields (Kolios et al., 2007)

• *Strymon Basin (Macedonia, Northern Greece)*: Three (3) low temperature geothermal fields were further explored:

i. **Sidirokastro**: An area of extensive hydrothermal alteration was recognized and mapped in the northern part of the field and four (4) new large diameter exploration/production wells were sited. Geothermal fluids of ~75°C are expected to be found at depths of 100-300m (Arvanitis et al., 2016b). The drilling works are scheduled to start in March 2020.

ii. **Lithotopos-Iraklia**: Following an extensive surface exploration project, described in Arvanitis et al. (2015), four (4) new production wells were constructed in the period 2016-2018, with depths ranging between 353 and 520 m. They produce fluids of 37.5-74.5°C, with low flow-rates (5-80m3/h).

iii. **Nigrita**: A new large-diameter production well was drilled at the depth of 216m, which produces 240-250m3/h of 61°C fluids.

• *Strymonikos Gulf (Macedonia, northern Greece)*: The past geothermal exploration and drilling research had identified and confirmed the existence of an important anomaly along the coastal zone, in the area of **Akropotamos** (westwards of Kavala). The deeper geothermal reservoir is located at 515m below surface, providing fluids of 90°C, whereas shallower reservoirs exist at depths of 130m (46°C) and 230m (85°C). Recently, long term production tests were performed in two of the existing (since 2003-2006) but unused geothermal wells, which showed high rate artesian flow (*AKR-1*: 220-230 m3/h, *AKR-3*: 150-160 m3/h) and produced fluids with temperatures 84-90°C (Papachristou et al., 2019).

• *Nestos Delta Basin (Macedonia, northern Greece)*: New exploration/exploitation activities took place in the two (2) low temperature fields of Nestos Basin:

i. The low temperature geothermal field of **Eratino-Chrysoupolis** lies on the western side of Nestos River, eastwards of Kavala. The exploration indicated high temperature gradients, up to 120°C/km, at the center of the field (Kolios et al., 2007). Low enthalpy (70-80°C) fluids were found at 600-700m, inside the carbonate formations that lie beneath a thick sequence of relatively impermeable sediments. Based on geology, lithology and geothermal gradients, it is highly probable that the main reservoir, with temperatures 150-180°C, is located at larger depths (1500-1800m), inside the metamorphic basement. In the frame of the Eratino exploitation project, one injection and two new deep (750m) production wells were drilled in 2015, providing fluids of 70-77°C at flow rates higher than 100-120m3/h each.

ii. The low temperature geothermal field of **Neo Erasmio-Magana** lies on the eastern side of Nestos River, south-southwest of Xanthi. Stratified aquifers are supplied by an active fault system that affects the basement of migmatitic gneisses. Temperature inversions have been observed in some wells, indicating lateral flow. Hot waters of 30-68°C have been found at depths of 150-500m in the basal part of the post-alpine sedimentary sequence and at the top of the basement (Kolios et al., 2005; Dalabakis et al., 2015). During October-November 2015, two production wells (255 and 243m deep) were drilled in order to cover greenhouse heating requirements. These wells cased to depths of 246 and 234m provide 120 m^3/h waters of 59 and 57°C, respectively. In August-October 2019, two additional production wells, 332 and 258m deep, were constructed and produce 120

m^3/h and more than 160 m^3/h waters of 62 and 70.2°C, respectively.

• *Evros Delta Basin (Thrace, northeastern Greece)*: The geothermal field of **Aristino** is located eastwards of Alexandroupolis, near the Traianoupolis thermal springs. An exclusive area of 16 Km^2 has been leased since 2013 to the Municipality of Alexandroupolis for further exploration and exploitation. The geothermal anomaly is characterized by high thermal gradients (>200°C/km), due mainly to the presence of sub volcanic bodies, deep slip normal active faults that intersect the geothermal area, and the extended vertical and lateral convective cells. Two distinct hot water bearing zones have been recognized: one towards the north, in the volcanic province, and the other towards the south, inside the volcano-sedimentary sequences.

The drilling exploration revealed two geothermal systems: the upper system of low temperature (50-55°C), which develops at depths 100-200 m in altered volcaniclastics of low permeability and low production rates (20-25 m^3/h), and the lower hot reservoir, but certainly not the main one, which has been found in tuffaceous horizons and/or in the widespread hyaloclastic breccias (assumed as ignimbrite) at depths between 200-400 m. Its temperature and production rates range from 32 to 99°C and 40 to 150 m^3/h, respectively.

A new production well was drilled in 2016 at the depth of 410 m. In this, very enigmatic, well borehole temperatures varies, in steady state conditions, from 75°C to 78°C, representing a thermal regime that is in full contradiction with the non-completely stabilized temperature of 99°C that was measured at the end of a pumping test with a maximum flow rate of 45m^3/h. This temperature is the highest ever encountered in the 'low enthalpy' geothermal fields of northern Greece.

3. GEOTHERMAL UTILIZATION

3.1 Power Production

The confirmed high temperature geothermal resources of Milos and Nisyros islands remain unexploited, thirty years after the shut off of the 2 MWe power plant in Milos. All past attempts for the exploration and exploitation of medium enthalpy resources (Andritsos et al, 2015) were not concluded successfully.

In July 2018, an international tender for a new geothermal power project was concluded successfully. It had been announced in 2017 by the Public Power Corporation (PPC) S.A. and regarded the selection of a strategic partner for the financing, development and management of small (5-8 MWe) power plants in the island complex of Milos and Kimolos, in Nisyros and Lesvos islands, and in Methana peninsula (NE Peloponnese). The company "HELECTOR S.A." was declared as the highest bidder and will hold a 51% stake in its joint venture with PPC. Given the, unchanged throughout the years, opposition of the locals in Milos and Nisyros, the project will start from Lesvos and Methana.

3.2 Direct Uses

Geothermal energy is mainly used in Greece for balneotherapy and greenhouse heating, whereas its utilization for soil heating, aquaculture and space heating is much less significant in terms of number and size of applications. The total installed capacity from direct uses is approximately 84.45 MW_{th} (Table 5).

3.2.1 Balneotherapy

The exploitation of thermal waters for their therapeutic properties constitutes the older and the most common geothermal use in Greece. More than 750 thermal and mineral springs have been recorded across the country, half of which are classified as "curative". The temperature of the thermal springs ranges between 25 and 92°C; however the temperature of the water that enters the bathing facilities does not usually exceed 35-39°C. Geothermal water is used in nearly 70 spas and bathing centers, as well as in more than 25 outdoor swimming pools. Most of the recreational centers operate from June to October, with only a few exceptions that remain open throughout the year. In addition to healing and recreation, the geothermal fluids were also used for heating the bathing and accommodation facilities in two cases: in Nea Apollonia (central Macedonia) and in Traianoupoli (Thrace). Unfortunately, the operation of the spa center in Nea Apollonia was very recently (early 2019) halted, due to financial problems.

The energy use in balneotherapy cannot be accurately calculated due to the absence of any systematic study and the lack of the necessary data. Nonetheless, taking into account an average ΔT=10°C and a maximum flow rate about 1000 kg/s, the energy use can be conservatively estimated to 260 TJ/y, corresponding to an installed capacity of 43 MWth (Table 5).

3.2.2 Greenhouse Heating

Most of the 18 geothermal greenhouses of Greece are located in the north (Macedonia and Thrace). Some of the older units are currently either closed or they use different energy mix. Nevertheless, the total greenhouse surface area has increased since 2015, reaching more than 40 ha in 2019. Most greenhouses are of glass type and produce various types of vegetables (tomatoes, cucumbers, etc.) and flowers, mostly for the domestic market. Their installed capacity is 38 MWth, while the annual energy use is estimated at 407 TJ/y (Table 3).

During the past five years new and significant investments were made in geothermal greenhouse heating, in two low temperature fields of northern Greece:

Neo Erasmio (Xanthi, Thrace): The biggest and most promising geothermal investment ever realized in Greece launched in this field in 2014. A new multi span geothermal greenhouses complex for hydroponic cultivation of tomatoes and cucumbers was constructed in 2014 by the company "THRACE Plastic Co S.A., which has been awarded the exploitation rights for this field. The unit has been gradually expanded from 4.2 ha in 2015 (Andritsos et al., 2015) to 18.5 ha in 2019 and will reach 20 ha in 2020. The investment has so far exceeded €20 million, offering 120-150 job positions to the nearby communities.

The heating requirements are covered by five wells that can produce more than 500 m^3/h of good quality geothermal water at 58-60°C. The circulation of the fluids inside the greenhouses is achieved through two independent, iron and plastic pipe arrangements, placed on the ground in the circumference of the planting rows. After their use, the geothermal fluids are reinjected with a mean temperature of 30-33°C. The installed capacity and annual thermal energy use in this greenhouse complex are 14.64 MW_{th} and 164.88 TJ, respectively (Table 3).

Eratino-Chrysoupolis (Nestos Delta Basin-eastern Macedonia): The local authorities (Municipality of Nestos) invested more than €10 million for the construction of the heat distribution infrastructure (two production and one injection wells, thermal stations and an 18 km distribution network) that can provide up to 8 MW of geothermal heat exclusively for agricultural use. This project was completed in 2015 and was fully operational in 2016. The same year, the first geothermal greenhouse (3.5 ha) was constructed by the company "SELECTA Hellas", for breeding and producing rooted cuttings of ornamental plants. The heat demands are totally covered by

geothermal energy. The temperature of the circulating fluids is 75□C and the maximum flow-rate is about 50m^3/h. The average required flow-rate however, is much smaller and does not exceed 9m^3/h. The installed capacity and the annual thermal energy use are 2.38 MW$_{th}$ and 24.27 TJ, respectively (Table 3). "SELECTA Hellas" has already invested €7 million in this undertaking, but the total invested amount will reach €10 million with the construction of additional units (2.5 ha) within the following years.

3.2.2 Soil Heating

The use of low temperature geothermal fluids for soil heating was applied for the first time in 1998 in Neo Erasmio (Xanthi). In 2005 a similar soil heating system was installed in Myrodato (Xanthi). Both plantations produce early-season white and green asparagus, and, occasionally, other vegetables (lettuce, watermelons, etc.) The total installed capacity and annual energy use are 0.83 MW$_{th}$ and 10.55 TJ, respectively (Table 3)

The soil heating is achieved by the circulation of geothermal fluids (up to 58°C) through plastic PP or PE pipes, placed either inside the subsoil beneath the asparagus crowns or in the ground at the base of the soil ridges, in a U-bond arrangement (Andritsos et al., 2015). The required heating loads range between 100-150 kW/ha, depending on the outdoor temperature and the heating onset. Heating usually starts in early February, whereas the harvesting period lasts from early March to mid-April.

The heated plantation surface in Neo Erasmio has decreased from 20 ha in early 2000s to 3.0 ha in 2019. This significant reduction is mainly attributed to the exceeding of the plants' life span (12-15 years), in combination to financial difficulties related to the general economic recession in Greece. In Myrodato, the cultivated area (3.0 ha) is heated by geothermal fluids of 50°C.

3.2.3 Fish-Farming

Geothermal energy had been used for several years for the anti-frost protection and heating of fish farming ponds in Porto Lagos and Neo Erasmio (both in Thrace Region). Unfortunately, the fish farm in Neo Erasmio has closed due to administrative issues, whereas the anti-frost protection in Porto Lagos is no longer implemented by geothermal energy, due to technical problems of the geothermal wells.

Moreover, the small pilot unit for ornamental fish breeding in geothermal water that was installed in Neo Erasmio in early 2014 (Andritsos et al., 2015), is no longer in operation. However, it has been a particularly interesting case of geothermal energy use, because the geothermal water (T=48°C, Conductivity = 1040 μS/cm) was not only used as a heating source but also served as the growing medium. After a few years of operation, it has been safely concluded that the adaptability of ornamental fish to geothermal water was excellent, and all the thermodynamic targets had been absolutely achieved, even with extreme outdoor temperatures (-10 to -12°C).

3.2.4 Aquaculture: Spirulina Cultivation

Spirulina cultivation in geothermally heated water has been practiced in Greece since the late 1990s. Today, three companies are active in this sector, with three plants operating in the low temperature field of Nigrita (Strymon Basin, northern Greece). The total surface of the raceway ponds is 0.9 ha. The average required flow-rate, for maintaining the temperature of the cultivation water at 33-36°C, is 20-21 m^3/h, whereas it might reach 35-40 m^3/h during very cold days. The installed capacity of the three units is 0.75 MW$_{th}$. (Table 3).

3.2.5 Dehydration

The only geothermal dehydration plant in Greece operates since 2001 in the geothermal field of Neo Erasmio (Xanthi, northern Greece). Up to now, it has produced more than 300 tn of dried tomatoes and, in recent years, increasing quantities of olives, other vegetables (e.g. asparagus, peppers and eggplants) and fruits (e.g. apples, lemons, melons). The unit typically operates each year for drying of tomatoes during the period June-September (and throughout the year when it is needed), using fluids of 58°C at an average flow rate of 32 m^3/h. The fluids pass through a water-air heat exchanger that produces hot air at 55-58°C, which is driven to the drying tunnels at a rate of 14.000m^3/h (Andritsos et al., 2003). The installed capacity of the unit is 0.24 MW$_{th}$ (Tables 3 and 5).

3.2.5 Space Heating

The use of geothermal energy for space heating is very limited. During the past years, a small school building in Traianoupolis, two spa centers (Nea Apollonia and Traianoupolis), a 2000 m^2 surface of offices and process facilities in the Erasmio greenhouse unit, and a few houses in northern Greece were heated by low temperature geothermal fluids. As mentioned above, the spa center of Nea Apollonia closed in early 2019, but efforts are being made to re-open under a new ownership scheme. The installed capacity of the space heating installations is currently at 1.65 MW$_{th}$ (Table 3).

3.2.6 District Heating

Greece does not have geothermal district heating (DH) systems that operate with the direct use of geothermal fluids. In 2016 a small (2.5 km) DH system supplied by GSHPs and solar panels was constructed in Attiki (Central Greece).

The project "Thermopolis" in Lesvos Island, which would use geothermal fluids of 88°C for the heating of five public and municipal buildings in the nearby town of Polichnitos (Andritsos et al., 2015), remains out of operation due to the failure of the submersible pump. A proposal for the replacement of the pump and the maintenance of the equipment is underway.

The first integrated geothermal district heating project is under implementation in the geothermal area of Aristino (Thrace) and will be ready for the startup procedures by the end of 2021. The main components of the district heating system, including end-users for agricultural purposes, are: two production wells, with a maximum total flow rate of 150 m^3/h and mean operational temperature of 89°C, a thermal station with three couples of plate heat exchangers, automations and an integral reinjection system comprising a storage tank and three parallel multi-stage injection pumps. The total length of the three independent recirculation networks is 16 km. End users will receive thermal energy at a maximum distance of 2200 m from the thermal station. 20% of the total installed heat capacity (2 MW$_{th}$) will be delivered to the ensemble of local edifices of public interest (schools, municipal administration buildings, churches, charitable organization "SOS Village", etc.) covering a total area of 8000 m^2. The rest 80% (8 MW$_{th}$) will be available on demand to private end-users for agricultural uses, with emphasis to the greenhouses. The final budget of the project has been finalized at €6 million.

3.3 Ground Source Heat Pumps

The shallow geothermal market remains the largest segment of the geothermal sector in terms of installed capacity and energy produced. The first documented shallow geothermal system was installed in Greece in the early 1990s. However, considerable growth of the GSHP market has been recorded after the mid-2000s, following a number of pilot projects and

informative/training workshops, funded by European or National Programs. The market exhibited different phases of development. In the beginning (mainly in the 2000s) the market penetrated mostly new constructed houses and small buildings and represented a very small share of the total residential heating equipment. The development of the market was definitely affected by the severe economic crisis during the 2010s, but in a different direction for houses and for large commercial and public buildings. For houses and small buildings there was a strong competition from natural gas (in areas in which it is available) and from air-source heat pumps, which, according to some designers of heating systems, overran GSHPs by 10 to 1. On the other hand, there is a strong trend in incorporating GSHP in large buildings (e.g. hotels, hospitals, schools, university buildings, and airport and port facilities) in order to meet the standards set by the (Hellenic) Regulation on the Energy Performance of Buildings (KENAK), which sets minimum requirements for the energy performance of buildings.

Official up-to-date data at national-scale are not kept, so it is extremely difficult to know with confidence the exact number or the size of the installed systems, especially of those in individual dwellings. Nevertheless, an estimate of more than 3500 operating systems at the end of 2020 is rather realistic. The total installed capacity is estimated to exceed 175 MW_{th} (Table 4). Most of the systems have a capacity of less than 100 kW (avg. 30 kW), whereas about 200 systems exceed 100 kW (avg. 350 kW).

The GSHPs are commonly used in Greece for both space heating and cooling, as well as for domestic water heating. Most installations regard residential and office buildings, however their use has progressively become popular in hotels, department stores, swimming pools, school complexes, etc.

The penetration of GSHP systems in the agricultural sector is poor; a soil heating system supplied by geothermal heat pumps was installed 13 years ago in a 19 ha asparagus plantation in Chrysoupolis (Kavala, northern Greece) for early season production. It has been operating effectively ever since, providing energy at low cost. Unfortunately, the asparagus plantation and a demonstration greenhouse in Thessaly (central Greece) are the only cases of using shallow geothermal resources in agriculture.

Recent data from GSHP installations in northern Greece, show that, after 10 years of continuous operation, the mean annual savings for heating and cooling exceed 65% (>70% for heating and ~50-55% for cooling), compared to conventional systems (oil boiler coupled to split air-conditioning units). Depending on the size and the type of the building, the payback period ranged between (3) and (9) years. A few indicative cases of new GSHP applications are as follows:

Building of Central Macedonia Regional Authority (Thessaloniki)*:* The installation of an innovative hybrid shallow geothermal system in this new public building constitutes one of the largest GSHP projects in Greece. It was completed in 2016 but it has not been in operation yet for reasons related to bureaucratic obstacles. The total installed capacity is 850 kW and can cover the heating and cooling requirements of a 22000 m2 surface. The obtained COP is 4.2. The installation cost for the heat exchangers reached €1 million, whereas, the annual savings were estimated to reach 70%.

The heat exchange is accomplished by a combination of open and closed loop systems that operate simultaneously:

(i) a 42000 m long horizontal (slinky) heat exchanger

(ii) four (4) coaxial geo-exchangers (each 150m deep)

(iii) an open loop system (doublet) that provides 45 m^3/h of water

The coaxial geo-exchanger was developed by the company "AM Constructions", according to which their innovative design and geometry (tube in tube) guarantee much higher output and top performance, reducing the installation and operation cost of the system.

District Heating/Cooling System in Nea Ionia (Attiki, central Greece)*:* A 2500 m long network for the heating and cooling of (9) public buildings was completed in 2016 in the city of Nea Ionia, near Athens. The system is supplied by GSHPs (1350 kW_{th}) and solar panels (100 kW_{th}) and cost €1.19 million. The pay-back period is estimated, under the current status of operation, at more than 10 years, however if more buildings are connected to the network, it can be decreased to less than 6 years. The expected annual energy cost savings have been estimated at approximately 55%. The replacement of fossil-fired installations results to the reduction of CO2 emissions by 612tn/year.

De-icing of pavements in Karpenisi (Evrytania, central Greece): A geothermal snow melting system was installed in 2014 at the center of the town 'Karpenisi', in order to prevent icing of the 1.2 km long pedestrian walkways. The system operated for the first time during the winter of 2015-2016. It is supplied by warm water (28°C) from a closed-loop GSHP, coupled to 18 borehole heat exchangers (100m deep). Heating is automatically turned on when the outdoor temperature drops below +2°C.

Heating and cooling of a winery: The first winery in Greece that uses geothermal energy is "Ktima Brintziki", located in NW Peloponnese, near ancient Olympia. The heating, cooling and chilling requirements of the facilities are covered by a closed loop GSHP system, which consists of 14 borehole heat exchangers (100m deep) and two heat pumps that provide 57 kW heating and 53 kW cooling each. The temperature of the water delivered by the heat exchangers to the heat pumps is 16°C in heating mode and 20°C in cooling. The installation cost was €60000, with a five-year payback time. The Brintziki winery is the first in Greece with zero carbon footprint, as, in addition to the GSHPs, photovoltaic panels are used to cover the electricity demands.

Bioclimatic Building of CRES: The GSHP heating/cooling system of the CRES bioclimatic building was renovated in the framework of the Horizon 2020 innovative action "Cheap-GSHPs". The system consists of one open loop doublet with titanium plate heat exchanger (borehole depth = 60m, flow rate = 1.25m^3/h) and four different types of borehole heat exchangers: 304L stainless steel coaxial with inner PEX insulated pipe (50m), spiral (15 m deep), single-U (120m) and double-U (120m). The GSHP provides heating and cooling to the building through fan-coils with seasonal performance efficiency (SPF) of 4.2.

4. REGULATORY FRAMEWORK

The National Renewable Energy Action Plan, endorsed in 2010, and the National Energy and Climate Plan that came into effect in 2019 set the main targets for the penetration of RES in the country's energy market. Moreover, the Energy Performance of Buildings Regulations (2010) is considered as the main legislative tool for the promotion of RES systems for heating and cooling at the tertiary and residential sector (Andritsos et al., 2015), and has, in fact, become the key factor for the growth of the GSHP market.

Recently enforced legislation comprises the new geothermal Law (n. 4602/2019), the new RES support scheme (L. 4416/2016) and the establishment of Energy Communities (L. 4513/2018), which are discussed in the following paragraphs.

4.1. New Geothermal Law

As of March 2019, Greece has a new geothermal Law (L. 4602/2019 "Exploration, exploitation and management of the country's geothermal potential") that replaced L 3175/2003 "Exploitation of geothermal potential, district heating and other provisions". The detailed concession procedures, contracts, terms, royalties etc., are expected to be re-determined by secondary legislation and Ministerial Decisions, which are under development.

The exploitation of shallow geothermal resources is mentioned in L. 4602/2019 and is further regulated by a number of Ministerial Decisions, which will probably be reformed as well.

The main changes in the new legislation can be summarized as follows:

- The threshold for the classification of a resource as "geothermal" is 30□C instead of 25°C
- A "geothermal field" is defined as the area where geothermal resources (T>30°C) have already been identified or accessed
- The geothermal fields are no longer classified as 'low' or 'high temperature' neither as "proven" or "probable", but only as of "local" or "national interest", depending on whether the product temperature is below or above 90°C, respectively.
- The term "area of geothermal interest" is introduced, describing the wider region with indications for the existence of geothermal resources with temperatures 30- 90°C
- The concepts "exploitation" and "management" of geothermal potential are explicitly defined and distinguished as:

  (i) *Exploitation*: all the activities aiming at the extraction of geothermal products and by-products and the safe disposal of the sub-products

  (ii) *Management*: all the activities regulating the exploitation of geothermal fluids, ensuring the sustainable, rational and integrated exploitation of the entire geothermal field

- The right to exploit is disconnected from management. Therefore, the concession may concern (i) exploration, (ii) exploitation, or (iii) exploitation and management
- The exploitation or exploitation/management leasing period increases from 35 (30+5 years extension) to 50 years (30+20)
- Pilot exploitation is allowed to begin even if the exploration leasing period has not been completed

The necessary permits and authorizations or special environmental provisions depend on the size, type and location of the geothermal project/plant. The licensing procedure for installing shallow geothermal systems is much simpler and requires the involvement of only one competent authority (Regional Administration).

The Law 4602/2019 also establishes a new legal entity for the geologic and mineral investigation on behalf of the Greek State that replaces the Institute for Geology and Mineral Exploration (IGME); it is called Hellenic Survey of Geology and Mineral Exploration (H.S.G.M.E.). One of the HSGME objectives is to perform geothermal investigation, to conduct geothermal studies, to provide consultancy and opinions on geothermal issues to the State, as well as to monitor geothermal areas and activities and create a national register for geothermal wells. thermal springs and monitoring stations.

4.2 RES Support Scheme

Greece has a new support scheme for renewable energy

sources (RES), which complies with the general conditions set by the European Commission. The new scheme is described in Law 4414/2016 on "New Support Scheme for Renewable Energy Power Plants and High Efficiency Combined Heat and Power Plants". Detailed provisions of the RES support scheme are determined in several Ministerial Decisions (ΑΠΕΗΛ/Α/Φ1/οικ.187701-187706) adopted in December 2016.

The basic principle of RES scheme is to promote the integration of renewables into the national electricity market at an optimum level of cost and benefit. More specifically:

(i) Renewable energy is given priority in regard to the use of the grid, in order to meet the renewable electricity generation targets

(ii) The feed-in tariff-based (FiT) scheme has been replaced by a technology-specific sliding scale Feed-in Premium (FiP). RES support is granted in a competitive "technology-specific" bidding process. Feed-in tariffs remain applicable only for RES plants ≤ 0.5 MW. The RES power plants installed on islands that are either not interconnected with the mainland of Greece or do not have a fully operational daily electricity market, will continue to access a FiT-based scheme (through the Power Purchase Agreement

(iii) The FiP is calculated on a monthly basis as the difference between technology- and capacity-specific Reference Prices and technology-specific reference market prices. The Reference Price for **geothermal energy** is 139 €/MWh for plants ≤5 MWe and 108 €/MWh for plants > 5MWe.

A new tax regulation mechanism and subsidies are available under the Development Law (2016) along with a net metering scheme. Renewable energy sources for heating purposes profit from a new tax regulation mechanism and subsidies foreseen in the Development Law, as well as from income tax relief. A scheme supporting GSHP and other energy saving interventions in private buildings provides direct subsidies and low interest loans to building owners.

4.3 Geothermal Communities

Following the European guidelines, Greece endorsed in January 2018 the Law 4513/2018, which introduces the establishment and operation of "Energy Communities", a concept widespread elsewhere in Europe, but until recently, quite unknown in Greece. The Energy Communities are, as a rule, non-profit organizations, with individuals, public or private legal entities and local or regional authorities, as participants. The main target is to deal with the energy poverty in Greece, as well as to create and promote more democratic and decentralized energy systems, by encouraging citizens to be directly and actively involved in energy projects, as both producers and consumers. The Energy Communities can be active in the fields of RES, Combined Heat and Power, Rational Energy Use, Energy Efficiency, Sustainable Support, Management of Demand and Production.

So far, it seems that this effort has had a positive response from several local communities, farmers, etc., since more than 60 Energy Communities (mostly for PV, none for geothermal energy yet) have been founded and many more are in the process. An initial sum of € 25 million will be made available for subsidies, through the National Strategic Reference Framework (ESPA).

5. GEOTHERMAL CONCESSIONS

As of the fourth trimester of 2020, the geothermal concessions regarded (17) geothermal fields, most of which in northern Greece. PPC has the exclusive rights for exploration, exploitation and management for the high temperature potential in Milos-Kimolos-Polyegos complex, in Nisyros island, Lesvos island and Methana peninsula, whereas the rights to explore or exploit the low temperature (up to 90-99°C) potential in five (5) important geothermal fields in Macedonia and Thrace (Lithotopos, Sidirokastro, Akropotamos, Eratino, Aristino) have been leased to the local municipalities.

Geothermal exploration or development activities have been carried out in those fields that private companies or local municipalities are involved. On the contrary, no real progress has been made, so far, as regards the four (4) allocated areas mentioned above.

6. ON-GOING GEOTHERMAL ACTIVITIES

The most important geothermal projects in progress are:

- *Geothermal Power Production Project*: The joint venture of PPC and HELECTOR S.A. is still going through a series of approvals and conditions.
- *Geothermal field of Aristino*: The geothermal energy exploitation project that has been carried out by the Municipality of Alexandroupolis is still in progress. An amount of €6 million will have been totally invested for the implementation of heat transfer and distribution networks.
- Two new reinjection wells at 550 m depth are under construction, constituting a vital part of exploitation project that is under implementation. This first exploitation attempt has been scheduled to cover, even for peak loads, district heating and greenhouses needs, for a maximum installed capacity of 10 MW_{th}.
- *Geothermal field of Nea Kessani*: The company 'AGRITEX Energy" was awarded the rights to exploit a part of the low temperature geothermal field. The investment pertains to the use of geothermal fluids (Tmax=82°C) for the heating of a 5 ha hydroponic greenhouse for cluster tomatoes. According to the investment plan the greenhouse units will gradually reach 10 ha and the total investment is estimated at €10 million.
- *Geothermal field of Akropotamos*: The Municipality of Paggaio has been awarded the rights to exploit the low temperature geothermal field and plans to invest €10 million for district heating/cooling networks and the distribution of heat to semi-urban settlements, greenhouses and spa resorts. The project is still in the early implementation phase.
- *Geothermal field of Lithotopos*: The exploration rights for the exploration of the low temperature field have been granted to the local authorities (Municipality of Iraklia). The exploration stage (drilling works and productivity tests) was recently completed. The Municipality of Iraklia will soon submit the relative feasibility study with the proposed investments for the field development.
- *Geothermal field of Nymfopetra (Mygdonia Basin, Macedonia)*: The exploration rights are leased to a private company which will use geothermal heat for agricultural purposes and plans to drill three new exploration boreholes and rehabilitate two pre-existing productive geothermal wells. The geophysical prospecting (electrical resistivity tomography) that was performed recently in the area, revealed a very low resistivity anomaly, most probably associated to a geothermal resource, in depths less than 250m.

7. DISCUSSION AND CONCLUSIONS

The current exploitation of geothermal energy in Greece remains far lower than its exploitable resources. This is a known fact for many countries; however it has a particular importance when, despite the urgent necessity to reduce the energy import dependency, Greece continues to import oil in order to provide power to islands, such as Milos and Nisyros, instead of using their significant high enthalpy potential.

The very long stagnation period and the total absence of geothermal electricity generation in Greece is the result of four main factors, related not only to past failures but also to present misconceptions, myths and constant delays: (i) the very negative public perception towards geothermal power production in the most favored geothermal areas of the country (i,e. volcanic islands of Milos and Nisyros), (ii) the failure of the involved parties to overcome bureaucratic, technical and social obstacles, and (iii) the high country investment risk since the beginning of the financial crisis in 2009, and (iv) the hesitation, if not unwillingness, of the decision/policy makers to proceed faster and efficiently to the development of the confirmed or probable high temperature resources.

Unlike power production, the geothermal market for direct uses has shown positive trends. During the past five years new significant investments have been made in the geothermal heating sector, mostly for agricultural uses (greenhouse heating). The successful operation of the new geothermal greenhouses in northern Greece proves that geothermal energy is a very attractive option for low cost energy. The cost of a geothermal MWh ranges from €10 to €30, depending on the energy use and the characteristics of the reservoir, whereas the investment cost per MWth generally varies from €150000 to €300000. For the climatic conditions of northern Greece, 1 MWth can cover more than 90% of the annual heating requirements of a 7-10 ha greenhouse unit.

The total amount invested in geothermal energy (GSHPs excluded) exceeds 32.4 million US$ (Table 8). More specifically, 1.596 million US$ was invested for research and development activities, 12.8 million US$ for field development and 19.6 US$ for utilization, indicating a 73.5% increase compared to the 2010-2014 period. All new investments regard geothermal fields in northern Greece. The total installed capacity from direct uses is 84.45 MWth (Table 5).

The exact number of the installed GSHP units is not known, but it can be reasonably estimated to more than 3500, with a mean COP at 4.5 (Table 4). The total installed capacity is 175MW, corresponding to 1380 TJ/yr energy use, for both heating and cooling (Table 4). The growth of the shallow geothermal market can be attributed to the simplified licensing procedures, but mostly to legislative initiatives and the implementation of certain measures and regulations that aim at fully decarbonizing the heating sector. All new buildings that accommodate services of the public sector must totally cover their primary energy consumption through energy supplied for RES, CHP, district heating and heat pumps. The same rule will stand for the private sector after 31.12.2019. Moreover, in November 2015, the EU Energy Efficiency Directive was enforced in Greece, for compulsory audits in large enterprises and minimum energy requirements for the public sector during refurbishing or purchasing of old buildings.

As regards exploration, most projects are focusing on northern Greece (Macedonia and Thrace) for the further investigation and development of known low or low to medium temperature resources. Since 2015, 13 new geothermal wells have been drilled (11 production and 2 injection) with a total depth of 5638 m (Table 6).

Although the Greek citizens have progressively become more sensitive to energy issues (climate change, greenhouse gas emissions, etc) and more familiar to the use of green technologies, geothermal energy remains less, if not the least, promoted and developed among other renewables, e.g. solar and wind energy. The public view has been the key factor for

the development of the geothermal sector in Greece, so it cannot be taken lightly. The environmental, economic and social impacts of geothermal energy should be discussed more openly and thoroughly in the frame of a public dialogue, especially when various concerns and ethical issues are raised. Therefore, the necessity of informational campaigns, especially through national or regional mass media, is imperative for the future of geothermal energy in Greece.

Local authorities have played a very important role, either positive or negative, in all geothermal regions. Northern Greece has attracted important investments because both local authorities and communities consider geothermal energy as a source of environmental, social and financial benefits. Furthermore, in some cases, like in Aristino and Eratino geothermal fields, the local authorities have been actively involved in exploration and exploitation projects, and operate today as managers of the field and/or distributors of heat.

For the past few years, the energy sector in Greece is being restructured, setting the base to move towards low-carbon-intensity energy systems. For that reason, several reforms have been implemented or planned, among which, the new geothermal Law, the new Development Law, the establishment of Energy Communities and so on. It is too soon to arrive to any conclusions about the effectiveness of the new geothermal legislation; it has been, however, a necessary and positive step for the reformation and modernization of the relative regulatory framework that could facilitate the further penetration of geothermal energy to the country's energy mix.

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TABLE 1: PRESENT AND PLANNED PRODUCTION OF ELECTRICITY

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (specify)		Total	
	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr
In operation in December 2019	0		12,000		3,630				5773*	11,300	21,403	55,240
Under construction in December 2019	0											
Funds committed, but not yet under construction in December 2019												
Estimated total projected use by 2020	0		12,000						6,500		22,500	57,000

*PV: 2492 MWe, Wind: 2693 MWe, Smal Scale Hydro: 239 MWe, Biomass/Biogas: 83 MWe

TABLE 3: UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF DECEMBER 2020 (other than heat pumps)

Locality	Type[1]	Maximum Utilization					Capacity[3]	Annual Utilization		
		Flow Rate	Temperature (°C)		Enthalpy[2] (kJ/kg)			Ave. Flow	Energy[4]	Capacity
		(kg/s)	Inlet	Outlet	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	Factor[5]
Nigrita	P (veg.)	7.5	57	25			1.00	2.50	10.55	0.33
Sidirokastro	G (flowers)	22	40	25			1.38	7.00	13.85	0.32
N. Apollonia 1a	G (veg.)	7	41	25			0.47	2.50	5.28	0.36
N. Apollonia 1b	G (veg.)	17	41	25			1.14	5.50	11.61	0.32
N. Apollonia 1c	G (veg.)	12	41	25			0.80	4.00	8.44	0.33
N. Apollonia 2a	G (flowers)	10	46	25			0.88	3.50	9.69	0.35
N. Apollonia 2b	G (flowers)	10	46	25			0.88	3.50	9.69	0.35
N. Apollonia 2c	G (flowers)	3.4	45	25			0.28	1.20	3.17	0.35
N. Apollonia 2d	G (flowers)	10	45	25			0.84	3.50	9.23	0.35
N. Apollonia 3	G (flowers)	27.7	50	30			2.32	9.50	25.06	0.34
Polychnitos 1	G (veg.)	19	82	43			3.10	6.00	30.86	0.32
Polychnitos 2a	G (veg.)	23	82	43			3.75	7.50	38.58	0.33
Polychnitos 2b	G (veg.)	9	82	43			1.47	3.00	15.43	0.33
Polychnitos 2c	G (veg.)	10	82	43			1.63	3.50	18.00	0.35
Milos	G (veg.)	4.2	46	24			0.39	1.00	2.90	0.24
N. Erasmio 1	P (veg.)	140	58	33			14.64	50.00	164.88	0.36
N. Erasmio 2	P (veg.)	4.5	60	40			0.38	2.00	5.28	0.44
Eratino_Chrysoupoli	P (veg.)	14.16	75	35			2.37	4.60	24.27	0.32
N. Erasmio 3	G (s.h)	3	58	30			0.35	2.00	7.39	0.67
Myrodato	G (s.h)	5.5	50	30			0.46	4.00	10.55	0.73
Trainoupoli	SH	16.7	52	38			0.98	5.90	10.89	0.35
N. Apollonia	SH	10	57	45			0.50	3.30	5.22	0.33
N. Erasmio 4	SH	4	42	32			0.17	1.30	1.71	0.32
N. Erasmio 5	D	9.7	58	52			0.24	6.00	4.75	0.62
Nigrita	SP	10	48	30			0.75	6.00	14.25	0.60
TOTAL		**409.36**					**41.18**	**148.80**	**461.54**	

G: Greenhouses-Glass
P: Greenhouses-Plastic
G(s.h): Soil Heating
SH: Space Heating
D: Dehydration
SP: Spirulina

TABLE 4: GEOTHERMAL (GROUND-SOURCE) HEAT PUMPS AS OF DECEMBER 2020

Locality	Ground or Water Temp. (°C)[1]	Typical Heat Pump Rating or Capacity (kW)	Number of Units	Type[2]	COP[3]	Heating Equivalent Full Load Hr/Year[4]	Thermal Energy Used[5] (TJ/yr)	Cooling Energy[6] (TJ/yr)
TOTAL GREECE	15	175000	3700	V, H, W	4.2	2190	1380	

TABLE 5: SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF DECEMBER 2020

Use	Installed Capacity[1] (MWt)	Annual Energy Use[2] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3]
Individual Space Heating[4]	1.65	17.83	0.34
District Heating [4]			
Air Conditioning (Cooling)			
Greenhouse Heating	38	407	0.34
Fish Farming			
Animal Farming			
Agricultural Drying[5]	0.24	4.75	0.62
Industrial Process Heat[6]			
Snow Melting			
Bathing and Swimming[7]	43	260	0.19
Other Uses (spirulina and soil heating):	1.56	17.94	0.70
Subtotal	84.45	707.52	
Geothermal Heat Pumps	175	1380	0.25
TOTAL	259.45	2087.52	

TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 2015 TO DECEMBER 2020 (excluding heat pump wells)

[1] Include thermal gradient wells, but not ones less than 100 m deep

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other (specify)	
Exploration[1]	(all)					
Production	>150° C					
	150-100° C					
	<100° C		11			4,672
Injection	(all)		2			0.966
Total			13			5,638

TABLE 7: ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES (Restricted to personnel with University degrees)

	(1) Government	(4) Paid Foreign Consultants	
	(2) Public Utilities	(5) Contributed Through Foreign Aid Prograr	
	(3) Universities	(6) Private Industry	

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2015	6	24	4	0	0	n.a.
2016	6	24	4	0	0	n.a.
2017	6	24	4	0	0	n.a.
2018	6	25	5	0	0	51
2019	6	25	6	0	0	51
Total						

TABLE 8: TOTAL INVESTMENTS IN GEOTHERMAL IN (2019 & 2020) US$

Period	Research & Development Incl.	Field Development Including Production	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
1995-1999	na	na	na	na	na	na
2000-2004	na	na	na	na	na	na
2005-2009	na	na	na	na	na	na
2010-2014	1.068	0.041	7.49	0	87.1	12.9
2015-2020	1.596	12.8	19.6	0	63	37

na = not available

Pretty Rocks Landslide

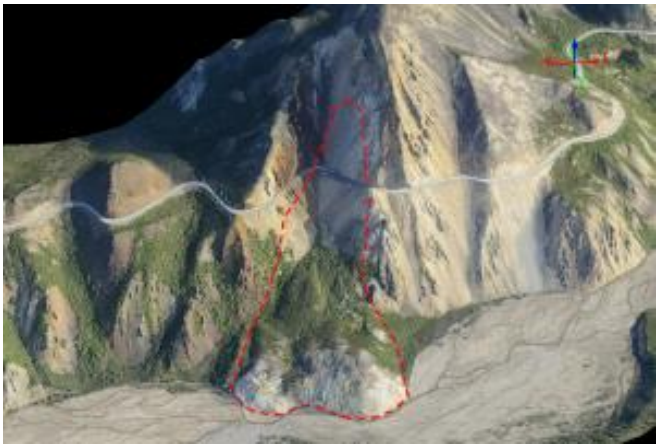
Overview

The Pretty Rocks landslide displaces 100 yards (90 m) of the full width of the Denali Park Road near its midpoint at Mile 45.4 (km 73). In recent years this landslide has evolved from a minor maintenance concern to causing substantial road restrictions.

Staff visit the Pretty Rocks site

Geotechnical investigations near the collapsed portion of the road at Pretty Rocks

The Pretty Rocks landslide has been active since at least the 1960s, and probably since well before the Denali Park Road was built through this area in 1930. Before 2014, the landslide only caused small cracks in the road surface and required moderate maintenance every 2-3 years. However, in 2014 road maintenance crews noticed a substantial speed up. By 2016 the movement had increased further and a monitoring program was begun. The rate of road movement within the landslide evolved from inches **per year** prior to 2014, to inches **per month** in 2017, inches **per week** in 2018, inches **per day** in 2019, and up to 0.65 inches **per hour** in 2021.



Composite photo of the Pretty Rocks Landslide area from 2015. Approximate landslide outline indicated by red dashed line.

Time lapse of the Pretty Rocks slump, from July 21 to August 25, 2021. In this time, the road displacement was ~6.5 meters (21 feet)

Pretty Rocks Landslide Time-lapse (July 25 to September 28, 2021)

Time-lapse video of the Pretty Rocks landslide from July 25th to September 28th, 2021, looking to the northeast. From July 25th until September 2nd, road maintenance crews were spreading up to 100 truckloads of gravel per week within the landslide to maintain the road.

Duration: 44.76 seconds

Pretty Rocks Time-lapse (Park Road, September 9 to 28, 2021)

Time-lapse video of the road within the Pretty Rocks landslide from September 9-28th, 2021, looking to the southeast.

Duration: 10.12 seconds

Pretty Rocks Time-lapse (September 15, 2021 to February 28, 2022)

Time-lapse video of the Pretty Rocks landslide from September 15, 2021 through February 28, 2022. Very cold temperatures and snowy days caused several low-quality images; these images were removed for clarity. Between September 2, 2021 and February 28, 2022, the road dropped approximately 38 vertical feet at the eastern scarp. Movement has slowed substantially, as is normal for this time of year, but we expect it to accelerate again this summer as the ground warms and thaws.

Duration: 13.7 seconds

Road Restrictions

While Pretty Rocks landslide had caused minor road restrictions in prior years, by 2019 conditions began to deteri-

orate further. In August 2019, heavy rains caused increased landslide activity, which resulted in road restrictions on the 8th and a 24-hour road closure that began on the 16th. In 2020 weather conditions were mild and the road crew was able to maintain a safe and drivable surface. In July and August 2021 the landslide sped up considerably, requiring the road crew to spread up to 100 truckloads of gravel per week to fill in the slumping road.

By August 24, 2021, maintenance activities could no longer keep up with the increasing displacement and road surface instabilities. Park managers recognized that adding gravel was no longer tenable or safe and enacted a road closure west of Pretty Rocks for the remainder of the season. The park's ability to adapt to future conditions will require transitioning to more expensive and novel construction methods to maintain road-based access beyond this point.

September 16, 2021 photo of eastern side of the Pretty Rocks landslide. The displacement of approximately 14 vertical feet seen below the person standing on the stable road surface (for scale) occurred over two weeks following the cessation of maintenance and road use on September 2, 2021.

Climate Change as Causal Agent

Based on climate data from 1950 to 2010, Denali National Park has experienced a temperature increase of 7.7°F ± 2.0°F (4.3°C ± 1.1°C) per century, the highest of all national parks (Gonzales, et al, 2018). A recent shift in mean annual temperatures in the area to near 32°F (0°C) (Swanson et al., 2021) combined with heavy rainfall events is believed to be causing permafrost to thaw, resulting in the recent acceleration of many landslides in Denali. In the case of Pretty Rocks Landslide, climate change has likely taken a problem previously solved by minor road repairs and made it difficult to overcome with short-term solutions. Temperature and precipitation increases are likely to continue, and the rate may worsen, over the coming decades.

While these changes were predicted by modelers (Rupp and Loya, 2009), the magnitude of the change has been greater than expected. For example, the area where Eielson Visitor Center is located (Mile 66 [km 106]) reached an average mean annual temperature of 32.4°F (0.2 °C) from 2015-2019 (Sousanes, 2020); this exceeds the temperature of 29.8°F (-1.2°C) projected for 2040 by Rupp and Loya (2009).

Next Steps

Last updated: October, 2021

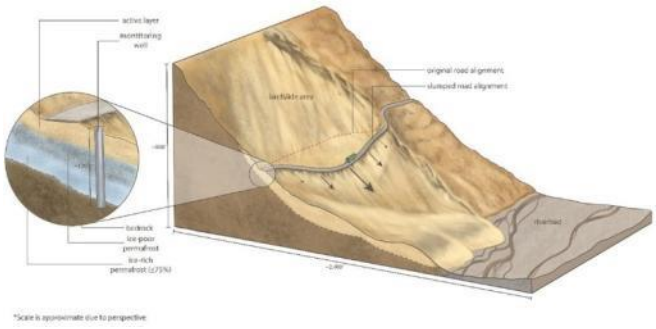
Park managers are weighing potential engineered solutions that will allow for short- and long-term access west of Pretty Rocks. To learn more about potential solutions, see the Polychrome Area Plan.

Pretty Rocks is one of several known landslides in the Polychrome Overlook area and one of the more than 140 mapped unstable slopes along the entire Park Road (Capps et al., 2017). As a result, even though Pretty Rocks is currently our most problematic unstable slope, we must manage the park road and its other unstable slopes proactively and wholistically.

Geology of Pretty Rocks Landslide

We have learned about the subsurface of Pretty Rocks through multiple borings (drilling) in and around the landslide. While conditions are variable, a representative cross section is shown in the following scientific illustration by Laurel Mundy. All borings within the landslide contain permafrost, or ground that is at or below freezing for two or more years. The shallowest material, the active layer, thaws seasonally and is therefore not permafrost. Permafrost can be essentially ice free (ex. granite high on Denali), ice poor, or ice rich.

Some of the substrate here is ice poor, meaning that ice volume is equal to or less than the pore space between debris. Some of the substrate is ice rich, meaning that ice volume exceeds the pore space between debris. Pretty Rocks contains abundant ice – we have drilled through up to 15' (4.6 m) of 85% ice directly beneath the road. The ice-rich permafrost typically is positioned directly above the debris and bedrock interface. Slope inclinometers (instruments that measure displacement) indicate that most movement is occurring at this interface.



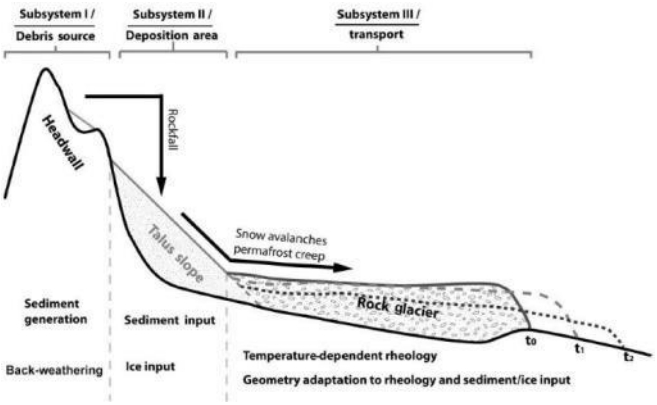
Scientific illustration of the surface and subsurface of the Pretty Rocks landslide

While it's appropriate to describe the substrate of Pretty Rocks landslide as ice-rich permafrost, it is most accurately described as a **rock glacier**. Rock glaciers are closely related to glaciers, but they contain much more rocky debris with ice in the pore spaces. Rock glaciers typically only move a few inches (several cm) per year, as was the case with Pretty Rocks prior to 2014.

However, Pretty Rocks and some other rock glaciers around the world have begun to advance quickly, with climate change as a major cause (Müller et al., 2016). Denali has many rock glaciers, likely thousands of them, and efforts are underway to identify and classify them. Some of these rock glaciers are currently advancing beyond their historic margins.

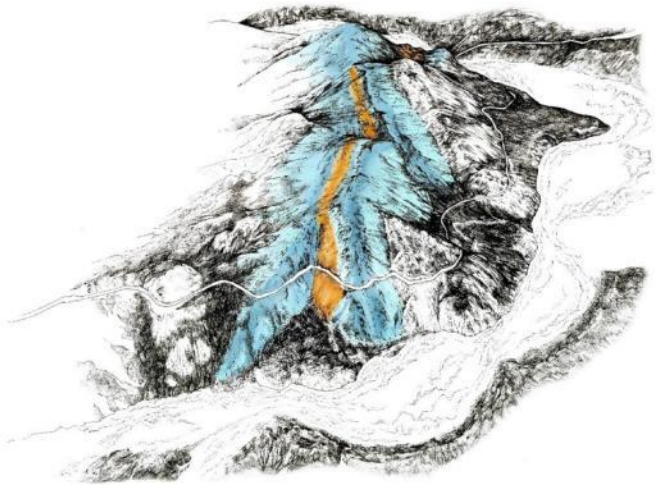
Many that learn about Pretty Rocks ask a reasonable question, "Why don't you just scrape off or blast into the material that is coming down and rebuild the road on bedrock?" The borings help us answer this question. The substrate that is now sliding was deposited horizontally about 55-million-

years ago in volcanic eruptions. Subsequent folding and faulting inclined the material to approximately 60°, as shown in the following scientific illustration by Tracey Faber. The blue highlighted layers are mostly competent rock. The orange layer is mostly volcanic ash that has altered to clay through time.



Conceptual model of the evolution of a rock glacier that illustrates the Pretty Rocks rock glacier accurately. Arrows show sediment transport. t0, t1 and t2 show rock glacier surfaces at different times resulting from variations in environmental factors such as warming and a decrease of sediment-ice - Müller et al., 2016 (unmodified)

The clay is very unstable on steep slopes like those at the road. The clay is also mostly frozen, but only barely – it is within 1°F (0.6°C) of thawing. Based on borings and surface mapping, the clay is known to extend hundreds of feet into the subsurface and laterally to the north-northeast all the way to the East Fork of the Toklat River just north of East Fork bridge. Where this same layer intersects the East Fork River, landslides similar to the one at Pretty Rocks are occurring but do not intersect the road. This long, vertical layer of unstable clay is the reason that we cannot simply dig the undesirable material out and put the road on competent bedrock farther in on the cliff face.



Scientific illustration of the Pretty Rocks area. Blue highlighted areas are mostly competent rock. The orange layer is mostly unstable clay. Pretty Rocks landslide is located where the road (white line) intersects the orange. The main branch of the East Fork River is near top right.

Monitoring System for Pretty Rocks Landslide

The Pretty Rocks landslide monitoring system is located on a stable bedrock ridge below the road and above the western side of the landslide. The robotic total station is a surveying instrument that uses a laser to accurately measure distances and angles from about 35 small prisms (mirrored reflectors) installed within and around the landslide. After staff complete initial measurements manually in the field, the total station repeats the measurements on a defined interval (typically every hour). The weather station includes a shielded thermometer, anemometer (wind speed and direction), and tipping-bucket rain gauge. We create time-lapse videos from photos taken every few hours.

Annotated image of the Pretty Rocks near-real-time monitoring system. To improve visitor safety and understand the movement of the Pretty Rocks landslide, we built a near-real-time monitoring system. The system has five main components: 1) a robotic total station; 2) a weather station; 3) a time-lapse camera; 4) a solar-power system; and 5) a satellite internet system

Because of the large amount of displacement that was occurring in the fall of 2021 and the road closure, we installed a second time-lapse camera looking down the axis of the road to create additional time-lapse videos. The solar-power system utilizes solar panels to charge numerous batteries that power the system during low-light times. The satellite internet system relays all the data from the above system to a computer at park headquarters.

This data is then processed by software and posted to a web interface that allows staff to view the data remotely at any time. Further, weather and movement threshold alarms alert staff automatically when thresholds (ex. heavy rain, increases in movement) are exceeded.

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(Updated: March, 2022, https://www.nps.gov/dena/learn/nature/pretty-rocks.htm)

Radical new methods for underground construction

Lateral thinking and technology transfer are set to revolutionise the construction of transportation and utilities tunnels, underpasses, car parks and other underground structures. Patrick Lane-Nott, director of engineering at hyperTunnel, explains how

When thinking about modern methods of construction, it's tempting to focus only on how these might improve the construction process itself. Tempting, also, to think first of structures built above ground. But let's broaden our minds for a moment.

Let's go underground, where there's an increasing need to take transportation and utility infrastructure because the world's population is growing fast and too many cities are getting overcrowded. And let's look at innovative new methods which not only improve the construction process itself – by reducing time, cost, and commercial risk – but also improve condition monitoring and maintenance so that whole-life costs can be lowered.

The size and number of underground construction projects commissioned around the world have traditionally been held back, of course, by high costs and high commercial risks. But forget that tradition. By replacing traditional methods – many of which have seen little fundamental change in 130 years – with revolutionary new alternatives, underground construction is poised to enter a new era. This means that projects previously considered prohibitively expensive can now be viable.

New techniques for constructing tunnels

The new methods I'll introduce you to here have been conceived by British start-up hypertunnel, but don't let that name confuse you – the company's innovations can also help improve other types of underground construction. True, hyperTunnel's main mission is to bring new techniques to constructing, enlarging, repairing, monitoring, and maintaining tunnels – but these techniques are also well-suited to the construction of underpasses and car parks, as well as burying power cables, rehabilitating water pipes, containing hazardous waste, fixing dams, and even securing coal tips and slag heaps.

First, though, hyperTunnel's new techniques are being applied to tunnelling. Last year, Network Rail awarded the company a contract to work on non-disruptive tunnel repairs for the maintenance and improvement of the railway infrastructure, which includes some 650 Victorian-era tunnels across the UK. New approaches to this kind of work are expected to bring significant cost and delivery-time improvements, as well as greatly reduce inconvenience for passengers. In parallel with this work, hyperTunnel is running life-size simulations on a cross-passage of the type that will be needed 100 times by HS2 and 27 times by the Lower Thames Crossing.

Free-thinking and technology transfer are driving innovation. Though hyperTunnel's techniques are either entirely new to underground construction or being applied more extensively than ever before, they have been proven in other industries with innovative digital technologies. In fact, the business' co-founders, Steve Jordan and Jeremy Hammond, first saw the need to modernise tunnelling when jointly exploring a new approach to tidal-range energy. Now the company is borrowing and adapting concepts and technologies from industries as diverse as mining, oil and gas, chemistry and surveying, and Formula 1 motor racing.

As a result, underground construction is poised to take a quantum leap. We're entering a new era of digital twins, 3D-printed structures, and the use of robots and swarm technology.

Building before excavating the underground asset

Whereas the conventional method is to dig a hole than build the tunnel or underground structure, hyperTunnel first builds the structure, then digs the hole. The structure is constructed in the ground before the underground asset is excavated.

Another significant break from convention is that the hole in the ground is not created by pushing through with a cylindrical boring machine or by drill-and-blast. Instead, the tunnel or hole is 3D-printed in the ground working to a fully parameterized 3D model (digital twin) of the tunnel or structure and surrounding ground.

This digital twin – supplemented by building information modelling – is created with a level of detail not previously seen in construction. Data is gathered by sending semi-autonomous robots and a proprietary 3D ground-penetrating radar system down a series of horizontal index bores. Seismic, tomographic, and thermal imagery data can also be meshed to add detail to the digital twin.

This is a big improvement over the current method of dropping vertical boreholes along proposed tunnel paths every several hundred metres or so – a distance over which geology can change. For the first time, a complete and detailed picture of ground conditions is created, removing any uncertainty about whether construction might encounter changes in geology, fissures, voids, or water. This eliminates the risk of delays and increased costs. What's more, the unprecedented accuracy of hyperTunnel's surveying and deployment methods is well-suited to dealing with a range of geologies. This will be especially advantageous if, as expected, the world's increasing need for more tunnels, underpasses, and other underground structures means that more has to be constructed through challenging geologies or soft ground.

When this preparation work is done, the index bores are ready to serve as a skeleton or scaffold during construction, when construction bores are populated by robots known as hyperBots. These semi-autonomous machines are similar to those seen in other applications, such as warehouse picking and packing, bridge-building, and pipe maintenance and repair. By using swarm technology, they can greatly improve the efficiency and speed of underground construction.

Swarming hyperBots

To understand the concept of swarming hyperBots, think termites. Not as pests, but as highly efficient builders. These insects are hardly the most intelligent form of life, and yet, by working together in large numbers and behaving in ways programmed by their DNA, they manoeuvre around each other in a combined effort that reshapes earth into remarkably complex structures.

In much the same way, hyperBots are relatively simple (and inexpensive), yet when many populate the same construction site, they can get a huge amount of work done. When the hyperBots are sent into the construction bores, they are able to pass each other to move freely and to perform a wide range of tasks. Their actions are coordinated and monitored according to a construction plan created by the digital twin and artificial intelligence.

Using hyperSwarm technology managed by standard industry software, hundreds or even thousands of hyperBots can work simultaneously at different locations. They can handle data gathering, chamber cutting, micro deep-mixing cement, chamber evacuation and replacement, cleaning, delivering

consumables, and the deployment into the ground of composite construction materials. And they can do all this in places where other machines would be too big or too costly, and where it's potentially too dangerous for humans.

3D printing the tunnel or underground structure

hyperBots are used to form the shell of the tunnel or underground structure in an additive manufacturing process which uses the same principle as 3D printing. This concept – creating a three-dimensional object by imposing successive layers of material – will play a big role in future construction projects, overground and underground. It's a versatile method of construction, capable of overlaying materials such as concrete, geopolymers, fibre, and sand, and of creating everything from small components and decorative elements to entire complex structures.

When hyperBots are tasked with deploying composite construction material into the ground (and later, perhaps also to spray a continuous concrete lining), each can carry a 20-litre cartridge of industrial chemicals which can be topped up by replenishing hyperBots. The exact deployment location, material strength, and chemical volume are determined by the construction plan. This provides for simple but accurate consolidation through to the precise manufacturing of the finished structure, building to higher standards than those achievable in a factory on the surface.

Best of all, this new method is fast and efficient: compared to traditional methods, 3D printing can reduce construction time by up to 70% and significantly cut material waste at job sites.

Long-lasting cost benefits

In a reversal of traditional methods, it's only after the structure's shell is complete that the untreated geology within the structure's space is disrupted and excavated. Some of the index bores originally used for surveying the geology are now reamed-out to facilitate a slump of the spoil. The spoil is not dug or drilled but gathered and removed, which is much easier and requires significantly less energy. Removal is done in smaller spaces by a standard excavator, but for larger projects, there's a new dragline shield technology, which utilises techniques used in open-cast mining.

These new methods of construction leave behind an infrastructure of pipes which really can be thought of as scaffolding – there to enhance asset-monitoring with cameras and sensors, and readily accessible by robots to conduct maintenance, repairs, or enlargement. And the existence of a highly detailed digital twin means that there's a 'single truth' database of construction and geology data to enhance asset maintenance and management over the lifetime of the structure, reporting on its health every day. For condition-monitoring, maintenance, and containment of whole-life costs, these are game-changers.

The innovative new surveying, preparation, construction, and excavation techniques are game-changers too. Which no doubt has you asking how soon these advantages will be realised. I can partly answer that by confirming that work on the first completely new tunnel built with hyperTunnel's techniques is expected to start next year. And I can partly answer it by disclosing that, in addition to the agreement with Network Rail, hyperTunnel is currently engaged in serious talks with a number of states, construction companies, and project leaders in the USA, Canada, India, Japan, the Middle East, and the UK. So watch this (underground) space!

(pbctoday, March 2, 2022, https://www.pbctoday.co.uk/news/featured/underground-construction/106768)

Standing foot firm

Ground stabilisation has played a key role in one of the most ambitious infrastructure projects in India's history

Spanning 467m above the Chenab River in India, 600km north of New Delhi, the steel arch of what will be the world's tallest railway bridge sits impressively astride the steep sides of the Chenab Valley. The eponymously named crossing is part of a mega project being undertaken by India's Northern Railway to build a 111km network across the territories of Jammu and Kashmir, including approximately 63km of tunnels and 7.5km of bridges.

The two sides of the arch met in April last year and work is ongoing to build the deck; however, numerous challenges have been overcome to allow the bridge to be constructed in the Himalayan foothills, which experience strong winds, earthquakes and landslides.

The two sides of the arch were connected in April 2021

To counteract potential destabilising forces and moments in the ground around the foundations and improve shear resistance along the slip surface – the surface along which an earth bank is liable to fail under load – ground anchors were installed at the abutting foundations on both the sides of the crossing. Geotechnical analysis revealed that south of the river at abutting foundation S-40 there were very good ground conditions. Consequently, it was deemed that the installation of the Dwyidag bar anchor system by main contractor AFCONS would be sufficient to secure the dolomite rock there.

However, on the northern side of the valley, at abutting foundation S-50, complete consolidation of the rock was required. Freyssinet was contracted to fabricate and install the cable anchors and rock bolts for this side of the bridge under the supervision of AECOM. Starting at an elevation of 670m, five rows of 23m-long 32mm-diameter rock bolts were installed, totalling 92 bolts at 3m spacing centre-to-centre in both directions. Above these layers of rock bolts, up to an elevation of roughly 705m, 237 40m-long prestressed cable anchors with 100Mt design capacity for slope stabilisation were installed in nine rows, with 2.5m between each anchor centre in both directions.

The cable anchors are doubly corrosion-protected and comprise eight steel cables 15.7mm in diameter. The portion of the cable anchors which transmits the force to the surrounding soil – the fixed length – measures 10m and is surrounded by two layers of HDPE corrugated ducts. These provide double corrosion protection when filled with grout. The 30m-long free-length section transfers the force from the fixed length through the anchor head to the wall and is surrounded by grease-filled sheathing and encased in an HDPE corrugated duct.

Preparing the holes for the cable anchors involved drilling to a depth of 40m and a diameter of 160-180mm, with a 200-300mm-deep borehole to guarantee complete grouting at the end of the fixed length. The entire hole was then checked and flushed with air to remove loose material.

A water permeability test was also conducted to ensure water loss of no more than 3 Lugeons. If excess water loss was found, the hole was grouted using neat cement. "Some of the anchor locations at the extreme edges of S-50 consumed more than 5,000 bags of cement grout. In these areas we spent a lot of time to achieve the right results from the water permeability tests," says Boovaraghavan Venkadesan, vice president of operations at Freyssinet India. The hole was then filled with water before the prefabricated anchors were inserted with a grout pipe.

One challenge involved finding access for the drilling rig required to prepare the ground for the first three layers of cable anchors, "Because of the minimum working width of the ledge at these locations, we had to modify the machinery, which took more than three months. For around 20% of the holes, we weren't able to drill with the regular machinery." The modified rig had a mast length of 3m and a crawler base of 2m by 2.8m, compared to 5.5m and 2.8m by 5.5m, respectively, on the regular rig.

The first stage of the three-stage grouting process involved grouting the space between the two HDPE ducts along the fixed length. Second, grout was injected into the pipes fixed inside and outside the HDPE duct until it overflowed from the top of the hole. After that, a precast reinforced concrete pad measuring 1.5m by 1.5m by 0.6m was placed around the grouted anchor using a crane.

Some 237 cable anchors were installed at one of the abutting foundations (Freyssinet India)

Stressing of the cable anchors was conducted 14 days after the first two stages of grouting were completed to ensure the grout had obtained a strength of 30MPa. After this, a 350mm by 350mm by 50mm bearing plate and anchor block were installed on top of the concrete pad, and a 200t-capacity hydraulic jack was brought into position over the anchor head to carry out the stressing procedure. Some 150% of the working load was applied to the strands before being released to 110% of the working load, where the strands were locked.

The third and final stage of grouting was then undertaken, which involved filling the unfilled portion of the anchor inside the concrete pad. A galvanised steel cap was then mounted on the bearing plate using galvanised bolts and filled with a corrosion protection compound to assist in future restressing operations. Long-term monitoring of the anchors will ensure

the safety of the slope along with timely restressing operations as required. The bridge is scheduled for completion in December this year.

Client: **Konkan Railway Corporation**

Contractor: **AFCONS**

Supply and execution of cable anchors: **Freyssinet**

Supply of bar anchors: **DSI**

Geotechnical Consultant: **Indian Institute of Science Bangalore (AFCONS)**

Geotechnical Proof Consultant: **AECOM International (Konkan Railways Corporation)**

Independent consultant: **SCOTT Wilson (Konkan Railways Corporation)**

(Khalifa Bokhammas / BRIDGE DESIGN & ENGINEERING, 07 Mar 22, https://www.bridgeweb.com/Standing-foot-firm/8777)

ΝΕΑ ΑΠΟ ΤΙΣ ΕΛΛΗΝΙΚΕΣ ΚΑΙ ΔΙΕΘΝΕΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΝΩΣΕΙΣ

International Society for Soil Mechanics and Geotechnical Engineering

ISSMGE News & Information Circular March 2022
www.issmge.org/news/issmge-news-and-information-circular-march-2022

1. Council Meeting - 1st May 2022 - URGENT!

The ISSMGE Board, together with the organisers of the 20 ICSMGE, have agreed that the next Council Meeting will be a hybrid event. Details on participation were circulated to officers of Member Societies on the 7th February 2022, including details on how to access the Agenda and Papers, and a survey on attendance (to be completed and returned to the ISSMGE Secretariat by the 15th February). Would Member Society officers check that they have submitted the survey and received an acknowledgement? If you have any queries, please contact the Secretariat.

2. 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.

Registration is now open via the conference website https://icsmge2022.org/registration.php

3. ISSMGE's innovation activities and unique resources for geotechnical engineers" a webinar presented by Dimitrios Zekkos, Chair of Innovation and Development Committee of ISSMGE & Associate Professor at UC Berkeley. March 28th 2022 - 6A.M. Pacific Time.

The Innovation and Development Committee of ISSMGE has been working with the Board, member societies and committees within ISSMGE to develop various resources and tools that can be of practical value to geotechnical engineers in practice as well as researchers and students. Dimitrios Zekkos will present these unique ISSMGE resources and tools with the goal to promote awareness among the geotechnical engineering community. The presentation will include a description of resources such as the open-access online library of ISSMGE, the conference paper review platform, the ISSMGE publishing capabilities, the Virtual University content and capabilities, as well as GeoWorld, ISSMGE Case Histories Journal and other additional resources on the ISSMGE website such as the Lexicon and the mailing lists available from Technical Committees. The presentation will be extremely practical with a focus on communicating the value that these resources can provide to the practice of geotechnical engineering.

Registration: https://zoom.us/webinar/register/WN_y5FtKsCWR6K6RCwsdD_6Jg

4. TIME CAPSULE PROJECT UPDATE

The Time Capsule Project (TCP) has attracted strong support, see https://www.issmge.org/the-society/time-capsule for an update.

In March 2022, a team of **discoverers** will work their way through the material placed online. This work will be an important element of the ISSMGE Time Capsule to be launched at the 20th ICSMGE in Sydney.

Individual members of the ISSMGE are welcome to indicate their interest in being part of the team of discoverers via the time capsule contact form available at: https://www.issmge.org/the-society/time-capsule.

5. NEWS FROM TC209 OFFSHORE GEOTECHNICS

ISSMGE Offshore Geotechnics is delighted to announce that Professor Richard Jardine of Imperial College has been invited to deliver the 6th McClelland Lecture. Scheduled for September 2023 at the SUT - Society for Underwater Tech-nology's Offshore Site Investigation and Geotechnics (OSIG) 9th International Conference Innovative Geotechnologies for Energy Transition. For more information, please see https://www.issmge.org/article/announcing-the-6th-mcclelland-lecturer-professor-richard-jardine.

6. VIRTUAL UNIVERSITY

The following have been added to the website:

Performance assessment of soils and structures by numerical analysis Prof. Toshihiro Noda

How to perform reliability analyses on a spreadsheet Dr Lei Wang

Collapse of Fujinuma Dam by the 2011 Great East Japan Earthquake and its reconstruction - Prof. Fumio Tatsuoka and Dr. Antoine Duttine

Probability Analysis in Civil Engineering Prof. Jie Zhang

7. BULLETIN

The latest edition of the ISSMGE Bulletin (Volume 16, Issue 1, February 2022) is available from the website https://www.issmge.org/publications/issmge-bulletin/vol16-issue-1-february-2022

8. ISSMGE FOUNDATION

The next deadline for receipt of applications for awards from the ISSMGE Foundation is the 31st May 2022. Click **here** for further information on the ISSMGE Foundation.

9. **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 events 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

Fifth International Conference on New Developments in Soil Mechanics and Geotechnical Engineering - 30-06-2022 - 02-07-2022 Atatürk Cultural and Congress Center Near East University, Nicosia, Northern Cyprus; English; Organiser: Turkish Society of Soil Mechanics and Geotechnical Engineering and Near East University; Contact person: Cavit ATALAR ; Address: Near East Boulevard; Phone: 05338342829; Fax: 00903922236461; Email: cavit.atalar@neu.edu.tr: Website: http://zm2022.neu.edu.tr; Email : zm.2022@neu.edu.tr

International Workshop: Advances in Laboratory Testing of Liquefiable Soils - 16-09-2022 - 17-09-2022 Acapulco Hotel, Kyrenia, North Cyprus; English; Organiser: TC101; Contact person: Satoshi Nishimura; Email: nishimura@eng.hokudai.ac.jp; Website: https://nce2022.ktimo.org;

16th International Conference on Geotechnical Engineering (16ICGE), 07-12-2022 - 08-12-2022 Civil Engineering Department, University of Engineering and Tech-nology (UET) Lahore, Pakistan; English; Organiser: Pakistan Geotechnical Engineering Society (PGES); Contact person: Dr. Jahanzaib Israr, Associate Professor of Civil Engineering; Address: Civil Engineering Department, University of Engi-neering and Technology (UET) Lahore, Pakistan. Phone: +923344132808 ; Email: 16icge@uet.edu.pk; Website: https://16icge.uet.edu.pk/;

8th International Conference on Unsaturated Soils - 02-05-2023 - 05-05-2023 Milos Conference Centre - George Iliopoulos, Milos Island, Greece[English; Organiser: Hellenic Society for Soil Mechanics and Geotechnical Engineering (HSSMGE); Contact person: Dr Michael Bardanis; Email: mbardanis@edafos.gr

Non-ISSMGE Events

The Third International Conference on Environmental Geotechnology, Recycled Waste Materials and Sustainable Engineering 15-09-2022 - 17-09-2022 Dokuz Eylul University, Izmir, Turkey; English; Organiser: Dokuz Eylul University; Contact person: Yeliz Yukselen Aksoy; Address: Dokuz Eylül University, Dept of Civil Eng, Tnaztepe Kampus; Phone: 905325164800; Email: egrwse2020@gmail.com: Website: http://www.egrwse2022.com

ISSMGE Technical Committee 209 - Offshore Geotechnics Survey

We invite all geotechnical practitioners with experience in offshore geotechnics (past and present, and including PhD students) to participate in a survey, which is aimed at investigating current perceptions and future trends in the field.

Initial findings will be included in the ISSMGE Time Capsule Project, with a complete summary and discussion to be proposed for presentation at a major (TC-209 supported) international conference.

Responses will be kept confidential and are requested by 31 March 2022.

The more thoughtful your responses, the more value to your profession!

See link below to have your say!

https://www.surveymonkey.com/r/TC209_Offshore

Rocscience Webinar - Analysis and Design of Tailings Dams using Numerical Methods

Description:

This free webinar brought to you by Rocscience will demonstrate how to Analyze and Design Tailings Dams using Numerical Methods.

Link for the registration:

https://www.rocscience.com/events/seminar-webinar-analysis-and-design-of-tailings-dams-using-numerical-methods-march2022

Data/Time:

Wednesday, March 23rd, 2022, at 1 PM Eastern Daylight Time

ISSMGE Webinar Announcement: ISSMGE'S INNOVATION ACTIVITIES AND UNIQUE RESOURCES FOR GEOTECHNICAL ENGINEERS

Over the last few years, the Innovation and Development Committee (IDC) of ISSMGE, in collaboration with the Board, member societies and committees within ISSMGE, has been developing various resources and tools that can be of practical value to the geotechnical engineer of practice as well as researchers and students. Dimitrios Zekkos will present these unique ISSMGE resources and tools with the goal to promote awareness among geotechnical engineers. The presentation will include a description of resources such as the open-access online library of ISSMGE, the conference paper review platform, the ISSMGE publishing capabilities, the Virtual University content and capabilities, as well as GeoWorld, the ISSMGE Case Histories Journal and other additional resources on the ISSMGE website such as the Lexicon and the mailing lists available from Technical Committees. The presentation will be practical with a focus on communicating the value that they can provide to the practice of geotechnical engineers.

Registration: https://zoom.us/webinar/register/WN_y5FtKsCWR6K6RCwsdD_6Jg

Speaker: Dimitrios Zekkos

ISSMGE Chair of Innovation and Development Committee (IDC)

Associate Professor at UC Berkeley

When: **March 28 2022 1:00 PM GMT**

Susceptibility and Adaptability in South East Asia: Theory to Practice

Given the role of unsaturated soil mechanics in the topic of the International workshop on Landslides Susceptibility and Adaptability in South-East Asia: Theory to Practice, we are pleased to consider attending this workshop, which is sched-

uleed from **29-30 March 2022** and is jointly organised by Durham University UK and IIT Mandi, India.

Participation is free and open to all. The workshop flyer is appended below and the link for registeration is: https://forms.gle/2uiTb6do3h9DRwGB9

For any enquiry, please direct to Prof. Ashraf Osman (ashraf.osman@durham.ac.uk) or Dr Ashutosh Kumar (ashutosh@iitmandi.ac.in).

UK Research and Innovation — Durham University

International Workshop

on

Landslides Susceptibility and Adaptability in South East Asia: Theory to Practice

Under the project theme

Understanding Landslide Susceptibility and Adaptability in South East Asia (SEAL)

(Funded by UKRI-NERC)

March 29-30, 2022

Jointly organised by

Durham University

Our speakers:

UK Research and Innovation — Durham University

Details of the workshop:

Sr. No.	Lecture Title	Speaker	Time
	Day 1 (March 29, 2022)		
Session 1: Risks and adaption		Session Chair: Dr. Ashutosh Kumar, IIT Mandi	
1.	Welcome address		7:30-7:40 BST 12:00-12:10 IST
2.	Using an unsaturated soil mechanics approach for analysing slopes	Prof. David Toll, Durham University, UK	7:40-8:30 BST 12:10- 13:00 IST
3.	Plant hydromechanical reinforcement to soil slopes: insights from plant-water relation	Dr. Anthony Leung, HKUST, Hong Kong	8:30-9:10 BST 13:00-13:40 IST
4.	Bio-slope engineering: a hybrid approach for sustainable slopes in Thailand	Dr. Apiniti Jotisankasa, Kasetsart University, Thailand	9:10-9:50 BST 13:40-14:20 IST
	Break (10 mins)		
Session 2: Experience from different parts of the world		Session Chair: Dr. Geoff Chao, AIT Bangkok	
5.	Role of Unsaturated Soil Mechanics in the Development of Slope Susceptibility Map	Prof. Harianto Rahadjo, NTU, Singapore	10:00-10:50 BST 14:30-15:20 IST
6.	October 2013 several storm-induced volcaniclastic debris avalanche on Motomachi area of Izu-Oshima, Japan: Phenomenon and mechanisms	Prof Gonghui Wang, Kyoto University, Japan	10:50-11:30 BST 15:20-16:00 IST
7.	A brief overview of the monitoring services of risk areas in São Paulo	Prof. Fernando Marinho, University of Sao Paulo, Brazil and Prof. Gabriela Medero, Herriot Watt University, UK	11:30-12:10 BST 16:00-16:40 IST
8.	Panel Discussion and Photo session		12:10-12:30 BST 16:40-17:00 IST
	Day 2 (March 30, 2022)		
Session 3: SEAL Project update presentation		Session Chair: Prof. Ashraf Osman, Durham University	
1.	Use of water treatment residue for developing capillary barrier systems	Dr. Sravan Muguda, Durham University UK	7:00-7:15 BST 11:30-11:45 IST
2.	Development of water barrier system for slopes	Dr. Ashutosh Kumar, IIT Mandi, India	7:15-7:30 BST 11:45-12:00 IST
3.	Numerical modelling of unsaturated slope under rainfall infiltration	Dr. Hamed Moghaddasi, University of Startholyde UK	7:30-7:45 BST 12:00-12:15 IST
4.	Social Vulnerability assessment for landslide hazards in Malaysia	Dr. Nor Diana Mohd Idris, UKM Malaysia	7:45-8:00 BST 12:15-12:30 IST
5.	DEM analysis of slopes in Kajang, Malaysia	Mr. Van Thang, Gunma University, Japan	8:00-8:15 BST 12:30-12:45 IST
	Break (15 mins)		
Session 4: Regulation on Landslides mitigations		Session Chair: Prof. Mohd Raihan Taha, UKM	
6.	Regulation in Malaysia	Dr. Nursal biah, JKR- Department of Public work, Malaysia	8:30-9:00 BST 13:00-13:30 IST
7.	Implementation of Manual for Landslide Vulnerability Index and Risk Classification for Critical Infrastructure (CI) in Malaysia	Dr. Mastura Azmi, Universiti Sains Malaysia, Malaysia	9:00-9:30 BST 13:30-14:00 IST
8.	Regulation in Indonesia	Dr. Ahmad RIFAI, Gadjah Mada University (UGM), Indonesia	9:30-10:00 BST 14:00-14:30 BST
	Closing Remarks		10:00-10:05 BST 14:30-15:35 IST

* BST=GMT+1; IST=GMT+5:30 hrs; ICT: GMT+7:00 hrs; MYT&SGT: GMT+08:00 hrs; BRT: GMT-3:00 hrs

UK Research and Innovation — Durham University

Who should attend

- UG/PG students
- PhD students
- Early career researchers
- Practicing engineers

Click here to Register your participation

Event Details

- Participation is free and open to the public.
- Prior registration is mandatory to all.
- Recording would be made available to the participant up on request.
- Participation certificate is provided for attending more than 80% of the session.

Conveners

Prof. Ashraf Osman — Prof. David Toll — Dr. Ashutosh Kumar

Acknowledgement

This workshop is organised as a part of the project "Understanding Landslide Susceptibility and Adaptability in South East Asia (SEAL) funded by UKRI-NERC grant.

For any query: ashraf.osman@durham.ac.uk; ashutosh@iitmandi.ac.in
Support Team: Ashwani Kumar (+91-9805396422), Sonu Kumar, Aditi Rana, Harshit Nayak, Ayush Kumar, Sunil Kumar

Patron

Prof. Laxmidhar Behra, Director IIT Mandi

SEAL Partners

Durham University; CIDB Malaysia; JKR; SEVEN

8th International Course on Geotechnical and Structural Monitoring (14-18 June2022)

Launched in 2014 by NHAZCA S.r.l., ICGSM is an important international professional training event on the role of monitoring activities in geotechnical and structural engineering. The first seven editions were attended by more than 600 experts, scholars and professionals in the field coming from over 60 countries across 6 continents.

The course is directed at engineers, geologists and technicians, but also at project managers and those responsible for risk management within the following main areas of activity:

- Large and small infrastructures
- Tunnels
- Dams
- Excavations
- Artificial and natural slopes
- Construction foundations
- Transport
- Mining
- Oil & Gas
- Cultural heritage

The 2022 edition of ICGSM will focus on the analysis of different monitoring methodologies with particular attention to the design of infrastructures in order to improve the awareness of their structural response during each operational phase and optimise maintenance programmes to ensure their safety.

The event will be structured as follows:

- 14th June 2022: Ice Breaking Field Trip (3.00 h)

- 15th-16th June 2022: Main Course (12.00 h)

- 17th June 2022: Valfabbrica Field Trip (10.00 h)

- 18th June 2022: Acuto Field Trip (6.00 h)

ISSMGE members are entitled to a **10% discount** on the registration fee.

For any details regarding **fees and registration** go to the website https://www.geotechnicalmonitoring.com/register-icgsm-2022.

ISSMGE RESOURCES AND TOOLS FOR TECHNICAL COMMITTEE MEMBERS

Dear members of Technical Committees of ISSMGE,

as the Chair of the Innovation and Development Committee (IDC) of the ISSMGE, and in coordination with TOC Chair Pierre Delage and President Ng, I am writing this e-mail to make sure you are aware of the tools and resources that IDC has developed the last few years and can support your technical committees. Our goal is to provide useful tools and resources that can empower your committee and enhance its impact on the profession. Here is a listing of some of these tools:

1. Online Library with Open Access Technical Papers: The online library has papers published in conferences that are freely available to everyone. In the last year we have expanded its functionality and its content. In the last four years the online library content increased from 9,200 in 2017, to 16,400+ currently. 68 conferences are now indexed. About 350,000 papers were downloaded just in 2021. If you are organizing a conference, we encourage you to consider making the proceedings available in open access, and we will be glad to host them. (URL: https://www.issmge.org/publications/online-library)

2. Development of a Conference Paper Review Platform in support of open access publications. IDC has developed a Conference Paper Review Platform (URL: https://www.issmge.org/publications/review-platform/ongoing-conferences) that aims to support the review of abstracts and papers for Conferences organized by ISSMGE Member Societies, Technical Committees and other groups affiliated with ISSMGE. This platform is provided at no cost with the only requirement that published papers become available in open access through the ISSMGE Online Library. The platform has already been used for three conferences and the papers are now published online at no cost. So if you are organizing a conference, consider using this platform at no cost.

3. Towards ISSMGE Publishing – Ability to issue DOIs: Through the conference paper review platform and the growth of the online library, ISSMGE provides the ability for papers to be submitted and published completely open access. Publication of proceedings is also feasible at some cost (in coordination with the Board). In addition, ISSMGE has now the ability to issue DOIs for papers in the online library, and even for its ISSMGE Reports. So if you publish ISSMGE reports and need a DOI, or you are considering other publications, please reach out to the IDC!

4. Development of ISSMGE Virtual University. According to the Vision of President Ng, the purpose of the Virtual University platform is to educate geoprofessionals at a global scale, and support Universities that may not have the resources to provide detailed educational material on specific topics. The platform was publicly launched in 2020 and is available at http://virtualuniversity.issmge.org/. The platform has the capacity to deliver educational content such as educational videos, webinars, keynote lectures, or short courses freely to anyone. The platform has many advanced capabilities that are described in the attachment. With the support of Board Member Prof. M. Bouassida, as well as many of you who contributed content, the Virtual University has now 149 videos, and 11 short courses that aggregate videos of similar content. Average visits/pageviews for 2021 was 6,500 per month. In total, since its launch in 2020, ISSMGE videos have been played 114,000 times. If your TC is generating educational content or high quality webinars, let us know and we will host the content on the ISSMGE website!

5. ISSMGE website upgrades for Technical Committees. IDC has been continuously upgrading ISSMGE's online presence with the goal to provide relevant and valuable content to ISSMGE membership. Hopefully you know already that your TC has a sub-website on the ISSMGE website. If you post news on the sub-website, it will be promoted through the main page of the ISSMGE website, its social media, and GeoWorld. In addition, visitors of the ISSMGE website have the capability to "sign-up" to receive updates from Technical Committees that fit their interests. Any content you post will reach them directly. This feature empowers your committee to promote its work and be successful in the activities you generate. So don't forget to post content on your TC sub-website! Professionals are waiting for it.

I attach here also the report of the IDC for the last four years, if you want to get more details on these activities and resources. In addition, on March 28 2022 I will be giving a webinar presentation on "ISSMGE's innovation activities and unique resources for geotechnical engineers" where I will be describing some of these innovations with a focus on practical tools. If you have an interest in this webinar, please consider registering here: https://zoom.us/webinar/register/WN_y5FtKsCWR6K6RCwsdD_6Jg and also feel free to forward to your colleagues.

If you have any questions, please reach out! Thank you for all that you do for ISSMGE.

Dimitrios

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Dimitrios Zekkos, Ph.D., P.E.
Associate Professor, University of California at Berkeley
Founder and CEO, ARGO-E LLC
http://www.dimitrioszekkos.org

ISRM International Society for Rock Mechanics and Rock Engineering

News

https://www.isrm.net

New ISRM course on Course on Crustal Stress Assessment and its Application in Engineering and Earthquake Engineering 2022-03-13

In order to improve the methods and techniques of borehole-based stress-strain observatory, especially for calibration technology, promote experimental studies on deep-borehole stress measurement, and advance research collaboration associating the crustal stress with seismicity, seismogenesis, and rock failure process, the ISRM Commission on Crustal Stress and Earthquakes invited five commission members to present a video course. This course includes two parts on the technology of in-situ stress measurement and its application in engineering, two parts on the technology of borehole tensor strainmeter and its calibration, and one part on the application of the crustal stress in Earthquake research:

- Part 0 - Furen XIE - Course Presentation
- Part 1 – Hong LI - Realization of multi-component and 3-D borehole strain-meter observation technology
- Part 2 - Takatoshi ITO - Core deformation: A new stress indicator applicable in a wide range of depth and temperature
- Part 3
  - Part 3.1 - Zhongqi Quentin YUE - Methane gas refined fault theory for cause of tectonic earthquakes
  - Part 3.2 - Zhongqi Quentin YUE - Methane gas refined fault theory for cause of tectonic earthquakes
  - Part 3.3 - Zhongqi Quentin YUE - Methane gas refined fault theory for cause of tectonic earthquakes
- Part 4 - Qunce CHEN - In situ stress measurements around Eastern Himalayan syntaxis
- Part 5 - Jiayong TIAN - Dynamic calibration of borehole tensor strainmeters

Visit the ISRM website to watch the course

The third ISRM Young Members' Seminar (YMS) will be held on 30 March at 9 P.M. GMT 2022-03-17

The ISRM Young Members' Seminar (YMS) Series is a new ISRM Young Members Group initiative. It consists of a series of virtual events, with the goal of providing a global platform for ISRM young members to share knowledge, experiences, and ideas. More details on the YMS are available on this page.

After very successful first and second editions, the third ISRM Young Members' Seminar will take place on 30 March at 9 PM GMT with two speakers from South America:

- Kimie Susuki (Chile)
  Topic: *Numerical modelling of rock masses in block cave mining*

- *Alexander Ramos (Peru)*
  Topic: *Strategy and tactics for burst-prone conditions in a deep underground mine*

You can join using the Zoom link created for each Seminar and you can participate in the question and answers period. The Seminars will also be live-streamed to the ISRM YM's YouTube channel, where they will be stored. Full information is available on this page.

Stay tuned for details on the 4th edition from the YMS organising committee.

Sevda Dehkhoda
Chair of the ISRM Young Members Committee

ISRM 2021 News Journal is now online 2022-03-26

Dear ISRM Member

The 2021 issue, volume 24, 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

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

Scooped by ITA-AITES #62, 1 March 2022

Auckland to get partially tunnelled light rail | New Zealand

LTA awards two Cross Island Line Phase 1 contracts | Singapore

Site report: Seattle wastewater tunnel project on track | United States of America

Major progress made on Gush Etzion/Yerushalayim tunnel project | Israel

India's longest rail tunnel in Kashmir connected; Railways makes a major breakthrough

We took a trip on board Dorothy - the huge HS2 digger tunnelling under Warwickshire woodland | UK

CRCC-led tie-up to build 40.8 million euro railway tunnel in Serbia

Tehran and Doha to study the feasibility of the longest tunnel in the world | Iran - Qatar

Madhya Pradesh: Six-lane tunnel under construction to be widest in state, canal to flow over it | India

Stonehenge Tunnel | Shapps asks National Highways for more carbon detail | UK

Scooped by ITA-AITES #63, 15 March 2022

Delhi Metro's Tughlakabad line to pass beneath 17 active railway tracks | India

University at Buffalo - UB engineers study tunnels for fire safety | United states of America

Australia's largest TBM starts on West Gate Tunnel

Modern underground network management using mixed reality | Hong-Kong - China

Minimal flood impact for areas within Smart tunnel coverage | Malaysia

DPWH speeds up work for Davao City Bypass Tunnel | Philippines

Melaka govt considering plans for rail tunnel to Sumatra | Malaysia

Vlog: Exploring under-construction tunnel across Yangtze River-Xinhua | China

Metro de Madrid awarded €27 million to upgrade Madrid underground | Spain

Undersea tunnel construction: Experts want govt to conduct feasibility study | India

Scooped by ITA-AITES #64, 29 March 2022

Japanese research body proposes 400 billion yen (€3 billion) undersea rail tunnel between Kansai and Kobe airports | Japan

Grand Paris Express: Tunnelling finished for lines 16 and 17 | France

Patna: Construction of underground metro stations to start soon | India

Construction to begin this year on $4B project including Massey Tunnel, Steveston interchange | Canada

Hyderabad likely to get India's longest road tunnel soon

Hanoi approves plan for underground construction space | Vietnam

Save on gas, save on time. The Gateway Hudson Tunnel would do both | United States of America

Penang Port Commission to submit written review on undersea tunnel construction next week | Malaysia

HS2 reveals noise-cancelling Chiltern tunnel portal design | UK

Elon Musk's Alamo Loop underground tunnel proposal advances | United States of America

Design and construction of a cavern in Downtown Los Angeles

Carlos Herranz – Mott MacDonald

Los Angeles Metro is constructing a light rail corridor beneath Downtown Los Angeles—The Regional Connector Transit Corridor (RCTC). To provide operational flexibility, RCTC required a track crossover adjacent to one of the stations. Right of way constraints required the crossover be constructed at relatively shallow depth using Sequential Excavation Methods (SEM), resulting in what is believed to be the largest mined cross section in Los Angeles. Challenges faced for the SEM cavern design and construction included strict limits for tunnelling induced displacements in surrounding structures and high seismic design loads with 2,500 year return periods. This presentation describes the design approach of the SEM cavern, with an emphasis on the seismic analysis, as well as the actual conditions faced during construction.

Thursday 17th March 2022 The lecture will also be streamed live at https://youtu.be/Bdjs3VnpYDs

Tunnelling in Rock using Drilling and Blasting Method

Mehdi Hosseini – London Bridge Associates Ltd.

Workshop will include the following themes :

1. Introduction to Drilling and Blasting Method in open surfaces and underground spaces
2. Comparison of different Drilling and Blasting patterns in tunnels
3. Design of Drilling and Blasting patterns
4. Controlled blasting and pre-splitting method
5. Impact of Drilling and Blasting on the Rock Mass
6. Rock engineering and rock support

Thursday 17th March 2022,
https://forms.gle/YNiitS5dq6oF4QsCA

Osterberg Memorial Lecturer

DFI's 2022 Osterberg Memorial Lecture will take place on Thursday, June 16. Harry Poulos, Ph.D., D.Sc. Eng., senior consultant, Tetra Tech Coffey, and emeritus professor of civil engineering, University of Sydney, has been selected as this year's lecturer. The lecture is titled, **"Foundations for Tall Buildings – Design and Risk Reduction."**

Harry Poulos, Ph.D., D.Sc. Eng. Tetra Tech Coffey

Poulos joined the Department of Civil Engineering at Sydney University, his alma mater, in 1965, and was appointed a professor in 1982, a position he held until his retirement in 2001. In 1989, he joined Coffey Partners International and is currently as senior consultant with Tetra Tech Coffey. He is also an emeritus professor at the University of Sydney and an adjunct professor at Hong Kong University of Science and Technology. He is also the ombudsman for the DFI Journal.

Poulos has been involved in a large number of high-rise and infrastructure projects in Australia and overseas, including the Burj Khalifa and the Dubai Creek Tower in Dubai, and the 720 km Egnatia Odos motorway in Greece. In 2010, he was elected a Distinguished Member of the American Society of Civil Engineers (ASCE), and in 2014, he was inducted into the U.S. National Academy of Engineering. In 2017, he was awarded the Outstanding Leaders and Projects (OPAL) Award for lifetime achievement in design by ASCE, and in 2020 was awarded the Peter Nicol Russell Memorial Medal by Engineers Australia.

The annual Osterberg Memorial Lecture and Award was established in honor of Dr. Jorj O. Osterberg to recognize innovations in deep foundations construction related to engineering design, testing or education.

To view a listing of previous Osterberg Lecturers, **visit our website.**

Foundations For Tall Buildings – Design and Risk Reduction

The main issues to be considered in the design of foundations for tall buildings will be outlined, and procedures that can be adopted to address these issues will be discussed. Despite the evolution of modern techniques of ground investigation and foundation design, there have been cases in which problems have occurred and the performance of the supported building has been compromised. Some of the risk factors in foundation investigation, design and construction will be discussed, and measures to reduce such risks will be suggested. Examples of the successful application of the design and risk reduction procedures to two prominent tall buildings will be presented. A contemporary case in which a less successful outcome occurred will be discussed briefly. Possible reasons for this lack of success, and some of the lessons learned, will be outlined.

https://www.xcdsystem.com/dfi/program/2D2hmzD/index.cfm?pgid=1317#osterberg

March, 2022

Climate change creates new risks to dam safety

Are the effects of climate change being considered in dam risk assessment? What happens during extreme rainfall or when water levels are higher than expected due to lower usage? Authors of a paper in the *Journal of Water Resources Planning and Management* looked at how risk assessments are used to ensure dam safety.

Watch Video

June 15, 2022, Prof. Vassilis Marinos will deliver the fist Mediterranean Lecture "In-Flysch-Structure. Addressing the Challenge of Flysch in Major Infrastructure Projects ". The event will be held in Naples at the faculty of Engineering. Further information can be found in our website: https://medgeocommunity.wixsite.com/website

The lecture will be followed by a lunch offered by the Università di Napoli.

The lecture will be spread also on-line.

The link: https://medgeocommunity.wixsite.com/website/about-3

Starting at 10.30 Rome time.

ΔΙΑΚΡΙΣΕΙΣ ΕΛΛΗΝΩΝ ΓΕΩΤΕΧΝΙΚΩΝ ΜΗΧΑΝΙΚΩΝ

Βράβευση Ακαδημίας Αθηνών
Δρ. Χ. Παρασκευοπούλου

Η Δρ. Χρυσόθεμις Παρασκευοπούλου, Γραμματέας της ΕΕΣΥΕ, Επ. Καθηγήτρια στο Univ. of Leeds, τιμήθηκε με το Βραβείο της Ακαδημίας Αθηνών για το έτος 2021.

Στις 23 Μαρτίου 2022 σε ειδική τελετή στο Μέγαρο της Ακαδημίας Αθηνών, της απονεμήθηκε το βραβείο Α' Τάξεως Θετικών Επιστημών, της οικογένειας Λουκά Μούσουλου, εις μνήμην του ακαδημαϊκού Λ. Μούσουλου, για ερευνητική εργασία στον κλάδο της Μεταλλειολογίας - Ορυκτών Πόρων, για την δημοσιευμένη εργασία της «Analysis of time-dependent deformation in tunnels using the Convergence-Confinement Method» [Ανάλυση της χρονικά εξαρτώμενης συμπεριφοράς (της βραχόμαζας) γύρω από υπόγεια ανοίγματα (σήραγγες) χρησιμοποιώντας την μέθοδο σύγκλισης-αποτόνωσης»] (Tunnelling and Underground Space Technology, Vol. 71, Jan. 2018, p. 62-80 - https://eprints.whiterose.ac.uk/123397/1/TUST_2016_719_Revision%201_V0.pdf).

ΠΡΟΣΕΧΕΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΚΔΗΛΩΣΕΙΣ

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

The Second Betancourt Conference "Non-Linear Soil-Structure Interaction Calculations", April 2022, mail@georec.spb.ru, ulitsky.vladimir@gmail.com, www.georec.spb.ru

16th International Benchmark Workshop on Numerical Analysis of Dams, 6–8 April 2022, Ljubljana, Slovenia, https://icold-bw2022.fgg.uni-lj.si

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

5ISEE 5th International Seminar on Earthworks in Europe 20-22.4.2022, Prague, Czech Republic, www.c-in.eu

RaSim 10 Rockbursts and Seismicity in Mines, 24 – 29 April 2022, Tucson, USA, www.rasimsymposium.com

HYDRO 2022 Roles of hydro in the global recovery, 25-27 April 2022, Strasbourg, France, www.hydropower-dams.com/hydro-2022

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

3rd International Conference on Geotechnical Engineering - Iraq 2022, 17 to 19 May 2022, University of Baghdad, Iraq, https://ocs.uobaghdad.edu.iq/index.php/ICGEI/ticgei

Transport Geotechnics 2022, 19 May 2022, London, United Kingdom, https://transport.geplus.co.uk/getr/en/page/

2022 ICOLD 27th Congress - 90th Annual Meeting 27 May - 3 June 2022, Marseille, France, https://cigb-icold2022.fr/en

Dear members of the EWG « Dams and Earthquakes »,

As I announced during the ICOLD meeting in November 2019, I am organizing a workshop on the sidelines of the ICOLD World Congress in Marseille. The meeting will take place on **Tuesday, May 31st from 8 a.m. to 12 a.m.** (a participation until 10:15 a.m. being compatible with the program of the technical visits).

I suggest that we dedicate this meeting to presentations centered on our practices in terms of ***Input ground motion selection for the seismic modeling of dams***. The idea is identify the existing practices and to highlight their advantages/disadvantages as regards to the seismic safety requirements of each of our countries.

The detailed description of these practices could be made on the basis of case studies in which we will explain:

- the method for the calibration of input accelerogram (linear scaling? spectrum matching?...),
- the chosen calibration criterion (PGA? IA? …),
- the number of accelerograms considered (3 ? 10 ?),
- etc.

As far as possible, it would be interesting to discuss the influence of the choice of these different approaches on the seismic performance of dams (permanent displacement, damage, etc.).

For now, I invite you to send me your intention to participate in the workshop and your possible wish to make a presentation.

Thank you in advance for your active participation in the life of this working group.

Kind regards.

Guillaume VEYLON
guillaume.veylon@inrae.fr

4th International Conference "Challenges in Geotechnical Engineering" CGE-2022
1 to 3 June 2022, Kyiv, Ukraine
www.cgeconf.com

Organiser: Kyiv National University of Construction and Architecture (Ukraine) and University of Zielona Gora (Poland)

Contact person: Viktor Nosenko, Vasyl Pidlutskyi, Liudmyla Skochko

Address: 31, Povitroflotsky ave., KNUCA, Kyiv, 03037, Ukraine
Phone: +38(097)3811265
Fax: +38(097) 381-12-65
Website: http://www.cgeconf.com
Email: info@cgeconf.com

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

PRF 2022 Progressive Failure of Brittle Rocks, June 20-24th, 2022, Flatrock, NC, USA, www.prf2022.org

3rd International Symposium on Geotechnical Engineering for the Preservation of Monuments and Historic Sites, 22-24 June 2022, Napoli, Italy, https://tc301-napoli.org

CPT'22 5th International Symposium on Cone Penetration Testing, 26-29 June 2022, Bologna, Italy, http://cpt22.org

Workshop on soil erosion for Europe – Emerging challenges, 27-29 June 2022 (WEBEX - Online) Landslides and soil erosion. Chair: Nikolaos Tavoularis ntavoularis@metal.ntua.gr

IS-Cambridge 2020 10th International Symposium on Geotechnical Aspects of Underground Construction in Soft Ground, 28 - 30 June 2022, Cambridge, United Kingdom, www.is-cambridge2020.eng.cam.ac.uk

5.ICNDSMGE – ZM 2020 5th International Conference on New Developments in Soil Mechanics and Geotechnical Engineering, June 30 to July 2, 2022, Nicosia, Cyprus, https://zm2020.neu.edu.tr

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

RocDyn-4 4th International Conference on Rock Dynamics an ISRM Specialized Conference, 17-19 August 2022. Xuzhou, China, http://rocdyn.org

ISFOG 2020 4th International Symposium on Frontiers in Offshore Geotechnics, 28 – 31 August 2022, Austin, United States, www.isfog2020.org

16th International Conference of the International Association for Computer Methods and Advances in Geomechanics – IACMAG 30-08-2022 – 02-09-2022, Torino, Italy, www.iacmag2022.org

WTC 2022 World Tunnel Congress 2022 - Underground solutions for a world in change, 2-8 September 2022, Copenhagen, Denmark, www.wtc2021.dk

11th International Symposium on Field Monitoring in Geomechanics, September 4 - September 7, 2022, London, UK, https://isfmg2022.uk

7th European Geosynthetics Conference, 4 to 7 September, 2022, Warsaw, Poland, https://eurogeo7.org

3rd European Conference on Earthquake Engineering & Seismology, September 4 – September 9, 2022, Bucarest, Romania, https://3ecees.ro

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

IAEG XIV Congress 2022, Chengdu, China September 14-20, 2022, https://iaeg2022.org

28th European Young Geotechnical Engineers Conference and Geogames, 15 – 17 – 19 September 2022, Moscow, Russia, https://www.eygec28.com/?

International Workshop on Advances in Laboratory Testing of Liquefiable Soils, 17 September 2022, Kyrenia, North Cyprus, https://nce2022.ktimo.org

10th International Conference on Physical Modelling in Geotechnics (ICPMG 2022), September 19 to 23, 2022, KAIST, Daejeon, Korea, https://icpmg2022.org

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

10th Nordic Grouting Symposium, 4 - 6 October, 2022, Stockholm, Sweden, https://www.ngs2022.se/

GROUND ENGINEERING
SMART GEOTECHNICS 2022
6 October | Park Plaza Victoria London

New for 2022, Ground Engineering is delighted to bring you Smart Geotechnics, an essential gathering that builds on the previous Instrumentation and Monitoring conference for anyone involved in monitoring and looking for up-to-date insight into projects, technologies and the use of cloud and AI.

These are exciting times for the industry as major projects prepare for construction whilst some come to an end, finding solutions to the challenges, new techniques begin to change how we monitor, and clients look to better understand the data collected and its applications.

Whether you are a project manager on a complex tunnel scheme, a designer looking to mitigate the risks to third party assets or a client engineer wanting to build and improve knowledge of your structures, this is an important event for you to attend.

We are delighted to be physically bringing the industry back together in 2022 and Smart Geotechnics will be co-located with our Basements and Underground Structures conference.

https://smartgeotechnics.geplus.co.uk/smartgeotechnics/en/page/home

IX Latin American Rock Mechanics Symposium - Challenges in rock mechanics: towards a sustainable development of infrastructure, an ISRM International Symposium, 16-19 October 2022, Asuncion, Paraguay, http://larms2022.com

5ο Πανελλήνιο Συνέδριο Αντισεισμικής Μηχανικής και Τεχνικής Σεισμολογίας
20-22 Οκτωβρίου 2022, Αθήνα

Ανακοινώνεται η συνδιοργάνωση εκ μέρους του Ελληνικού Τμήματος Αντισεισμικής Μηχανικής και του Τεχνικού Επιμελητηρίου Ελλάδας του 5ου Πανελλήνιου Συνεδρίου Αντισεισμικής Μηχανικής και Τεχνικής Σεισμολογίας (5ΠΣΑΜΤΣ), στην Αθήνα στις 20-22 Οκτωβρίου 2022. Αποτελεί τη συνέχεια της σειράς των σχετικών συνεδρίων με τελευταίο το 4ΠΣΑΜΤΣ που διοργανώθηκε στην Αθήνα το 2019 και θα πραγματοποιηθεί στους χώρους του Royal Olympic Hotel.

Θεματικές Ενότητες

- Αντισεισμική Ανάλυση και Σχεδιασμός Κτιρίων από Ο/Σ
- Αντισεισμική Ανάλυση και Σχεδιασμός Μεταλλικών Κτιρίων
- Αντισεισμική Ανάλυση και Σχεδιασμός Κτιρίων από Τοιχοποιία
- Αντισεισμική Ανάλυση και Σχεδιασμός Γεφυρών
- Αντισεισμική Προστασία Μνημείων και Ιστορικών Κατασκευών
- Ευρωκώδικας 8 & Σύγχρονοι Κανονισμοί Σχεδιασμού, Αποτίμησης και Ενίσχυσης Κατασκευών
- Προσεισμικός Έλεγχος Δημοσίων Κτιρίων και Κρίσιμων Κατασκευών
- Αντισεισμική Θωράκιση και Αναταξιμότητα Δικτύων και Υποδομών
- Νέες Τεχνολογίες Σεισμικής Αναβάθμισης με βάση την Επιτελεστικότητα
- Επισκευές Βλαβών από σεισμούς και ενισχύσεις κτιρίων
- Σεισμική Μόνωση Κατασκευών – Καινοτόμες Μέθοδοι αναβάθμισης της Σεισμικής Επίδοσης
- Ενοργάνωση Κατασκευών και δίκτυα Καταγραφής της Ισχυρής Σεισμικής Κίνησης
- Σύγχρονες Αριθμητικές Μέθοδοι Ανάλυσης Σεισμικής Συμπεριφοράς Κατασκευών – Υπολογιστικές Μέθοδοι Υψηλής Επίδοσης
- Πειραματική Σεισμική Μηχανική
- Μηχανική / Ανακυκλιζόμενη Συμπεριφορά Δομικών Υλικών – Νέα Υλικά
- Γεωτεχνική Σεισμική Μηχανική
- Αλληλεπίδραση Εδάφους – Κατασκευής. Εδαφική Απόκριση.
- Τεχνική Σεισμολογία
- Αποτίμηση Σεισμικής Επικινδυνότητας
- Σύνθεση, επιλογή, αναγωγή και ενόργανη καταγραφή σεισμικών κινήσεων
- Μέθοδοι Αποτίμησης και Στρατηγική Διαχείρισης Σεισμικής Διακινδύνευσης
- Προσεισμικός σχεδιασμός της Πολιτείας και Μετασεισμική Διαχείριση Κρίσεων
- Εκπαίδευση Μηχανικών και ευαισθητοποίηση Πολιτείας σε θέματα Αντισεισμικής Προστασίας
- Θεσμικό Πλαίσιο Ενεργειακής Απόδοσης Κτιρίων και Αντισεισμική Προστασία
- Εμπειρίες από πρόσφατους Σεισμούς Σάμου (2020), Θεσσαλίας (2021) και Αρκαλοχωρίου (2021)

ΕΠΙΚΟΙΝΩΝΙΑ

Γραμματεία του Συνεδρίου 5psamts@eltam.org

2022 GEOASIA7 - 7th Asian Regional Conference on International Geosynthetics Society, October 31 – November 4, 2022, Taipei, Taiwan, www.geoasia7.org

3rd International Conference on Coupled Processes in Fractured Geological Media: Observation, Modeling, and Application
https://coufrac2022.org

Coupled thermal-hydro-mechanical-chemical (THMC) processes in fractured geological media are critically important to the evolution of the earth, and they play key roles in a number of near-surface and subsurface activities, including carbon sequestration, energy storage, nuclear waste disposal, geothermal exploration, oil and gas exploitation, and mining. Fractures also play an important role in processes that take place in shallow groundwater systems, where they can influence drinking water quality, and the Critical Zone, where they influence greenhouse gas cycling, soil development, and plant processes. Numerical modeling and experimental observations of THMC processes are crucial for advancing the scientific discoveries, and for analyzing, managing and optimizing the subsurface engineering practices.

The 3rd International Conference on Coupled Processes in Fractured Geological Media: Observation, Modeling, and Application (CouFrac2022) invites you to Berkeley, California, November 14-16, 2022. The conference, which succeeds the first held in Wuhan, China in 2018 and the second held in Seoul, Korea in 2020, will focus on new and exciting advances in all areas of coupled processes associated

with fractured geological media, including numerical methods, in-situ tests, lab experiments, machine learning, and applications to different activities in the near-surface, subsurface, and Critical Zone. The conference will be held in person in Berkeley with the possibility of participation through video conferencing. We look forward to your participation!

SUBJECT AREAS

- Carbon sequestration
- Energy storage
- Geothermal exploration
- Hydrocarbon exploitation
- Nuclear waste disposal
- Mining engineering
- Petroleum engineering
- Hydraulic fracturing
- Induced seismicity
- Contaminant transport
- Clay science
- Salt mechanics
- Diagenesis
- Enhanced weathering
- Critical Zone
- Numerical modeling
- Lab and in situ testing
- Machine learning

CONTACTS

Jonny Rutqvist Lawrence Berkeley National Laboratory *(Chair)*
Mengsu Hu Lawrence Berkeley National Laboratory *(Co-Chair)*
Carl I. Steefel Lawrence Berkeley National Laboratory *(Co-Chair)*

GENERAL SECRETARY

Shelby Bemiss
Earth & Environmental Sciences Area
Lawrence Berkeley National Laboratory
1 Cyclotron Road, MS74R316C
Berkeley, CA 94720

Conference email: coufrac2022@gmail.com

This second joint conference of the Piling and Foundation Specialists Federation (PFSF) and Deep Foundations Institute (DFI), at the historic International Convention Centre (ICC) Sydney, will promote all aspects of deep foundations, and retention and ground improvement works. Sessions will promote all aspects of deep foundations, earth retention and ground improvement works, including:

- Design and construction approaches and solutions for deep foundations
- Use of innovative site investigation methods and techniques
- Foundation testing methods and analyses
- Ground improvement for structural support and retention works
- Developments and innovations in deep foundation equipment, methods and materials
- Risk and project delivery practices, and interaction between structural, geotechnical and construction
- Challenging project case studies with lessons learned

This conference will gather design professionals, engineers, contractors, researchers, material and equipment suppliers, and government agencies involved in the design, construction and research of piling and ground improvement solutions for building and infrastructure projects.

International experiences with worldwide experts will be shared along with interactions with practitioners specializing in cutting-edge technologies. All delegates can participate in technical sessions that include design methods, testing and quality control/assurance, equipment developments, and more.

Contact Information

Phone: +1 (973) 423-4030
Fax: +1 (973) 423-4031
Email Us
https://events.american-tradeshow.com/pilingconference2022

AUSROCK Conference 2022, 6th Australasian Ground Control in Mining Conference –an ISRM Regional Symposium, 29 November – 1 December 2022, Melbourne, Australia, www.ausimm.com/conferences-and-events/ausrock/

16th ICGE 2022 – 16th International Conference on eotechnical Engineering, Lahore, Pakistan, 8-9 December, 2022, https://16icge.uet.edu.pk/

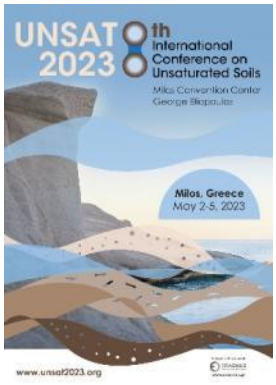
4th African Regional Conference on Geosynthetics – Geosynthetics in Sustainable Infrastructures and Mega Projects, 20-23 February 2023, Cairo, Egypt, www.geoafrica2023.org

Water Resources and Renewable Energy Development in Asia
14 - 16 March 2023, Kuala Lumpur, Malaysia
www.hydropower-dams.com/asia-2023

MISSION OF ASIA 2023

As with the previous conferences in this series, which took place in Bangkok, Danang, Kuching, Chiang Mai, Colombo, Vientiane and Danang (again), the emphasis will be on helping to turn renewable energy and water resources development policies into practice. By bringing together a multidisciplinary group of international experts, to focus on issues of specific relevance to Asia, we aim to stimulate new partnerships, and produce concrete outcomes from the sessions and workshops. All those engaged in promoting, planning, financing, developing, constructing, supplying or studying water resources and renewable energy schemes in Asia should attend.

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



8th International Conference on Unsaturated Soils
2-5 May 2023, Milos island, Greece
www.unsat2023.org

The Hellenic Society for Soil Mechanics and Geotechnical Engineering (HSSMGE) is delighted to welcome you all to the **8th International Conference on Unsaturated Soils "Towards Unsaturated Soils Engineering"** to be held on Milos Island, Greece, between May 3rd to 5th, 2023. The UNSAT2023, organized under the auspices of the ISSMGE Technical Committee TC106, follows the successful past UNSAT conferences held in Hong Kong (2018), Sydney (2014), Barcelona (2010), Phoenix (2006), Recife (2002), Beijing (1998) and Paris (1995).

As past UNSAT conferences, UNSAT2023 aims at providing researchers and practitioners alike with a unique opportunity of sharing up-to-date knowledge on Unsaturated Soil Mechanics and Engineering. The 3rd Blight Lecture, several keynote lectures by renowned experts in the field, numerous papers and a parallel technical exhibition in a relaxed environment will make for a most fruitful scientific event and a unique opportunity for the unsaturated soils community to meet again in person after several years of Covid restrictions. Recent experience in Greece has shown that in-person events are now possible provided nothing new emerges with the world pandemic.

Conference Themes

- Fundamental soil behaviour (water retention, stress-strain behaviour, micro- and macro-structure etc)
- Behaviour of naturally occurring unsaturated soils, especially unsaturated hard soils-weak rocks
- Cyclic/dynamic behaviour of unsaturated soils
- Multi-phase media and multiphysical couplings (thermal, chemical, biological etc)
- Advances in testing techniques, methods and equipment
- Advances in suction and water content measurement sensors and their use especially in the field
- Physical, numerical and constitutive modelling
- In-situ/Field testing
- Long-term measurements of suction in the field and their relation to climatic parameters
- Geoenvironmental and geoenergy applications of unsaturated soil mechanics
- Applications of unsaturated soil mechanics in geotechnical practice, especially simple and straightforward cases showing the importance of unsaturated soil mechanics for the introduction of unsaturated soils in geoengineering education
- Introduction of unsaturated soil mechanics in undergraduate courses: methods, experiences, material to assist geotechnical engineering educators
- Unsaturated soil mechanics in the preservation and pathology of historic monuments
- Unsaturated soil mechanics principles in the context of rammed earth applications and mudbricks
- Unsaturated soil mechanics in slope stability/landslides with emphasis on open pit mining
- The importance of unsaturated soils in many problems of forensic geotechnical engineering
- Hydro-mechanical and thermal properties of bentonites and bentonite-based mixtures, especially Milos Bentonite
- Unsaturated soils for foundations, fills, levees, embankments, dams, roads & pavements, railways and other pieces of infrastructure
- Understanding the effect of climate change on the environment and infrastructure through unsaturated soil behaviour
- Codes and regulations including unsaturated soils mechanics principles
- Any other possible application in the field of unsaturated soils

Organising Secretariat

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www.erasmus.gr

World Tunnel Congress 2023
Expanding Underground
Knowledge & Passion to Make a Positive Impact on the World
12 - 18 May 2023, Athens, Greece
https://wtc2023.gr

Rapid **urbanization**, natural **hazards**, **climate** change, sustainable **energy** geo-resources, people's mobility and transportation of goods are first-priority demanding challenges that the globe is facing.

Cities and infrastructure expansion towards underground provide safe, sustainable and **green solution** facilitating the transformation of millions of people's lives into a more **resilient** lifestyle. A comprehensive understanding, **rethinking and reshaping** of the underground spaces have become even more vital and crucial in the urban transformation of **future** cities. For the latter to be attained, planning and organization of **underground development**, a **holistic approach** is required not only in terms of spatial organization or overcoming engineering challenges, but also in regards to the establishments of policies, regulations and consideration of social factors.

WTC 2023 in Athens will highlight the multiple advantages and solutions that underground space could provide, at the prospect of a whole new era of **smart technology** where sophisticated **"digital tools"** change investigation, design, construction and operation methods and **strategies** rapidly. WTC 2023 will additionally provide an ideal opportunity to showcase recent innovations and the perspective of technology to further efficiently upgrade underground infrastructure assets, transforming the industry and the **societies** it serves.

Athens (Greece) has the knowledge, and we strongly believe we have the **means** and the **responsibility** to literally make a **positive impact** on the world.

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NROCK2022
The IV Nordic Symposium on Rock Mechanics and Rock Engineering
24 – 25 May 2023, Reykjavic, Iceland
www.nrock2023.com

Address

Icelandic Geotechnical Society Engjateigur 9 105 Reykjavík ICELAND

Contact Person Name Thorbjorg Thrainsdottir
Email jardtaeknifelagid@gmail.com

The 17th Danube - European Conference on Geotechnical Engineering
7-9 June, 2023, Bucharest, Romania
https://sites.google.com/view/17decgero

3rd JTC1 Workshop on "Impact of global changes on landslide risk",7 – 10 June 2023, Oslo, Norway, https://jtc1-2023.com

9th International Congress on Environmental Geotechnics Highlighting the role of Environmental Geotechnics in Addressing Global Grand Challenges, 25-28 June 2023, Chania, Crete island, Greece, www.iceg2022.org

17ARC 17th Asian Regional Geotechnical Engineering Conference, 14-18 August 2023, Nur-Sultan, Kazakhstan, https://17arc.org

IS-PORTO 2023 8th International Symposium on Deformation Characteristics of Geomaterials, 3rd - 6th September 2023, Porto, Portugal, www.fe.up.pt/is-porto2023

Innovative Geotechnologies for Energy Transition, 12-14 September 2023, London, UK, www.osig2023.com

SAHC 2023 13th International Conference on Structural Analysis of Historical Constructions "Heritage conservation across boundaries", 12-15 September 2023, Kyoto, Japan, https://sahc2023.org/

XII ICG - 12th International Conference on Geosynthetics, September 17 – 21, 2023, Rome, Italy, www.12icg-roma.org

2023 15th ISRM Congress, International Congress in Rock Mechanics Challenges in Rock Mechanics and Rock Engineering, 9÷14 October 2023, Salzburg, Austria, https://www.isrm2023.info/en/

6th World Landslide Forum "Landslides Science for sustanaible development", 14 to 17 November 2023, Florence, Italy, https://wlf6.org

World Tunnel Congress 2024
Shenzhen, China

China is the official host of the ITA-AITES World Tunnel Congress 2024 and 50th General Assembly.

The General Assembly which took place on June 30th by video-conference, has confirmed the candidacy of Shenzhen to organise the WTC 2024.

XVIII European Conference on Soil Mechanics and Geotechnical Engineering
25-30 August 2024, Lisbon, Portugal

Organiser: SPG
Contact person: SPG
Address: Av. BRASIL, 101
Email: spg@lnec.pt
Website: http://www.spgeotecnia.pt

ΕΝΔΙΑΦΕΡΟΝΤΑ ΓΕΩΤΕΧΝΙΚΑ ΝΕΑ

Centrifuge experiments

Centrifuge experiments are considered ideal benchmarks when validating numerical models. However, such models are installed in (rigid or flexible) model containers. How important are boundary effects? To answer this fundamental question, we numerically investigate the influence of different types of centrifuge containers on shallow foundations subjected to liquefaction. Boundary effects are minimized with a laminar container, where a normalized boundary distance L/DL ≥ 1 is found to be adequate for all liquefiable layer depths (DL) examined. The use of a rigid container is proven problematic, as it always imposes an unrealistic wave propagation pattern. The use of Duxseal inclusions offers a major advantage, allowing accurate reproduction of foundation settlement even with L/DL ≥ 1, a key conclusion for the design of centrifuge tests. The quantification of the influence of lateral boundaries in function of their type and distance to the structure is considered of importance to centrifuge modellers, allowing for optimized design of future experiments, but also to numerical modellers simulating such experiments for validation purposes.

The relevant journal publication is available here (open access): https://lnkd.in/dF6uUBaH. Visit our website for more details: https://lnkd.in/dXVi7mZf

ETH Chair of Geotechnical Engineering

Investigation of boundary effects imposed by different types of centri… / 29.03.2022, https://www.linkedin.com/posts/geotechnics-ethz-ch_investigation-of-boundary-effects-imposed-activity-6914448182567411712-8Nlb?utm_source=linkedin_share&utm_medium=member_desktop_web

Shallow strip foundations subjected to earthquake-induced soil liquefaction: Validation, modelling uncertainties, and boundary effects

K. Kassas, O. Adamidis & I. Anastasopoulos

Highlights

- Numerical analysis of shallow strip foundations during earthquake-induced liquefaction, employing the PM4sand model.
- Validation against centrifuge tests based on pore pressure, settlement, rotation time histories and deformation mechanisms.
- The response of Duxseal material needs to be taken into consideration for the interpretation of a centrifuge experiment.
- Boundary effects are minimized with a laminar box, where a normalized boundary distance is shown to be adequate.
- The Duxseal inclusions offers a major advantage, allowing accurate reproduction of foundation settlement even with

Abstract

Despite recent advancements in predicting the response of shallow strip foundations during earthquake-induced liquefaction, significant modelling–related uncertainties remain, which are the focus of this paper. The problem is analysed through coupled hydromechanical analyses, employing an advanced constitutive model. The model is calibrated based only on the initial void ratio, and then validated against 6 centrifuge model tests, conducted at the University of Cambridge. Through a strict validation procedure, based on pore pressures, settlement and rotation time histories, as well as deformation mechanisms, the strengths and weaknesses of the numerical model are identified. It is shown that final settlement and rotation can be predicted with adequate accuracy, but more work is needed to achieve accurate predictions of settlement rate, maximum rotation, and pore pressures in the vicinity of the foundation. The numerical model is then used to investigate key modelling uncertainties. After revealing the sensitivity to initial soil density and to parasitic vertical acceleration, the effects of the centrifuge model container and of the distance of lateral model boundaries (L) are parametrically investigated. Boundary effects are minimized with a laminar container, where a normalized boundary distance $L/D_L \geq 1$ is shown to be adequate for all liquefiable layer depths (D_L) examined. The use of a rigid container is proven problematic, as it always imposes an unrealistic wave propagation pattern. The use of Duxseal inclusions offers a major advantage, allowing accurate reproduction of foundation settlement even with $L/D_L \geq 1$, *a key conclusion for the design of centrifuge tests*.

…

https://doi.org/10.1016/j.soildyn.2021.106719Get rights and content

Soil Dynamics and Earthquake Engineering, Volume 147, August 2021, 106719, https://www.sciencedirect.com/science/article/pii/S026772612100141X?via%3Dihub

Geo Legends S02 E02 - Norbert "Nordie" Morgenstern

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

The Geo-Legends series features our most eminent members. In episode 2 of season 2, John Sobkowicz of Thurber Engineering interviews Norbert "Nordie" Morgenstern, Professor Emeritus at the University of Alberta. Nordie was the 1992 Terzaghi Lecturer, and the 2011 Seed Lecturer. He is also a recipient of the 2005 ASCE Peyton Award for Cold Regions Engineering and the 1971 ASCE Huber Research Prize.

He talks about everything from his time at Imperial College London, his thoughts on interactions between academia and practice, and a lot more!

Special thanks to Michel Aubertin, Heinrich Heinz, Gord McKenna, and Sally Petaske.

The Geo-Institute is a technical society with about 12,000 geotechnical engineers and geologists as members. Find out more or join at geoinstitute.org.

Music in this episode: Gerry Rafferty - Baker Street. From the 1978 album City to City.

Geo-Institute of ASCE, Mar 8, 2022

A drone video of the B4069 Lyneham landslide

On 25 February I blogged about the Lyneham landslide, a substantial failure on the B4069 road at Dauntsey Banks in Wiltshire, in southern England. With thanks to Stuart Lewis, who highlighted in a comment to that original post that a video has now been posted to Youtube that provides drone footage of the landslide:-

https://www.youtube.com/watch?v=jh1OAb_i39Q&t=104s

The video, which was collected on 8 March 2022, provides both aerial views and static shots of this most interesting landslide. In my original post I noted that there appears to have been construction activity in the field directly upslope of the road. The video provides clarification on this. The image below is a still from the video – it is most interesting:-

The Lyneham landslide, showing construction activity in the field upslope of the road.

Here is another view of the site:-

The Lyneham landslide, showing construction activity in the field upslope of the road.

I think there are a few things to note here. First, the landslide has extended most of the way through this field, with the largest rear scarp area being located adjacent to the pad on which the new buildings are being constructed. Second, the failed section of road corresponds very closely to the eastern boundaries of the field in which construction was being undertaken. This is particularly evident in the first of the two images above. Third, it appears that although building construction has occurred in only a part of this field, it appears that the surface cover throughout has been changed. This is the field in 2019, from Google Earth:-

Google Earth image of the site of the Lyneham landslide in Wiltshire.

I am speculating here, but has the field been regraded (note the scarps downslope of the tracks in the second image)?

Of course, I cannot provide a link between the activities in this field and the reactivation of the landslide – that could only be established through a proper site investigation. I am sure that this is being undertaken. There are other possible causes. But it is certainly a line of enquiry that is worthy of deeper examination.

As I noted in my first post, this is an area that shows clear signs of previous landslide activity, and the failure appears to me to be a reactivation. This highlights why it is important to get input from an engineering geomorphologist before undertaking works such as this in these areas.

(Dave Petley / THE LANDSLIDE BLOG, 15 March 2022, https://blogs.agu.org/landslideblog/2022/03/15/lyneham-2)

Retamas: a fatal landslide caught on video in Peru

On 15 March 2022 a large landslide occurred in the town of Retamas in La Libertad region of Peru.

https://www.youtube.com/watch?v=93HcpBAyoHc&feature=emb_imp_woyt

https://www.youtube.com/watch?v=93HcpBAyoHc&feature=emb_imp_woyt

The aftermath of the landslide is captured in this Reuters image:-

The aftermath of the 15 March 2022 landslide at Retamas in La Libertad, Peru.

The landslide has come after a period of heavy rainfall, although the conditions at the time of the landslide appear to have been dry. Reports indicate that 60 to 80 homes were buried (this looks surprisingly high to me). Apparently 15 people were initially trapped in the landslide, although many have been rescued. There are some indications that six people remain missing, including three children, although this will become more clear in the next day or so.

The precise location of this landslide is not yet clear to me- I suspect that is is -8.0233, -77..4760, but this is unconfirmed. This is a Google Earth image of Retamas, collected in August 2020:-

Google Earth image of the town of Retamas in Peru. Image collected in August 2020.

The stand out feature of this image is that this is an area that is dreadfully impacted by landslides. This is an area that is heavily affected by mining, including one of the largest gold mines in Peru. There is also a large amount of informal mining, which might explain the environmental damage seen in the images. These informal mines are reported to employ up to 5,000 miners.

(Dave Petley / THE LANDSLIDE BLOG, 16 March 2022, https://blogs.agu.org/landslideblog/2022/03/16/retamas-1)

(videos from Teo Blašković / THE WATCHERS, March 16, 2022, https://watchers.news/2022/03/16/la-libertad-landslide-peru-march-2022)

Gjerdrum committee: The risk of quick clay landslides in Norway is unacceptably high

The Gjerdrum committee believes that it is not possible to eliminate all danger of quick clay landslides but that the risk of landslides is now greater than what can be accepted.

"All the danger related to quick clay landslides can not be eliminated, and there is a question of what level of risk society is willing to accept when it comes to such landslides," it

is stated in a new report.

The first preliminary report was presented in September 2021. It addressed the causes of the landslide that cost ten people their lives in Gjerdrum in 2020.

The majority in the committee believes that Norway should have a "vision zero" approach when it comes to deaths in quick clay landslides. To achieve that goal, they recommend a national action plan.

The main conclusions are to clarify the actors' responsibilities, map known quick clay zones, secure existing buildings, ensure that new construction takes place in line with safety requirements, better monitoring of erosion and other terrain changes, and ensure that all actors responsible for prevention are aware of the danger of quick clay landslides.

"The lessons learned from the Gjerdrum landslide show that landslides can cross danger zone boundaries and that assessment of landslide safety must not be limited by the planning area," the committee noted in the report.

(Norway Today Staff, 28. March 2022, https://norwaytoday.info/news/gjerdrum-committee-the-risk-of-quick-clay-landslides-is-unacceptably-high)

Landslide on central B.C. coast caused lake tsunami more than 100 metres high: UNBC study

A landslide in a rural part of the central B.C. coast two years ago displaced enough water to cause a tsunami more than 100 metres high, according to a study by the University of Northern B.C.

The aftermath of a landslide that devastated salmon habitat in Elliot Creek and the Southgate River in central B.C. in 2020. Photo by UNBC /PNG

On Nov. 28, 2020, the landslide near the West Grenville Glacier in a remote valley resulted in "catastrophic damage" to the land and waterways in Homalco First Nation territory, according to a news release from UNBC.

New research from UNBC scientists, in partnership with the Hakai Institute and B.C.'s Forests Ministry, and published in the journal Geophysical Research Letters, found that a rare cascade of events in the southern Coast Mountains caused a landslide that triggered the tsunami in a glacial lake and then flooding.

The report says this caused extensive damage to the salmon habitat in Elliot Creek and the Southgate River.

Flood water, organic debris and fine sediment entered a fiord where it produced a more than 60-kilometre-long sediment plume. That changed the water temperature, water chemistry and amount of suspended solids in the water for weeks, the report said, destroying forest and salmon spawning habitat.

According to the Hakai Institute, when the slide hit Elliot Lake "50 million tonnes of rock — roughly equal in weight to 150 Empire State Buildings — dropped from a sheer mountainside."

Photos from the November 2020 landslide into Elliot Creek in central B.C. Photo credit: Hakai Institute. Photo by Hakai Institute /PNG

The science team used various observations, including seismic energy, laser mapping, satellite imagery and state-of-the-art computer simulations, according to UNBC.

"Imagine a landslide with a mass equal to all of the automobiles in Canada, travelling with a velocity of about 140 kilometres an hour when it runs into a large lake," said the lead author, Marten Geertsema, who is an adjunct professor in UNBC's ecosystem science and management program.

Geertsema said the landslide displaced enough water to cause a tsunami with a wave height that exceeded 100 m.

"This drained most of the lake water, which then travelled down (a 10-km)-long channel causing widespread channel erosion and loss of salmon habitat," he said. "It took about 30 seconds from when the rock started to detach on the slope for that mass of rock to enter the lake and, that produced a huge displacement wave. And everything was removed, all the trees and the soil, and so that was pretty spectacular."

The region had been soaked in up to 103 millimetres of rain in the week leading to the landslide, while snowmelt may have also contributed up to 30 mm of water, the report said. Other factors the researchers say led to the slide were fractured bedrock at the base of the slope due to glacier retreat.

The report said this kind of hazard in high mountains can happen as a result of rapid deglaciation.

"It's certainly consistent with what we might expect under a

changing climate," Brian Menouno, a UNBC geography professor and co-author of the study, said.

Photos from the November 2020 landslide into Elliot Creek in central B.C.

He said these landslides can occur when the glacial ice fills some of these valleys and the supports of these steep, unstable slopes are removed.

"Then those steep unstable slopes are susceptible to failure. And that's what we think happened. We're still not entirely certain what the actual trigger was, but we know that the removal of that ice played an important role."

Both Menounos and Geertsema said their work couldn't have been done without the partnership of the Homalco First Nations and the data from the Hakai Institute.

The study notes that while landslides and outburst floods aren't new in the mountain regions, salmon are now experiencing low returns because of a variety of factors, including climate change and habitat degradation.

"Under a warmer climate, we know glaciers are continuing to retreat. And will continue to do that, in large part due to greenhouse-gas emissions. And as they do that, they expose not only steep terrain, but they can also start to expose areas where there are large lakes," said Menounos.

Photos from the November 2020 landslide into Elliot Creek in central B.C.

Landslides have created tsunamis before. For example, there was one on Mount Colonel Foster on Vancouver Island just over five years ago and it created a 50 m wave.

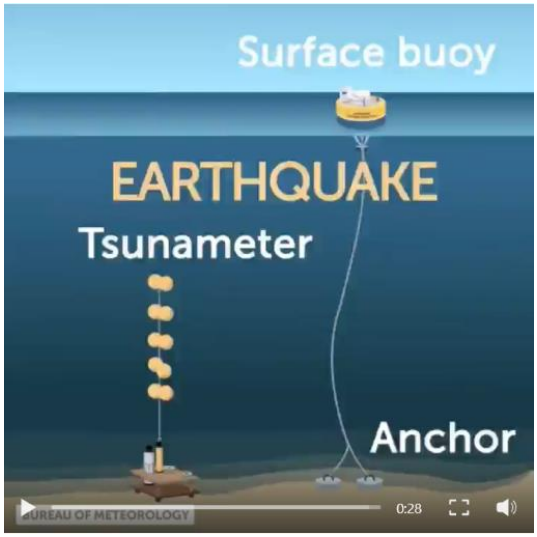
Photos from the November 2020 landslide into Elliot Creek in central B.C.

Photos from the November 2020 landslide into Elliot Creek in central B.C. Photo credit: Hakai Institute. Photo by Hakai Institute /PNG

(Tiffany Crawford / VANCOUVER SUN, Mar 30, 2022, https://vancouversun.com/news/unbc-study-landslide-tsunami)

ΕΝΔΙΑΦΕΡΟΝΤΑ - ΣΕΙΣΜΟΙ & ΑΝΤΙΣΕΙΣΜΙΚΗ ΜΗΧΑΝΙΚΗ

Impressive science of tsunami detection buoy



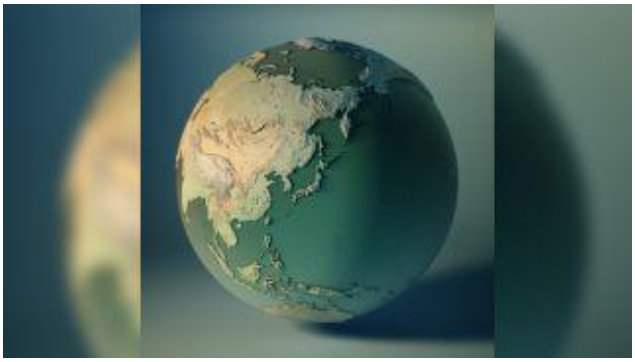
Impressive science of tsunami detection buoys, a critical element for tsunami early warning systems. Please share, comment, and connect for more Felipe Ochoa Cornejo, Bureau of Meteorology, AU.

https://www.linkedin.com/feed/update/urn:li:activity:6913101696093028352/

Mountain-sized chunk of rock hiding under Japan is channeling earthquakes

The Kumano pluton plays an important role in the subduction of Japan's southern coast.

An underground mountain-sized chunk of rock may be affecting paths of large earthquakes in southern Japan.

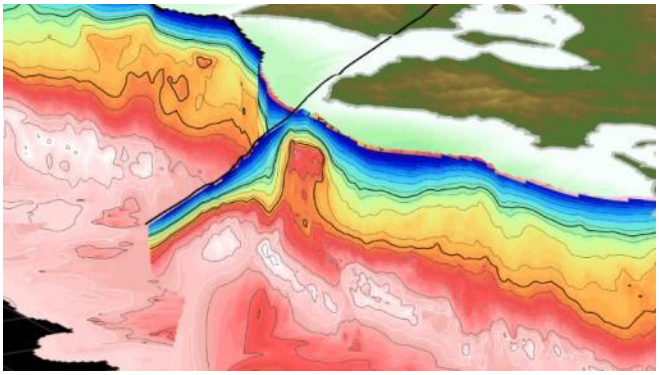


The dense igneous rock, known as the Kumano pluton, is lurking about 3.1 miles (5 kilometers) below the surface beneath Japan's Kii Peninsula. It sits in the crust of the continental Eurasian plate. Under this slab of continental crust, the oceanic Philippine plate is taking a dive toward the Earth's mantle, a process called subduction. New research suggests that the heavy pluton within the Eurasian plate changes the slope of that dive, forcing the Philippine plate down more steeply.

The pluton also sits near the epicenters of two large 1940s earthquakes, each of which traveled in opposite directions and did not rupture through the pluton itself.

"Ultimately, we don't really know why these earthquakes didn't overlap in the region of the pluton," said study co-author Dan Bassett, a marine geophysicist at New Zealand's GNS Science, an Earth science research service. "It does appear to be playing a really key role in nucleating these earthquakes and preventing them from joining up." (An earthquake's nucleation point is where it begins to rupture the crust.)

Though it sits relatively near the surface, the pluton may have a big influence on how water moves from Earth's oceans into its mantle. The Philippine oceanic plate's subduction is twice as steep under the pressure of the pluton. This seems to create more fractures in the subducting plate, which allows it to carry more seawater down toward the deep crust and mantle. Water in the mantle then drives things like volcanic eruptions.



The Kumano Pluton in southern Japan appears as a red bulge (indicating dense rock) in the center of this new 3D visualization. The mountain-sized chunk of rock is nestled in the crust of the continental Eurasian plate, under which the oceanic Philippine plate is taking a dive toward the Earth's mantle. (Image credit: Adrien Arnulf)

How the crust breaks

The Philippine plate is grinding under the Eurasian plate off the coast of Japan at a rate of about 1.78 inches (4.5 centimeters) per year. This process, called subduction, triggers earthquakes and volcanism. Scientists use seismic monitors to try to understand the geological structures within subduction zones, but this is often a spotty record, especially in submarine trenches where placing equipment isn't easy.

The coast of Japan, though, is one of the best-monitored places in the world, seismically speaking. The Japanese Agency for Marine-Earth Science and Technology (JAMSTEC) has blanketed the Nankai Trough region with seafloor monitors, and Japan's seismologists have also put together the densest array of borehole seismometers — seismic monitoring equipment buried deep in the crust to minimize disruption from non-earthquake vibrations — on the planet.

"We recognized that we had this gigantic dataset, which had

swelled for a couple of decades and was really unique in that it would enable us to produce a really high-resolution three-dimensional model of the entire subduction zone," Bassett told Live Science.

The team did not discover the Kumano pluton, which has been known since about 2006, but they did get the clearest picture ever of how this structure influences the subduction zone. What they found was a surprise: Most research on subduction zones focuses on the structure of the plate that's diving beneath the surface, but doesn't consider the plate sitting over it. The new findings indicate that the slab of crust sitting over the subducting plate may be more important than anyone had realized.

"We think a lot about the angle of the slab that's going down and hadn't spent a lot of time thinking about how the properties of the upper crust impact the downgoing slab," said Wendy Bohon, a geologist at the Incorporated Research Institutions for Seismology (IRIS), who was not involved in the study.

The findings, published in the journal Nature Geoscience on Feb. 3, raise new questions about the role of the pluton in earthquakes. In 1944, a magnitude-8.1 quake started on the edge of the pluton and shook the ground to the northeast. Two years later, a magnitude-8.6 earthquake started close to the epicenter of the first quake but ruptured in the southwest direction.

"You have these points along faults that are like little rough spots or, in this case, big rough spots and they can stop the earthquake from unzipping," Bohon said, referring to structures such as the Kumano pluton. "They can act as nucleation points, places where the earthquakes starts, or they can act as, like a backstop, places where the earthquake could stop."

It's not clear why the pluton is having this effect, Bassett said. It could be that the dense volcanic rock is putting so much pressure on the subducting plate that it resists the sort of dramatic rupture needed to continue an earthquake. Or it could be due to the way the pluton alters the shape of the subducting plate below it. At the region of the pluton, the subducting plate doubles the steepness of its downward dive. This means that this oceanic crust drops very deep, very fast. Earthquakes happen more readily at shallower depths where the crust is cool and brittle, so the quick drop-off could limit the area of crust capable of generating a quake.

Moving water

The sharp downward trajectory of the subducting plate forced by the Kumano pluton has a clearer impact on the way that water moves through the subduction zone. This water cycle isn't directly connected to earthquakes in the region, but it's important for the creation of magmas and for large-scale mantle processes, said Donna Shillington, an Earth scientist at Northern Arizona University who was not involved in the research but who wrote an accompanying News & Views article on the findings.

For these processes, the pluton seems extremely important, Shillington told Live Science. The huge structure seems to create the pressure that forces the subducting plate into a steep dive. That steep dive forces the subducting plate to warp and crack, creating fractures that seawater can seep into. The trajectory of the dive also influences where the water ends up and which minerals it can chemically react with. The seismic waves in this region slow dramatically, suggesting an area of the richly hydrated mineral serpentine, the researchers found.

"Those minerals are stable up to somewhere in the ballpark of 400-600 degrees Celsius [472 degrees to 1112 degrees Fahrenheit], so it has to get carried down a ways before that plate will heat enough that that water will be released," Shillington told Live Science. "So that's likely to have a deeper effect."

Much as in earthquakes, geoscientists have focused more on the subducting plate when trying to understand the deep-Earth water cycle, Shillington said. The new study suggests the overriding plate is important, too.

"If we want to understand this water in the plate, now we have another variable that we need to think about," she said.

The research team now plans to build three-dimensional models of the subduction zone in northeastern Japan where the 2011 Tohoku earthquake originated and the Hikurangi subduction zone off New Zealand's North Island. Those should be ready within a year or two, Bassett said.

"Being able to compare high-resolution 3D models of Earth structures across the three subduction zones should enable us to think a little bit more carefully about how the structure of subduction zones is impacting earthquake behavior," he said.

(Stephanie Pappas / LIVESCIENCE, 02.03.2022, https://www.livescience.com/kumano-pluton-japan-earthquakes)

Upper-plate controls on subduction zone geometry, hydration and earthquake behaviour

Adrien F. Arnulf, Dan Bassett, Alistair J. Harding, Shuichi Kodaira, Ayako Nakanishi & Gregory Moore

Abstract

Many characteristics of the incoming oceanic lithosphere, such as its age, rigidity, fabric orientation or sediment thickness, are often cited as important properties controlling the geometry, state of stress, dynamics and hazard potential of subduction zones, yet the links between upper-plate structures and subduction zone processes remain poorly understood. Here we report that high forearc wavespeeds (v_P greater than 6.6 km s^{-1}) beneath 8,000 km^2 of Kii Peninsula are associated with the Kumano pluton. We show that the dense, high-rigidity Kumano pluton generates a large vertical load, which forces the incoming Philippine Sea Plate to subduct with a trajectory that is a factor of two steeper than adjacent regions. Beneath the region of maximum curvature and faulting of the Philippine Sea Plate, reduced mantle velocities (6.5–7.5 km s^{-1}) within a 25-km-thick, 100-km-wide region at 5–30-km sub-Moho depths may reflect serpentinization (more than 40% antigorite) of the subducting mantle and enhanced porosity from bending stresses. We further report that great (larger than M_w 8) earthquakes nucleated from the flanks of the Kumano pluton in 1944 and 1946. Our study demonstrates the profound impact of upper-plate structures on the geometry, hydration state and segmentation of large megathrust earthquakes at subduction zones.

Arnulf, A.F., Bassett, D., Harding, A.J. *et al.* Upper-plate controls on subduction zone geometry, hydration and earthquake behaviour. *Nat. Geosci.* **15,** 143–148 (2022). https://doi.org/10.1038/s41561-021-00879-x

Nature Geoscience **volume 15**, pages 143–148 (2022)

(https://www.nature.com/articles/s41561-021-00879-x#citeas)

ΕΝΔΙΑΦΕΡΟΝΤΑ - ΓΕΩΛΟΓΙΑ

Curiosity rover snaps close-up of tiny 'mineral flower' on Mars

The beautiful branching rock formed when water still covered the Red Planet.

A photo of the "mineral flower" alongside other diagenetic features on the surface of Mars captured by NASA's Curiosity rover on Feb. 25. (Image credit: NASA/JPL-Caltech/MSSS)

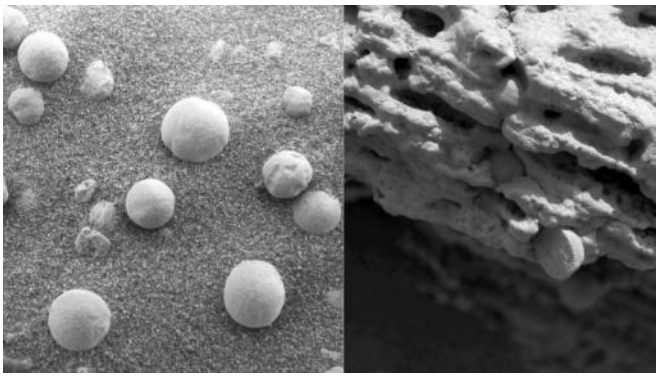
NASA's Curiosity rover recently got up close and personal with a tiny, flower-like mineral deposit on the surface of Mars. The beautiful branching rock, which is just 0.4 inch (1 centimeter) wide, looks a bit like a coral or a sponge. Despite its likeness to a living organism, however, the deposit is not alive and is a fairly common sight across the Martian landscape.

Curiosity snapped a picture of the tiny mineral flower on Feb. 25 near Aeolis Mons, also known as Mount Sharp, at the heart of the 96-mile-wide (154 kilometers) Gale crater, which the rover has been studying since its arrival on the Red Planet in 2012. The image is a composite of multiple shots taken by Curiosity's Mars Hand Lens Imager, which takes close-ups using a magnifying lens. This type of composite photo allows the rover to produce much more detailed images, according to NASA.

The flower-like rock, which has been named the Blackthorn Salt, is a diagenetic feature, or one made from minerals that precipitated from ancient water that had previously been mixed with Martian rock, Abigail Fraeman, a planetary scientist and deputy project scientist for the Curiosity rover, told Live Science. Diagenetic features found on Mars are similar in size but can have either a branched shape, also known as dendritic form, like the Blackthorn Salt, or be more rounded or even spherical, like other rocks in the same photo, she added.

"We've seen diagenetic features with similar shapes before," Fraeman said, "but this dendritic shape is particularly beautiful."

Curiosity has uncovered several other diagenetic features since its arrival in Gale crater. That's not surprising given that the crater could once have been a lake that would have provided the water from which such features precipitate. In 2015, several other flower-like deposits were discovered in the Pahrump Hills area, and in 2019, other diagenetic features were found at the Murray formation.



A black and white photo of the "Martian blueberries" on the Martian surface (left) and a close up of their surface (right), both taken by NASA's Opportunity rover on Feb. 9, 2004. (Image credit: JPL-Caltech/Cornell/USGS)

And in 2004, Curiosity's older sibling, the Opportunity rover, found a number of spherical features on Meridiani Planum — a plain-like area near the Martian equator — with a bluish-silver hue, earning them the nickname "Martian blueberries." These rocks were blue because they were composed of hematite, a type of iron oxide, Fraeman said. The Blackthorn Salt and other features photographed by Curiosity have a composition and color almost identical to those of the surrounding bedrock, she added.

Continuing to document new diagenetic features like the Blackthorn Salt is important because it could help researchers figure out when liquid water disappeared from Mars. "We can learn more about the complex and long-lived history of water at Mount Sharp," Fraeman said. This could reveal more information about how long the environment could have been potentially habitable to life, she added.

(Harry Baker / LIVESCIENCE, 02.03.2022, https://www.livescience.com/tiny-mineral-flower-on-mars)

Καρστ - Maganik, Montenegro

Οι στήλες του Λένα

Στο Ούλους Χακαλάνσκι (περιοχή) της Γιακούτια, στην ανατολική άκρη της Ρωσίας, και μόνο **300 Km από τον αρκτικό κύκλο**, το πιο σκληρό και παγωμένο τοπίο της Σιβηρίας κρύβει σε μια μακρινή περιοχή ένα σχηματισμό από βράχους απίστευτης ομορφιάς που ο ποταμός Λένας σμιλεύει εδώ και χιλιάδες χρόνια σχηματίζοντας ένα μοναδικό τοπίο, το οποίο αφήνει άφωνους τους τουρίστες που τολμούν να πλησιάσουν: το **πέτρινο δάσος του Λένα** (ή οι στήλες του Λένα).

Αυτό το πέτρινο δάσος, αποτελούμενο από στήλες βράχου που φτάνουν τα 150 μέτρα σε ύψος, εκτείνεται **80 χιλιόμετρα** δίπλα στις όχθες του ποταμού Λένα.

Πρόκειται για ένα προϊστορικό τοπίο, διαβρωμένο εδώ και χιλιάδες χρόνια, και με ένα γεωλογικό πλούτο που διατηρεί μαρτυρίες για εξαφανισμένα είδη ζωής. Στο μέρος **του πέτρινου δάσους του Λένα** έχουν βρεθεί απολιθώματα μαμούθ και άλλων ζώων που έχουν εξαφανιστεί. Αλλά επίσης διατηρούνται μορφές ζωής 464 καταγεγραμμένων ειδών πλούσιας πανίδας και χλωρίδας. Η ιδιαιτερότητά του είναι ότι εκτός από τα πιο όμορφα τοπία της Ρωσίας αποτελεί και την πιο δύσβατη περιοχή της.

Νησί Aogashima, Ιαπωνία

Το Aogashima είναι ένα ενεργό ηφαίστειο που βρίσκεται περίπου 220 μίλια νότια του Τόκιο στον Ειρηνικό Ωκεανό. Το νησί έχει πληθυσμό περίπου 170 ανθρώπους που ζουν μέσα στον κρατήρα του μεγαλύτερου ηφαιστείου, καθιστώντας το το το μικρότερο χωριό σε ολόκληρη την Ιαπωνία. Το ηφαίστειο εξερράγη τελευταία φορά το 1785, σκοτώνοντας τον μισό πληθυσμό του νησιού.

ΕΝΔΙΑΦΕΡΟΝΤΑ - ΠΕΡΙΒΑΛΛΟΝ

Terrawatch: how carbon-eating rocks could help fight climate crisis

Recent experiments highlight potential of some rocks to lock in more carbon than previously thought

Olivine in lava rocks in the Canary Islands. Crystals that appear during mineralisation, when the rock takes carbon from carbon dioxide, expand the rock, creating new cracks that enhance its carbon storage capacity.

In the not too distant future we're probably going to have to remove carbon dioxide from the atmosphere, to address the climate emergency. Most carbon capture and storage methods involve injecting gaseous or dissolved carbon dioxide into underground reservoirs, but there is always a niggling worry that it could leak out again. The alternative is carbon mineralisation: a chemical reaction where the carbon from carbon dioxide is locked into a mineral.

Carbon mineralisation happens naturally during rock weathering and stores carbon safely for thousands of years, but until now its potential was thought to be limited because mineralisation clogs up the pores in a rock, blocking entry and preventing further reactions. However, recent experiments indicate that in some rocks (such as olivine) the crystals created during the process of mineralisation expand the rock and force new cracks to appear, which create fresh surfaces and enhance the rock's carbon storage capacity.

The results, which were presented at a meeting of the American Geophysical Union in December 2021, showed that some rocks carried on absorbing carbon for more than a month.

"Now we're hoping to find a way to optimise this process so we can help implement more pilot projects around the world," says Catalina Sanchez-Roa, from Columbia University Climate School in New York.

(Kate Ravilious / The Guardian, Wed 2 Mar 2022, https://www.theguardian.com/science/2022/mar/02/terra-watch-how-carbon-eating-rocks-could-help-fight-climate-crisis)

ΕΝΔΙΑΦΕΡΟΝΤΑ - ΛΟΙΠΑ

Incredible Animation Shows How Bridges Were Built in 14th-Century Prague

We're used to driving across bridges to get from place to place, but have you ever wondered how these ambitious architectural Goliaths were first created? Engineering and Architecture dives into the *how* with an eye-opening animation that demonstrates the construction of the Charles Bridge in Prague from 1357-1402. The bridge is part of an iconic composition across the Vltava (Moldau) river in the popular Czech Republic city. Spanning nearly 1,700 feet and over 33 feet wide, it is a popular tourist destination and holds high historical significance for the city.

The video itself cleverly breaks down the nearly 50-year-long construction process of the Charles Bridge. First, we see the execution of individual footings in the water, from preliminary structural elements to the draining of water from the interior of the footing. It later zooms out from the individual footings and explains the bridging across each element.

These arches are supported by temporary wooden frameworks used for the creation of perfect brick arches. A pulley system is used to lift supplies from boats waiting beneath the structure. Impressive piles of stone and other materials create the infill for all elements. Once the footings and arches are completed, the animation demonstrates the infill and pavement used for the top walking surface of the bridge. Finally, the animation zooms out to the completed box bridge—an impressive structure of 16 arches.

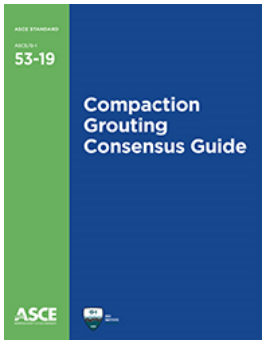
The Charles Bridge was not a new project, it was commissioned to replace the old Judith bridge that was flooded and seriously damaged in 1342. The current bridge was completed under the name *Stone Bridge* or *Prague Bridge*, but was later named Charles Bridge after King Charles IV who commissioned it.

Watch the animation below to take trip back in history and learn more about the construction of the Charles Bridge.

https://www.youtube.com/watch?v=nJgD6gyi0Wk&t=7s

(Samantha Pires / MY MODERN MET, October 23, 2020, https://mymodernmet.com/animation-charles-bridge-prague)

ΝΕΕΣ ΕΚΔΟΣΕΙΣ ΣΤΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΠΙΣΤΗΜΕΣ



Compaction Grouting Consensus Guide (53-19)

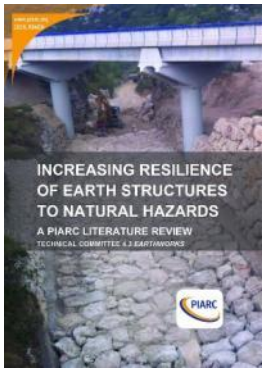
Prepared by the Compaction Grouting Standard Committee of the Geo-Institute of ASCE

Compaction Grouting Consensus Guide, ASCE/G-I 53-19, focuses on the practical and engineering aspects of compaction grouting as a technique of ground improvement. Compaction grouting increases the density, strength, and stiffness of the ground through slow, controlled injections of low-mobility grout that compacts the soil as the grout mass expands. The technology can be applied to a wide range of soils, in most cases being used to improve the engineering properties of poorly compacted fills and loose native soils. Compaction grouting can be applied equally well above or below the water table.

Sections on monitoring and verification have been expanded with new technology-driven content covering both sensitive and routine structures. The material describes automated monitoring of grout injection and ground and structure movements, additions to the finite analysis and soil mechan-ical verifications, and data processing and field practices to implement the technology.

This standard promotes good practice in compaction grouting and is essential reading for those involved in specifying, designing, or undertaking compaction grouting.

(American Society of Civil Engineers, 2019)



Increasing Resilience of Earth Structures to Natural Hazards

PIARC Technical Committee 4.3 / Earthworks

This report provides preliminary background on the topic of "Increasing Resilience of Earth Structures to Natural Hazards" assigned to WG1 of PIARC TC 4.3 as part of the 2020-2023 Work Program. This topic will be further developed as part of the 2020-2023 Work Cycle and is expected to be completed by two adittional doc-uments for this topic: a Case Studies Report and a Full Re-port. This Literature Review provides general insight on how the concept of resilience is currently being considered among the academic and technical community. Adapting and refin-ing this concept and determining how it applies to earth structures and natural hazards will be developed in the subsequent reports.

The production of this report was carried out in multiple phases. The first phase involved a cursory review and selection of relevant documents that address, directly or indirectly, the concept of resilience. The selected documents address the concept of resilience in various ways, from the most general meaning of the concept, to its specific application in road infrastructure. In the second phase, the selected documents had been analyzed in order to extract and highlight any factors that may impact resilience, any hazards that may be present, and any existing methodologies for the measure of resilience and corresponding indicators.

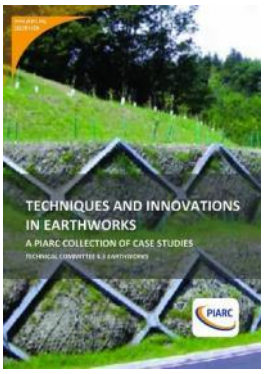
This literature review presents all relevant information, under appropriate subcategories, namely complex systems, infrastructures and assets. Case studies presented in this literature review have also been listed in Chapter 8.

In order to serve its function as preliminary background for future works, conclusions and reccommendations have been provided in Chapters 9 and 10 of the document.

As a result of this literature review, it was concluded that resilience is not a well established or extensively studied concept and, therefore, an unambiguous definition valid for every technical field of interest does not exist. Moreover, no specific consideration to earth structures was found in reference documents when adressing the concept of resilience. This topic is expected to be further developed in future works planned by WG1 of PIARC TC 4.3 during the 2020-2023 working cycle, including coordination with other PIARC Technical Committees.

https://www.piarc.org/en/order-library?publication=35932&solo

(PIARC, 2021)



Techniques and Innovations in Earthworks

PIARC Technical Committee 4.3 / Earthworks

This report presents the summary of thirty-six cases studies compiled by Working Group 2 of Technical Committee 4.3 under the theme "Techniques and Innovations in Earthworks". This document will be further developed as part of the 2020-2023 Work Cycle and is expected to be accompanied by one additional document in publication, a full report. The information contained herein provides general insight, innovative techniques, and unique solutions to problems related to earthworks and earth struc-tures from around the world, with the focus on making these elements of infrastructure more resilient. This document de-scribes interesting solutions to solve damage occurring due to natural adversaries, specifically water and fire, in a several diverse geologies and geotechnical conditions.

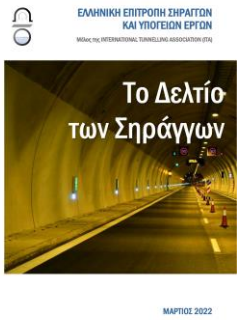
The case studies address a wide range of issues across five of the seven continents: Europe, Africa, Asia, and North and

South America. The issues addressed several areas, including advanced materials, unique techniques and methodologies, innovative technologies, and project specific solutions, all focused on repairing a geotechnical structure after a damage while improving its resilience.

https://www.piarc.org/en/order-library?publication=37708&solo

(PIARC, 2022)

ΗΛΕΚΤΡΟΝΙΚΑ ΠΕΡΙΟΔΙΚΑ



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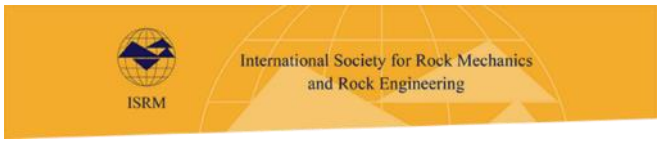
Κυκλοφόρησε το Τεύχος Μαρτίου 2022 του ηλεκτρονικού περιοδικού της Ελληνικής Επιτροπής Σηράγγων και Υπογείων Έργων με τα ακόλουθα περιεχόμενα:

- Νέα & Εκδηλώσεις ΕΕΣΥΕ
- Νέα Σηράγγων και Υπογείων Έργων στον Ελλαδικό Χώρο
- Παύλος Μαρίνος – Αποχαιρετισμός σε ένα Δάσκαλο
- Επιστημονικό Άρθρο: Βέλτιστος σχεδιασμός μέτρων προϋποστήριξης του μετώπου εκσκαφής σηράγγων
- Special Report – Γραμμή 4, Μετρό Αθηνών
- Ελλάδα – ITA Activity Report 2021
- Παγκόσμιο Συνέδριο Σηράγγων 2023 – Athens WTC2023
- Βιβλία – Νέες Εκδόσεις
- Επιστημονικές Συναντήσεις – Συνέδρια



ISRM Newsletter No. 57 - March 2022
https://isrm.net/newsletter/show/222

Κυκλοφόρησε το ISRM Newsletter No. 57 - March 2022 με τα ακόλουθα περιεχόμενα

- Invitation to the ISRM 2022 International Symposium – LARMS IX, Asunción, Paraguay, 16-19 October 2022
- 37th ISRM online lecture by Prof. Yuzo Onishi
- Volume 24 - 2021 of the ISRM News Journal is online
- ISRM launched a survey in English, Spanish and Chinese
- Prof. E.T. Brown elected as an International Member of the U.S. National Academy of Engineering
- Prof. Álvaro González García passed away
- New ISRM course on Course on Crustal Stress Assessment and its Application in Engineering and Earthquake Engineering
- Eurock2022, Helsinki, Finland, 12-15 September
- 15th International ISRM Congress, Salzburg, Austria – Call for Abstracts
- AusRock 2022, Melbourne, 9 November-1 December
- ISRM Young Members' Seminar Series
- 5th Symposium of the Macedonian Association for Geotechnics, Ohrid, 23-25 June
- RocDyn-4, Xuzhou, China, 17-19 August 2022
- 9th Brazilian Rock Mechanics Symposium, 23-26 August 2022, Campinas, Brazil
- CouFrac 2022, 14-16 November, Berkeley, California, USA
- Renew your access to the ISRM Digital Library
- ISRM Rocha Medal 2024 - nominations to be received by 31 December 2022
- ISRM Sponsored Conferences

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

IGS NEWSLETTER – March 2022

Helping the world understand the appropriate value and use of geosynthetics

httpwww.geosyntheticssociety.org/newsletters

- Announcing Candidates for IGS President, Vice President and Council: Term 2022 - 2026 READ CANDIDATE BIOS
- Did You Know: Geosynthetics and the Circular Economy READ MORE
- Australasian Chapter Launches New Conference READ MORE
- Chapter Focus: Egypt READ MORE
- Chapter Focus: India READ MORE
- A Year On With IGS Secretariat-Manager Elise Oatman READ MORE
- Upcoming Webinars
- Geosynthetic Clay Liners For Dams And Dykes March 17 (repeated March 23), Presented by Kent von Maubeuge REGISTRATION INFORMATION
- Slope stabilisation between a rail line & a high voltage substation on a new campus at The University of Birmingham, March 22, Presented by Alan Richardson REGISTRATION INFORMATION
- Geosynthetic Performance Testing and Integration of Results, March 29, Presented by Eli Cuelho, P.E. REGISTRATION INFORMATION

- Double lining systems utilizing geomembranes and geosynthetic drains: why are they so much better? March 30, Presented by Eric Blond REGISTRATION INFORMATION
- Railway Ballast Stabilization and Mitigation of Ballast Degradation using Geogrids, March 30, Presented by Erol Tutumluer REGISTRATION INFORMATION
- Spanish Webinar: Investigaciones sobre el uso de geoceldas para capas granulares de pavimentos y muros de contención, March 31, Presented by Bernardo Caicedo, Ph.D REGISTRATION INFORMATION
- Calendar of Events

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